Making Sense of Gravity

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Version 8.0 was the first version of this document to be made available on the internet at www.fullyrelative.com . Version 8.11 is the eleventh updated version to be posted.

The document became the draft of a book at the end of 2019 but grew out of a paper entitled: “A Fully Relative Theory of Gravitation”, first published on Deakin Research On-line in 2013, with successive versions up until 2016.

The hope is that this setting out of the ideas and arguments will encourage anyone interested in fundamental physics to critically evaluate and improve the arguments and further develop the ideas, predictions and consequences.

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Outline

A new understanding of gravity, Full Relativity, explains gravitational attraction as a decrease in the stored energy (mass) of matter when closer to other mass. When work is done in lifting an object further from the Earth, that work is stored in the object as an increase in mass. When the object falls this stored energy is released as kinetic energy of motion. This is a radical change from the current theory of gravity, General Relativity, which explains gravity as a distortion of the geometry of a claimed fabric of spacetime linked by a constant speed of light.

Such a fabric (a pseudo-background) arose in Special Relativity. It is based on the misunderstanding that the measured speed of light is independent of movement of the observer. The observational requirement is, and was, that the speed of light is independent of the speed of the emitting object. For a constant underlying speed of light, the distance travelled by light, per unit of observed time (ticks of the clock), increases if the observer's clocks are slowed. Keeping the measured speed of light constant, instead, requires distances (the space between objects) to be reduced when time is dilated. Under Full Relativity, time dilation arises because the clocks of objects and observers (which have mass) are slowed by high-speed motion relative to the background from all other massive objects (primarily galaxies). However, the speed of (massless) light is not affected. Consequently, its speed will measure faster, but is constant if the background is constant. The misunderstanding explains why the "space" of Special Relativity's spacetime, the distance between observed objects, appears to be reduced by the slowing of time when there is movement of the observer relative to the background.

Einstein at first claimed that an aether or background was unnecessary in Special Relativity. He later conceded that, since in General Relativity this new aether determines the distortion of spacetime, it must be looked upon as real, if acceleration and rotation are real. General Relativity took the pseudo-background of spacetime and allowed its geometry to be altered by a field of gravitational acceleration. This force field per unit mass (acceleration) arises from a conserved flux from massive objects. The force decreases inversely with distance squared. However, it is a vector field so that fluxes from opposite directions cancel. This is surprising for distortions that reduce distance and time.

General Relativity has had some mighty successes, but the revised theory can reproduce its key experimentally confirmed predictions using a new background. This background alters the speed of light with each contribution reducing inversely as the distance from that massive object. These scalar components sum, independent of direction, just as does gravitational potential energy. Full Relativity replaces spacetime with a variable time altering the apparent distance-travelled in an undistorted space. They are linked by a speed of light that is faster if the size of the scalar background from massive objects is larger. The increased speed of light reduces the mass (stored energy) that can be held by the same matter, in accordance with $m = E / c^2$. This reduction means that clock-rate slows (time is dilated). The reduced mass is seen as the familiar reduction in gravitational potential (energy) that gives rise to the kinetic energy gained by objects accelerating in a gravitational field. Spacetime with its non-Euclidean geometry (altered by the gradient of the potential) is an illusion.

The apparent loss of energy of a photon (an apparent redshift relative to the detecting atoms) in escaping a gravitational field is instead a real increase (by the opposite amount) in energy (a blueshift) of the atoms. The atomic transitions of increased energy happen faster (clock-rate is faster). The decrease in energy held per unit matter at very high mass densities avoids General Relativity's necessary singularities inside black holes. These arise from a positive feedback in which distortions of spacetime give rise to increased energy which further increases distortion. Under Full Relativity, visible light would not be emitted and there would be no black hole horizon behind which a gravity which travels at the speed of light should be trapped. This permits black holes to rotate around stars and each other, whereas an event horizon should prevent them.

Full Relativity has the background field arising from opposing contributions from matter and antimatter. It is like opposing springs where winding up one is resisted by an unwinding of the other. It means that gravitational potential, the effect of an excess of either type, only falls off inversely with distance (as observed) rather than with distance squared. Consequently, the enormous and equal numbers of distant galaxies dominate in determining the total field and the speed of light (c). This means that changes in c are small, so that gravity appears weak. However, any asymmetry between the contributions determines the oscillation frequency per unit of mass. The oscillations/rotations resist changes in the velocity of objects, that is, give rise to inertia. Asymmetry, and therefore inertia, reduces with distance from the centre of an isolated galaxy giving rise to an apparent increase in the strength of gravity. This overcomes the need to hypothesise an invisible dark matter and explains the observed rotational curves of galaxies. Inertial and gravitational mass can only be equated, as is done in General Relativity, after allowing for changes in inertia when the background asymmetry changes.

Clock-rate slows as the energy of massive objects decreases. Thus, clocks on Earth run slower than those of the GPS satellites. However, distances between separated objects cannot be altered by speed of movement of the observers or by the energy of their clocks. Clumping of matter over time, as the Universe has evolved, has led to a contraction of galaxies as inertia increases but the closer proximity of other matter has reduced the energy held per unit of matter, giving a decrease in the speed of light. The mean background and speed of light were therefore higher in the past. Correcting for a previously faster speed of light removes the apparent accelerating expansion driven by an unexpected dark energy. The reduction in mass going back in time is the cause of lower atomic energy levels, giving a redshift of earlier emissions. This change therefore also removes the need for any expansion. There is no need to hypothesise dark energy, a Big Bang, or the faster-than-light initial expansion called cosmic inflation. The idea that "space is not a thing" and can expand (even faster than the speed of light) without objects moving is nonsense.

The apparent dearth of antimatter appears to be because initially opposite regions annihilated and contracted until they became separated into interlaced regions of gravitationally bound like-matter.

The removal of the need for ad hoc hypotheses, the avoidance of singularities inside black-holes and that gravity can cross their supposed uncrossable event horizons, together with new explanations and successful predictions, provide strong evidence for the validity of Full Relativity. Moreover, unlike General Relativity, it is consistent with Quantum Mechanics and appears to remove all current evidence for physics beyond the Standard Model of particle physics and is consistent with the Higgs mechanism as a source of mass. Nevertheless, critical analysis and further development are needed and the suggested observational tests should be made and new ones explored.

"Let every man be respected as an individual and no man idolized."

"The important thing is never to stop questioning."

— Albert Einstein

One such questioner was Martinus (Tini) Veltman (1931-2021). A polite and modest man who was ever the sceptic, but never with malice and always seeking to improve understanding. To my knowledge, the only person to have shared the Nobel Prize (Physics 1999) for work done with his PhD student.

He participated in a discussion on "Is dark matter real?" at the Meeting of Nobel Laureates Lindau in 2012 and made these comments.

"I say it doesn't exist."

"I see so many failures of Einstein's theory of gravitation and present-day astrophysics that I tend to think that's where the problem is."

"Most galaxies have spiral arms. If the spiral arm is made of stars, then it doesn't agree with Newton's equation of motion…. How come these things are still aligned so far in(to) their existence?"

"One thing that I.., really shocked me, which is the following. I've.., humanity has lived until roughly the year 2000 or maybe a bit beyond not knowing about dark energy, and hup(!) dark energy comes about as a result of one experiment by the astrophysicists. Now can you imagine that. They have been overlooking three-quarters of the energy in the universe! Astrophysics is in a sense not like, for instance, particle physics where you come with a model and that they go (and) verify it up to and including the Higgs."

"In the present-day time and the present established theory there is no hint for something beyond the Standard Model (like dark matter and dark energy)."

Preface

This book is dedicated to the memory of my parents, mentors and teachers who gave me the desire and opportunity to embark on this journey. I would particularly like to acknowledge David Caro and Geoff Opat at Melbourne University and Peter Davey at Oxford University. These three were exemplary, caring, hands-on physicists and engineers with a deep love of their work and of those around them together with an enthusiasm and commitment to high standards in all their endeavours. I thank them all for their love and support and for instilling in me the desire to contribute to our understanding of the universe.

The reader is invited to see this document as an on-going work-in-progress. Hopefully, it can be improved and extended by you. It sets out an alternative to General Relativity's explanation of gravity as a distortion of a fabric of spacetime. The initial concept of such a union of space and time arose in Special Relativity in which the Lorentz transformation was derived. The observed behaviour, encapsulated in the Lorentz transformation, can be explained by an altered understanding of how movement affects time and distance intervals. This explanation frees space and time from being linked in a manner that keeps the measured speed of light constant. A variable speed of light then allows Full Relativity's explanation of gravity as a decrease in the energy stored as mass by a fixed quantity of matter. Mass decreases in moving to a region where the speed of light and background field from the mass of surrounding matter is larger. Gravitational acceleration comes from the energy released from that stored in objects as mass rather than from an increased distortion of space and time.

Some of the implications of this new perspective still need further investigation. However, the potential rewards are great because it appears to retain all the verified predictions of Special and General Relativity while removing what seem to be ad hoc hypotheses. These include the need for dark matter, dark energy, and cosmic inflation. Crucially, it avoids the singularity at the centre of a black hole without needing a quantum gravity. Several predictions have been developed which appear to be in good agreement with observation or allow the theories to be distinguished experimentally. Full Relativity also calls into question the current claims for new physics beyond the Standard Model of particle physics and appears to resolve the inconsistency with Quantum Mechanics.

Early attempts at formulating the new theory unfortunately had many mistakes and inconsistencies, which have gradually been resolved. Some faulty ideas and arguments are almost certainly still present, but the reader is invited to critically review the arguments, to take the theory further and to discover new predictions and observable consequences.

The love, support, interest and encouragement of my wife Jane, family and long-time friends was vital. It made it possible to keep going during the long gestation and difficult challenges of this work. These include my brothers, Graham, Robert, John and Trevor; our daughters Caroline, Stephanie, Belinda, and their families; friends including David Anderson, Kevin Essery, Brian Foster, Richard Hemingway, Chris King, Sandy Macintyre, Robert Niall, David Phillips, Terry Reichl, Peter Robertson, Peter Smith, John Tacon and Brian Thompson. John Field and Paul Lasky also shared some of their understanding and Tony Klein listened and advised. I wish to thank Xungai Wang, Jane den Hollander and the library and computing staff of Deakin University for their support, and CSIRO for a 27-year career that provided me with a secure superannuation income. I also wish to thank The Royal Commission for the Exhibition of 1851 for a Science Research Scholarship; colleagues and supervisors at Oxford, including John Mulvey and Louis Lyons; and collaborators at CERN; for their support which enabled me to successfully undertake a D.Phil. in experimental particle physics so many years ago.

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Introduction

The current theory of gravity, Einstein's General Theory of Relativity, is regarded as one of the greatest intellectual achievements of human thought. It explains and predicts how matter and energy will behave. It appears to hold from within our solar system to the furthest galaxies over the time, and speeds, since the universe came into existence. General Relativity (GR) has made a truly impressive range of successful predictions and so has been accepted as fundamentally correct even if it may need additions or to be modified at the fringes. Such additions include dark matter and dark energy hypothesised to explain observations which suggest that the matter with which we are familiar only contributes 5% of the energy and substance of the universe. Modifications are assumed to be necessary to handle very small distances and high energies, where Quantum Mechanics (QM) reigns. The hoped-for solution is referred to as quantum gravity.

GR explains gravity as a distortion of the geometry of a fabric of spacetime. This fabric alters the perceived time and distance of a linked combination (spacetime) in which objects are unchanged and the speed of light is constant. It was built on the success of Special Relativity (SR) which explained the observed behaviour of objects moving at high speed in terms of their relative motion altering the perceived space and time seen by an observer, without any need for a medium (aether).

The replacement theory, labelled Full Relativity (FR), re-introduces a real background that replaces the pseudo-background fabric of spacetime. An increased distortion of the geometry of spacetime in which unchanged objects are embedded is replaced by an undistorted space in which objects, and speed of light, are altered by the background. Movement relative to this background, from all other mass, slows time. The speed of light and properties of objects, including mass, frequency and inertia, are altered by the magnitude and asymmetry of the background.

Gravity can then be understood as a reduction in the energy (mass) that can be stored in matter when it gets closer to other matter. An increase in the speed of the fields, whose standing wave patterns give rise to particle states, reduces the momentum that can be trapped in their oscillations. The work done to lift objects in a gravitational field (seen as their gravitational potential energy) is stored in the objects as mass, not in GR's less-distorted fabric of spacetime in which objects reside. The stored energy is released, appearing as kinetic energy of the object as it accelerates (falls) in a gravitational field. Photons, having no mass, do not lose energy in moving higher in a gravitational field. Instead, massive particles (i.e. those carrying mass) gain energy from the work done to lift them higher. Photons are not redshifted, they do not lose energy in escaping a gravitational field, it is the energy of (massive) atoms that is blue-shifted.

The amount of energy (m) stored by the same matter (which locally stores energy E) varies. Einstein's famous $m = E / c^2$ then implies that the speed of light decreases, and the same clock ticks faster, as the magnitude of the background decreases. It is shown that these simple changes, a variable mass and light speed, are consistent with observations including those that gave rise to SR. However, they also provide encouraging advantages. They remove the singularity at the centre of black holes and allow black holes to interact gravitationally beyond their event horizon. (Under GR, nothing travelling at the speed of light, including therefore gravity, should be able to cross the event horizon.) FR implies the speed of light was faster earlier in the history of the universe. The adjusted travel time for light from the standard candles of distant supernova explosions then implies a constant rate of change of redshift, with time since emission, avoiding the need for dark energy. The redshift of distant galaxies arises not from expansion but from the lower frequency when light-speed was higher, meaning matter held less energy and massive clocks ran slower. These differences also remove the need for the hypotheses of a Big Bang and an incredibly rapid initial expansion of the Universe, called cosmic inflation.

The nature of momentum, the handedness (chirality) of weak interactions and the Higgs mechanism for giving particles mass, indicate that a two-component, chiral background from matter and anti-matter is required. The inertia and frequency of oscillations of all particles varies with the matter/antimatter asymmetry of the background. One consequence appears to be that most of the initial matter and antimatter will have annihilated leaving behind equal quantities of interlaced regions of non-interacting galaxy clusters. The presence of the antimatter regions will no longer be revealed by annihilation. However, the decrease in gravitational potential, inversely with distance rather than distance squared, means that the two background contributions are dominated by the large number of distant galaxies and are nearly matched except within isolated concentrations of one type of matter, such as the core of galaxies. The decrease of frequency and inertia with decreasing chiral asymmetry then removes the need to postulate dark matter by explaining both flat galaxy rotation curves and increased gravitational lensing.

The slope of the supernovae distance data with redshift also gives a measure of the fractional change of stored energy (galaxy redshift) with fractional changes in light-speed over time. The rate is tiny (approx. $2.14 \times 10^{-18}\ s^{-1}$) but becomes visible looking back in time over more than a billion years. The rate has doubled in roughly 15 billion years of current time.

Many details of FR need more work and many consequences need to be examined. Exciting new possibilities include: the unification of the four forces (strong, electromagnetic, weak and gravity) in terms of one underlying field; a deeper understanding of elementary particles in which the apparent dearth of antimatter and neutrino oscillations do not constitute new physics beyond the Standard Model; that the values of G_N and Planck's constant reflect the current background and its asymmetry at our position in the galaxy; that other fundamental "constants" will be calculable; and, even, that quantum entanglement does not constitute the "spooky action at a distance" which Einstein hated.

An understanding of the differences between GR and the new perspective, as explanations of gravity, requires a quick review of many standard concepts of physics. These include Newton's gravity, mass and inertia, the experimental and theoretical background to SR, and the nature and theory of elementary particles. GR was built on SR and any changes to GR necessarily flow back to SR and vice-versa. Finally, the physics background needs to include something of the current understanding of the four forces of nature and how all of the matter with which we are familiar is built up. The first three forces (strong, weak and electromagnetic) have been unified in terms of consistency with SR (relativistic), with QM (quanta) and with underlying fields that carry the quanta. These relativistic quantum field theories of elementary particles and their interactions are collectively called the Standard Model. Under GR, the fourth force, gravity, involves a distortion of time and it is not possible to unify it with the other three. Moreover, there is a different explanation of mass in the Standard Model, in which it arises from the "Higgs field", which is potentially inconsistent with SR and GR.

The first step in Chapter 1, before introducing GR, is therefore to outline essential background ideas. It is mostly the broad concepts, rather than the detail, that need to be appreciated. The experienced physicist can skip much of this but the information enables GR to be put into context; including Einstein's deduction that gravity was a distortion of spacetime. The nature, explanations and tremendous predictive successes of this theory are briefly set out. This is followed by an overview of current cosmological observations and their explanation. Some unexpected observations have led to the hypotheses of invisible dark matter and dark energy. These seek, respectively, to explain the gravitational behaviour of galaxies and the apparent increasing rate of expansion of the universe.

The stage is then set for a questioning of current perspectives. The seemingly simple change from the idea that a massless photon loses energy in escaping a gravitational field to one in which its energy is unchanged but massive atoms gain energy, has enormous consequences. It demands that gravity arises from a loss of mass when matter is closer to other matter. In turn, this means that the speed of light is not constant and that gravity is not a distortion of spacetime. The concept of spacetime first arose in SR so its claimed derivation and the interpretation of the Lorentz transformation (LT), which explained high-speed observations, is examined. The two derivations put forward by Einstein were based on the hypotheses that the laws of physics were independent of motion at constant velocity (the "principle of relativity") and that the observed speed of light was independent of the motion of the observer. It is argued that these hypotheses can be replaced by a speed of light that is independent of the speed of the emitting object (which was the original observation) but which depends on the magnitude of the background, while the time and frequency of massive objects depends on their speed relative to the background due to all other massive objects. The result is that the increased speed of light with decreased gravitational potential (increased background) reduces the energy that can be stored by massive particles, and this is the source of gravity. In addition, the distance between stationary objects (misleadingly labelled as "space") cannot be altered by the presence of other massive objects, or by the speed of the observer. The variable speed of light links an undistorted distance divided by a clock-rate that depends on the mass held per unit matter and movement relative to the background. This replaces the fabric of spacetime linked by a constant speed of light, in which both distance and time are distorted by mass and energy, and by relative movement of the observer. This is the first and most important step in making sense of gravity.

The reader should appreciate that this significantly contradicts the current paradigm. Mass and the speed of light are no longer (locally) invariant and the laws of physics are not independent of the magnitude of, or motion relative to, a uniform stationary background. Some immediate concerns, such as the possibility and observational consequences of a variable speed of light, are addressed.

However, the re-introduced background field must also explain inertia and the bending of light in an undistorted space. This requires some further appreciation of the differences between a scalar (background-dependent) field theory (FR), that includes time-dependence, and a tensor theory (GR) that distorts a background of spacetime. That ends Chapter 1. The subsequent chapters aim to explain the reasoning behind, then demonstrate the viability and advantages of, the replacement theory.

The concept of a fabric of spacetime arose in SR so a long Chapter 2 is devoted to explaining how it happened and why it is mistaken. The postulates and derivation of SR are carefully examined. This is essential if such an established theory is to be in any way challenged. It is pointed out that Einstein's method used to derive the LT sought to relate the same events (locations in space and time) seen in a moving and stationary frame, with all values referred back to the stationary frame. It appeared to indicate that time was slowed in the moving frame. A priori, such a method cannot yield the time (clock-rate) of a clock moving (with speed v) without the clock being examined, unless additional assumptions are made. SR claimed that all clocks that were stationary relative to their observer would show the same time i.e. have the same clock-rate. The assumption (the first postulate of SR) that only relative motion mattered appeared to indicate that this rate would be the same in all inertial frames.

This was claimed to be confirmed by a two-fold application (v followed by $-v$) of the LT. The doubly-transformed coordinates had no time dependence. This was taken to mean the double transformation gave a return to the original (stationary) frame and, therefore, to its clock-rate. Thus, relatively moving observers would each see the other's clocks as slowed. However, the time-independence is not because of a return to the stationary frame. Such a two-fold application compares the coordinates (relative to the stationary frame) of two frames moving at the same speed in opposite directions away from the origin after initial coincidence (i.e. after all three frames overlapped at time zero). Their position coordinates match with time except for a change in sign.

Subsequently, it was argued that the postulate that only relative motion mattered was confirmed because the LT converted $x^2 + y^2 + z^2 = c^2t^2$ into $x'^2 + y'^2 + z'^2 = c^2t'^2$. It was argued that this means that spherical radiation of light, at speed c, in the stationary frame is also observed in the moving frame (i.e. is seen by both moving and stationary observers). This is false. It means, instead, that spherical radiation of light occurs independent of movement of the emitter. The radius of the sphere will be doubled if the clock-rate is halved. Independence of the speed of the observer only gives the same measured speed of light if the scales of distance and time are shortened by matched amounts. Moreover, the distortions are only for the "time" and distance along the direction of motion. It arises from assuming that a constant underlying speed of light (when the observer is moving in the x direction) means $c = x'/t' = x/t$. The faulty assumption requires that the distance travelled by the same light is changed by the same amount as the change in clock-rate of the observer (but only in one direction). The correct interpretation of the LT has elapsed time decreasing by $1/\gamma$ giving distances that appear to increase by γ.

Under SR, the measured speed of light (distance travelled per unit time), of the same photons, is claimed to be unchanged even if the clocks of the moving frame/observer are slowed. Instead, the apparent spacing between distance markers will be reduced if the same light is measured using slower clocks. If the speed of light is independent of movement of the emitting source, but the scale of distance is constant for all observers, then a decreased clock-rate (slowing of time) for a moving clock means that the same light should be observed to travel further per tick (increased distance). The numerical value for the speed of light, measured within the moving frame, will then be faster.

The observations of the effects of high-speed relative motion can only be explained by a real slowing of time with movement of massive clocks relative to an effectively stationary background from other mass. The slowed decay rates of unstable elementary particles are because they are moving at high-speed relative to the locally balanced background. If observers could survive travelling at high speed in a linear accelerator, they would see stationary, unstable elementary particles and clocks, decaying and ticking faster relative to their clocks.

A real slowing of time can be explained by a frequency and clock-rate of massive objects that is reduced by motion relative to the background from all other massive objects. The interpretation in SR of time dilation being matched by length contraction has allowed the incorrect conclusion that space and time are linked into a fabric of spacetime that keeps the observed speed of light constant. If "observed" equates to "measured" then such a linkage requires that larger intervals between ticks, giving slower time (time dilation), be matched by larger length intervals travelled by the light. This is inconsistent with Lorentz's formulation of the LT to explain why the Michelson-Morley interferometer experiments showed no evidence of movement relative to the aether. Time being slowed was mistakenly assumed to mean that the light would appear to travel more slowly, so that it took the same time to travel a length of the arm that was contracted by a matched amount. The revised understanding is that the speed of massless fields (including light) is independent of motion of a source (that has mass) relative to the background. However, all sources and clocks have mass and their time is slowed by movement, but changes in distance are only apparent and not real. It enables a theory in which LT-like behaviour holds but the speed of light varies with the magnitude of the background. Gravity can then be explained by a background that requires an increase in the energy stored as mass when the speed of light decreases. The increase in energy increases the clock-rate (time) of massive objects. Gravity is not due to differences in mass/energy density distorting the geometry of spacetime (the metric) nor is it independent of a uniform, stationary background (as claimed by GR). FR has an opposite link between constant distance and variable time via a variable speed of light.

The origin and many consequences of this core difference - background dependence versus a distorted spacetime - are set out in Chapter 3. The speed of light is not constant, but proportional to the magnitude of a balanced background and there is a real slowing of time (for massive objects) with movement relative to this background. Consequences include: the distinction between light travel-time intervals (synchronisation) and clock-rate; that mass does not distort distance; and that the strength of gravity depends on the size of the background from other mass. Variable mass overcomes a serious unrealised problem. The differential form of Newton's equation, on which Einstein's field equation of GR is based, assumes that the flux of the purported field of gravitational acceleration (the force per unit mass) through the surface enclosing a fixed amount of matter is constant (independent of the density of that matter). This is not true under FR, because the mass stored by the matter reduces as its density increases. The consequence, under GR, is that empty space free of matter (i.e. nothing) will appear to act as a source of repulsive gravitation.

The background from distant stored energy, and the speed of light, will decrease as the universe evolves, becoming increasingly clumped. Together they will, under GR, give the appearance of an invisible (dark) energy whose magnitude grows in an apparently expanding universe. Background dependence avoids the expansion and the ad hoc hypothesis of dark energy. Space is undistorted, but the properties of objects and the speed of light (linking distance and time) depend on the background. However, more is needed, and the reasoning and proposals of FR are set out in Chapter 4.

A simple scalar background can explain the energy conservation of gravitational attraction. A more complex background is needed to explain the vector nature of momentum. A two-component chiral background is required by the Higgs mechanism as well as being needed to explain momentum and inertia, and to avoid the need for dark matter. The opposing chirality (handedness) of matter and antimatter means that one component inhibits a change in the other component. The two-component background can then give rise to a "clout" that only falls off as $1/r$ from a point source (an excess of either stored energy). This is consistent with the dependence of gravitational force on the gradient of a potential energy that varies as $G_N M/r$. On the other hand, the flux (per unit area) from an unopposed radiation (e.g. light) falls off in inverse proportion to the increase in surface area of $4\pi r^2$.

The total background determines the speed of light and hence the conversion factor between mass and energy. The effect of a given excess of stored energy is therefore reduced as the background flux from all other sources increases. In contrast, GR assumes that static gradients in potential from opposite directions cancel, so that mass is independent of a uniform, stationary background. The revised theory has gravity, energy and momentum, fully dependent on the background which is why it has been called Full Relativity. The proposed underlying physical picture of FR and a set of hypotheses consistent with this picture is given. One postulate is that the oscillation frequency of light and matter is proportional to the asymmetry in the contributions to the background from components of opposite handedness (i.e. matter and antimatter). The difficulty of changing such an oscillation depends on its cyclic frequency and hence inertia depends on asymmetry. The magnitude and asymmetry of such a background affects the properties of massive and massless objects replacing the distortable geometry of spacetime between objects.

Consequences for cosmology of the many changes in understanding are set out in Chapter 5. FR asserts that the kinetic energy of objects falling in a gravitational field comes from a loss in mass and that only stored energy contributes to the gravitational field. Therefore, the contribution per unit matter decreases as the background increases. GR has all energy contributing to the field, including a claimed increase in gravitational energy as objects move closer, so the field increases non-linearly which gives rise to singularities. Under FR, the decrease in mass per unit matter, with increasing density, avoids the singularity. Other benefits include the allowed presence of an equal amount of antimatter and black holes which can interact gravitationally. It is shown that FR reproduces the standard well-confirmed predictions of GR for the current background. Time is altered by the background but space, the distance between separated objects, is unchanged.

Key new predictions of FR and their comparison with astronomical observations are presented in Chapter 6. The predictions of FR and GR diverge with increasing difference in the background which affects the speed of light and clock-rate via stored energy. This leads to a re-analysis of the redshift versus distance data of the standard candles of type 1a supernovae. The change in speed of light with clout means that light from earlier supernovae has travelled faster and therefore further. The correction entirely removes the claimed accelerating expansion and hence the need for dark energy.

However, FR also has changes in asymmetry altering oscillation frequency and, therefore, inertia. The reduced change in the speed of light, when only one component of the two-component background changes, and the increase in inertia, together lead to ongoing clumping within regions of like matter and a reduction in the background elsewhere over time. This means that the increasing redshift of galaxies with distance, arises from a decrease in energy levels and does not require an ongoing expansion. No driving force for expansion is needed and there is no requirement for an initial Big Bang. The corrected supernovae data also gives a measure of the current rate of change of energy with time.

Further predictions and consequences are outlined in Chapter 7. The incredibly rapid initial expansion of the entire universe, called cosmic inflation, is no longer needed. It had been postulated to explain the observed large-scale uniformity of the distribution of distant galaxies. The effect of asymmetry on inertia explains the flat rotation curves of spiral galaxies, and gravitational lensing, without the need for dark matter. Inertia depends on the fractional asymmetry in clout from just an excess of one type of matter against a background of near-zero asymmetry. Gravitational attraction depends on the gradient in stored energy determined by the large total background of clout from matter and antimatter. The total clout determines c and the asymmetry of its components determines inertia. These differences can explain the Tully-Fisher relationship between the asymptotic speed of galaxy rotation curves and galaxy luminosity and why Modified Newtonian Dynamics (MOND) appears to explain galaxy observations better than dark matter halos. Additional experimental and observational tests that can distinguish between FR and GR are set out in Chapter 8.

However, FR also links gravity to particle physics and quantum mechanics via the shared background. This is strongly supported by the speed of propagation of electromagnetic fields being the same as that of gravity. It is proposed that mass arises from any force (strong, electromagnetic, weak or gravitational) that confines momentum to a location. It is not just the purported "Higgs field", but any trapping of momentum, that can give rise to mass. The explanation of the nature of particles and their fields is linked to the explanation of the gravitational field. All particles appear to be standing wave patterns of multiple chiral components of the underlying field. The model that unifies all four forces must not only be consistent with the Standard Model but explain it. Some initial implications for particle physics, including the nature of massless and massive particles, and of quantum mechanics, are developed (Chapter 9). These include that the photon is the "missing" ninth gluon that has no strong interactions; and that neutrinos, like the photon, are massless (although they carry energy) because they have zero net angular momentum along the direction of motion. Ultimately, FR should lead to prediction of all the masses and coupling constants of the Standard Model.

The last chapter takes a look back and a look forward. There is also an appendix because the changed understanding of particle states suggests that there is no need for "entanglement's" non-locality.

Chapter 1

The background to, and of, a revised understanding

The revised theory (FR) follows from the assumptions of the current understanding being challenged and from observations being interpreted in a different way. Therefore, the crucial physical concepts needed by the reader are presented. This is followed by an outline of GR and an overview and interpretation of what our observations of the universe reveal. The path to the revised theory is then set out. It involves two key changes in perspective that allow a background dependence to replace the GR explanation of gravity as a distortion of spacetime. Immediate advantages are the removal of the singularities in black holes and the removal of the need for an enormous pool of energy in empty space. However, consequences that must be, and will be, addressed include a variable speed of light and how this can be consistent with SR and GR. Finally, the re-introduced background field must also be able to handle the time dependence of the motion and propagation of the field including explaining inertia and the bending of light.

1.1 The needed physics background

1.1.1 Newton's Laws

Isaac Newton formulated a universal law of gravitation:

$$F = G_N M m_g / r^2$$

The gravitational force (F) due to a large point source of mass (M) on a small test mass (m) falls off as the inverse square of the distance (r) between the masses. The conversion factor (G_N) is referred to as Newton's gravitational constant. This law is said to be "universal" because it accurately describes the movement of all massive bodies in our solar system except in the limit of very high speeds. It is a static law, having no time dependence. This corresponds to instantaneous propagation of the gravitational field, which enables the observed action at a distance, across empty space. It is now known that gravity propagates at the speed of light so this equation breaks down in the limit that the massive objects are travelling at speeds that are a significant fraction of the speed of light.

Newton also formulated three laws of motion:

1. An object either remains at rest, or continues to move at a constant velocity, unless it is acted upon by an external force.
2. Force is equal to mass times acceleration.
3. For every action there is an equal and opposite reaction.

Combining the law of gravitation with the 2nd law gives the magnitude of the acceleration (g) per unit mass of a gravitational force:

$$F / m = g = G_N M / r^2$$

Work is the energy given to an object by a force acting over a distance. Hence, the energy, per unit mass, given to an object accelerated by a gravitational force is the integral of F/m over distance. Thus, the field provides energy to the object proportional to the change in:

$$\Phi = -G_N M / r$$

This quantity is known as the gravitational potential (Φ , the potential energy per unit mass, of a small test mass, as a function of distance from a point source of mass).

Combining the law of gravitation with the 2nd law includes the subtle assumption that gravitational mass, as seen in the strength of gravitational attraction, is the same as inertial mass, as seen in the force resisting acceleration. This is known as the equivalence of inertial and gravitational mass. A priori, it seems like a coincidence. It seems more likely that the ratio of the masses might be fixed for all objects at any one location, which is strongly confirmed by experiments, but vary between locations.

1.1.2 Energy, momentum, and inertia

Energy is a familiar expression of a quantity needed to make things happen. It comes in different forms such as the energy of chemical reactions, the kinetic energy of moving objects which we also feel as heat and see in the emission of energy-carrying light. It has been found that the form of energy can change but the total amount is constant. It is conserved over time.

Momentum is commonly understood as a quantity proportional to mass times velocity. Momentum is also a conserved quantity but, like velocity, has a magnitude (speed) and direction. If two objects collide, and there is no change in energy, then the momentum (in every direction) is the same before and after the collision. If there is a loss in energy as heat, but we could measure the momentum of all the excited (heated) atoms, then we would still find that total energy and momentum were conserved.

Newton's first law of motion, that objects would continue in the same motion unless acted on by a force, took mankind a long time to realise. The Greeks had thought that the natural state of bodies was to be at rest. However, experiments showed that objects only resisted changes in speed and direction. The resistance was given the name of inertia and momentum is the product of this inertia of mass and its velocity. In the absence of a force, a rotating object also has inertia but maintains a constant speed of rotation with the axis of rotation maintaining a fixed direction. Interestingly, this direction is fixed relative to the background of stars. The apparent plane of oscillation of a very low friction pendulum can be seen to change with the rotation of the Earth. This led Ernest Mach to propose that inertia arose from an interaction with the background from all other matter.

1.1.3 Waves, particles, and fields

Photons are the fixed quanta ("lumps") of light. They have both particle and wave properties. The wave property is seen in the way that light diffracts and there is interference between two paths for the same light. The particle property is shown in the way one photon can knock an electron out of an atom. However, none of the photons of a beam will knock an electron out of an atom unless any one photon carries enough energy to boost the electron free. The amount of energy carried by the photon is directly proportional to the frequency (f) of the light, and inversely proportional to its wavelength (λ), according to $E = hf = hc / \lambda$, where h is known as Planck's constant and c is the speed of light. Red light has a lower frequency and longer wavelength than blue light and so its photons carry less energy. However, all photons travel at the same speed (c) independent of frequency or wavelength.

It has been found that all particles of matter, including electrons, protons and atoms, have wave properties with the size of the wavelength also obeying $\lambda = hc / E$. This "de Broglie" wavelength decreases as the energy of the particle increases.

Fields are the mediums observed or hypothesised to explain action at a distance. They are something which we cannot see but which carry effects from one location to another. Air pressure can be thought of as a field in which oscillations in pressure (called sound waves if audible) can be transmitted from one place to another. The oscillations are actually variations in the mean density of the molecules that make up the atmosphere. However, there are also fields, for example those from a concentration of electric charge or magnets (which involve rotating charge), that can carry effects across a vacuum in which no matter is present. James Clerk Maxwell built on the discoveries that changing magnetic fields induced changing electric fields and vice-versa to find that such fields would propagate as an electromagnetic wave of fixed speed. The speed turned out to be the same as the speed of light and it was realised that light was just a tiny visible part of the spectrum of electromagnetic waves that goes from very low frequency radio waves to ultra-high frequency gamma rays.

Prior to 1900 it had been observed that light always travelled at the one speed, independent of the speed of the emitting source of the light. The amount of energy that could be transferred to a receiver then depended on the relative speed of source and receiver. Relative movement apart shifted the frequency of the signal towards the red (lower energy), while movement towards shifted it towards the blue (higher energy). This appeared like the Doppler shift of the note from an ambulance siren as it passes an observer.

The assumption, before 1900, was that light had to be carried by a medium, called the aether. Any differences in speed of movement of the emitter or receiver relative to the aether should therefore be detectable. However, no experiments showed any evidence for such movement even though the Earth was changing direction relative to the Sun and stars throughout the year.

1.1.4 Simultaneity and synchronicity

In his introduction to SR, Einstein pointed out that the time order of events at different locations was uncertain when the speed of transmission of information was finite. A track-side observer opposite the middle of a moving train when it was struck by two bolts of lightning at the front and back would judge them as simultaneous. However, an observer in the middle of the train would move towards the front bolt of lightning and away from the other during transmission of the light and so judge that they were not simultaneous. The concept of simultaneity, at different locations, varied with relative motion. The apparent timing of events depended on relative motion.

Nevertheless, if the speed of light is the same in all directions, it is possible for observers to synchronise clocks at different locations. That is, to have a whole array of clocks, stationary relative to each other, so that they are at known fixed distance intervals, that are all ticking at the same rate (synchronised). This is the concept of a frame (a set of coordinates) that is stationary relative to an object or observer. Because the simultaneity of time and agreement over distance can depend on relative motion, Einstein allowed for the time and distance in relatively moving frames to be different.

1.1.5 The Lorentz transformation

Prior to Einstein's paper introducing SR in 1905, and unknown to Einstein, Lorentz had found that the signals from, and behaviour of, charged particles moving at high speed (v) could be explained if there was a dilation (slowing) of time and contraction of length with speed by the factor $\gamma = 1/\sqrt{1 - v^2/c^2}$. This could be set out mathematically as a relationship between the space and time coordinates of events in a frame stationary relative to the observer and a frame moving at constant speed in the x-direction:

$x' = \gamma(x - vt)$, $y' = y$, $z' = z$, $t' = \gamma(t - vx/c^2)$

The transformation between the two coordinate systems became known as the Lorentz transformation (LT). The derivation of the LT in his 1905 paper, and its apparent explanation of how the constancy of the speed of light demanded that space and time change with relative motion, was taken as strong evidence for the correctness of SR. Einstein also showed that Maxwell's equations were invariant under such a transformation. The LT appears to encapsulate all the experimentally observed behaviour of objects moving at high speed, and its linking of space and time via a constant speed of light was taken over into General Relativity.

1.1.6 Special Relativity and inertial frames

Einstein based SR on observed behaviour. The phenomena of electrodynamics and mechanics did not appear to possess any properties corresponding to the idea of absolute rest and experiments had been unable to detect motion relative to the aether. His first postulate was the "principle of relativity" - that behaviour, the interaction of objects, depends only on relative velocity and is therefore independent of, and not relative to, any background. A person below-decks on a ship, or in an enclosed train carriage, could not tell whether they were moving relative to the nearby land. Bodies moving at constant speed stayed moving at the same speed unless acted on by a force. There appeared to be no difference between being stationary and moving at constant speed. Hence, all frames that were not accelerating, called inertial frames, were equivalent.

His second postulate was that the speed of light was constant, which was based on its observed independence of the speed of the emitting object. This was consistent with the inability of any experiments, like the interferometer experiments of Michelson and Morley, to detect motion relative to the supposed aether. It was also consistent with the light emitted from binary stars. If the light emitted by a star moving away travelled more slowly, then by the time it reached us it could be overtaken by light emitted later in its orbit when it was moving towards us. There was no evidence for such an effect. It was also consistent with the aberration of starlight. This is a movement in the apparent direction of the stars with the speed of the Earth's movement in its orbit at right angles to the direction of the star. The effect is similar to what we observe when riding in the rain. Rain that is coming from one side when we are stationary appears to come increasingly from the front as our speed increases. The amount depends on relative velocity.

Einstein then examined the distance and timing of events in a relatively moving frame, seen by an observer in a stationary frame, and deduced the LT based on these postulates. He also deduced that an observer in the moving frame would see the same changes in distance and timing of events in the stationary frame even though the underlying rate of clocks travelling with both observers was the same. Both observers would find the clocks of the moving frame were slowed. The amount of slowing was by the factor gamma, independent of whether the clock was moving towards or away from the observer.

The conclusion was that the time and space that we perceive is malleable, dependent on relative motion. The results of measurements of time and space depended on motion relative to the object being measured. Only the combination into a fabric of spacetime, which keeps the speed of light constant, is maintained.

Minkowski subsequently put this combination forward in terms of an invariant interval (ds), where: $ds^2 = dx^2 + dy^2 + dz^2 - c^2 dt^2$, with $dx = x_1 - x_2$ etc. and $distance = \sqrt{dx^2 + dy^2 + dz^2}$ (Pythagoras), so that ds is a separation in a 4-dimensional spacetime with time along an imaginary ($c \times \sqrt{-1}$) axis.

1.1.7 What is mass?

The simple answer, that is not fully appreciated, is that it is localised energy. Energy confined to a location. This immediately means that it is also momentum confined to a limited region, even if the time-averaged sum of the component momenta, added vectorially, is zero.

If light is trapped in a box with perfect mirrors, so that the photons are continuously reflected in all directions, then the total (vectorially-added) momentum is zero in the box's frame of reference, but not the energy. Therefore, the light adds a small contribution to the mass of the box. It is similarly accepted that confining a gas inside a container increases the mass relative to the same amount of unconfined gas. Moreover, the additional mass increases with the temperature [1], and hence kinetic energy, of the gas. It also increases when the same amount of gas is confined in a smaller container. This is consistent with quantum mechanics (QM) where the lowest energy level increases as the width of the potential (energy) well (i.e. box) decreases.

Einstein deduced the equation $m = E / c^2$ using SR. It arose from the interconversion of energy and momentum for observers moving at constant relative velocity. It tells us something about mass. As Einstein put it: "Mass and energy are therefore essentially alike; they are only different expressions for the same thing. The mass of a body is not a constant; it varies with changes in its energy" [2]. Hence, all mass should just be seen as stored energy; energy sustained by oscillation/rotation, held at a location, i.e. trapped momentum, with the conversion factor for mass into energy being c^2. It should be noted that the trapped momentum must be moving, e.g. oscillating or rotating. This requires a continuous force as seen in the rotating centripetal force that maintains angular momentum.

The idea of a box also throws light on the nature of inertia. If a box of gas is accelerated then the molecules impacting one wall will be hit harder, they will be accelerated, while those impacting the opposite wall will have a softer impact. If the change in velocity is small the momentum gained by one group will match the momentum lost by the other, and there will be negligible change in temperature. The molecules will share their momentum and, if the acceleration stops the box and contents will continue at the new speed. The force needed for acceleration will be directly proportional to the rate of change of the trapped momentum.

1.1.8 The Standard Model

The Standard Model (SM) of particle physics describes all interactions, except gravity, in terms of relativistic, quantum, field theories. These cover the strong, electromagnetic and weak forces. The forces bind elementary particles of half-integral spin (fermions) together via the interactions of a small number of particles of integral spin (bosons). The strong force binds the proton and neutron together in the nucleus of the atom, while electrons are bound to the nucleus by electromagnetic forces. However, protons and neutrons are composite particles made up of the more elementary quarks (fermions) bound by massless gluons (spin 1). The electromagnetic force binds charged particles together by massless photons (spin 1). The weak force mediates interactions via three massive bosons, the charged $\mathrm{W}^{\pm}$ and neutral Z_0 (all spin 1). The final boson is the Higgs (spin 0) which couples to all other particles in proportion to their mass.

The model is based on underlying symmetries with stronger interactions having more symmetry. The weak interaction violates mirror symmetry, so that some interactions, which would look the same in a mirror, do not occur. The strength and properties of the interactions between particles can be calculated in terms of the exchange of the relevant bosons. Particles with a property labelled "colour", such as quarks, exchange gluons. Particles with charge exchange photons. Particles with "weak charge" exchange the massive bosons.

The fermions come in three families of successively greater mass. Each family has a pair of quarks (charge ⅔ and ⅓), a lepton (charge 1), and a neutrino (no charge). The first family has the up and down quark, the electron and the electron neutrino. The second family has the charm and strange quark, the muon and the muon neutrino. The third family has the top and bottom quark, the tau and the tau neutrino. Every particle with charge has an anti-particle of opposite charge. Each particle with colour (quarks) can come in three colours and each gluon can have colour plus anti-colour (so that there are 8 plus a ninth that has no net effect). All other particles (including the proton and neutron) are composite particles made up of the above set of "elementary" particles.

It all sounds messy and complex, and it is! Gluons can even interact with gluons. However, SM forms a self-consistent whole in which the masses and interactions of all particles can be calculated from a limited number of inputs. These being the masses of the elementary particles and the strengths of the three underlying interactions. However, the model does not explain what determines the values of the input masses and strengths. These should come from a deeper underlying theory.

In the 1960's Peter Higgs and others came up with a theory, within the SM, that there was a spontaneous breaking of an underlying symmetry that meant that most particles would gain mass. The theory predicted another massive (Higgs) boson of zero spin and zero charge, to go with the $\mathrm{W}^{\pm}$ and Z_0. Space would be filled with a sea of virtual Higgs bosons – now known as the Higgs field. Massless photons and gluons are insensitive to the Higgs field. Quarks, electrons and other particles interact with it, by an amount that determines their mass. Eventually, in 2012, the Higgs boson was observed at the Large Hadron Collider. This discovery completed the particles required by the SM.

However, the SM does not explain everything. Where do dark matter and dark energy fit in? Why is the universe made of matter and not antimatter? The really big question though is how this model of the source of mass ties in with the concept of mass as a form of stored energy, and with a gravity whose strength is proportional to mass. According to GR, gravity is not a force; it is a property of spacetime. Such a force would appear incompatible with the other forces. Moreover, under GR, mass and energy increase the distortion of spacetime which then increases the amount of energy, which further increases the amount of distortion.

1.2 General Relativity

Special Relativity was given that name because it applied to the special case of relative motion at a constant velocity. Einstein realised that it needed to be generalised to include accelerated motion. SR proposed that space and time are not fixed and instead are part of a linked "fabric". In GR, Einstein proposed that the geometry of spacetime is also not fixed. Spacetime could be distorted by matter (via its energy and momentum): it tells matter how to move and matter tells spacetime how to curve. Under GR, gravity is not a force. It is just the curvature of spacetime. The more massive an object the more spacetime is bent, which appears as a stronger gravitational acceleration.

The path to GR was complex. The first step was what is now called the weak equivalence principle – that there is no difference between inertial and gravitational mass. The next step was Einstein's realisation that an observer in free-fall felt no gravitation. Gravity appears to be transformed away by acceleration and the laws of physics are (appear to be) the same as in an inertial frame. This invariance of the laws of physics is called the Einstein or Strong Equivalence Principle. This principle claims firstly that physics in a frame, freely falling in a gravitational field, is equivalent to physics in an inertial frame without gravity. It then claims that physics in a non-accelerating frame with gravity $\vec{g}$, is equivalent to physics in a frame without gravity, but accelerating with $\vec{a} = -\vec{g}$.

This ultimately led Einstein to replace the invariant interval of the undistorted (flat) space of SR,

i.e.: $ds^2 = c^2dt^2 - (dx_1{}^2 + dx_2{}^2 + dx_3{}^2)$ where $x_1 = x,\ x_2 = y,\ x_3 = z$

with: $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$ where $x^0 = ct,\ x^1 = x,\ x^2 = y,\ x^3 = z$.

The metric $g_{\mu\nu}$ is a 4 x 4 matrix and there is a sum over the indices for repeated terms. The flat, undistorted metric of SR has only the diagonal terms of (-1,1,1,1) with the others zero.

Einstein concluded that the metric was the relativistic equivalent of the gravitational potential (Φ) seen in Newton's gravitational equation (Section 1.1.1). His replacement equation then expresses how mass, energy, and their movement, distorts space and time. Once an initial distribution of matter, energy and movement is set out then Einstein's gravitational equation can be used to predict how it will evolve over time.

Einstein used his new equations to explain the small mismatch between the predicted and observed orbit of Mercury. The point of closest approach (the perihelion) of the elliptical orbit advances slightly faster than expected from Newtonian gravity. Under GR, the change in spacetime means that orbital velocity varies slightly with distance from the Sun. He proposed two further predictions. The next was the amount light would be bent when it travelled past a massive object, such as our Sun. The bending would be twice as strong as it would be if Newton was correct and light fell in a gravitational field.

During a total solar eclipse in 1919, the position of the stars in the bright Hyades star cluster was photographed. The positions of the stars were compared with photographs of the same cluster taken at night. Einstein's prediction was correct and he immediately became famous and GR rapidly grew in acceptance. This bending of light around massive objects is now called gravitational lensing and has been seen in the distorted and multiple images of distant galaxies and quasars as the light is bent by a much nearer galaxy or cluster of galaxies.

The third prediction was of a gravitational redshift or slowing of time deeper in a gravitational potential. It was not confirmed until 1959 when changes in the frequency of light moving in the Earth's gravitational field were measured. Subsequent tests using a maser sent into space have confirmed the predicted redshift to an accuracy of 0.01%. Remarkably, the effect is also needed in everyday life for the Global Positioning System (GPS) to work. Your phone receives signals from the GPS satellites orbiting Earth to pinpoint your location. The satellites need to be precisely synchronised. However, from SR, their speed means that their time will run slightly slower and, from GR, the weaker gravitational field means their time will run slightly faster. If the satellites' clocks were not corrected for these competing effects, the GPS triangulation of position would drift. So the predictions are good.

A fourth prediction (by Shapiro), which is primarily a result of the bending of light, is a delay in the travel time of electromagnetic radiation (e.g. radio waves) from planets or spacecraft as they pass near or behind the Sun. This Shapiro delay has been observed.

Subsequent predictions have included an expanding universe, gravitational waves and black holes. The latter, an extremely dense concentration of mass, produces such a large gravitational redshift that time stops and nothing travelling at the speed of light (electromagnetic radiation) can escape. Hence the name. Such a feature was first imaged in a relatively close galaxy with a very large, compact, concentration of mass at its centre. It has now also been imaged (at long wavelengths) in our galaxy where the orbits of stars around its centre indicated a very compact object smaller than our solar system but with millions of times the mass.

Einstein's equations also predicted that gravitational waves would exist. According to GR, these will be caused by the movement of non-spherical systems of massive objects but only become significant in catastrophic cosmic events like colliding black holes. The waves are ripples in the fabric of spacetime that fan out through the universe at the speed of light. The first evidence was from changes in the orbital motion of binary pulsars (rapidly rotating neutron stars). The changes in their orbits over time were consistent with the expected rate of energy loss from gravitational radiation. The incredible technology of the LIGO interferometers has now enabled the observation of gravitational radiation (waves) from merging black holes and neutron stars.

Under GR, there are other, more complex, predictions of delays and changes in behaviour due to the changes in distance and timing of cosmological events. All such predictions appear to be in agreement with observation. It is therefore necessary for any replacement theory of gravitation to be able to reproduce such predictions.

1.3 Unexpected aspects of the current understanding

Observations have been made of the distance and redshift of galaxies in every direction. It has been observed that there is a steady increase in the mean redshift of their light with distance. This is the Hubble redshift and is taken as evidence that the universe is expanding. The expansion means that the universe was much more dense and hotter in the past. GR then leads to the prediction that about 13.8 billion years ago the universe started out from a single location in an enormous explosion – the Big Bang. After several hundred thousand years it had cooled enough for atoms to form which allowed light to escape. This light has now been stretched so much by the expansion that it has been shifted into the frequencies of microwaves and is observed as an almost uniform background in every direction – known as the cosmic microwave background (CMB).

There are, however, very small variations in the temperature (wavelength) of this radiation which are understood as indicating differences in density which, with gravitational collapse, eventually gave rise to the galaxies we see today.

Given that, under GR, light moves at a known, constant velocity, then the speed of recession at the time the light was emitted can be calculated. The observed increase in redshift, going back in time, was initially interpreted as a Doppler shift so that more distant objects were moving away faster. The integrated speed of recession increases with distance. The somewhat revised explanation, under GR, is that the space between galaxies is expanding. The wavelength of light then gets stretched, shifted towards the red, with time since emission.

The current distribution of galaxies has been plotted, primarily using information from their redshifts and direction. Huge voids between galaxies and strings and clusters of galaxies have been found but, on a very large scale, the distribution appears uniform in every direction.

The speed of movement of the stars within relatively nearby galaxies has been determined from differences in Doppler shifting. For spiral galaxies like our own, it is found that, at large distances from the centre of the galaxy, the orbital speed is approximately independent of distance from the centre. The rotation curve is flat. This was quite surprising because it is unlike the speed of rotation of the planets in our solar system, where their speed falls off as $1/\sqrt{r}$, with distance (*r*) from the Sun. Such a fall-off is expected for a Newtonian law of gravitation when the mass is concentrated at the centre. The hypothesis was therefore that the enclosed mass increased with distance, so that the galaxy must be immersed in a diffuse cloud of something that gave additional gravitational attraction (had mass). However, this matter must not interact with electromagnetic radiation because it neither emits nor absorbs light. Therefore, it was named “dark matter”, although “invisible mass” might be better.

A second reason to postulate dark matter has been the gravitational lensing of light by galaxies. The light from a very distant light source such as a quasar or galaxy can be bent by an intervening galaxy or cluster of galaxies. This leads to multiple and/or distorted images of the distant source. The amount and distribution of the mass in the intervening galaxy or cluster can then be calculated using G. It is found that large diffuse clouds of additional invisible mass are again needed.

Additional lines of evidence for dark matter come from the higher-than-expected speed of galaxies within clusters and from simulations of galaxy evolution. The simulations, of the time evolution of the anisotropies observed in the CMB into the current structure, require additional amounts of invisible matter consistent with the estimates that the ratio of dark matter to ordinary matter is about 5:1.

The hypothesis of “dark energy” arose from observations of distant supernovas made in the late 1990s. A particular type of supernova (type 1a) occurs when a neutron star gains mass from its surroundings and exceeds a certain value. As soon as it reaches the critical size it explodes. Thus, apart from some minor effects, it always goes off with the same bang, emitting the same amount of energy and light. These explosions can therefore be used as “standard candles”. Measuring the brightness, and adjusting for the inverse square law, gives a measure of distance. A second measure of distance can be obtained by measuring the redshift of the host galaxy of the supernova. Two large surveys of such supernovas were then used to examine how the rate of expansion of the universe had changed over the time in which it had taken the light to reach us. This was expected to reveal the amount of slowing due to gravitational attraction. The unexpected observation, however, was that the more distant supernovae were fainter than expected. Fits to the data using the standard GR model (ΛCDM), surprisingly indicated that the rate of expansion was “now” increasing instead of decreasing. (This “now” referring to the last approximately 4 billion years of the universe’s age of 13 billion years.)

This increasing rate of expansion led to the hypothesis of a dark energy which provided gravitational repulsion instead of gravitational attraction. This sounds reasonable, at first, but is an unusual sort of energy because its repulsion has become stronger as the universe has expanded. This is surprising because energy density would be expected to decrease as the matter density decreases. Instead, the amount or importance of this energy increases as the density of the universe decreases, i.e. as the empty space between matter increases.

It turns out that the required current amounts of dark energy, dark matter and ordinary matter are, approximately, 70%, 25% and 5% of the full amount. This full amount is that needed to account for the currently observed (Minkowski) flatness of spacetime. Thus dark energy and dark matter are hypotheses postulated to explain the apparent, unexpected presence of invisible and, so far, undetected sources of energy and mass. The amounts required are those needed, by GR, to explain the lack of a currently visible distortion by energy and mass. They are not required by, or expected from, the SM of particle physics. They constitute twenty times the amount of the familiar forms of energy and visible matter which we can measure directly and from which we are made.

Cosmic inflation is a third ad hoc hypothesis. It is an extremely rapid expansion of the very early universe. It was initially hypothesised to explain why the universe appears so uniform and isotropic on a large scale. Gravitational attraction was expected to rapidly destroy any uniformity. Such uniformity could have been present initially if distant regions had been in thermal equilibrium. However, these regions are now so far apart that energy, travelling at the speed of light, could not have passed between them during the age of the universe.

Under GR, the general belief is that the universe is expanding because “*space itself is expanding*” and carrying the galaxies with it. Cosmic inflation has it that space expanded extremely rapidly within the first fraction of a second after the Big Bang. This "metric" expansion (in the geometry of spacetime) has the sense of distance within the universe changing rather than objects, such as galaxies, expanding. An extremely rapid expansion locks in most of the initial uniformity. The amount that is required is approximately 20 orders of magnitude in size in the first 10^{-35} seconds after the Big Bang.

A final aspect of the current understanding is that the visible universe is made up of only matter. There appears to be good evidence that there are no significant concentrations of antimatter within any cluster of galaxies. This is based on the lack of the enormous energy that would be released by collisions between concentrations of matter and antimatter and the characteristic frequencies of the emitted radiation. This dearth of antimatter is not expected from the degree of symmetry between the interactions and properties of matter and antimatter.

1.4 The path to a new understanding

The first step forward came from accepting the few published arguments that massless photons do not lose energy in escaping a gravitational field. Strangely, this is what most people initially assume follows from Newton's law which has gravitational attraction proportional to mass but it is disputed under GR. The evidence that a photon has no mass seems quite strong. For example, it is consistent with the apparent infinite range of electromagnetic interactions. Newton's equation implies that massless photons should not be attracted by a massive object or, conversely, to gravitationally attract a massive object.

However, a beautiful series of experiments by Pound-Rebka, and later Rebka-Snider, examined light sent up or down between sensors in a tower. They found that photons emitted at a lower excited crystal were not resonantly absorbed at the matched upper detecting crystal unless they were given a Doppler boost in energy (by motion of the emitter). The experiment was repeated with the positions of the source and receiver reversed. The photons (gamma rays) were only resonantly absorbed when the boost (or decrease) in energy compensated for a gravitational redshift with height. This appeared to confirm that photons lose energy with increased altitude and hence were redshifted. Consequently, most textbooks state or imply that a photon loses energy in escaping a gravitational field. It is common to see the statement that a photon falls in a gravitational field, even though it has no mass.

This redshift is in agreement with GR which attributes the loss in energy to the distortion of time by a difference in the gravitational potential. The first author to suggest that the energy of photons is not altered by a gravitational field appears to have been Schwinger [3]. He argued that gravitational time dilation causes the frequency to appear to be changed. The change in frequency was because the "standards" of frequency had changed. An apparent blueshift in the energy levels of atoms arose from a change in the units of time. Okun *et al*. made it clear that the explanation of the gravitational redshift in terms of a naive "attraction of the photon by the earth" is wrong [4], but this does not seem to be widely accepted. More recently, Cheng has explained that the idea that a light-pulse loses kinetic energy when climbing out of a potential well is erroneous [5]. A photon is not a massive particle and cannot be described as a nonrelativistic massive object having a gravitational potential energy [4,5]. Photon energy should be conserved in a gravitational field.

Here is the Conclusion from the Okun paper [4]: *The gravitational red-shift being, both theoretically and experimentally, one of the cornerstones of General Relativity, it is very important that it always be taught in a simple but nevertheless correct way. That way centers on the universal modification of the rate of a clock exposed to a gravitational potential. An alternative explanation in terms of a (presumed) gravitational mass of a light pulse – and its (presumed) potential energy – is incorrect and misleading. We exhibit its fallacy, and schematically discuss red-shift experiments in the framework of the correct approach. We want to stress those experiments in which an atomic clock was flown to, and kept at, high altitude and subsequently compared with its twin that never left the ground. The traveller clock was found to run ahead of its earthbound twin. The blueshift of clocks with height has thus been exhibited as an absolute phenomenon. One sees once over again that the explanation of the gravitational red-shift in terms of a naive "attraction of the photon by the earth" is wrong.*

Cheng [5] agreed and refers to "blueshifting" of the energy level of atoms. He attributed the change in frequencies of the massive atoms to them being at different points in a gravitational field. All these authors appear to have accepted the GR explanation that a changing gravitational potential, an acceleration field (for massive objects), corresponded to a changed distortion of the metric of spacetime.

It is proposed that the simpler alternative is to accept that there is a real increase (blueshift) in the energy levels of receiver atoms at a higher gravitational potential, while the energy of the photon is unchanged. A real increase in energy levels will give a real increase in their frequency, massive clocks will tick faster, as observed in the clocks of the GPS satellites.

At first sight this might seem like a trivial semantic issue, but it then necessarily follows that massive atoms gain energy when they are “lifted” in a gravitational field. The beautiful change in perspective is that gravity arises from a gradient in energy stored as mass. It reflects conservation of energy. The kinetic energy of gravitational acceleration comes from a loss in the stored energy of objects (seen as gravitational potential), rather than from an increase in the distortion of spacetime between objects.

The understanding that mass is stored energy means that the work done in lifting objects is stored, in the objects, as increased mass. Mass is not constant. Thus, $m = E / c^2$ indicates that the amount of stored energy (m) of the same amount of matter (same particles that had energy E) increases as they are lifted into a region with a lower stored energy “density” (a weaker background field). If $m = E / c^2$ holds for all heights, then the speed of light (c) decreases with distance from other matter. (A variable rest mass theory has been put forward previously [6], but the mass varied with the strength of the gravitational field, i.e. with the gradient of the background potential.)

The variability of mass and the speed of light appear to be a strong contradiction of the tenets of both GR and SR and so must, and will be, addressed. Two initial comments are: that the required change in mass is, within our solar system, extremely small; and that the gravitational force is per unit mass so that predicted orbits are independent of the mass of the object.

Since a photon has no mass but carries energy in the form of momentum, it was concluded, under GR, that all energy gives rise to gravitational attraction. The apparent loss in energy of a photon escaping gravitational attraction then gave rise to the belief that the massless photon was attracted because of its momentum (giving kinetic energy). It therefore became a pillar of GR that all energy gave rise to gravitational attraction. The result was that even gravitational energy gives rise to more gravitational energy. This non-linearity then leads to an exponential growth of energy in a very strong gravitational field and the singularities inside black holes.

The alternative is that the photon momentum, and the kinetic energy it can deliver, is energy moving freely at the maximum speed allowed by the medium (i.e. at the speed of light). It is a free oscillation of travelling components that are always matched but 180° out-of-phase. If there is no resistance to a change in speed (i.e. no inertial mass), then photons will not gain or lose momentum (energy relative to c) in a gravitational field. The change in perspective from a redshift of photons to a blueshift of atoms means that photon energy is unchanged. The apparent gravitational redshift of light is because the energy (and clock-rate) of the emitting or receiving atoms is lower when closer to other matter, i.e. deeper in a gravitational potential. The revised theory has the mass and movement of matter dependent on the mass and movement of all other matter. It proposes that all mass, from strong, electromagnetic, weak, and gravitational interactions, is a result of constraining energy/momentum to a location.

If massive objects hold more energy higher in a gravitational field, then massive clocks should be expected to tick faster. This is a real effect observed in the GPS satellites and claimed by both GR and FR. However, under FR, an increase in clock-rate (faster ticking) is associated with a decrease in c. This requires a distinction between the increased time intervals (c / c') that slower light (c') takes to travel a set distance and the decreased time intervals (c' / c) between the ticks of a more massive clock. The ratio of clock-ticking to light-speed time intervals is background-dependent and changes by $(c' / c)^2$.

SR asserts that (in the absence of acceleration, including that from gravity) the measured speed of light is the same for all observers and that time and space can be unified into a spacetime. However, although the speed of light is constant within an inertial (i.e. acceleration-free) frame, it does not have to have the same value in different inertial frames with different backgrounds. The proposed alternative is that time intervals for (massless) light to travel a fixed distance decrease with increasing c , while (massive) clock-time intervals increase with increasing c . This forces a re-examination of the derivation of the Lorentz transformation (LT) in SR.

Lorentz based the transformation, which now bears his name, on a dilation of time and a contraction of the length of objects in a frame moving at constant speed relative to the observer. He had found that this combination of altered time and length explained all experimental observations. In particular, if movement relative to the background caused a contraction of length of objects (e.g. the arm of an interferometer) then this could cancel the effect of a slowing of time. It was the derivation of the LT in SR that enabled SR to be widely accepted. However, Einstein's derivation refers all measurements of distance and time back to a stationary observer. Such a procedure effectively examines changing position with "stationary" time based on reflected signals. This means that the time (clock-rate) applicable to the moving object is not examined. Only the timing of returned signals is examined. Their timing is altered by the movement of the object during the finite propagation time of the signals. The changes in timing are larger in proportion to the distance to the moving object. They can be interpreted as an apparent increase in speed of movement, and reduction in time and distance intervals, whether the object is moving towards or away from the stationary observer.

Einstein's derivation found a contraction in distance (seen as a contraction in length of the object) would be matched by a slowing of time. However, the conclusion is not possible without examining signals emitted by the moving object. Instead, it is argued that the observed behaviour can only arise from an increase in time intervals (a slowing of time) for massive objects with increased speed relative to the background arising from all other matter, giving an apparent reduction in distance intervals. The SR derivation incorporated hidden assumptions and does not establish either of the postulates claimed to have been used. These postulates were that the (observed) speed of light is constant, the same for all observers moving at constant velocity, and that the laws of physics (what is seen and measured) are independent of steady motion.

Prior to SR, the independence of the speed of light from the speed of the emitting object had been well established. In addition, observations of the aberration of starlight and the null result of the Michelson-Morley experiments appeared to indicate that it was not possible to detect speed of motion relative to the background aether that carried light. Subsequently, the arrival time of the light from binary star systems showed no evidence of a dependence on whether each star was moving towards or away from us. Behaviour appeared to depend only on relative motion. Einstein raised this "principle of relativity" and the independence of the speed of light from the speed of the emitter to postulates. However, in his derivation of the LT he replaced the postulate of a speed of light that was independent of the speed of the emitter by the subtly different postulate that the observed speed of light was constant independent of the speed of the observer. FR proposes that the speed of massless photons is independent of the speed of the emitting object, but that the inertia and clock-rate of massive objects depends on speed relative to a background medium from massive objects.

The altered postulate (the constancy of the measured speed of light) requires that a change in distance intervals must be matched by a change in time intervals. The measured ratio (i.e. speed = distance/time) is then constant. This was the claimed interpretation of the LT in SR. However, the interpretation had a dilation of time arising from an increase in time intervals while a contraction in length arose from an increase in distance intervals.

The claim of FR is that the interpretations of both redshift (to blueshift) and time versus distance need to be inverted. The result is a cancellation that enables FR to reproduce the predictions of SR. The predictions of GR are also reproduced for the current local background. However, discrepancies between FR and GR will emerge when the background is significantly different. The change in speed of light going back in time when the background was larger removes the apparent accelerating expansion and hence the need for dark energy. It will be argued that the changes in the background with location within a galaxy and clusters of galaxies is also able to remove the need for dark matter.

FR has the speed of light and mass dependent on the background. It frees space and time from being locked into the fabric of a pseudo-background. However, GR took the idea of spacetime a step further than SR by explaining gravity as a spacetime distorted by massive objects, but with the local speed of light a universal constant (in the absence of gravity). GR also has gravitational behaviour dependent on only the gradient of a potential. This keeps mass constant, independent of the total potential, removing the effect of a steady background. Under GR, the strength of gravity is independent of a uniform, homogeneous, stationary potential. This is embodied in the Einstein (or Strong) Equivalence Principle which claims that the laws of physics in a gravitational field are equivalent to the effects of a constant acceleration. Gravitational acceleration (proportional to the gradient of potential per unit mass) can then be equated with a curvature of space and time, but with mass unaltered. GR achieves this by distorting the time and place in which events occur while keeping the local value of c constant. The new background-dependent perspective of FR replaces the GR fabric of spacetime that is alterable by relative motion and by gradients in energy/momentum. Under FR, the speed of light and the energy per unit momentum carried by objects is dependent on the background, while the momentum and energy that can be transferred depends on relative velocity. The background can affect the time, in terms of clock-rate, mass, inertia and frequency of massive objects. However, space is not distorted and empty space cannot "itself" expand.

1.5 A background field as an explanation of gravity

Newtonian gravity has a field of gravitational acceleration that is proportional to the gradient of a potential. The differential form of Newton's field equation ($\nabla^2\Phi = 4\pi G_N \rho$) has the second derivative (the Laplacian) of this gravitational potential (Φ) directly proportional to mass density (ρ). GR generalises this formulation so that the second derivative of the metric (the fabric of spacetime) is directly proportional to the energy/momentum tensor (the generalisation of mass density).

Newtonian gravity has no time dependence and so does not allow for a finite propagation speed of gravity. The Minkowski metric of SR builds in a link between time and distance, and hence of speed relative to the speed of light. The GR distortion of this metric by massive objects and their movement builds in a dependence of the apparent speed of light on the energy and relative velocity of nearby massive objects. The use of derivatives means that contributions from equal gradients in opposite directions cancel, removing any dependence on a uniform background potential. Changes in the distance of matter with time can alter the distortion of time and space, but not the properties (e.g. mass) of the matter. However, the distortion (curvature) arises from a symmetric tensor of second derivatives with respect to time and distance. Cross-terms can involve products of derivatives in both time and distance.

Under FR, the background field whose gradient gives rise to gravitational acceleration is the negative of the total gravitational potential. The acceleration is dependent on the amount of stored energy and its inertial resistance and both of these depend on the background. The magnitude of the field determines the speed of light and thereby alters the amount of energy stored in the same amount of matter. The energy decreases with increasing background potential. The kinetic energy delivered by the same quantity of trapped momentum also increases with the speed of the object relative to the speed of light. The gradient of the potential is the fractional decrease in stored energy with position (distance) as the potential from the surrounding matter increases. Hence, the gravitational force on a massive object will be proportional to its mass. The ratio of inertial to gravitational mass may also depend on the background.

The heart of FR, in explaining gravity, is that stored energy is held in massive objects as mass rather than as a distortion of time and space in the vacuum in which particles are embedded. The local properties are determined by the energy and distribution of all other objects. By contrast, GR proposes that the energy comes from the surrounding gravitational field, which is a distortion of the metric of spacetime. If the energy gained by the object in falling in a gravitational field comes from the field, rather than the object, then an undistorted spacetime must contain an enormous pool of energy. Over fifty years earlier, Maxwell (1864) could not understand such a field [7]. To paraphrase him: *If gravitation arises from the action of the surrounding medium then every part of this medium must possess an enormous intrinsic energy that is diminished by the presence of dense bodies. I am unable to understand in what way a medium can possess such properties.*

Under GR, having a photon lose energy in escaping a gravitational field, even though it has no mass, meant that its energy of motion had to be the source of gravitational attraction. Consequently, all energy must contribute to gravitational attraction, including KE (and photons). Hence, when a body accelerates in a gravitational field, it gains energy from the field, and this energy contributes to the field, so the field (distortion of spacetime) becomes stronger! The gravitational field of GR increases non-linearly, with the energy of the gravitational field further contributing to itself, which leads to black holes with a singularity at their centre and the severe warping of spacetime at short distances called "quantum foam" [8]. Moreover, the full pool of energy is present when there is no matter and no distortion, so the source of the energy is unclear. Then, as the distortion increases, the rate of withdrawal from this pool of energy increases.

Einstein is quoted as stating: "Black holes are God dividing by zero". A half-share of the 2020 Nobel prize in Physics was awarded, in part, "for the discovery that black hole formation is a robust prediction of the general theory of relativity". According to the citation - "black holes hide a singularity in which all the known laws of nature cease". Such a singularity should be seen as confirmation that the theory has been pushed beyond the limits where its inherent assumptions apply. A singularity which owes its existence to being able to extract an enormous, arguably infinite, amount of energy from an initially empty space demands that the assumptions of the theory be examined.

FR provides a simple explanation for the enormous pool of energy. It is the mass stored in matter. The enormous energy released in the first atomic bombs corresponded to only about one gram of mass. The change in perspective from a redshift of photons to a blueshift of atoms means that photon energy is unchanged. The gravitational redshift of light is because the energy of the emitting atoms is lower when deeper in a gravitational potential.

However, FR provides an even more attractive advantage. The decreasing stored energy of atoms, as the amount of surrounding matter increases, means that the field becomes self-limiting. The lost stored energy (mass) appears as kinetic energy of motion, which does not contribute to gravitational attraction. Energy is conserved, but mass is reduced, so the gravitational potential of the same amount of matter reduces. This avoids the singularity at the centre of a black hole. It also means that photons are not trapped (in a black hole) by loss of energy after emission. The redshift occurs before emission. This does not mean that black holes do not exist, but the energy of the matter will be strongly redshifted and, if any photons are still emitted, most or all would be trapped by the strong bending of light travelling other than exactly along the gradient in potential.

Newton's law is a scalar, energy-balance equation in which mass decreases as the magnitude of the field from all other matter increases. The equation has no time dependence. The time dependence of events reflects the propagation speed of fields and the speed of particles as a function of energy. This is incorporated via the concept of inertia, the resistance to changes in the movement of energy, and the velocity-dependent concept of momentum. Inertia resists changes in motion, but not steady motion and requires both a more complex background and that massive particles can carry information about their current motion relative to this background. The variable speed of propagation of changes in the field(s) must also be incorporated into FR. An effectively variable speed of light is already incorporated into GR by a distorted spacetime changing the apparent speed. Thus, a fuller development of the nature and effects of the background of FR will be required. This background alters the speed of light which determines the stored energy; and alters inertia, the resistance to changes in motion.

1.6 Addressing some immediate concerns

Two immediate concerns for those familiar with SR and GR will be the claims by FR that the speed of light is not always the same for the local observer, and the proposed re-introduction of a background against which relative motion can be judged. The bigger challenge of demonstrating that FR can reproduce the many successful predictions of GR will be postponed to later chapters.

1.6.1 Special Relativity does not eliminate background dependence

So, what is meant by a background? The simple answer is a field or fields that permeate all of space and alters the properties of objects and signals embedded in that space. The concept of a field was introduced, as a medium to carry effects between locations, to explain action at a distance. It was therefore expected and understandable that there would be a finite speed of propagation. Perhaps the simplest familiar field is the atmosphere which is characterised by an air pressure. Gradients in air pressure cause a flow in the magnitude of the medium (a wind) and oscillating waves of pressure (sound) propagate in the medium at a finite speed. Pressure is a scalar property. It produces a force that acts in all directions and pressures coming from any direction add.

Air pressure has the same units as energy per unit volume, i.e. energy density. If the pressure of the air in a balloon increases, then its volume increases until it matches the external background pressure. Similarly, if the background pressure increases then the balloon volume will shrink. If the gas is enclosed in a stiff container and the temperature increased, then so does its mass. Hence, it is reasonable to expect that the energy stored in an object might change if the background energy density changes.

Originally it was assumed that light must also be carried by a medium and the changes in the timing of the orbits of Jupiter's moons established that it had a finite speed. Maxwell's work revealed that light is just the visible frequencies of self-propagating oscillating electromagnetic fields. However, various experiments showed that its speed was independent of frequency and of the speed of the emitting object. Einstein, in SR, concluded that it was unnecessary to postulate a medium (the aether) and derived that relative motion at constant velocity altered the subjective space and time but c was constant. Under GR, gravity is a distortion of spacetime and gravitational influences also travel at the speed of light. Recently, the propagation of gravitational disturbances from the merger of a pair of neutron stars has been observed together with emitted electromagnetic radiation including a gamma ray burst within 2 seconds of the gravitational wave. This provides convincing evidence that gravity also propagates at the speed of light.

The fabric of spacetime acts like a pseudo-background. Firstly, it changes the perceived time and space that applies to objects moving relative to the observer, even though the time and space of the same object, perceived by an observer not moving relative to the object, is unchanged. Secondly, this spacetime fabric can be distorted by concentrations of mass so that the geometry of space is no longer Euclidean. The effects of changes in velocity (i.e. acceleration) are claimed to be equivalent to such distortions. The spacetime of an observer freely falling in the gravitational field, so not feeling any force, is claimed to be undistorted. Under SR and GR, time and space are malleable, it is only their combination in terms of the speed of light that is fixed (in the absence of a gravitational force).

Prior to the development of SR, Lorentz with corrections from Poincaré had developed a theory that was consistent with observations. The theory had time dilation and a FitzGerald-Lorentz length contraction and a preferred stationary frame. It provided an explanation of the Michelson-Morley and Fizeau experiments. It was consistent with the observation that the speed of light was independent of the speed of the emitting object, and with the aberration of starlight. The latter is the change in apparent direction of stars as a function of the relative motion between the Earth and stars at different times of the year. Electrodynamic interactions appeared invariant under what became known as a Lorentz transformation.

In his 1905 paper, Einstein used the postulate that the laws of physics (electrodynamics and kinematics) were dependent on relative motion but independent of absolute motion at constant velocity, together with the postulate of the constancy of the speed of light, to deduce the equations of the Lorentz transformation [9]. This implied that the postulate that only relative motion mattered was correct. Therefore, a luminiferous aether was superfluous as there was no need for an absolute stationary space. It was later realised that, if the postulate that physics results were independent of movement at constant velocity was correct, then the reference frame was arbitrary, and the chosen perspective was just a matter of preference. Even under SR, a stationary frame was not eliminated.

However, it is shown in Chapter 2 that Einstein's analysis, in deriving the LT, was faulty. The first postulate, that only relative motion matters, applies approximately at low speeds. Observations at high speeds are better explained using a stationary background. The second postulate was originally that the speed of light was independent of the speed of the emitting object. However, it was replaced by the subtly different postulate that the measured speed of light was constant independent of the speed of the source or observer. In addition, there were several incorrect steps in the derivation. Consequently, the analysis cannot be used to establish either of the used postulates and so does not establish background independence. SR holds that a background is superfluous and there is no need for an absolute stationary space against which speed of motion can be judged.

In GR, when gravity is present, the SR combination of space and time is altered by mass/energy but in a way that keeps the local speed of light constant. GR holds that: inertial and gravitational mass are equivalent; the non-gravitational laws of physics are independent of the time and place at which they occur; and the outcome of any local non-gravitational experiment is independent of the velocity of the freely falling apparatus [10]. The physics is therefore independent of a uniform, homogeneous, stationary background of matter. Their replacement (FR) is background-dependent and movement relative to this background causes time to slow for massive objects. Moreover, under FR, the speed of light (c) depends on the background and therefore contradicts the core claim of GR that it is locally invariant if there is no gravitational field (i.e. that c is independent of a constant background).

1.6.2 Does the speed of light have to be constant?

FR proposes that $m = E / c^2$ implies that increased mass is associated with a decreased speed of light. The possibility that the locally observed c could vary was eliminated in SR and GR by having it as a postulate. However, the original postulate of SR was that the speed of light was independent of the speed of the emitting body. In the derivation, this was replaced by the postulate that the speed of light measured by different observers was always the same; which is quite different (see Chapter 2). The revised postulate was combined with the postulate that only relative motion mattered so that the speed of light was independent of the speed of the frame relative to anything. As shown in Chapter 2, the latter postulate, that only relative motion matters, is also faulty and inconsistent with observation.

An amended understanding and applicability of the Lorentz transformation (LT), which successfully describes the observed behaviour of electromagnetic interactions between particles moving at high speed, does not require that c have the same constant value between frames with different constant backgrounds. The deduction of the LT in the SR analysis was taken to mean that the postulate of a constant speed of light was correct. However, the LT only requires that the speed of light be the same, and independent of direction, within a frame moving at constant velocity in a constant background. A constant background is one in which there is no gradient and so no gravitational field. Movement into a new background involves an acceleration due to the gravitational field, which involves a non-inertial transformation. It cannot be used to establish that the postulate holds for different inertial frames.

A variable speed is not forbidden because SR applies to inertial frames, and so to regions without gravitational acceleration due to gradients in mass density, and hence to regions of constant speed of light. So, $m = E / c^2$ can remain valid within each region, even if c changes. If it does, then mass, size, and time intervals change. If the stored energy density of the background increases, then c increases, and the embedded particles cannot store as much energy.

If distance intervals between stationary objects do not change but light travels at different speeds in different regions, then time intervals vary. The frequency of "light-clocks" need not be the same in different regions. These are clocks based on the time for light to return from mirrors the same distance apart perpendicular to the direction of motion. The ratio of time intervals follows $dt' / dt = c / c'$.

If light travel-time varies then the concept of absolute simultaneity, that there exists an underlying absolute time for sets of simultaneous events throughout space, needs to be refined. An underlying time still exists, but is no longer absolute. The speed of identical clocks at different locations varies and the time for the influence to travel the same distance in different directions, and at different locations, can vary. In addition, if mass or inertia varies, the time intervals between ticks of identical massive clocks will not change in the same way as the time intervals of light-clocks. The concept of causality (the ability to influence events at another location) must also take into account the fastest time an interaction along a particular path can be transmitted.

Time, in the sense of massive-clock rate is observed to vary in a gravitational field. The solution, according to GR, is to have c as only a local constant. Although the apparent speed of light can be altered if the observer is in a different gravitational (acceleration) field, there is no change in the locally measured value of c from being in different regions. GR has the perceived space and time altered (distorted) by the difference in gravitational potential between the observer and the event location.

The alternative explanation of changes in time provided by FR, implied by $m = E / c^2$, is to have c increase, and inertia per unit matter decrease, as the total background potential (due to sources of stored energy in any direction) increases. Changes in light-time intervals reflect the change in time taken for light to traverse a constant distance. Under FR, the decrease in stored energy implies that the length of the same rod (the separation distance between connected ends) will increase in proportion to c, which would match the decrease in light travel time. The speed of light, measured by a local massive rod, would then appear constant. However, the light travel-time between unconnected objects at a fixed separation will decrease by c / c' if light speed increases by c' / c.

1.6.3 A variable speed of light is not in conflict with observation

The arguments of why the speed of light must be a local constant assume, and require, that the clock-rate of a clock travelling with an observer (no relative motion between clock and observer) maintains a standard time (proper time) which is independent of location (if free of forces), and hence independent of a uniform background potential. This embodies the Strong Equivalence Principle, which claims that the non-gravitational laws of physics are independent of the location and time at which events occur. However, it is observed that stationary clocks in regions of different background potential tick at different rates. Both FR and GR attribute this to differences in the gravitational potential. However, the potential of GR is the integral of the gradient of the acceleration, which removes any contribution of a constant uniform background. This potential has no effect on mass or c, whereas FR has mass, c and inertia dependent on the magnitude and asymmetry of the total background potential. The laws of physics are only equivalent after correction for the background.

Under FR, changes in the speed of light (c to c') and inertia have already been observed in terms of the increase in clock-rate with altitude, seen in the need to correct timing in the GPS satellite system. Energy increases by $(c/c')^2$, suggesting the wavelength of the transition (spacing of the charges) decreases by c'/c. The observation that clock-rate increases in proportion to $(c/c')^2$, implies that the speed of light decreases by the same amount as the wavelength. It is the interpretation, under GR, that distance and time are distorted while the speed of light is kept constant that needs to be amended. Objects gaining stored energy (mass) as the surrounding potential reduces, means their components (e.g. protons and electrons) are more strongly bound. So, the size of their wavefunctions, and the spacing of their charged components, decrease. Every measurement instrument (massive object) becomes smaller in proportion to the speed of light. The increase in energy levels will parallel the increase in binding energy and will be inversely proportional to the square of the decrease in radius so that the circumference will decrease in proportion to the speed of light for the same standing-wave pattern. Although the speed of light decreases the traverse time for the same measuring rod is unchanged, allowing the speed of light to appear constant. Thus, c appears constant for such measurements but is not, while clock-rate of massive clocks containing more energy increases in proportion to $(c/c')^2$. The scale of space (apparent distance between stationary objects, using massive measuring rods) will increase as background density reduces (because the length of the measuring rod decreases), but the actual distance (between separated, stationary objects) is unchanged. The underlying time (u-time), in which momentum is conserved, is distance divided by the speed of light.

The observational evidence for the speed of light being constant, for example from studies of the Hubble expansion and gravitational lensing are based on consistency with the predictions of GR, which assumes c is constant. It is not easy to detect changes in the speed of light at a distant location unless there are separate means of measurement of distance or time than those that depend on the speed of propagation of electromagnetic radiation. Moreover, the local differences in the speed of light are very small. The fractional change in mass with distance from a spherical object of mass M, is $G_N M / rc^2$. Under FR, the gravitational potential, the change in inertial energy per unit of gravitational mass ($\Phi = \Delta E / m$), is the fractional change in energy or mass ($\Delta E / E = \Delta m / m = \Delta E / mc^2 = \Phi / c^2$) when moving to a region with a different background. The value is of order 10^{-16} per metre change in height at the Earth's surface. So what we are used to thinking of as Φ is just the fractional release (as kinetic energy) of the stored energy held by a small amount of matter when it moves closer to a large source of mass. Because it is a derivative, the fractional change will be smaller when the total background is larger. The fractional change in clock-rate with altitude is also $\Delta\Phi / c^2$. It is the change in time from the changes in frequency and energy stored in the atoms of the clock. Under GR, the change in time is seen as due to the change in Φ, which is assumed independent of any background and which has c constant. Under FR, it is primarily due to the change in kinetic energy with change in inertia, but driven by the small change in c which depends on the magnitude of a large background.

Photons, having no mass, always travel at constant speed in a constant background. The speed is independent of the velocity of the emitting massive object but proportional to the local background potential. The local speed of light is independent of direction, and the time interval for light to traverse the same measuring rod moved to a new background is constant. These properties appear consistent with the Michelson-Morley and Fizeau experiments, and aberration of starlight, and with the speed of light appearing constant but actually being proportional to the background potential.

1.7 The background must explain more than gravity

GR and SR provide explanations for the observed amount of bending of light and for the increase of inertia with speed. Under SR, the rest mass is an invariant with inertial and gravitational mass equated. Gravitational attraction depends on the rest mass plus kinetic energy, with kinetic energy depending on speed relative to the observer. This total energy/momentum determines the amount of warping of spacetime. FR must also explain inertia and its increase with speed as well as the bending of light.

FR proposes that the magnitude of momentum (energy divided by c) of a photon is not changed in moving higher in a gravitational potential so that light does not slow down (fall backwards). If bending was caused by loss of energy, then light would be bent by a gravitational field, but by only half as much as that predicted by GR based on the distortion of both space and time. However, FR has no distortion of space, so the observed bending of light needs to be explained.

Inertia is familiar to all of us but is really rather strange. It is a resistance to changes in direction or speed of motion, but not to steady motion. Force (and therefore an input of energy) is needed to get to a new speed of linear or rotational motion but once at the new speed the motion continues indefinitely in the absence of any external force. At low speeds, the resistance is proportional to the mass of the object times the change in speed. As the speed approaches that of light it takes more energy to produce the same change in speed or the same change in direction. If, as SR claims, there is no need for a background, how does the object know how fast it is going? How does it know that it is changing direction but is oblivious to changing position? If the increased energy needed to travel faster is stored in the object, why is it not freely released by the object slowing down?

The beginning of an understanding of inertia comes from the observation, initially suggested by de Broglie, that all objects (massive and massless) have wave properties. Heisenberg's uncertainty principle reveals that both wavelength and momentum, and frequency and energy, of the oscillations are related via a constant with the dimensions of angular momentum. An oscillation implies that the magnitude or direction of momentum is moving back and forward or rotating and also that there are at least two components involved. The frequency of rotation/oscillation of trapped momentum will depend on the magnitude of the components and any imbalance, asymmetry, between components.

Gravitational mass, if it varies with the speed of light (as $1/c^2$), has a scalar (or single, directionless) dependence on background. This implies that asymmetry has little or no effect on gravitational mass. However, it could still be correlated with inertial mass or it may be that local variations in asymmetry are small. The slowing of time and frequency, with speed of movement relative to the background (under FR), indicates that a larger force is needed (with increased speed) to accelerate a given amount of stored energy (gravitational mass). This implies that the ratio of inertial to gravitational mass is sensitive to movement relative to a balanced/stationary background. Fractional changes in asymmetry may be small within our solar system, if the background asymmetry from our own galaxy is much larger than the changes due to local matter, i.e. the Sun. The changes in inertia with asymmetry will appear similar to changes in mass and so will be absorbed into the apparent value of the gravitational constant. The speed of movement of massive objects under the expected gravitational force would then differ in regions of different asymmetry (if inertia is determined by asymmetry). The fractional change in asymmetry in moving away from a concentration of just one type of matter will depend on the total clout of that component from all directions. However, the gravitational force is proposed to arise from a gradient in the total clout (altering the speed of light and the energy stored) while inertia is proposed to arise from differences in asymmetry. The effects of the nearly constant backgrounds are locally hidden but the variation in asymmetry will mean that the decrease in inertia with distance from one nearby source will be by a smaller amount when there are background sources from other distances and directions. The reduction in inertia would appear like an increase in the strength of gravity as the sources of asymmetry became more like a single point. Changes in inertia therefore appear, at first sight, to be a possible route towards explaining the flat rotation curves of galaxies. This change in the asymmetry of a two-component background should always be much larger than the change in total background which, FR proposes, determines c and gives rise to gravity.

1.8 General Relativity versus a time-dependent scalar gravity

FR provides an explanation of a static, scalar Newtonian gravity in terms of a change in the stored energy of matter. One object is affected by the constant (for fixed distance and direction) gravitational field of another object. This means that it is the slow-speed limit of a theory in which changes in gravity are instantaneous. Relativity proposed that nothing could travel faster than the speed of light, and it is now observationally confirmed that the speeds of gravity and light are the same to high accuracy. A post-Newtonian theory therefore needs to incorporate the finite speed of light, and to be able to explain resistance to changes in speed of movement and the vector nature of momentum. GR links the finite speed of light to that of gravity via a spacetime in which inertial and gravitational mass are equated. The force apparent in the acceleration of gravity is equated with the force due to the inertial resistance to acceleration. Energy and momentum are also linked via a constant speed of light.

FR similarly needs to introduce a relationship between space (distance) and time in terms of the finite speed of propagation of the gravitational field. It does this by requiring that gravitational energy be consistent with $m = E / c^2$, with a variable speed of light/gravity. This implies that Newton's scalar gravitational <u>potential</u> (which determines the stored energy per unit of matter via c) should be the field which propagates at the speed of light. On the other hand, in formulating GR, Einstein equated inertial and gravitational <u>acceleration</u> by keeping the ratio of inertial to gravitational mass constant. This meant that the vector force fields, the gradients of the inertial and potential (energy) fields, were equated. Therefore, a brief introduction to scalar and vector fields is given as a prerequisite to the understanding of some of the similarities and differences between FR and GR.

Electric and magnetic fields are vector fields that come in two forms (arising from positive and negative charges and their movement). The fields have magnitude and direction and the effects of like charges (or like magnetic poles) in opposite directions cancel. A small test charge enclosed within a spherical shell of isotropically distributed (stationary) charge (or poles) does not feel any force. Static electric and magnetic fields hold energy and a propagating electromagnetic wave carries energy proportional to its oscillation frequency. Light impinging on a surface delivers energy (the radiant exposure). The delivered radiant energy density is $\partial Q / \partial \mathrm{V}$, where Q is radiant energy (the amount of energy being propagated at speed c) and V is volume. So, Q is the amount of energy in a volume, but it is passing through that volume. If there are no photons, then Q is zero. Energy (and mass) are lost by objects when they emit photons. However, an electric field due to stationary charge does not disappear or change over time unless the sources (charges) move.

Gravity can also be seen in terms of a vector field. Newton's universal law of gravitation has:

$$\vec{F} = m_i\vec{g} = G_N M m_g \hat{r} / r^2 \qquad (1.1)$$

where $\hat{r}$ is the unit vector in the direction of increasing distance.

It can be expressed in terms of a vector field of gravitational acceleration ($\vec{g}$), by cancelling the mass terms. The acceleration is the force per unit mass experienced by objects in this field. This force (vector) is equal to the gradient of a potential (a scalar), which is the gravitational energy (per unit mass), held at that location, that can be given to objects. The energy given to objects becomes kinetic energy of motion which reflects inertial mass (the difficulty of changing momentum). Under GR, inertial (m_i) and gravitational mass (m_g) are seen as the same property (m). The force resisting acceleration and the force of gravitation are equated. It is assumed that their ratio is fixed.

Gravity has been presumed, like photons, to be carried in quantized packets (oscillations of the field) called gravitons. The assumption that the graviton is quantized is because the strong, electromagnetic, and weak forces have been successfully described in terms of relativistic quantum field theories in which the forces involve the exchange of discrete quanta. Under GR, the graviton must be a spin-2 boson because the source of gravitation is the stress-energy tensor, a second-order tensor. A photon is an oscillation of the components of the electromagnetic field that can carry a fixed quanta of energy to a new location. However, the stored energy (gravitational mass, which is the source of gravitational attraction) held in an object is reduced by the amount carried by any photons that are radiated.

Under GR, the kinetic energy of pairs of rotating binary stars, or black holes, can also be carried away by gravitational waves, and these are assumed to be made up of gravitons. However, observations suggest that for both gravitational and electromagnetic fields, once the field has been established, a continual flow or input of energy is not required to maintain a constant field. If a photon accelerates a charged particle, then the electromagnetic field is altered by the movement of the charge with the change in the field propagating at the speed of light. If a particle emits a photon, then the gravitational field of the particle is reduced with the change in the field propagating at the speed of gravity.

For Newtonian gravity, the gradient of the potential (the field), appears to be unchanged by the kinetic energy it gives to objects, but the field increases as massive objects move closer together. For GR, the distortions of space and time, and the energy that can be given to objects by that distortion, increase when an object is accelerated and so gains kinetic energy.

The differential form of Newton's gravitational field equation is:

$$\vec{\nabla}.\vec{g} = -4\pi G_N \rho \qquad (1.2)$$

where $\vec{g} = \nabla\Phi$ is the gravitational acceleration field (force per unit mass), ρ is the mass density function and Φ is the gravitational potential. The equation has the divergence of the acceleration field directly proportional to mass density. In this formulation, the mass density function is determined by the total mass in a given volume. The energy density is in proportion to the mass density according to the conversion factor between mass and energy.

Mass density is understandable as the total mass (M) in an enclosed volume (V). Under equation 1.2, this function produces the divergence in gravitational acceleration. It somehow represents the influence of mass at a distance. In physics, fluence is defined as the time-integrated flux of some radiation (wave) or particle stream. If both sides of equation 1.2 are integrated, the acceleration becomes proportional to the perpendicular flux through the surface surrounding mass M . The field of gravitational acceleration can be pictured in terms of flux lines that decrease in areal density with increasing surface area around a source (i.e. as $1/4\pi r^2$ for a point source). However, flux or radiance involves flow. Gravitational and electric fields are present when mass or charge are present and move when the masses or charges move, but the energy of the field does not flow away or move unless the sources move, and/or massless energy is radiated in the form of wave/particles (photons or the hypothesised massless gravitons).

The big difference between scalar and vector fields is that vector fields from opposite directions cancel, whereas scalar fields add. The contributions of a homogeneous, isotropic distribution of sources of a vector field, surrounding a location, cancel each other. Therefore, there is no electric field inside a sphere covered in an isotropic distribution of charged particles. However, outside the sphere there is an electric field whose average strength decreases in proportion to the change in surface area, i.e. as $1/4\pi r^2$. An electric field can be seen as arising from a scalar electric potential (whose strength decreases as $1/r$). The large forces between charges and their ease of movement means that it takes enormous energy to establish and maintain concentrations of like charges because they will be quickly cancelled by the movement of particles carrying the opposite charge.

For gravity, on the other hand, mass does not appear to come in a pair with an opposite state that repels. Only a like state that attracts is seen and the force is extremely weak. For a scalar gravitational potential, all contributions to the total field decrease in proportion to $1/r$. The contribution of every small mass δM has to be summed inversely as its distance d, i.e. according to $\Sigma(\delta M / d)$. This means that the contributions from surrounding uniform shells of equal mass density increase with distance because their surface area grows as $4\pi d^2$. A uniform surrounding density of matter will therefore contribute an enormous background potential.

A scalar field will exist inside and outside a sphere of uniformly distributed matter. It will affect objects in the field in proportion to its fractional change in magnitude with change in position. Thus, the effects will be closely proportional to the gradient in the limit that the fractional change is small. The larger the background, the smaller the fractional change from the same nearby excess of energy (mass). The proposed scalar background of FR will alter the speed of light and hence the energy stored by matter. The effect on energy (per unit mass) of a nearby source on top of a large background will therefore be proportional to minus the potential (divided by c^2, for energy per unit energy). The proportionality factor will vary with the size of the large background via its effect on c.

A potential field has a magnitude at all points in space and the force will depend on the fractional change in magnitude with distance, i.e. on the gradient of the field. The magnitude of the potential is the sum of all contributions from sources of excess stored energy. However, the term "clout" will be used to represent the magnitude of the background which determines the speed of light. This is to distinguish clout from minus the potential of the stored energy whose gradient has previously been assumed to be independent of a constant background. Under FR, the speed of light is proportional to the local magnitude of the total background, with the amount of momentum that can be trapped varying as $1/c$ and the stored energy as $1/c^2$.

In GR, Einstein introduced the idea that gravitational acceleration could be seen as a distortion of the geometry of space and time (the metric). A distortion has the advantage of remaining present in the absence of an ongoing input of energy. Massive objects and their movement (and the momentum of massless photons) distort the geometry of this spacetime fabric in which all things move, but the (rest) mass of objects is unchanged. The size of the distortion (curvature) is the second derivative of the metric, which acts as a relativistic generalisation of the static gravitational potential [11]. That is, the size of the distortion at a location can vary with time, with the variations travelling at the speed of light. Einstein's field equation is a generalisation of equation 1.2. The curvature, via the magnitude of the distortions, is proportional to the stress-energy tensor, the generalisation of mass density to the density of energy and momentum. The finite propagation speed, absent in Newtonian gravity, is introduced into GR by its equation of motion, the geodesic equation. This equation of motion is the generalisation of Newton's second law. The forces that give rise to movement come from the curvature, which is determined from the stress-energy tensor, with its value changing with time and position. The distorted fabric of GR alters the space and time in which objects are embedded and so can alter their apparent energy and momentum (via velocity) but it does not alter their mass (because c observed at the object is kept constant).

This background fabric, and also relative movement of object and observer in an undistorted fabric, change perceptions. It is claimed that the fabric just expresses a relationship between space and time and has no substance. Thus, space and time are free to distort and only their combination in terms of a fixed speed of light is constrained.

The alternative to GR (i.e. FR) is to have the scalar background clout from other mass change the energy stored by matter by altering the speed of light. The background can therefore alter the energy and time of objects rather than the time and space (distance between them) in which they reside. Changes in clout propagate at the speed of light.

1.9 Summary

Einstein's General Theory of Relativity (GR), put forward more than one hundred years ago, has had remarkable success at explaining observations of the cosmos. It is based on a fabric of spacetime, which always yields the same locally measured speed of light. Gravitational acceleration arises from a distortion of the geometry of this fabric by matter and energy. However, GR has required additional hypotheses to explain cosmological observations. These include dark energy, dark matter, cosmic inflation, and black holes with a singularity at their centre. In the past, singularities have been seen as an indication that a theory has been pushed beyond its limits. GR also appears to be incompatible with Quantum Mechanics (QM), which has been verified to remarkable accuracy.

This book argues for, and sets out, an alternative that removes the need for these ad hoc hypotheses. The title of Full Relativity is proposed for the alternate theory because motion, properties and interactions depend on the amount and distribution of all other matter/antimatter. Hence, FR reasserts the Machian philosophy that motion can only be judged relative to all other objects. FR necessarily challenges many aspects of the current theory. It claims that the key concept of a fabric of spacetime can be replaced with a different sort of background. The background affects the properties of objects rather than the spacetime in which objects are embedded. However, it needs to be, and will be, demonstrated that this alternative can reproduce the successful, standard predictions of GR.

FR does not require quantum gravity or string theory. Its core aspects are required by a careful analysis of existing arguments and of the meaning and interpretation of apparent effects. The changed perspective arose from accepting that a massless photon should not lose energy in escaping a gravitational field. The existing understanding from SR is that mass is just a form of stored energy. Therefore, if photons do not lose energy, the stored energy of massive atoms must increase with increasing gravitational potential. Immediate advantages of the changed perspective are that it removes the singularities of black holes and the need for an enormous pool of energy in empty space. However, if mass is not constant, then $m = E / c^2$ implies that the force of gravity varies with, or arises from, changes in the speed of light.

Under FR, <u>gravitational</u> time dilation (slower time) is attributed to a decrease in mass with an increase in the speed of light. It is not attributed to a distortion of the spacetime fabric between objects proportional to the difference in gravitational potential. Clock-rate goes faster with increasing distance from a concentration of matter because the stored energy of massive clocks increases with decreasing clout (higher potential) and lower c. The claim that $E = hf$, as observed for photons, means that the photon has lost energy because of an apparent redshift in wavelength ($\lambda = c / f$) in escaping the Earth's gravitational field is inconsistent. Massive objects should also lose energy in escaping a gravitational field, so there would be no relative change in energy between photons and the atoms of a detector. Time going faster should also mean that the frequency (f) of the same standing-wave of a given atomic transition (atomic clock) is higher. The frequency of an unchanged photon emitted at a lower altitude, but measured at a higher altitude, will then appear slower.

FR has the speed of massless particles, including photons, independent of the velocity of the emitting source. This was the original second postulate of SR which was based on experimental observation. The speed depends on the magnitude of the background but not its movement or direction.

The subtly changed second postulate of SR was that the speed of light will be measured/observed to be constant. This can be true within any inertial frame, but only after correcting for changes in signal arrival time due to relative motion between emission and absorption. The speed is independent of the speed of the emitting object but is free to vary with the magnitude of the background. The Lorentz transformation (LT) holds for electromagnetic fields because they propagate at the speed of light.

Under SR, clock-rate is slowed and distances (space) contracted by relative motion in a way that keeps the speed of light constant. Under FR, clock-rate is slowed for massive objects/clocks moving relative to an effectively stationary background. This background changes the properties of objects rather than the perceived spacetime between objects. Space is not distorted by motion or matter, but the speed of light, and the properties and movement of objects embedded in the background are affected. The background dependence removes the need for invariance of mass and the speed of light, and it is the speed of propagation of massless fields which is independent of motion of the source.

Under FR, the speed of light has a scalar dependence on the background. Time, in terms of the clock-rate of stored energy (massive objects) depends on velocity relative to the background that arises from the stored energy, position, and movement of all other massive objects. Motion relative to this background (which is itself massless), and its size, affects the magnitude of physical laws. The energy that can be held by massive objects, and hence clock-rate, reduces as c increases. The distance between separated objects, not in relative motion, is constant. Space is not distorted, although the size of objects will change as the background changes. The speed of light is independent of the speed of the emitting massive object and constant if the background due to other matter is constant. The assertion that the magnitudes of physical laws are independent of the background is rejected. The "principle of relativity" is a mistaken claim that behaviour, in the absence of gravitational acceleration, depends only on relative velocity.

The invariant interval of Minkowski spacetime (under SR) appears consistent with moving clocks, as seen in the decay rates of unstable elementary particles, being slowed independent of whether they are approaching or receding from the observer at speeds close to c. However, as massive observers we are approximately stationary relative to the mean background from all other objects. Any object moving at speed close to c will be moving at high-speed relative to this background whether it is moving towards or away from us.

As will be explained in more detail in Chapter 2, the derivation of the LT in SR is faulty. The accepted interpretation requires that the radiation of light from a stationary source will, to an observer moving at constant speed, also be measured to spherically expand at speed c. This requires real, rather than imagined, matched distortions of distance (x) and time. However, the mathematical demonstration of supposed spherical expansion misinterprets the terms of the LT and only applies when $x = \pm ct$.

The derivation of the LT included the deduction that two relatively moving observers would observe the same underlying clock-rate on identical clocks that were stationary relative to the respective observer. This was based on a faulty assumption. It was argued that the lack of a difference in distance with time of two clocks moving in opposite directions after coincidence at time zero meant that the frames were stationary relative to each other. The claimed derivation of the LT did not establish the SR postulate that only relative motion is important, or that space is distorted by relative motion. The experimental observations embodied in the LT require a real decrease in clock-rate when a massive object moves relative to a stationary background. On the other hand, the observed isotropic constancy of c, and the dependence of electromagnetic interactions on only relative speed, means that the speed of propagation of massless objects (photons) is not sensitive to motion relative to the background. Thus, photons and massive objects respond differently to the background and there is no requirement that the speed of light be the same for different backgrounds.

FR has the inertial and gravitational mass of the same amount of matter proportional to the stored energy. This stored energy is constant within a region of constant gravitational potential, and hence of a constant speed of light. The predictions of SR and FR will then agree if movement relative to the background introduces a real decrease by $1/\gamma$ in decay rates.

It is proposed that the amount of trapped momentum and the frequency of its rotation/oscillation will depend on the magnitude of the components of a two-component background. The magnitude of the combined components will determine the speed of light and the imbalance, asymmetry, between components will determine inertia, the resistance to changes in motion per unit of stored energy.

Under FR, space and time are not linked into a spacetime. So, gravity cannot arise from a distortion of the geometry of spacetime between massive objects (as set out in GR). Such a distortion is difficult to reconcile with mass arising from the Higgs mechanism of particle physics. Instead, gravity comes from a reduction in the energy that can be stored by particles, when the speed of light increases. Distances between stationary objects are not altered but the time of clocks will depend on the background because their mass will change. The background can also affect size, inertia, and frequency of oscillation, and hence direction of travel, of massive objects and photons. However, it is the objects and their properties that change and not the geometry of space and time between objects.

FR overcomes many problems and inconsistencies with both SR and GR and can avoid the need for the ad hoc hypotheses of dark energy, dark matter and cosmic inflation. However, it first needs to be demonstrated that the derivation of SR was faulty and that the linked fabric of spacetime is an illusion.

Chapter 2

Special Relativity, space and time re-visited

It is a difficult task to challenge aspects of Special Relativity because it is now so strongly embedded in our scientific education and culture. There is also a huge range of experimental evidence that supports its validity. Much of this is set out in resources available on the internet, such as "What is the experimental basis of Special Relativity?" However, the experimental evidence, which amounts to consistency with the Lorentz transformation (LT), is not being challenged. FR maintains the validity of the behaviour captured by the LT but challenges its interpretation under SR and that it establishes the validity of the hypotheses used. The key conclusions of SR such as time dilation, that nothing can travel faster than the speed of light and the deduction of $E = mc^2$ remain. However, the claims that physical laws are completely independent of a constant velocity (only relative motion is important), that the speed of light is the same for all observers, and that there is a fabric of spacetime, all need qualification or rejection. FR involves subtle differences in meanings or interpretations of terms, particularly between apparent and real effects seen by observers in different "frames".

The first step is to give a brief outline of the historical development of the LT and SR. Next, the original and a later derivation of the LT under SR are examined in detail and the inconsistency of some steps is explained. It is impossible to use distances based on changes in the arrival time of reflected signals, to deduce the time experienced by a moving object, because the time of the moving clock is not examined. If emitted signals are used then the relative clock rates of observer and object must be known. Otherwise the distinction between "apparent" and "real" effects becomes blurred. This is also seen in the subtle change of the observation that (in a constant gravitational field) the speed of light is independent of the speed of the emitting object to the postulate that the "measured" speed of light is independent of the speed of the observer. An alternative explanation of observations based on revised hypotheses is presented. The changed understanding means that consistency with the LT can be maintained but only with a new understanding of its applicability and interpretation. Finally, the implications of the new perspective for space, time and relativity are presented.

2.1 Historical background

An aether (background) was originally assumed on the basis that the propagation of light must require a medium. This view was strengthened when Maxwell showed that his differential equations of electromagnetism indicated that all electromagnetic waves propagated at a velocity which turned out to be the observed velocity of light. The problem was that observations of the aberration of starlight, the Fizeau experiment and the Michelson-Morley experiment all indicated that the speed of light was independent of the speed and direction of the emitting body. In 1900 these experiments suggested seemingly contradictory conclusions: that the aether is mechanically independent of ponderable matter, but the effects of the necessary aether drift from the motion of the Earth cannot be detected [12].

Lorentz, as set out by Bohm [13], with corrections from Poincaré, proposed a theory which potentially explained why interactions via electromagnetic fields are invariant under what became known as a Lorentz transformation. The theory had a (FitzGerald-Lorentz) contraction in the length of objects and a dilation (slowing) of time, with velocity relative to the aether (background). The locally measured speed of light then always had the same value, so the aether appeared to be at rest. Neither the Michelson-Morley nor the Fizeau experiments could then provide knowledge of the speed of the Earth relative to the aether. Lorentz's original proposal was that the actual speed of light has a fixed value in the aether but that an observer moving relative to the aether does not realise that both their time and distance are altered.

The behaviour of space and time depended on motion, but the speed of light appeared independent of any absolute reference. This agreed with the observation that below decks on a ship sailing at constant speed you could not tell that you were moving relative to the shore. It seemed to be impossible to tell from the behaviour of objects (physical laws) whether an observer was stationary (absolute rest) or in a windowless enclosed space and moving with constant velocity. The lack of dependence on absolute motion, at constant velocity, appeared to apply more generally (to kinematics – the motion of massive objects). Physical laws appeared to be identical within any inertial frame, i.e. at all non-accelerating locations. The idea that behaviour was independent of motion at constant speed became known as the "principle of relativity".

Einstein's approach was to upgrade this "principle of relativity" (independently put forward by Poincaré) to a postulate together with the (second) postulate that the speed of light in vacuo was constant [9]. In his analysis he was able to derive the Lorentz transformation and concluded that only relative motion mattered and the concept of velocity relative to an aether (present in the vacuum) was not needed. He also showed that Maxwell's equations were invariant under the LT. The Lorentz-Poincaré theory proposed a stationary background with real changes in size and time. However, it was later argued by Bell [14] that the postulate that physical laws were the same for a fixed observer and for one in uniform motion meant that the two viewpoints (stationary or no background) could not be distinguished experimentally, so the choice was a matter of preference.

Einstein's theory became known as Special Relativity (SR). It has the time and distance of events dependent on the relative speed of the observer, while the speed of light is the same for all observers. Time slows, and length decreases, for events in another frame whether it is moving towards or away from the observer. Motion distorts the space and time of an object moving relative to the observer. There has been ongoing debate as to whether the effects are apparent or real. However, the current interpretation of the LT in SR, as a transformation between the times and coordinates of different inertial frames, treats the effects as real. The interpretation is that changes in time and distance apply to the measured time and distance of moving objects. This has always been a difficulty when Einstein's own analysis concluded that underlying clock-rate was the same in the moving frame. Under SR, lengths and time intervals become subjective, based on relative motion. The claim is that the observed time of objects moving relative to the observer will be slowed independent of whether the object, and its frame, is moving towards or away from the observer. The effect on time is real in the sense that clocks (as seen in the decay rates of unstable elementary particles), moving at high speed towards or away, are predicted to be slowed.

The formulation of SR in terms of invariant intervals in spacetime by Minkowski together with apparent experimental confirmation, e.g. of time dilation by the slowing of the decay rate of high-speed muons, meant that the SR hypotheses, including spacetime combined into a fixed speed of light (c), became the accepted norm. This was further strengthened by the formulation, in the theory of General Relativity (GR), of gravity as a distortion of spacetime with a locally constant speed of light, and by the remarkable agreement of observations with the predictions of GR.

2.2 The Lorentz transformation in Special Relativity

Lorentz had shown that the behaviour of high-speed objects and the null result of the Michelson-Morley experiments could be explained by a dilation of time and a contraction of the length of moving objects. This could be put in the form of the LT in which space and time were both altered by motion relative to the aether so that the speed of light was constant. Einstein took this a step further by deriving the LT based on the postulates that physical laws depended only on relative motion and the speed of light was constant. The changes in space and time kept the speed of light constant independent of any aether. The LT and its interpretation in terms of a fabric of spacetime is at the heart of SR and GR. Therefore, it is necessary to examine both its derivation and its interpretation.

The LT for constant velocity (v) in the x-direction is:

$$x' = \gamma(x - vt)$$
$$y' = y$$
$$z' = z$$
$$t' = \gamma(t - vx/c^2)$$

where $\gamma = 1/\sqrt{1 - v^2/c^2}$.

The vx/c^2 term can be seen as a correction to the arrival time (in the time units of the stationary observer) of signals received by the moving observer. These will be advanced or delayed by the movement during signal transmission. The amount depends on the fractional relative movement (v/c) during the transmission time (x/c).

2.2.1 Einstein's original derivation of the Lorentz transformation

In his 1905 paper [9], Einstein pointed out that the apparent simultaneity of events was altered by relative motion. He concluded that an absolute significance could not be given to simultaneity of separated events in a stationary frame, if assessed by an observer in a moving frame, due to the finite travel time of light. He therefore imagined an experiment in which the timing of events in a moving and stationary frame were always referred back to an array of synchronous clocks in the stationary frame. Otherwise the effect of the finite speed of propagation of light on simultaneity needed to be taken into account. Since timing could depend on motion, he also sought to allow for the possibility that identical clocks in relative motion might not tick at the same rate.

Einstein sought a relationship between an event with coordinates (x, y, z, t) in a stationary frame (K) and the same event with coordinates (ξ, η, ζ, τ) in a frame (k) moving with velocity v. A point at $x' = x - vt$ in the stationary frame will be at rest in the system k with a set of values x', y, z independent of time.

He argued that "the principle of the constancy of the velocity of light" in the stationary system, in combination with the first postulate - the "principle of relativity" - that the laws of physics are independent of motion at constant speed, meant that light also propagated with velocity c when measured in the moving system. The analysis therefore demanded that $c = x/t = \xi/\tau$ for light in both frames. However, the original second postulate was that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body. The subtle change amounts to the assumption that: if the time of a moving system proceeds at a slower rate than in the stationary frame, then distances must be reduced in the same proportion, so that the measured speed of light, using the time and distance of the moving frame, will be unchanged. The constancy of the measured speed was built into the derivation. However, if clocks are ticking slower in the moving frame, then the apparent speed of light for the same distance must be increased.

He then considered a ray of light, emitted from the origin of system k at time τ_0 along the x-axis to x' where at time τ_1 it is reflected back to the origin, arriving at time τ_2. These times are those in the moving system so it was claimed that $\frac{1}{2}(\tau_0 + \tau_2) = \tau_1$ must hold. This equation was used to deduce a relationship between the time (τ) of the moving frame and the time (t) of the stationary frame. The difference between τ_0 and τ_2 was ($\frac{x'}{c-v}+\frac{x'}{c+v}$) in the units of time of the stationary frame, because a light ray moving relative to the origin of the moving frame, when measured in the stationary system, will have a velocity $c \pm v$. The speed is unchanged but the distances travelled are different because of the movement between source and receiver during the propagation time of the light.

Applying the principle of the constancy of the velocity of light in the stationary system gave:
$\frac{1}{2}[\tau(0,0,0,t)+\tau(0,0,0,t+x'/(c-v)+x'/(c+v))]=\tau(x',0,0,t+x'/(c-v))$
However, although events at time $\tau_{0,}\ \tau_1$ and τ_2 are stationary in the moving frame and can be synchronised in that frame, positions 0 and 2 are not the same location in the original stationary frame. The average distance to their positions is slightly larger than the distance at the time of reflection because the signal transmission time is larger for the longer path. The needed equation was:
$\frac{1}{2}[\tau(0,0,0,t)+\tau(0,0,0,t+\Delta x/(c-v)+\Delta x/(c+v))]=\tau(\Delta x,0,0,t+\Delta x/c)$
However, the separation Δx is increasing with time in both the stationary and moving frames. The use of x' instead of Δx in the time of each event removes the effect of the $\Delta x = x' - vt$ and instead incorporates the change in simultaneity into the supposed time of the moving frame.

The separation between the frames is growing with time so the difference in simultaneity (due to movement during signal transmission) is increasing in proportion to $(v/c)(x'/c)$. The equality of the times (simultaneity) at different locations in the stationary frame (which is in relative motion) therefore introduces a dependence of the apparent time (in the units of the observer's time) that is proportional to the change in timing of returned signals due to motion during signal transmission.

The faulty equation was used to determine that $\tau = a(t - vx'/(c^2 - v^2))$ where a is a linear function of velocity yet to be determined. This expression for τ was used to derive expressions for ξ,η,ζ for light emitted at speed c in the stationary frame. The assumption was made that the velocity of light was c when measured in the moving system, so that $\xi = c\tau,\ \eta = c\tau,\ \zeta = c\tau$. For the ξ - axis, it was claimed that the ray moves relatively to the initial point of k, when measured in the stationary system, with the velocity $c - v$, so that $x'/(c-v) = t$, giving $\xi = ax'c^2/(c^2 - v^2) = a\gamma^2 x'$. This is not correct. The time taken for the measured distance must invert the change in clock-rate for the moving system. For a ray of light propagating along the y-axis in the moving frame it was asserted that $\eta = c\tau = ac(t - vx'/(c^2 - v^2))$, and that this would correspond to $y/\sqrt{c^2 - v^2} = t$ at $x' = 0$, under the requirement that the measured speed in the moving frame must also correspond to c for all relative speeds and distances along the perpendicular axes. It gives $\eta = a\gamma y$. However, $t = t' = 0 = y$ for any ray emitted from the origin at coincidence, and these are the only rays whose apparent positions are not distorted by different clock-rates. The arbitrary choice amounts to the requirement that perpendicular distances in the moving frame must be multiplied by $a\gamma$ when distances along the direction of motion are multiplied by $a\gamma^2$. For $x' = 0$, $\tau = at$. The resulting equations are then:

$$\tau = at,\ \xi = a\gamma^2 x',\ \eta = a\gamma y,\ \zeta = a\gamma z$$

Einstein replaced a with the factor $\phi(v) = a\gamma$ and went on to claim:

$$\tau = \phi(v)\gamma(t - vx/c^2),\ \xi = \phi(v)\gamma x',\ \eta = \phi(v)y,\ \zeta = \phi(v)z$$

The equations are those of the Lorentz transformation within the multiplicative factor $\phi(v)$. If, however, $a = 1/\gamma$, as demanded by $\eta = y,\ \zeta = z$, then no multiplicative factor was ever introduced, and $\tau = t/\gamma$ from $\tau = at$ and from $\tau = \gamma(t - vx/c^2)$ when $x = vt$.

The analysis then examined a third frame (K') relative to which the origin of system k was moving in the opposite direction (velocity $-v$) and found that a twofold application of the equations gave:

$$t' = \phi(v)\phi(-v)t,\ x' = \phi(v)\phi(-v)x,\ y' = \phi(v)\phi(-v)y,\ z' = \phi(v)\phi(-v)z$$

The lack of any dependence on time, of the transformation between x and x', led to the claim that the systems K and K' must be at rest with respect to each other. As a result, it was concluded that $\phi(v) = \phi(-v) = 1$. That is, the clock-rate in the two "stationary" frames, moving in opposite directions relative to k, was identical. This led to the further conclusion that the time and distance of the stationary frame, perceived by the moving observer, were identical to those of the moving frame perceived by the stationary observer. Thus, the underlying rate of clocks that are stationary relative to the events is constant, but relative movement makes space and time subjective.

However, the analysis has the frame (k) moving away, in opposite directions, from frames K and K' with increasing time, after all origins were set coincident at time zero. The systems K and K' are the same stationary frame but k is two frames moving in opposite directions, or vice-versa. Thus, there are two moving frames, both moving towards or away from co-location at the origin at the same speed, but in opposite directions. This explains the lack of a time dependency but there is a second reason why such a two-fold application of the LT appears to give a return to the original coordinates. Transforming from the time (τ) of the moving frame back to a stationary frame requires using the inverse transformations for the same events. If time is actually slower in the moving frame, then the inverse transformation is $\phi(-v) = 1/\phi(v)$ and all dependence on the unknown clock-rate in the moving system is removed.

The claimed derivation is also remarkable because it is claimed to be based on reflected signals. Such signals can give a measure of the apparent position with time of an object moving relative to the observer. However, timing of light rays from and back to an observer cannot give any information about the clock-rate in the moving system since the clocks of the moving frame are not interrogated. This initial SR derivation of the LT has involved the assumption that the measured speed of light in the moving frame and stationary frame have the same numerical value even if the clock-rate in a moving frame is not the same as the clock-rate in a stationary frame. The faulty equivalence in the timing of reflected signals (i.e. $\frac{1}{2}(\tau_0 + \tau_2) = \tau_1$) introduces a dependence of time (clock-rate) in the moving frame that is related to vx/c^2. The term will be examined later. However, it must be stressed that is not possible to derive clock-rate in a moving frame solely from an analysis of timings of the position of moving objects.

Lectures on SR and GR that are readily available on the web include a derivation of the LT [15]. The method used is to examine coordinates of the moving frame in terms of the coordinates of the observer's frame using clocks synchronised within each frame. This cannot yield information about the time (clock-rate) experienced in the moving frame. A priori, the relationship between the times in each frame is an unknown unless an additional assumption is made, for example about the behaviour of identical travelling and stationary clocks. Nevertheless, the claim is made that the speed of light will have the same value in each frame. However, the experimental observation is that the speed of light is independent of the speed of the emitting object. For the speed of light to also have the same measured value in each frame the clock-rates must have the same value unless the scale of space is different (i.e. unless the distance between the same objects can change without them moving).

2.2.2 Later derivations of the Lorentz transformation in Special Relativity

In his original derivation, Einstein noted that a light beam emitted at time $t = \tau = 0$ would attain the location (x, y, z) at time t, such that $x^2 + y^2 + z^2 = c^2t^2$. Transforming this equation with

$\tau = \gamma(t - vx/c^2)$ and $\xi = \gamma(x - vt)$, $\eta = y$, $\zeta = z$ AND substituting $x = ct$ gave $\xi^2 + \eta^2 + \zeta^2 = c^2\tau^2$. Therefore, he argued that the wave under consideration was "no less a spherical wave with velocity of propagation c when viewed in the moving system". However, the correct expression for τ is $\tau = \gamma(t - v\Delta x/c^2)$, where $\Delta x = vt$ is the separation between the same location in space for all points in the two frames after they were coincident at $t = 0$. The LT requires $\Delta x = vt$ giving $\tau = t/\gamma$. Using $\Delta x = x = ct$ is faulty. It yields $\xi^2 + \eta^2 + \zeta^2 - c^2\tau^2 = \gamma^2(ct - vt)^2 + y^2 + z^2 - \gamma^2 c^2 (t - v/c)^2 = 0$. It is merely a comparison between $y'^2 + z'^2$ and $y^2 + z^2$ when $y^2 + z^2 = c^2t^2 - x^2 = 0$ and the x-axis and time (t) have been multiplied by the same factor $\gamma(1 - v/c)$. No conclusions about spherical radiation in the transformed coordinates can be made because the result is independent of the values of y and z. The velocity of light is necessarily the same because distance and time have been altered by the same factor. Moreover, the result only applies to $x = \pm ct$.

Subsequent derivations of the LT, by Einstein [16] and others, have used a shorter route. The postulates are the "principle of relativity" and the constancy of the "observed" speed of light (using the supposed space and time coordinates of the moving frame). It is claimed that a ray of light leaving the origin of the stationary system will have coordinates $x^2 + y^2 + z^2 = c^2t^2$ and that, since the propagation speed of light in empty space is c with respect to both reference systems, this must be equivalent to $x'^2 + y'^2 + z'^2 = c^2t'^2$ (if the laws of physics are independent of motion at constant speed of the reference system). Given that $x' = 0$ when $x - vt = 0$ and assuming $x' \propto (x - vt)$, the LT then follows. [Note that (ξ, η, ζ, τ) has been replaced with (x', y', z', t').]

However, there has been a sleight-of-hand. The distance between matching points in the two frames is $\Delta x = vt$, so that $x' = x - \Delta x$. The time in the moving frame, after $t' = t = 0$ when $x' = x$ for all x, including $x' = 0$, is $t' = \gamma(t - v\Delta x/c^2)$. Substituting $x' = a(x - vt)$ and $y'^2 + z'^2 = y^2 + z^2 = c^2t^2 - x^2$ because $x^2 + y^2 + z^2 = c^2t^2$, yields:

$$x'^2 + y'^2 + z'^2 - c^2t'^2 = a^2(x - vt)^2 + c^2t^2 - x^2 - c^2\gamma^2(t - v\Delta x/c^2)^2.$$

If $x = \Delta x = ct$ is examined, then it is found that $a = \gamma$ gives $x'^2 + y'^2 + z'^2 - c^2t'^2 = 0$.

If $\Delta x = vt$ and $x = ct$ are examined, then it is found that $a = 1/\gamma$ gives $x'^2 + y'^2 + z'^2 - c^2t'^2 = 0$.

The requirement that $c = x/t = x'/t'$, when time has slowed, has forced an expansion of the distance travelled by the light. If the distance is constant then the slowing of time will lead to an apparent decrease in the distance (spacing between objects) based on a constant underlying speed of light.

The claim that a spherical wave of light emitted from a stationary source would also appear as a sphere (expanding at the speed of light) to the moving observer is misleading. First, an observer cannot "see" the light. The appearance is based on a concept of instantaneous awareness of where the light would be in the two coordinate systems. The light from the more distant parts of the sphere does not arrive at the same time, at a different location, even if the observer is stationary. Moreover, it arrives later/earlier, than expected, by an additional amount if the observer is moving. Secondly, the hypothesis that the speed of light has the same measured value, even if clock-rate is different in moving frames, is inserted as fact. Thirdly, the assumption $x' \propto (x - vt)$, rather than $x' = x - vt$, allows a variable scale (a distortion) to be built in between the primed and un-primed systems of coordinates. The requirement of a constant observed value of c, despite differences in the distance the light rays travel, forces a distortion in time proportional to vx/c^2 which compensates for the delay or advance in light travel time when there is movement during the time needed for signal transmission over distance x.

The misleading derivation replaced the observation that the speed of light was independent of the emitting object with the flawed claim that the "observed" value of c would be the same. This requires an imagined (unobserved), distorted, set of distance and time coordinates for the moving frame. The distortions of distance and time are forced to match by inserting the requirement that the observed speed of light be constant.

The equivalence of the spacetime intervals is taken to mean that spherical radiation of light is what actually occurs; rather than being faked by imagined distortions. The arrival time of signals needs to be adjusted by $-v\Delta x / c^2$ with $\Delta x = vt$ for the frame of the moving observer. This yields a correction factor of $(1 - v^2 / c^2)$ or $1/\gamma^2$, so that $t' = t/\gamma$. However, the advance or delay in arrival time of signals due to motion during signal transmission has nothing to do with time in the moving frame. The expression $x' = \gamma(x - vt)$ gives rise to a distortion of the x'-axis with increasing distance from the origin which is taken to mean a reduction in lengths (i.e. the FitzGerald length contraction) by the factor $1/\gamma = \sqrt{1 - v^2 / c^2}$. This is matched by a dilation in the arrival times of $1/\gamma$, seen in a relatively moving frame. The matched changes keep the (un)measured speed of light unchanged.

The original and subsequent derivations of the LT in SR do not establish the hypothesis that the speed of light has the same measured value in the time and distance coordinates of the moving and stationary frames. Instead the assumption that the measured speed of light is constant despite movement of the observer forces a distortion of unobserved space and time that is wrongly claimed to confirm spherical radiation of light at unchanged speed.

2.2.3 Mapping of coordinate frames and the interpretation of the LT

Einstein's original derivation referred the position and time of events in a moving frame back to a stationary observer. If the underlying space (the distance between objects not in relative motion) is constant over time, then the method can be seen as a mapping of the position coordinates of sets (frames) of simultaneous events whose separation with time is determined by the distance moved since the frames overlapped. If clocks in the two frames tick at different rates, then the apparent speed of separation in each frame will be different. The ratio of the measured speeds of separation will be the inverse of the ratio of clock-rates. However, the ratio of clock-rate in the moving frame to that in the stationary frame cannot be determined via a mapping without accessing timing signals from the moving frame.

The first, and basic, interpretation of the LT is that the transformation maps the same locations with time of two arrays of points in space (frames) when the arrays are moving apart at constant velocity after coincidence at time zero. The frames correspond to a set of positions at fixed relative positions within each array. The time (clock rate) within each array is constant (all clocks within a frame are synchronous) but could differ between the two frames, depending on the velocity. The value of x, in the LT equation for t', is then $x = \Delta x = vt$; the separation of the location of every matched point in terms of the time (t) of the (nominally) stationary frame. Hence, $t' = \gamma(t - v^2 t / c^2) = t/\gamma$.

The LT requires that the rate of passage of time in the moving frame be slower; divided by the factor γ. The equation for x' at $t' = t = 0$, relative to the origin of and within the moving frame, is $x' = \gamma x$ and $x = x'/\gamma$. This requires a change in the accepted interpretation, which does not seem to have been put forward previously. The scales of the matched arrays of points in each frame, that remain matched for all time, are not the same in the two frames if time is proceeding at different rates in each frame. The locations are coincident, but not the scale of the x and x' axes. Matched locations require the change in distance scale to be inverted relative to the change in time scale.

This use of x to mean both $\Delta x = vt$ for matched points and for distance relative to the origin in the stationary frame explains why a two-fold application of the LT appeared to return all coordinates to those of the stationary frame, when two frames moving in opposite directions relative to the stationary frame were being compared. The LT for the scales of time and matched positions are $t' = t/\gamma$ and $x' = \gamma x$, for the moving frame and their inverses back to stationary frame are $t = \gamma t'$ and $x = x'/\gamma$.

Einstein argued that the distance expression $x' = \gamma(x - vt)$ means that "a rigid body which, measured in a state of rest [$v = 0$], has the form of a sphere, has in a state of motion (viewed from the stationary system) the form of an ellipsoid of revolution" with $x' = \gamma x$ (i.e. the scale of the *x*-axis is increased by the factor γ). Taking the distance to the moving frame as $x = vt$ after coincidence at $t = t' = 0$, means that the LT expression for time in the moving frame of $t' = \gamma(t - vx/c^2)$, becomes $t' = \gamma t(1 - v^2/c^2) = t/\gamma$. If time is running slower, then apparent distances should increase. However, if the expression $x = vt$ applies to a separation Δx then, for the origin, it should be decreasing when $t < 0$ and increasing when $t > 0$. The sign of the $(v/c)(x/c)$ term changes sign at $t = 0$, for the origin. It should be used as a correction for the change in arrival time of signals due to relative motion during transmission. Inserting $v = xt$, means that the time in the moving frame must be $t' = t/\gamma$ if the LT is to explain observations. If the scale factor for time changes by $1/\gamma$ going from frame A to B, then it must change by γ in going from frame B to A. It does not give an ellipsoid. A slowing of time that occurs independent of movement towards or away implies that the slowing is inherent to the movement and the changes in distance are apparent. Such a slowing of time for the object that is viewed implies that it is the movement of the object that causes the slowing. A slowing, and never a speeding up, of a time whose magnitude depends on only relative motion, implies that the effects of motion are real, and must be able to be sensed by the object.

Einstein's interpretation arrived at $x' = \gamma x$ and $\tau = t' = t/\gamma$. Next, he took $x = x'/\gamma$ as the length that objects of length x' (in the moving frame) will have in the stationary frame, so that the size (length) of moving objects appears shorter (FitzGerald contraction) in the stationary frame. On the other hand, he took the time (τ or t') of a clock in the moving system as "nothing else than the summary of the data of clocks at rest in the system" [9]. This is the time at rest in the moving system. However, this leaves out the inversion used in interpreting lengths, which should have $t = \gamma t'$ being the size of time that moving time has in the stationary frame. Therefore, $t' = t/\gamma$ was taken to be the time of the moving clock (in terms of the elapsed time in the stationary frame) and, since $t' < t$, time was slowed (less time occurred for the moving clock).

If the elapsed time within a frame is the sum of time intervals (summary of data of clocks at rest in the moving system) the interpretation should be that time intervals are smaller. Minkowski [17,18,19] made this interpretation, that total time was $\int dt$. If $\tau = t/\gamma$ refers to time intervals (i.e. $d\tau = dt/\gamma$) then the intervals between ticks of a clock in the moving frame are smaller and time is proceeding faster (more ticks than in the stationary frame). If $x' = \gamma x$ is also taken to mean $dx' = \gamma dx$, then the distance intervals of the moving frame should be larger than those of the stationary frame. Larger distance intervals should then mean that an object of the same length will appear shorter. Either way the inconsistency between the treatment of lengths and times means that lengths and times change in unison keeping the "measured" c constant. However, a mapping in which time is slower (intervals between ticks larger) in the moving frame means distances travelled per unit time will be larger (meaning fixed length objects will appear contracted).

The interpretation of the LT in SR is that relative motion causes the perceived space and time to have matched changes in length and time which then keep the measured speed of light constant. The changes perceived in the other location depend only on relative, not absolute, motion. Observers in either location "see" a time and space for the other location that are altered by matched amounts. An altered time and space are not seen by an observer moving with the object. Time and space are malleable but all observers measure the same speed of light.

This interpretation is faulty; the changes in distance covered per unit time in the other frame should be opposite to the change in their clock rates. The deduction that the changes would be reciprocal, and depend only on relative motion, arose from mistakenly assuming that frames moving in opposite directions were the same frame. Time is altered for moving massive clocks and observers but the distance travelled by the same light ray is unaltered. The measured distance will be the same once the measurements are corrected for changes in clock-rate and for apparent changes due to movement during signal transmission. There is no reason to believe that the empty space or distance between objects, not in relative motion, can be increasingly reduced as a function of the speed of the observer, and by the same amount independent of whether the observer is approaching or receding.

2.3 An alternative perspective on relativity, space and time

It is proposed that events have an existence at a location (space) and an underlying time that is independent of the speed of any observers and their clocks, even if moving clocks tick at different rates, and even if the fastest speed at which signals can be transmitted is finite. In principle, sets of simultaneous events can be perceived to exist in terms of their instantaneous location such that the arrival time of signals at an observer could be determined from a known speed of signal transmission and the distances travelled by each signal between emission and reception. This is analogous to what we accept is the case for the transmission of sound relative to a near-instantaneous location seen with light signals. The expectation is that the relative distance between locations is not affected by motion of the observer, but the arrival time of signals (whose speed is independent of motion of the medium) has to take into account the relative motion of the observer between emission and reception.

There is no requirement in this proposal that time (clock-rate) be the same for identical clocks that are each stationary in their frames, one relative to the emitter the other to the receiver, but where there is relative motion between emitter and receiver. Nor is there a requirement that the speed of signal transmission be independent of location. It is observed that the speed of light (that we observe) is independent of the speed of the emitter, but this does not require that the measured speed (distance per unit time of the clock used) be the same over a constant distance unless the clocks used are ticking at the same rate.

The proposal appears to be able to accommodate observed behaviour. These observations include - that the speed of light is independent of the speed of the emitting object; that clocks further from a concentration of matter tick faster; and that unstable particles decay more slowly if moving at high-speed relative to observers. However, it is also observed that the relative speed between an emitter and receiver can be determined from Doppler shifting of light, even though the speed of light is observed to be independent of the speed of the emitter. This would appear to indicate that light carries information that enables a determination of relative speed.

The alternative hypothesis being put forward is that the speed of massless particles (e.g. light) depends on the magnitude of the background (medium) while massive particles carry with them a property that alters with speed relative to the background. The speed of light has a scalar dependence on the background. The speed depends on the magnitude of the background (field) but the light self-propagates at the maximum speed allowed by the medium, independent of any internal frequency of oscillation (which is in the plane perpendicular to the direction of motion). It is proposed that an internal frequency of massive objects (such as clocks) is sensitive to their speed of motion relative to the background (medium) from all massive objects. Once emitted, electromagnetic radiation travels at a speed that relates only to the properties of the medium, but the rotation or oscillation speed of its component fields relative to those of the emitter and receiver determine the energy that can be transferred. It is further proposed that the oscillation frequency, and hence time, of massive particles slows (as $1/\gamma = \sqrt{1 - v^2/c^2}$) with increasing speed relative to a background that is in equilibrium when objects are in free fall (when inertial and gravitational forces balance).

The next step is to establish whether these proposals reproduce a transformation that is consistent with the LT, with observations and with the successful predictions of SR.

2.3.1 The needed transformation under the revised hypotheses

The revised hypotheses allow a mapping of the space and time coordinates of the same events seen from a moving frame in terms of those of the stationary frame. The distance to all points in the moving frame is changing by $\Delta x = vt$, after $x' = x$ at $t = 0$. (Note that this requirement amounts to $x' = x - vt$ for $\Delta x = vt$ if v is negative for increasing t when $\Delta x = 0$ at $t = 0$.)

If the underlying distance between objects and the speed of light are not altered by relative motion of the observer, then light must travel further to reach any point in a frame moving away or a shorter distance for movement towards. However, this does not change the time (clock-rate) in either frame, it just alters the timing of events that were coincident in the stationary frame when seen from the moving frame. If the changed distance travelled by the light is Δx , then the change in time taken is equal to v/c times $\Delta x/c$, i.e. to $-v\Delta x/c^2$, where v is positive for movement away with increasing time. The corrected time is $t_c = t - v\Delta x/c^2$, in the time and velocity units of the stationary frame. If $\Delta x = vt$ is substituted, then the time taken will be $t' = t(1 - v^2/c^2) = t/\gamma^2$. This Δx is also the distance which the frames move apart with time after coincidence at $t = 0$. The appropriate Δx must be used depending on whether time delays are being corrected or known instantaneous positions inserted.

Under the revised hypotheses (slower time in the moving frame), the transformation relating time and apparent distance in the moving frame to that in the stationary frame is:

$$t' = t/\gamma \ , \ \ x' = \gamma(x - vt), \ y' = y, \ z' = z$$

Note that the presence of γ is to obtain agreement with observation and, in due course, needs a theoretical basis. Distances are unchanged, just apparent distances due to the slowing of time. The factor γ multiplies both x and $-vt$ if x' takes into account the apparent distance travelled per unit of slowed time of an unchanged distance x in the stationary frame. The revised hypotheses also mean that the transformation from a moving frame back to the frame that is stationary relative to the free-fall background is:

$$t' = \gamma t \ , \ \ x' = (x + vt)/\gamma, \ y' = y, \ z' = z$$

2.3.2 Consistency with experiment and with the LT

It is being claimed that all current experimental evidence for time dilation (after corrections for, or in the absence of, differences in gravitational potential) is consistent with the time of a moving clock, that is moving faster relative to the free-fall background, being slowed. Speed is relative to the equilibrium background from all other massive objects and time slows with increased speed.

The first transformation above is identical with an LT in which $t' = \gamma(t - vx/c^2)$ applies to an object or a frame that is undistorted by motion. The coordinates of such objects or frames that overlap at $t = 0$ have $x' - x = vt$ for all points in the frame so that $t' = \gamma(t - v\Delta x/c^2)$ with $\Delta x = vt$. The resultant transformation is: $t' = \gamma t(1 - v^2/c^2) = t/\gamma$ and $x' = \gamma(x - vt)$.

The null result of the Michelson-Morley experiments is explained by a speed of light that is independent of the speed of the emitting object. There is an increase in time intervals (slower clock-rate) for massive clocks with movement relative to a position that is approximately stationary relative to the background from massive objects. However, both arms of the interferometer are travelling at the same speed relative to the background so no change in the interference pattern will be seen, provided there is no distortion in lengths (or the amount is the same in all directions).

The SR interpretation of the LT uses the timing correction factor vx/c^2 in determining time (t') that applies to signal transmission distances of x. However, it then uses the separation $x - vt$ of the two origins with time, in determining distance (x'). This separation distance ($x - vt$) only stays the same as the signal transmission distance (x) for the origins of the two coordinate frames. The inconsistency yields imagined (unobserved), distorted, distance and time coordinates for the frame moving away from the stationary source of spherical emission. Under these distorted coordinates, the distance and time for light to propagate both reduce making the signal arrival times consistent with an imagined spherical set of locations with the same speed of light.

The cause of the distortion and the apparent equivalence of $x^2 + y^2 + z^2 = c^2t^2$ and $x'^2 + y'^2 + z'^2 = c^2t'^2$ results from unseen distortions in distance and time. These distortions can be seen as arising from either using $c = x'/t' = x/t$ or from a misinterpretation of x in the vx/c^2 term and the assumption that $t' = \gamma t$ applies to all points when $v = 0$. The latter only applies to the origin where $t' = \gamma t = t/\gamma$ because $t = 0$. The separation distance of matched locations, x' and x, is $-vt$ after coincidence at $t = t' = 0$. Lorentz invariance remains (for massless fields) under the revised perspective because the underlying speed of light is constant (when SR applies). For massive objects, distance is unaltered but the time in the moving frame is slowed, meaning the apparent distances travelled and the measured speed of light will increase. There are no constraints on the speed of light having the same value, in regions with different mass density, from the proposed alternative perspective. The proposal is that its value is proportional to the magnitude of the background. Currently, the proportionality factor is a matter of observation rather than theory.

2.3.3 Apparent behaviour can appear consistent with the LT

Consider two inertial frames, together at time zero, with one nominated as "stationary" and the other moving away at velocity v in the positive *x*-direction. The position of an object (stationary in the moving frame) that was at x at time $t = 0$, relative to the origin of the stationary frame, is: $x' = x + vt$. This uses the "known" velocity (v), rather than the apparent velocity, to specify the actual position of the object independent of any finite propagation time of signals. A steady underlying distance scale is assumed to exist. The observer assesses the movement using pulses received from the object by examining the time intervals between successive pulses, with the pulses moving at speed c, independent of the direction of travel.

The time interval between pulse emission and receipt increases linearly with the instantaneous distance (x') to the object at the time the pulse is emitted (t'). This is the time (t) on the stationary observer's clock, ONLY if they are ticking at the same rate. The observer and moving clock were together at $t' = t = 0$, so the separation distance is $x' = vt'$. The pulse will have been emitted from $x' = 0$ at $t = t' - x'/c$, if c is independent of the speed of the emitting object.

An apparent velocity of $v' = \gamma v$, increases the apparent distance travelled to $x'' = \gamma x'$ and reduces the apparent time (t'') interval to travel a given distance by $1/\gamma$. The actual time needed for light to travel the mean apparent distance (x'') is $\gamma t'$. Therefore, if such an apparent velocity is used to calculate the apparent distance (x'') and if the signal could return the time on the moving object (at the apparent distance), it would be the increased time ($\gamma t'$), provided the clock on the object was ticking at the same rate as the clock of the stationary observer.

However, if the actual velocity, and hence correct instantaneous distance (at the time of emission from the moving object) is used, then the returned time of such a clock on the moving object will be faster than expected by γ. The time of the moving clock needs to be running slower by the factor $1/\gamma$ (i.e. $d\tau = \gamma dt' = t_{avg}/\gamma$), if the time received at the stationary observer is to match the actual distance at emission. The slowed clock must have the spacing between ticks increased by γ, when the apparent distance is $x'' = \gamma x'$ but the instantaneous distance is x' and the time for light to travel x' is x'/c in the time of the moving frame, but also $(\gamma x'/c)/\gamma = x'/c$ in the time of the stationary frame. Hence, the apparent velocity and distance based on the timing of signals can appear consistent with the LT.

For an approaching object, the apparent velocity will be increased by γ, with the ratio of average time intervals (relative to that for instantaneous signals) changing by the same factor (γ^2) per unit time or unit distance from coincidence at $x' = 0,\ t = 0$. If the time of the moving object is running slower by the factor $1/\gamma$, then the time intervals in terms of the time on a moving clock approaching an observer will also be $d\tau = \gamma dt' = t_{avg}/\gamma$. The time of moving clocks, whether approaching or receding, must be dilated (slowed) for consistency with observations of the frequency of timing signals emitted by the object.

If there is relative motion between objects, but a finite signal speed, then the apparent time and distance intervals between them will be altered. If pulses of light are emitted and the time of arrival is used to determine the location and motion of the object, then the finite propagation speed of light will alter the apparent distance. If the actual speed of the object is not known, but its position is assessed using the constant time intervals of the observer, then it will appear to be moving further (towards or away) per time interval, than if light speed was infinite.

Consistency with corrected observations demands a real time dilation as seen in the changed decay rates of unstable elementary particles. However, it requires that high speed motion of massive objects, whether towards or away from our approximately stationary position relative to the background of stars and galaxies, causes a slowing of clock-rate (of massive objects) by $1/\gamma$. It is only the speed of massless objects (photons) that is insensitive to the speed of the emitting atom or clock. Space and time are not linked into an invariant interval via a constant speed of light.

FR has the clock-rate of massive objects a non-linear function of speed relative to the stationary background. This explains the apparent non-linear addition of velocities under SR.

The LT will be observed, for the apparent velocity, time and distance and unchanged clock-rate AND for the actual velocity and instantaneous distance together with a real dilation of time intervals. The latter requires that time for the moving object is slowed (intervals increased by γ), independent of movement towards or away from the stationary observer. The distance scale is unchanged, but distance travelled per unit time of the moving frame will be increased. Under the first interpretation, the time dilation is only apparent and not real. If the timing is corrected for actual velocity and position, then no change in clock-rate (of signals sent from the moving object) should be seen.

The inverted changes in distance relative to time mean that the two interpretations match for reflected signals when $\gamma^2 = 1/[(1-v/c)(1+v/c)]$. The first interpretation of the LT allows the sum of time intervals of returned signals (stretched by γ^2) to be attributed to an increase (by γ) in the velocity of, and distance to, a moving object. This requires that apparent time intervals be reduced by $1/\gamma$. Observations of emitted signals instead require a real increase in time intervals by γ. For SR to appear correct, the reduction in apparent time intervals needs to be assumed to correspond to a real slowing of time. Only FR is consistent with a real time dilation (larger intervals) and with the real changes in time seen in the changed decay rates of unstable elementary particles.

The sign of velocity in the LT can be reversed for objects moving towards rather than away from the observer, but care must be taken because movement towards changes to movement away as objects cross, and the convention is to have the frames overlapping at time zero and time always increasing. This convention means that, for the LT with plus signs, $x' - x$ is the separation distance and objects approach from the negative *x* direction during $t < 0$. The LT with minus signs means the separation distance is $x - x'$ with objects approaching from the positive *x* direction during $t < 0$.

2.3.4 The relativistic Doppler shift

The time applicable to a moving object cannot be determined from reflected signals, it requires that the emitted signals of the object be examined. If the velocity of the moving object is determined from Doppler shifting of signals emitted by the object, then a real change in clock-rate will be seen via its effects on the emitted signals. A real reduction in clock-rate (frequency slowed by $1/\gamma = \sqrt{(1+v/c)(1-v/c)}$) with movement relative to a stationary background will change the expected non-relativistic forms of the Doppler shift of $(c+v)/c$ and $(c-v)/c$ into the accepted relativistic forms. The emitted frequency is blueshifted by $\sqrt{(1+v/c)/(1-v/c)}$ for movement towards and redshifted $\sqrt{(1-v/c)/(1+v/c)}$ for movement away. Thus, the relativistic Doppler shift arises from the classical Doppler shift and the slowing of time, as for SR, but only for the observer stationary relative to the background. A speeding up of the time of events in the stationary background should be seen by the observer that is moving relative to this background. None of the tests of SR appear to have had the massive observer travelling at high speed and examining signals from objects that are stationary relative to the background from massive objects. Modern experiments [20] have the moving clock taking a circular or oscillatory path about the mean free-fall position. The moving clock consistently runs more slowly by the expected amount. However, identical clocks with negligible drift (on spacecraft in a uniform gravitational field) that are matched before and after one is accelerated should see each other slowed (under SR) while the moving clock as it passes the stationary clock should see the stationary clock running faster (under FR). The technical difficulty appears to be to keep any changes in gravitational potential to a minimum.

2.4 Implications for spacetime and Special Relativity

The SR derivations of the LT have been based on the assumption that a speed of light that is independent of the speed of the emitting object means that the measured speed of light is the same independent of motion. This seems to follow from the principle of relativity – that observed behaviour appears independent of motion at constant speed. However, this observation does not carry any requirement that time (the rate at which identical events, involving massive objects, occur) should be independent of motion relative to a background from massive objects. The agreement of the LT with observations led to the belief that the postulates used in SR are correct, and that space and time are malleable, but the speed of light is constant. The changes in perceived space and time intervals, dependent on speed relative to the observer, are matched so that their combination retains a fixed speed of light. The alternative interpretation of the LT, required by observations of emitted signals and decay rates, has a real slowing of the time of a moving clock. This gives rise to an apparent increase in distance travelled. Light-speed is independent of travel direction and of the speed of the emitting object but does not have to have the same value in different inertial frames, which have a different constant background. The alternative interpretation (FR) explains why there has been such vigorous arguments over claimed conceptual inconsistencies between apparent and real changes in time and distance. However, it comes at the price of requiring that high speed motion of massive objects, whether towards or away from our approximately stationary (free-fall) position relative to the "background of stars", gives rise to a slowing of clock-rate (of massive objects) by $1/\gamma$. On the other hand, the speed of massless objects (e.g. photons) is insensitive to the speed of the emitting atom or clock. Invariance of Maxwell's equations under the LT is because massless electric and magnetic fields travel at the speed of light and their relative oscillation frequency depends on their relative motion.

2.4.1 Time and distance are not subjective

Einstein's derivation of the LT included a deduction that the clock-rate factor was one, so that observers moving with their respective clocks saw the same time. The underlying clock-rate was deduced to be constant, even though it is impossible to make this deduction from the method used, which did not examine the clock-rate in the moving frame. If it was true, then any change in clock-rate should only be apparent, not real. This lack of reality was put aside by concluding that time and distance are subjective, so that there are as many times (and distances and velocities) as there are observers moving at constant relative speeds. This interpretation requires that the components of spacetime in which objects and clocks exist are altered by speed relative to the observer, while the objects and clocks are unchanged for the observer moving with the object. It seems to be argued that, because the simultaneity (time order) of events can be altered by relative motion, time is not fully real. Thus, the perceived (measured) time in the one moving frame has as many values as there are speeds relative to the stationary observer, whether movement is towards or away. As Einstein put it in his review article of 1907 [16], as set out by Pais [21]: 'Surprisingly, it turned out that it was only necessary to formulate the concept of time sufficiently precisely [to explain the Michelson-Morley result, i.e. c being independent of motion]. All that was needed was the insight that an auxiliary quantity introduced by H. A. Lorentz [i.e. $t' = \gamma(t - vx/c^2)$] and denoted by him as "local time" can be defined as "time", pure and simple.'

If the underlying clock-rate, as measured by clocks stationary relative to the observer, is unchanged then the decay rates of unstable elementary particles should not be altered by motion. The change in the decay rate of muons with speed, independent of direction of motion relative to the observer, contradicts a deduction of SR. If the muons were all created at the same instant, and the underlying clock-rate was constant (SR), then the decay rate would not change if allowance was made for the transition time of the decay signal back to the observer. If the position of the creation and decay were recorded by sensors, then the mean decay length would be the mean decay time multiplied by the mean velocity. No dilation would be observed. SR has it that space and time are subjective dependent on relative motion. However, they become real in terms of altering the behaviour of the time and distance experienced by the object rather than that apparent to the observer. This is nonsense.

2.4.2 The underlying inconsistency in Special Relativity

Under the Lorentz-Poincaré theory, the LT had been explained in terms of a dilation of time and a FitzGerald-Lorentz contraction in length of rods. A contraction in the length of moving rods is taken to mean that distances are smaller. Light travelling at the same underlying speed should take less of the slower time to travel the length of the shorter rod. This was used to explain why the Michelson-Morley experiments did not detect movement relative to the background. Einstein's interpretation was that shorter rods meant that lengths in the moving frame were smaller. The distances between stationary objects in a frame moving relative to the observer decreased the faster the relative motion. The space (i.e. distance) between objects contracted without the objects moving relative to each other. Contracted space corresponded to moving distance intervals being smaller. Time in the moving frame is dilated meaning a slower clock-rate. Less time corresponds to longer intervals between ticks. Light travelling at the same speed should travel further in the same number of ticks (time). Keeping the underlying speed of light constant requires an increased distance travelled when time is running slower. SR's altered hypothesis, and claimed demonstration, is that the measured speed of light is constant (in the transformed coordinates). This requires $c = dx / dt = dx_0 / dt_0$, so that dt increases when dl increases and vice-versa. Consistency with observation and an LT (after substituting $x = vt$) requires that slower (less) time corresponds to larger time intervals (between ticks). The measured speed of light will be greater, but the actual speed will be constant, if distances are constant.

The claim that light leaving the origin of a stationary system that propagates spherically will, if it was made visible, also be seen to propagate spherically by a moving observer is incorrect. The equation $x'^2 + y'^2 + z'^2 - c^2t'^2 = 0$ is satisfied because the coordinates must be corrected for movement during the transmission time of the signals. The mean distance travelled by returned signals, based on the velocity in the stationary frame and position at the time of reflection, is increased by the factor γ^2. If this correction is made to the time taken, then both time and distance in the LT are multiplied by the factor γ. This makes it appear as though there are matched changes in distance and time that keep the speed of light constant. Space is undistorted but distances travelled per unit of slowed time are larger by γ. The underlying speed of (massless) light is independent of the velocity of the source, but the measured speed will appear faster if measured using a constant distance and a moving clock.

2.4.3 The "principle of relativity" does not hold

Under the changed understanding of the LT, length contraction, in the sense of distance travelled, is only apparent and not real. Time runs slower in the moving frame whereas distances between stationary objects are constant. This frees spacetime from being a fabric whose components are distorted by relative motion. It also removes the requirement that the speed of light be a universal constant, in the absence of a gravitational field, and rejects the "principle of relativity".

The "principle of relativity" is the claim that (when velocities are constant) behaviour depends only on relative velocity and is therefore independent of, and not relative to, any background. It is a postulate that the laws of physics are the same for all observers moving at constant velocity. All inertial frames are equivalent. It is a part of the hypothesis that, in the absence of a gravitational field, the laws of physics are independent of the place and time at which events occur (and hence independent of a uniform stationary background). However, this is a belief based on observations by massive observers approximately stationary, and in almost free-fall, relative to the total background from all mass.

FR has the speed of massless particles, including light quanta, independent of the velocity of the source. The speed depends on the magnitude of the background but not on movement relative to a uniform background of massive objects. However, the clock-rate of stored energy (massive objects) does depend on velocity relative to the background due to the stored energy, position, and movement of all other massive objects. Motion relative to this background (which is itself massless), and the size of this background, affects time. However, space is not distorted.

Under FR, an observer moving at high-speed relative to the background and viewing unstable elementary particles, approximately stationary relative to the background, would see their decay rate increased, not decreased as claimed by SR. This has not been experimentally tested but the difference between colliding beams and fixed target experiments, when the total energy of the interacting particles is the same but their relative velocities different, is evidence against the principle.

The form of the laws of physics appears unchanged by relative motion but, under FR, the magnitudes, e.g. the speed of light and mass, depend on the total background. In addition, clock-rate and inertia of massive objects depend on speed relative to the background. They do not just depend on the rate of change in direction or change in speed relative to their current motion. The "principle of relativity" holds only approximately for low-speed motion within an inertial region.

2.4.4 The strange idea of a fabric of spacetime

Under SR, supposedly invariant intervals of a four-dimensional space and time, with time along an imaginary axis, could be constructed. Thus, space and time were combined into a fabric that permeated the empty vacuum between objects. Relative motion then changed the fabric in a way that affected the measured properties of the time and space of the objects embedded in the fabric. The intervals are also invariant under FR if the background is constant, and adjustment is made for the effect of motion on clocks. However, the measured speed of light will change with movement or if the background changes. The intervals are not invariant if the density of surrounding matter is different.

The concepts of a fabric of spacetime and that only relative motion mattered were taken over from SR into GR. The latter was consistent with Newton's law of gravitation being due to differences (a gradient) in potential, i.e. dependent on slope but independent of a constant (or absolute level of) background. If the effects of gravity disappear for the observer in free-fall, then the frequency of a constant photon, needs to be matched by the change in time seen by a relatively moving observer. This led to the expectation that the same frequency would appear faster deeper in a gravitational field. It corresponds to a redshift of the photon with altitude even though there is no relative movement of source and receiver. Mass and the speed of light are assumed constant even though a falling object is progressively moving deeper into a region with a larger background (an increasing mass density and larger surface flux). Under FR, the apparent redshift of photons is a blueshift of the energy of atoms with decreasing background and the energy of photons is unchanged after emission.

This spacetime fabric, in which objects are embedded, is strange in many ways. The derivation of SR not only claimed to establish that a background medium (aether) was unnecessary but also deduced that the time of stationary clocks in different inertial frames was the same. The paper establishing SR incorrectly derived (see Section 2.2) that the underlying rate of clocks stationary in a frame, was independent of any relative (at constant velocity) movement. If this is the case, then changes in time should only be apparent, not real. The time dilation was also claimed and observed to vary with speed relative to the observer, independent of direction (approaching or receding). However, the changed decay rate, seen either in a circular accelerator or in a straight line from the point of generation, is real. SR implies that there are as many spacetimes and decay rates for one frame as there are observers moving towards or away from that frame at different relative speed, and that the addition of velocities is non-linear. Under FR, it is the change in clock-rate with increasing velocity relative to the stationary background that is non-linear. The relativistic Doppler shift arises from the classical Doppler shift and a real slowing of time for massive objects moving relative to the background.

The fabric of spacetime, under GR, is even stranger than under SR. GR has it that matter distorts the geometry of spacetime, but c is always the same for the local observer (i.e. at the same location, and independent of the background matter/energy density). The magnitude of the effect on “time”, from the difference in energy density (via potential) between observers, is seen in the increase in the clock-rates of the GPS satellites. This is a confirmed effect in the ratio of clock-rates of the satellites relative to identical clocks on Earth. However, the presumed decrease in distance intervals does not appear to be observable. It is claimed to be present because of the bending of light.

2.4.5 The fabric of spacetime is an illusion

A common argument used to support the reality of the changes in spacetime from relative motion, that can be found in many textbooks, is the perpendicular light-pulse clock. This basic clock has a mirror at a fixed distance (perpendicular to the direction of motion) and each tick corresponds to the time for a light pulse to take the return trip to the mirror and back. For an observer moving to, or away from, the clock at speed v, and perpendicular to the direction of the light pulse, the light will appear to traverse a longer distance such that $\Delta t' = \gamma \Delta t$, where Δt is the interval of “proper time” seen by an observer co-moving with the light-pulse clock. However, the factor $\gamma = 1/\sqrt{1-v^2/c^2}$ only arises for the right-angle triangle of the perpendicular orientation and, under the same argument, would be one for the parallel orientation. Moreover, the moving observer cannot see the time intervals of the clock or the direction in which photons are sent without a light signal being emitted and received by the light-pulse clock. The movement of the observer during the time taken for the signal to propagate will also alter the apparent time intervals and the amount will decrease or increase by the same incremental factor ($\mp v\Delta x / c^2$) according to whether the observer is moving to or from the clock.

Einstein expected the principle of relativity, “like every other general law of nature” [22], to apply to light. He, and many others, have then claimed that the speed of light in vacuo is constant, independent of the speed of the observer, consistent with the theory of electrodynamics. The claim has become that (in the absence of gravitational acceleration) all moving observers, independent of their speed, will observe the same speed of light. It amounts to the claim that the physical perceptions of space and time are altered when observing objects in relative motion and only their combination in the speed of light is constant or invariant. The addition of velocities is then non-linear, and their sum can never exceed the speed of light.

This claim, that the speed of light will be “seen” or “measured to be” constant independent of the speed of the observer, is a subtle but remarkable alteration of the observation that the speed of light is independent of the speed of the emitting (massive) object. It is based on the belief, set out in Section 2.2 of the later derivation of the LT, that the unseen light rays emitted by a stationary source would also appear to be expanding spherically to a moving observer. This is not true.

If the measured value of c is to be the same, when time is dilated, then distances must be contracted for an observer stationary in the moving frame. This means that objects must move a greater distance in an unchanged time, because time dilation means they move the same distance in less time. The incorrect contraction/expansion of both time and distance intervals will give an increase/decrease in the unseen (imagined) speed of light that cancels the effects of delays/advances in propagation times due to receding/approaching motion during signal propagation. Observations require that the time in the frame of the moving object must be slowed (intervals expanded) because the decay rates and emission frequencies of such objects (massive clocks) are slowed. Apparent distance intervals are then reduced (contracted) because clock-rate is slowed.

This alternative perspective (put forward in Section 2.3) alters the understanding of the spacetime diagram in which ct is plotted on a vertical axis against two of the spatial dimensions plotted on the horizontal plane. Cones with different angles to the horizontal correspond to the expanding circles of unseen light rays emitted by a stationary source at the origin and viewed by an observer moving at v/c. They relate the coordinates of events that would be judged as simultaneous in the stationary frame to the distorted coordinates of apparent time and distance intervals that would make them appear simultaneous (have simultaneous arrival times) in the moving frame.

The arrival times of light pulses at an observer moving away from the source of the pulses must be adjusted for the movement of the observer during the transmission of the pulses. The stationary observer beside the tracks of the moving train, in Einstein's thought experiment, sees lightning strikes at the front and back of the train as simultaneous but they are not simultaneous to the observer on the train. However, the dependence of apparent simultaneity on relative movement does not mean that the rate of passage of time is subjective. The LT can be used to convert observations of the known location of a moving object by a stationary observer to an apparent, but not actual, position and velocity of the moving object (based on returned light signals). The change in apparent distance with signal arrival time can be interpreted as an increase in distance moved and an increase in time intervals, both by γ, but only if the clock-rate of the object is the same as the that of the receiver.

FR claims a real increase in time intervals experienced by massive clocks moving at high-speed relative to the mean free-fall background due to all other massive objects. This does not contradict a speed of light, of massless photons, that is independent of the velocity of the emitting object. The time dilation for massive objects appears to only have been observed at speeds that are much larger fractions of the speed of light than is the movement of the Earth and solar system relative to the background from all other matter, or for objects that have a motion that has a mean speed larger than the reference clock. Moreover, the solar system is in free-fall and therefore accelerating by an amount that presumably keeps the background isotropic.

The frequency of signals emitted by objects was not part of Einstein's thought experiment. His analysis actually assumed that the measured speed of light was independent of the speed of movement and deduced that identical moving clocks would show the same time for observers stationary relative to each clock. However, observations of signals emitted from objects moving at high speed can only be explained by a real time dilation. The fabric of spacetime in which the perception of space and time is distorted by relative motion between object and observer is an illusion.

2.5 Replacing Special Relativity

Einstein's derivations of the LT replaced the postulate of a speed of light that was independent of the speed of the emitting object with the assumption that the measured speed of light is the same for all observers. This requires that changes in length and time intervals match, which is the opposite to distance contraction matching time dilation. However, an LT in which the interpretation of time and distance intervals matches observations, and in which the original second postulate holds, is possible. It requires a background-dependent theory in which the first postulate, the principle of relativity, is a good approximation at low speeds. It also requires real time dilation with movement relative to the stationary background from all other massive objects. Although electrodynamic interactions between objects emitting and receiving the massless quanta of these fields depend only on their relative velocity, this does not apply to massive objects, and hence to gravitational interactions. The Michelson-Morley result, the Fizeau experiment, the aberration of starlight and Maxwell's equations apply to massless photons. They imply that both the energy and velocity of transmission of the massless fields are independent of any movement of the vacuum in which they propagate. (The Fizeau experiment saw an effect of the time spent in a moving liquid.) The speed of light is independent of the speed of the emitter or observer, within an inertial frame. Distances are not distorted so the arms of a Michelson-Morley interferometer do not change in relative length with movement because both arms are going at the same speed relative to the background.

Under FR, there is no requirement that the properties of massive objects be independent of the background. Nor is the speed of light required to be the same for all inertial frames. A real dilation of time will give an apparent decrease in distance. The invariant interval of flat Minkowski spacetime, within a region in which the underlying speed of light is constant, will only be found if the meaning of distance intervals relative to time intervals is inverted. In his original derivation [9], Einstein arrived at $dt = \gamma dt_0$ and $dl = dl_0 / \gamma$, where dt_0 and dl_0 are duration and length intervals in the rest frame, but then inverted their interpretation so that $c = dl / dt$.

Consistency with the revised interpretation of the LT and observations requires that motion relative to a stationary observer, i.e. stationary relative to a background from all other masses, causes a time dilation. It requires, rather than rules out, a background-dependent explanation of the observed kinematics and dynamics of massive objects. Observed behaviour arises from a different pair of postulates than ostensibly used to derive the LT. The underlying speed of light is constant, independent of the velocity of the emitting object (rather than appears, or is measured, to have the same value using inverted time relative to distance intervals) within a constant background. However, the measured value will be altered if the clock used is slowed because of movement relative to the background. In addition, the constancy only applies within an inertial frame, which, in turn, requires a constant background because the speed of light varies with clout. Massive clocks must run slower (time dilates) when moving relative to the background from all other massive objects, although the mechanism is not yet spelled out. The approach replaces the fabric of spacetime, opening a path to explaining gravity without the need to hypothesise dark energy and dark matter.

The restriction of the LT to a transformation in which $t' = t / \gamma$, because $x = vt$, matches the requirement for a real time dilation with movement and an apparent, but not real, contraction of distance. This allows all the supposed experimental confirmations of SR to be retained but rules out both the postulates used and that there are matched changes in space and time (clock-rate) which keep the measured speed of light constant.

2.5.1 The relativistic invariant spacetime interval

Under the SR interpretation of the LT, position and time are both dependent on relative motion, but an invariant interval $\Delta s^2 = \Delta x^2 - c^2 \Delta t^2 = \Delta x'^2 - c^2 \Delta t'^2$ can be constructed. Proper time, the time interval ($\Delta \tau$) measured in the rest frame of the clock ($\Delta x = 0$), corresponds to $\Delta s^2 = -c^2 \Delta t^2$. It is claimed that since there is only one rest frame for a clock, its time interval must be unique – the same for all observers. Since the speed of light is postulated to be absolute, the interval must be invariant.

If the background magnitude is the same, then the same time units should apply to any frame not moving relative to the observer, or any objects not in relative motion. However, there is no requirement that the time interval of clocks be the same in all moving frames or that the speed of light measure the same. There can still be the concept of an underlying time in which clock-rate is adjusted for the amount of movement and the magnitude of the background.

Under FR, the distance between unconnected objects, not in relative motion, is independent of the magnitude of the background. However, the length of a standard massive ruler may change with the background. Similarly, a time can exist that is independent of relative motion or the magnitude of the background, but the rate of massive clocks can be dependent on the magnitude of the background and "absolute" movement relative to the background.

Under FR, there is always an invariant interval independent of the background, provided underlying time and distance are used or the rates of massive clocks and the size of rulers is adjusted for the magnitude and relative motion of the background. “Proper time” then corresponds to the clock-rate applicable to an object for a given background and any movement relative to the “stationary” background due to other massive objects.

2.5.2 The energy-momentum interval and 4-vectors

The invariant interval of SR led to the concept of a 4-vector. The position coordinates (x_1, x_2, x_3) are matched by a time coordinate along an imaginary axis ($x_0 = ct\sqrt{-1}$). SR also introduced a 4-vector for velocity. This necessitated the definition of velocity as the differential relative to proper time (τ) rather than observed (coordinate) time, i.e. $U_n = dx_n / d\tau = \gamma dx_n / dt = \gamma(c, v_1, v_2, v_3)$. The velocities appear larger by the factor γ . For constant mass, the momentum increases according to $p = \gamma mv$. This was in agreement with measurements of the ratio of mass to charge for cathode rays in magnetic fields and was seen as strong confirmation of SR. It also led to the concept of a conserved energy/momentum 4-vector $p_n = \gamma(mc, mv_i)$, so that $p_0 = \gamma E / c$, giving an invariant (rest) mass of $m = E / c^2$ (when the velocity was zero).

Under FR, and the same constant background, mass is constant and so is the underlying time. Therefore, the decrease in clock-rate with speed must be associated with an increase in inertia for massive objects due to movement relative to the stationary background. The increase in inertia means that more energy is required per unit increase in speed relative to the background. The addition of momenta is non-linear, not the addition of velocities. However, just as FR has time altered but distance intervals unaltered, it has inertia altered but mass, in a constant background, unaltered. Kinetic energy addition, as well as momentum, appears non-linear.

The observation that colliding beam experiments enable larger energy transfers, for the same relative velocity, than fixed target experiments does not confirm SR. The deduction of an apparent invariant energy-momentum interval arises from $E = pc$. It suffers from similar errors of interpretation as the apparent invariant spacetime interval that simply arises from $x = ct$. FR and SR have $p = \gamma mv$ meaning that energy and momentum increase by the factor γ . Under SR, the effective mass γm increases, because the addition of velocities is non-linear. Under FR, the increase in energy is due to an increase in the difficulty of acceleration (the ratio of inertial to gravitational mass increases by γ) with speed relative to the background. The gravitational mass remains m , otherwise the decay rate of unstable particles would increase with the increase in stored energy. There is no requirement for c to be constant for different backgrounds.

2.6 Summary

Einstein’s derivation refers all measurements of distance and time back to the stationary observer. Such a procedure effectively examines position with time based on reflected signals and it is impossible to deduce the time (clock-rate) applicable to the moving observer because it is not examined. The timing of returned signals is increased by γ^2 due to movement of the object during the propagation time and this leads to an apparent increase in speed of movement both towards and away. The SR interpretation of the LT matches the apparent increase (by γ) in distance travelled per unit time (velocity) with an increase in time intervals (by γ instead of γ^2) as real for measurements by the observer while leaving the speed of light unchanged. Under SR, the perceived time and distance are slowed even though there is no change in clock-rate for the observer moving with the object. However, such conclusions are not possible without examining signals emitted by the moving object.

The observed timing of emitted signals can only arise from a real increase in time intervals (a slowing of time) for the object with increased speed relative to a stationary background, giving an apparent reduction in distance intervals. The existing derivations of the LT in SR do not establish either of the postulates used, i.e. that the observed speed of light is constant, independent of relative movement at constant speed, or that only relative motion matters. There is no requirement that the speed of light have the same constant value between different but constant backgrounds. The deduction of SR of invariant intervals of spacetime and energy-momentum does not constrain the speed of light or mass to be constant. However, the invariant intervals were taken over into GR and its metric of spacetime, including the inversion of time versus distance intervals.

The flawed derivation of SR has given rise to the concept that the space and time seen by a moving observer are subjective, while the speed of light is fixed (always having the same measured value). This is argued to be possible because space and time coordinates consist only of sets of relationships between observed phenomena and instruments. The relationship of observations between two relatively moving coordinate frames can then only depend on relative motion because of the supposed equivalence of all inertial frames. The concept is flawed. The same observed behaviour can be achieved if there is a slowing of time with speed relative to the background from other matter.

The observed behaviour can be explained if the speed of light (massless quanta), but not massive objects, depends on the magnitude but not on movement relative to the background from all other massive objects. The real slowing of clock-rate for moving massive objects implies that the current observations are made from an approximately, or effectively, stationary background. It leads to the prediction that decay rates of particles, stationary relative to the local "free-fall" background, will be faster than those stationary relative to a fast-moving observer. The "principle of relativity", that the laws of physics are independent of motion at constant velocity, does not hold. Faster movement relative to the background slows time for the moving object/observer. Space is not locked into a 4-D spacetime that is distorted by motion or matter. Instead, the speed of light and properties of objects embedded in the medium, arising from the background due to matter and antimatter, are altered.

However, Lorentz invariance can still be maintained for massless fields and there is a link between space, time and the speed of light because speed = distance/time, and space is the distance between objects not moving with respect to each other. Together with stored energy and therefore clock-rate being altered by the speed of light, this allows FR, with a variable speed of light and an undistorted space, to produce many similar predictions to GR.

Chapter 3

Background dependence versus General Relativity

The deduction in SR of invariant intervals of spacetime and energy-momentum does not constrain the speed of light or mass to be constant. However, this framework with its inversion of distance relative to time intervals was taken over into GR. It has the distortion of the fabric of spacetime (in which objects are embedded) dependent on the difference in gravitational potential. The proposed changes in understanding of FR demand a background-dependent theory of gravitation in which the speed of light and mass both vary with the total background potential. The differences between GR and such a background-dependent theory are explored and the consequences examined.

The proposed background (of FR) alters properties of objects with the rate of events (time) decreasing with background magnitude (the clout or the negative of the potential). However, time intervals for light to travel the same distance increase with the magnitude of the background. Time (clock-rate) is not altered by the presence of a gradient (i.e. of a gravitational force), only by being in a new, different background or by movement relative to the stationary background. Clock-rate depends on the energy of the clock, which increases as the background potential decreases. Space is not distorted. Distances are not altered but the time of clocks will depend on the background because their mass will change.

GR does not have a background in the sense of a medium, instead it has a distortion of a linked fabric of subjective space and time. Under GR, the speed of light is a universal constant in the absence of a gradient in potential or of movement of mass/energy, but both a gradient and relative movement of the observer distort the linked fabric of time and distance. GR has time being altered by the force acting on objects (as evidenced by their acceleration) and, in the absence of such a force, or relative motion, that time is constant. Hence, time has a fixed rate far from a gravitational field.

In a 1920 lecture, Einstein saw this spacetime as a real medium. He pointed out that, '*according to the general theory of relativity space is endowed with physical qualities; in this sense, therefore, there exists an ether. According to the general theory of relativity space without ether is unthinkable; for in such space there would not only be no propagation of light, but also no possibility of existence for standards of space and time (measuring-rods and clocks), nor therefore any spacetime intervals in the physical sense. But this ether may not be thought of as endowed with the quality characteristic of ponderable media, as consisting of parts which may be tracked through time. The idea of motion may not be applied to it.*' [23]. Having noted that motion (at constant speed) relative to the ether is not detectable, but that mechanical behaviour depends on relative positions, relative velocities, and acceleration, he proposed that the ether, '*must be looked upon as real, to enable acceleration or rotation to be looked on as something real*' [24]. He further proposed that, '*the new ether… determines the metrical relations in the spacetime continuum*' [25]. Thus, spacetime acts as a pseudo-background that carries light and gives rise to changes in observed behaviour.

The core difference between FR and GR is background dependence. Both Newtonian gravitation and GR have mass, inertia and the speed of light independent of a uniform, constant background. FR has mass, inertia and c dependent on the background and inertia also dependent on movement relative to the background. Newtonian gravity has a static background in that the field of gravitational potential exists as soon as the massive object is present. The propagation is instantaneous. GR has space and time distorted by the energy/momentum density that gives rise to the Newtonian gravitational potential, but the amounts are independent of the absolute level. The distortions depend on gradients in energy/momentum. The gradients affect time and distance, but not mass or inertia.

3.1 Where did the core difference arise?

It turns out to be at Einstein's "happiest thought", which was that a gravitational field only has a relative existence, because for an observer freely falling there exists no gravitational field. The assumption is made that the value of the fixed relationship between inertial and gravitational mass, as observed for all matter (independent of the material) at the same location (Eötvös experiments), is the same for all locations, even if the background changes. This is the weak equivalence principle – that inertial and gravitational mass are equivalent (have a fixed relationship).

The idea that gravity is a fictitious force because a freely falling observer no longer feels a gravitational field is strange because the observer is still accelerating and therefore gaining momentum and force is understood to be proportional to the rate of change of momentum. If an observer is being accelerated by being pushed with a narrow rod, then an uncomfortable force is felt. If the same force is spread out uniformly over one side of the body, then it may be hardly noticed. If it spread uniformly over every atom in the body, then it will no longer be sensed. The force is exactly balanced by the resistance of every particle to acceleration. The force is still present and will change as the observer moves into a region with a different background and will increase with increased speed relative to the background against which the observer is stationary.

Under GR, the local observer cannot tell whether they are being accelerated (e.g. in a rocket without windows) or are stationary in a constant gravitational field (of the right strength). The idea that gravity only has a relative existence was combined with the SR postulates that only relative motion is important and the speed of light is constant. It is assumed that mass is constant independent of the size of the gravitational field. This means the absolute level of the background is assumed to have no effect, only the gradient of the potential.

However, under FR, an observer being accelerated in a gravitational field is moving into a region of increased matter density. An equivalence remains but mass, clock-rate and the speed of light change, and inertia may change. The physics is the same within a region of constant clout but not between regions. The behaviour may appear the same to the one observer but, under FR, the magnitudes of the laws are not the same in different environments. FR is background-dependent whereas, GR assumes independence from the absolute level of a uniform, stationary background (which, at least for electromagnetism, is another way of saying "gauge invariance" or scale independence). Under GR, and the standard interpretation of Newton's law, it is the gradient in the field due to nearby masses that determines the strength of gravity. An unchanging, uniform and isotropic background field has no effect. This is familiar in electrodynamics which is independent of a uniform, isotropic, stationary background of electric and magnetic fields. The effects from the same, unchanging electric or magnetic fields in opposite directions cancel because the gradients of their potentials cancel. The Newtonian gravitational equation, on which GR is based, treats gravitational acceleration as a vector field, so contributions from opposite directions cancel. The force is per unit mass and any dependence on a uniform background affects both the nearby source and the test mass and so is hidden.

Background invariance cannot be true for a theory where matter distorts space (i.e. GR), because distortions of space can only be expansions or contractions and the same distortion from opposite directions (two expansions or two contractions) cannot cancel. GR contrives a cancellation by using second derivatives in an asymmetric tensor formulation. Static gradients from opposite directions cancel so there is no contribution from a uniform, stationary background. The lack of an effect of such a background (a difference in surrounding mass) is justified by claiming that space should be "coordinate free" (because coordinates are arbitrary). This is too big a claim because, while the first choice of coordinate scale is "free", a second set of coordinates in a different region has a fixed scale relationship to the first set, in proportion to the ratio of the total backgrounds from stored energy.

3.2 The nature of time

Background dependence introduces a changed understanding of time. As massive observers our time is clock-rate, which is a measure of how quickly the "same" events happen. However, this clock-rate depends on the background, which affects the speed of light and the energy stored. The processes associated with life and clocks can vary between locations, so that the number of events (ticks of an identical clock in a new location) can differ even if there is no gradient in mass density and no relative motion. This time will get faster, clock-rate will increase if the background decreases (for example, in an expanding universe), while light-clock time interval, which depends on the speed of massless photons, will decrease. Time, the light-speed interval of massless photons, and clock-rate of massive objects must be distinguished from each other. The energy levels of massive objects reduce, and clock-rate slows, with increased background, while the speed of massless photons, per unit time, increases.

If the speed of light varies and energy levels of massive objects vary, then it is necessary to distinguish: i) between time in terms of light-clock time intervals, and clock-rate of massive clocks, and ii) between distance and size. Current clocks define time based on the frequency of massless photons from a known transition. However, it may also be necessary to allow for the possibility of a variable ratio of inertial to gravitational mass, if movement of massive objects is involved. Mechanical clocks would be sensitive to changes in inertia. Light-clock time interval for the same distance reduces if the speed of light increases, and so reflects the distance massless information will travel in different regions in the "same" time (a synchronisation time that applies across regions). This underlying rate when light takes different times to travel the same distance in different regions will be referred to as "u-time". This understanding of time necessarily includes the concept that the separation distance of stationary objects remains unchanged even if the density or magnitude of a homogeneous background changes.

If the background increases, then the speed of light will increase, and the stored energy levels of massive particles will decrease in proportion to $1/c^2$, while momentum will decrease as $1/c$. The time taken for light to travel the same distance will decrease in proportion to $1/c$, but the size of particles and objects made from connected particles will increase in proportion to c. Separated stationary particles will maintain their separation unless a force acts to change their position.

Clock-rate is currently based on the frequency of photons emitted when an electron changes energy levels in an atom. However, under FR, the background affects the energy and momentum of the atom via the speed of light. Clock intervals (between ticks) increase, so that clock-rate reduces, when the speed of light increases; while light-clock time intervals reduce, as light travels further in a given time. Clock-rate, in terms of synchronicity with the same atomic clock moved to a region with a different background, is observed to be proportional to $1/c^2$. Photon energy is directly proportional to photon frequency ($E = hf$) and corresponds to a photon momentum ($p = E/c$). The revised picture is that photon energy and momentum are unchanged after emission when c changes in a gravitational field. However, the energy levels prior to emission, and frequency of clocks are changed by $(c/c')^2$.

The conservation of photon energy (after emission) suggests that photon frequency per unit of energy (h) has no dependence on the background. However, measurements of frequency with energy have been carried out in the same or very similar background. It is observed that time (clock-rate), the inverse of frequency, does vary with the gravitational potential as Φ/c^2, but this is consistent with the change in energy proportional to $1/c^2$. Nevertheless, the constancy of h can be questioned if it varies with a property of the background that does not affect stored energy (mass). The measurement of h is not accurate enough to detect the very small changes comparable with the local fractional changes in gravitational potential and speed of light. Matter and photons share a de Broglie wavelength proportional to $p = h/\lambda$. If distance and hence wavelength are not distorted by the background, but c varies, then momentum is the equivalent property for both photons and massive particles at the same location. All this seems to imply that momentum and u-time will have a fixed relationship (via h) at a given location but the relationship may be different at other locations. Changes in Planck's constant, or the ratio of inertial to gravitational mass, are not ruled out.

3.2.1 Time versus clock-rate

In formulating SR, Einstein introduced the concept of an array of clocks that could be verified to be synchronous and a concept of simultaneity of separated events by allowing for the time it took light, at constant speed, to travel both directions between events. Background dependence assumes a relative underlying rate of passage of time exists and that spatial distances are undistorted. The latter might seem like postulating a fixed and absolute space, but it is a more limited postulate. The distance between separated objects that are stationary relative to each other, with vacuum in between, remains fixed (even if atoms change size). The spacing between such objects cannot change unless the objects move. The limit on a causal relationship between separated events, even when the speed of light varies, is maintained. However, there will be a light-clock time interval defined as distance divided by the speed of light. This concept of a constant underlying "u-time" is based on a constant underlying distance in which the light-speed interval is corrected for the speed of propagation of massless fields. The concept of time in terms of synchronicity of events in different regions can then be extended to cover a speed of light that changes with the background. A concept of simultaneity which allows for a time that varies with location and a variable speed of light can also be set out.

This concept of a simultaneous time of events must be in terms of the clock-rate that applies to massive objects. The synchronous or light-time concept is based on a constant underlying distance scale and "u-time". The light-clock time interval then reflects the speed of transmission of interactions by massless quanta, such as photons, whose energy does not change in a gravitational field. The clock-rate of events, e.g. the ticks of a massive clock, is then "u-time" multiplied by c, if $m = E / c^2$. It allows for the relative rate of events involving the same massive object in different environments if momentum and energy are conserved, but mass changes. It is essential to make this distinction if the stored energy of the "same" massive object changes with the background according to $m = E / c^2$.

A sensible definition of time, for massive observers, would seem to be the duration of events. Such time is a measure of how quickly the "same" events happen. If all the processes associated with life occur at the same rate for the same objects in two locations, remaining synchronous, we would feel entitled to say that time was passing at the same rate. This time will be distinguished from light-time interval, which depends on the speed of massless photons, by referring to it as clock-rate.

However, this clock-rate will only apply to the movement of massive objects if inertial mass (as used in kinetic energy) has a fixed relationship to the gravitational mass of stored energy. If the ratio of these masses varies with some other aspect of the background, then a clock-rate based on movement may not be quite the same as the rate of a clock based on the energy of a given frequency of oscillation of massless photons times a fixed Planck's constant. The oscillation frequency for a given energy may vary with the background, giving a variable Planck's constant. The discussion of the next sub-section ignores this possibility, as the inertia per unit mass appears to be constant (at slow speeds) within our solar system. Further comments on time can be found in Section 4.5.2.

3.2.2 Clock-rate and time dilation

In a gravitational field, clock-rate increases at higher gravitational potential. Under FR, clock-rate increases because the speed of light reduces and the stored energy of massive objects increases. So, mass and decay-rate are not independent of the background or of high-speed movement relative to the background. In SR, mass is frame-independent and an invariant. In extending the ideas of SR to objects in an accelerating frame (i.e. GR), Einstein altered the flat fabric of spacetime. Under GR, the scale of distance and passage of time are distorted by the presence of a gravitational field, but the speed of light is a local constant. The field arises from a gradient in the gravitational potential (in which the divergence of the gradient depends on mass density).

The FR perspective is consistent with the observation that clock-rate varies with altitude by an amount related to the change in gravitational potential (ϕ). This gravitational potential corresponds to the change in energy, work done per unit mass, in accelerating an object through unit distance in a gravitational field. Experimentally, it is observed that clock-rate decreases, meaning time slows. The spacing between ticks (dt) increases in moving to a region (ϕ_2) of lower potential ($\phi_1 - \phi_2 > 0$), e.g. lower altitude, according to $dt_1 = (1 - \frac{\phi_1 - \phi_2}{c^2})dt_2$, so that $dt_1 < dt_2$. This is what is expected if the amount of mass (stored energy) changes in proportion to c_1^2 / c_2^2. More energetic clocks tick faster.

GR has the gravitational time dilation, based on the apparent redshift of the photon, proportional to: $dt_1 = (1 + \frac{\phi_1 - \phi_2}{c^2})dt_2$, [note the change in sign] so that time intervals are smaller at a higher gravitational potential [26]. The elapsed time is taken to be the sum of time intervals. However, a smaller sum is taken to mean less time has occurred, whereas it means that the same number of ticks has taken less time. Thus, GR agrees on the slowing of time, but only because of the faulty expectation that time passes more slowly in a region with shorter intervals between ticks. An increase in clock-rate at a higher potential is an increase in frequency and a decrease in time intervals. This emphasises the need to distinguish between light-speed time intervals and massive clock time intervals. Light-time intervals reduce, as c_1 / c_2, when the speed of light increases, while massive clock intervals increase by c_2 / c_1 (clock-rate slows). The faulty interpretation of the blueshift of atoms with increasing potential as a redshift of photons hides the inversion in the interpretation of time intervals.

Minkowski [27] recognised that the time and distance intervals of SR transformed like the rotation of an invariant interval in a 4-dimensional spacetime with time along an imaginary axis. However, this construction requires a faulty interpretation of time intervals and the only real effect is time dilation. The observation that the actual clock-rate of moving objects slows, whether they are moving toward or away from us, means that massive objects sense a different background when moving relative to our "stationary" location. The collisions of high velocity particles into stationary particles (in a gas as well as a solid) seem to depend only on relative velocity, but the calculated momentum ($p = \gamma mv$), based on the difficulty of accelerating the particle, increases non-linearly with relative velocity. Under FR, the inertia increases as γv, so that momentum and kinetic energy increase with speed relative to the background, but the stored energy (m) is unchanged. A given change in velocity requires more energy but the stored energy (mass) is unaltered. The energy needed to reach a speed v relative to the stationary background is higher than that needed to reach $v / 2$ from opposite directions.

This dependence of clock-rate on movement relative to a background rather than only on relative motion appears consistent with experimental observation for changes in time intervals between clocks flown in opposite directions around the equator [28] and the lack of any contraction in length intervals [29]. Possible experimental tests are discussed in Section 8.2.

3.3 Gravity and mass in General Relativity

In SR, the equations describing electromagnetic interactions were found to be invariant under a Lorentz transformation. For both movement towards, and movement away, the time and distance scales appear to be altered by the factor γ. Only relative motion appeared to affect behaviour.

Extending this "principle of relativity" (beyond electrodynamics and optics) to include the kinematics of massive objects meant that their properties (momentum, energy) and their apparent movement in time and distance had to be adjusted according to their relative velocity. The acceptance of the idea that the time in the moving frame was dilated, by the factor γ, led to the expectation, from conservation of momentum, that apparent mass would also increase by the same factor. This agreed with measurement of cathode rays in magnetic fields. The hypothesis that the kinematical physical laws were identical in magnitude and form, at different times and places, meant that a uniform background of matter had no effect. The required equivalence, under SR, of the change in energy, as assessed by two observers moving with constant relative velocity, of the same object before and after it radiated opposing photons led to the conclusion that: "If a body gives off energy E in the form of radiation, then its mass diminishes by E / c^2", i.e. $E = mc^2$ [30].

In GR, Einstein extended the principle of the independence of physical laws, from time and place in a uniform, homogeneous surrounding environment, to include accelerated motion. Independence of time and place assumes that physics is unchanged by the overall magnitude of the background field. However, movement due to a gradient in the surroundings will, over time, take an object into a region with a different background. The principle assumes that the properties of matter, including mass, are independent of a homogeneous, uniform, stationary distribution of surrounding matter. All locations in spacetime at which there is no gradient in energy or flux density from mass are (postulated to be) equivalent and indistinguishable by observations of physical laws.

This postulate, the Einstein equivalence principle, should be considered unlikely when gravitational acceleration has been found to depend on the change in flux density from surrounding mass. It implies that the effects of identical masses, disposed in opposite directions from the observer, cancel. Gravitational potentials from opposite directions sum, but there is no gradient. Identical scalars, such as pressure, do not cancel. Moreover, the postulated background independence should also apply to inertia, if the ratio of inertial to gravitational mass is independent of background. Inertia would then be due only to any inhomogeneity in the surrounding matter distribution. Yet we observe that an oscillating Foucault pendulum maintains its swing relative to the "fixed" stars and not the Earth.

Under GR the motion of an object in a gravitational field is independent of the properties of the body. The (local) speed of light and the propagation speed of gravity are the same and universally constant. Gravity is then a distortion of the flat Minkowski spacetime of SR. The vacuum appears empty but curved. It is therefore surprising that there is no effect on an object midway between identical masses because matched distortions (either an expansion or a contraction) should not cancel. A distortion in space and/or time from one direction should not cancel the distortion from an identical mass in the opposite direction unless time depends on the spatial direction to the source. Newtonian gravity and GR achieve a cancellation by using the gradients of potentials (whereas FR uses the sum of potentials).

3.4 The Einstein Equivalence Principle does not hold

GR makes a set of faulty assumptions including that the mass of a given amount of matter is invariant and the speed of light is independent of a uniform, constant background. These derive from the postulated Einstein equivalence principle (EEP). The EEP claims that the weak equivalence principle holds, and that the result of any local non-gravitational experiment in a freely falling laboratory is independent of the velocity of the laboratory and its time and place. A slightly stronger version, called the Strong Equivalence Principle, has it that the value of G_N is everywhere constant.

The apparent disappearance of gravitational effects for a freely falling observer was elevated to a principle (the EEP) by Einstein. It was argued that physics in a frame freely falling in a gravitational field is equivalent to physics in an inertial frame without gravity. It seemed that the acceleration exactly cancelled a uniform gravitational field and that no sign of either acceleration or gravitation could be found by any physical means. Hence, physics in a nonaccelerating frame with gravity $\vec{g}$ is equivalent to physics in a frame without gravity but accelerating with $\vec{a} = -\vec{g}$ [31]. The EEP and these statements should be seen as remarkable leaps of faith. They lead on to the idea that accelerating frames can be treated exactly the same as inertial frames and that an inertial frame is one in which there is no effect of gravity. Instead, an inertial frame should be seen as any frame within which gravity is constant (no gradient along the path) and there is no acceleration.

No gravitational acceleration just means that there is no gradient in the potential (or clout), not that there is no potential. Why should a gradient in the potential have an effect but not total clout or potential? A freely falling observer will accelerate until the force due to the rate of change of momentum matches the force due to the gradient in clout. The observer no longer feels a net force but the acceleration continues. It does not mean that the background has disappeared.

The requirement that the laws of physics are the same for observers moving with objects freely falling in a gravitational field (even though accelerating into a region of different mass density) equates to background-independence from any constant potential due to surrounding matter. However, also keeping c constant, in empty space, requires a distortion of length and time that depends on the gradient in gravitational potential, and that all clocks, not subject to a gradient, tick at the same rate. It makes more sense that the background determines clock-rate whether or not a gradient is present.

GR proposes a constant spacetime in a location without a gradient in the gravitational field from massive objects. The geometry of this spacetime is an invariant metric, whose magnitude is not relative to any background. This conflicts with Mach's principle that our ability to sense absolute rotation relative to the "fixed" stars, and hence rotational inertia and presumably linear inertia, must be determined by the large-scale distribution of matter. This lack of relativity and the inconsistency with Mach's principle can be traced back to the effective incorporation of the assumption that a constant and stationary surrounding, uniform background of matter has no effect. GR has a form of gauge invariance in which gravitational effects are independent of a constant background potential.

FR proposes that there is no such thing as empty or distorted space. A background is always present that both allows and alters the transmission of light and gravity. Mass at a given location is determined by the background clout. A lack of gradient does not imply that there is no background. Distances are unaltered, and time (clock-rate) and size are properties of massive objects, not of the spacetime between objects. The properties of objects depend on the number, size, and movement of all surrounding massive objects. There is no requirement for a metric theory, that is, there is no need for a fabric of spacetime whose distortion provides a geometric explanation of gravity.

3.5 Lack of gauge invariance (background dependence) should be expected

The interactions of charged particles and photons (electrodynamics including optics) are independent of an isotropic, homogeneous, stationary background of charge. Hence, a constant isotropic background electric potential (charge distribution) does not affect the observed interactions. This scale independence gained the name of gauge invariance and was seen to reflect an underlying gauge symmetry of the interaction. For electrostatics, this symmetry arises from the pure vector nature of charge interactions, which means that the effects of symmetrically placed equidistant charges cancel. It turns out that magnetism, and the strong and weak interactions also have increasingly more complex forms of gauge invariance and their interactions can be successfully calculated in terms of gauge invariant relativistic field theories. A field theory of gravity was therefore expected to be gauge invariant. However, Newton's law, on which GR is based, has a scalar gravitational potential. Scalars from opposite directions do not cancel and gravity should not be expected to be gauge invariant.

There is a common rubber sheet analogy for GR in which massive objects distort the sheet (fabric of spacetime) so that light from distant stars appears bent. With a real rubber sheet, the distortion by a central mass decreases if the surrounding sheet is loaded by additional masses. This is like a waterbed. The initial occupant moves higher if another occupant arrives! However, it is not true for GR. Under GR, the distortion by a given amount of matter and the speed of a (light) wave are independent of a uniform background of other masses. However, for GR the amount of distortion of the fabric around the matter increases as the density of the same amount of mass increases, and the ease of distortion increases with the amount by which it is already distorted. After a certain point, the same mass "burns" an infinitely deep hole in the fabric. In a background-dependent theory, the mass of the central matter decreases (less distortion of the sheet), and the speed of light increases, as the background increases. The size and ease of the changes also decreases as the background increases. This is the same as a real rubber sheet (or drum), the speed of a wave (note of the drum) will be higher, and the distortion due to the central mass will decrease, when the surrounding weights increase.

3.6 Background dependence can appear consistent with SR and mimic GR

Einstein appeared to derive the known equations of the LT based on the postulates of SR [9]. He claimed, like Lorentz, that changes in a moving frame can be interpreted in terms of a dilation of time and a contraction of length, with relative speed. It was shown, however, in Chapter 2 that the method used (observations of reflected signals by a stationary observer) will yield an apparent LT from the increase in the travel time of return signals by γ^2, over that expected for the instantaneous distance, when objects are in relative motion, and there is a finite speed of signal propagation. The transformation, derived using the delayed time signals, applies to the apparent, but not actual, speed and distance of the moving object. It splits the time delays seen in returned signals (due to movement during signal transmission) equally between a contracted distance and reduced delays (of γ rather than γ^2). This means that the delayed time and apparent distance are both shortened by γ. The result is that the distorted coordinates remove the transmission delays making the imagined radiation appear spherical for the moving observer. The imagined speed of light remains constant because the changes in distance and time intervals are matched.

However, agreement of observations with the LT when using signals emitted by a moving object requires a real decrease in clock-rate of the object (by $1/\gamma$) when it is moving relative to our approximately stationary free-fall position against the background of "fixed" stars, i.e. of other matter. It also requires that a dilation of time corresponds to an increase in time intervals. The <u>real</u> dilation in time in the moving system then gives an <u>apparent</u> contraction in distance intervals, i.e. an increase in distance covered during the longer time.

Minkowski unified space and time, and energy and momentum, in terms of the invariant interval $ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2$ [17]. If time is placed along an imaginary axis, then the LT corresponds to a rotation in this new spacetime combination. The interval can be invariant because the difference in simultaneity (apparent time interval between events) is the distance interval divided by a constant speed of light. It corrects for the extra distance travelled if there is relative motion. That is, the change in distance between objects minus the product cdt will add to zero, if time interval is $distance/c$. This means that changes in length and time intervals (times c) are matched.

The procedure can also be used with energy and momentum because energy and momentum interconvert with relative motion. The definition of velocity as $distance/dt$ incorporates the time interval (dt) into the conversion between energy and momentum. Energy depends on the square of velocity (hence on $1/dt^2$) and momentum depends on velocity (hence on $1/dt$). An invariant interval can be formed based on $(E/c)^2 = p_x{}^2 + p_y{}^2 + p_z{}^2$, if energy minus the product pc adds to zero.

Einstein [9] and Minkowski [17] made the same interpretation, that total time was $\int dt$. However, this contradicts the understanding that dt refers to time interval (i.e. the interval between events, such as the ticks of a massive clock), if dx refers to length intervals. Apparent agreement of SR with observations has only been possible by confusing clock-time with light-clock time intervals and having smaller time intervals mean slower time. In constructing an interval for energy and momentum, SR has kept mass and the speed of light as invariants and interpreted apparent changes in speed and distance as real. FR has a real change in the inertia and clock-rate of massive objects and observers that are moving at high-speed relative to the mean background arising from all massive objects. The observed change in decay rates of particles moving at high-speed relative to the background is real. If we, as massive observers, were going at high speeds relative to the background, rather than the particles, then our time would be slower relative to the time and decay rate of the particles, so they would appear to decay faster. However, this opposite claim to SR appears to never have been tested.

In extending the concept of spacetime to regions with different backgrounds GR has kept mass and the speed of light as invariants and used light-clock time intervals. These differ from clock-rate time intervals by $1/c^2$. Under GR, gravity distorts the geometry of the unified spacetime in a manner consistent with the observed change in clock-rate with changing gravitational potential and has the frequency (of photons) proportional to the inverse of the local (proper) time interval, i.e. $\omega \propto 1/dt$ [26]. Hence, these time intervals are larger at higher gravitational potentials (lower mass densities) meaning the frequency of photons is lower (redshifted). Under GR, the total time is also $\int dt$, the sum of time intervals, so that more time elapses, the passage of time (clock-rate) is faster (bigger) when the time interval is larger. This interpretation of time intervals is required by the supposed gravitational redshift of the photon. The interpretation, that relatively more events happen in a region where time intervals are smaller/shorter, is required if time intervals apply to massive clocks (not massless photons) and the energy levels of clocks are blueshifted at higher gravitational potentials.

GR's constant speed of light requires that distortions in distance and time match. A decreased/slower time corresponds to an increase in time intervals (between ticks) and decreased/shorter lengths should correspond to an increase in distance intervals. SR claims a constant speed of light by interpreting $t' = t/\gamma$ as slowed (dilated) time but $x' = \gamma x$ as shorter objects. Time is slowed for a moving clock, so a clock that is more nearly stationary relative to the background, will show a longer time. The distance between objects will then appear shorter given the time taken at a known, constant speed.

If the energy of a photon is unaffected by a gravitational field, then (under FR) $E = pc$ implies that photon momentum will increase as c decreases in moving away from a concentration of matter. However, both momentum and energy of the photon are claimed to be conserved. Under GR, the equation reflects the assumed and apparent constancy of c. However, both GR and background dependence have clock-rate increasing in moving away from a concentration of matter. The apparent inconsistency, for both GR and FR, is resolved because force is the rate of change of momentum with time, and work is force by distance, so that the time intervals, inherent in momentum and the speed of light, cancel. Alternatively, but equivalently, the energy of a photon of a given momentum is smaller if the speed of light is smaller for the same distance scale. For GR this corresponds to larger time intervals, and larger light-clock time intervals but smaller clock-rate intervals, respectively. Increased clock-rate is mistakenly interpreted as larger time intervals by GR. This subtle but very important difference means that the concept of spacetime and energy-momentum four-vectors requires a faulty treatment of time intervals. There is an alternative to a warped spacetime geometry with a hidden curvature. The revised space is inherently flat and the concept of a fabric relating space and time is imaginary (in a different sense).

3.7 Background dependence overcomes problems with spacetime

GR is built on the interval $ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2$ of SR which appears to be invariant under LTs (if there is no gravitational acceleration). SR has the apparent time and distance intervals dt and dx, altered in way that keeps the speed of light constant. Under SR, the square of a change in space interval is compensated by a change in the square of the product of the time interval and c (along an orthogonal axis) so that a constant spacetime interval is maintained. Under GR, the presence of a gravitational field distorts ("curves") the underlying geometry of space and time in such a way that the distortions from opposite directions cancel. However, the curvature grows non-linearly with increasing gravitational gradient, eventually leading to space folding back on itself ("quantum foam") and the event horizons and singularities of black holes. These are signs that the theory has broken down. A background in which the mass of objects decreases as the background increases (i.e. FR) makes the gravitational field self-limiting and overcomes these problems.

A long-running concern with SR has been the effect of relative motion on clock-rate. It is understandable that a clock of an observer moving away from you would appear to tick more slowly, but why should clocks moving towards you appear slowed? Consistency with observations necessitates a real slowing of timing signals and decay rates of the moving object, in the frame of the moving object. However, in Einstein's derivation of SR he also concluded that the underlying clock-rate, on a clock that was stationary relative to the events (i.e. in the moving frame) was the same for all identical clocks. Under SR, time and distance are subjective, only their combination is constant. Apparent effects (observed in measurements that incorporate changes due to movement during signal transmission) become real for any observer by an amount dependent on relative speed. The time and distance of events in a relatively moving frame are subjective, being dependent on relative motion. The observed increase in lifetimes of relativistic particles, such as muons generated by cosmic rays or in an accelerator, is proposed (under SR) to hold true for all relatively moving observers.

Under SR, the lifetimes are increased, for all observers, independent of whether the particles are moving towards or away from the observer. Thus, decay rates (time) of the one moving frame, have as many values as there are speeds relative to the stationary observer, independent of whether the movement is towards or away. This requires that the spacetime in which objects and clocks exist is alterable by velocity relative to the observer, while the objects and clocks are unchanged for the observer moving with the object. It seems to be argued that because the apparent simultaneity (time order) of events can be altered by relative motion then time is not fully real.

If the underlying clock-rate, as measured by clocks stationary relative to the observer, is unchanged, then the decay rates of unstable elementary particles should not be altered by motion. The change in the decay rate of muons with speed, independent of direction of motion relative to the observer, contradicts a deduction made in the SR analysis. If the muons were all created at the same instant, and the underlying clock-rate was constant (SR), then the apparent decay rate would not change if allowance was made for the transition time of the decay signal back to the observer. If the position of the creation and decay were recorded by sensors, then the mean decay length would be the mean decay time multiplied by the mean velocity. No dilation would be observed.

SR has it that space and time are subjective dependent on relative motion. However, they become real in terms of altering the behaviour of the time and distance experienced by the object rather than the observer. It has been suggested that the past, present and future therefore form an already existing block with the particular slice of spacetime observed dependent on the speed of the observer. Thus, the future already exists, and time is an illusion. This is nonsense, causality is maintained, it is the fabric of spacetime that is an illusion. Time and clock-rate are real but relate to the rate of change of position and time of massive objects and these are dependent on the background.

A different version of the problem, for SR, of time dilation being seen by both observers is the expectation that a twin sent on a round trip to a distant star at a velocity that is a large fraction of the speed of light will age less than his twin who remains on Earth, even though the relative velocities are the same for both twins. This lack of reciprocity is known as the "Twin Paradox". The supposed paradox is that, from the point of view of the second twin, it could be argued that the first twin went on a comparable journey. Maudlin has pointed out that the standard resolution, including by Feynman and Einstein, is that the twin that feels the acceleration is always the younger [32]. However, he argues that, under SR, this explanation is faulty because the first twin can be accelerated just as much, or even more, than the second and still end up older.

Background-dependent FR has clock-rate slowing for the twin (massive object) who is moving faster relative to the background from other massive objects. The speed of light, however, has only a scalar dependence on the background. Under FR, the speed of a massive object will slow both oscillation frequency and clock-rate, but increase inertia. The combination of effects explains observations and agrees with Maudlin that the standard resolution claimed for SR is faulty. The lack of reciprocity (after allowing for acceleration) has not yet been tested (for massive objects) because all current observers have been travelling at low speeds relative to the local background while observing particles travelling at close to the speed of light relative to this background.

There are some more subtle problems for GR. One is how a distorted spacetime can either act on objects or be acted upon, leading to spacetime being labelled as a glorious non-entity [33]. Another is that the concepts of time in quantum field theories and GR appear incompatible [34]. The absolute character of Newtonian time is present in QM, and also partially in quantum field theories which consider the Minkowski metric as the background spacetime. However, the local dynamical spacetime of GR causes problems because it interacts with quantum phenomena. Background dependence overcomes these problems because time (clock-rate) alters the properties of objects. Time reflects the rate of change of the position and oscillation frequency of particles. FR also distinguishes between light-clock time intervals, with causality limited by the speed of light; and u-time, which reflects synchronisation of identical events (if inertia is constant); and clock-rate, which depends on the stored energy of the clock.

3.8 Empty space cannot be a source of spacetime gravity

A problem with GR that does not seem to have been pointed out previously is that its field equation implies that empty space, free of any matter or a source of energy that is independent of matter, can act as a source of gravity.

Einstein's field equation is a generalisation of the differential form of Newton's gravitational equation:

$$\vec{\nabla}.\vec{g} = -4\pi G_N \rho \qquad (1.2)$$

The curvature of spacetime and the differential (divergence) of the acceleration are directly proportional to the stress-energy tensor, the generalisation of mass density (ρ) to the density of energy and momentum. The hidden assumption in deriving this differential form (Equation 1.2) is that mass is independent of the surrounding mass density.

Newtonian gravity gives rise to a force field ($\vec{F} = m\vec{g}$) that maintains its value while a static distribution of mass is present. This appears analogous to electrostatics where an electric field ($\vec{E}$) due to a static charge distribution gives rise to a force ($\vec{F} = q\vec{E}$) on another charge (q). The derivation of the differential form follows from applying Gauss's law to the gravitational force law, as is done for electromagnetic fields [35]. The first step of the derivation is to equate the gravitational mass of Newton's universal law of gravitation with the inertial mass of his equation of motion. This yields a vector gravitational acceleration field (force per unit mass $\vec{F} / m$) due to a point mass M of:

$$\vec{g}(\vec{r}) = -G_N M\hat{r} / r^2 \qquad \text{where } \hat{r} \text{ is the unit radial vector.} \qquad (3.1)$$

This field can be expressed, for an arbitrary mass distribution, as Gauss's law for the gravitational field:

$$\oint_S \vec{g} \cdot d\vec{A} = -4\pi G_N M \qquad (3.2)$$

The area integral on the LHS is the gravitational field flux through any closed surface S, and M on the RHS is the total mass enclosed inside S. However, constant flux through the enclosing surface assumes that the flux from an arbitrary distribution of matter is constant, independent of the distribution. This requires the mass of each component to be independent of the location of other components (as applies to charge). If mass is dependent on the clout from surrounding matter, then this assumption does not hold.

If the flux is assumed to be constant, the divergence theorem, where the area integral is the volume integral of the divergence of a vector field, can be used on the LHS, and the mass on the RHS can be expressed as the integral of the mass density function ρ , giving:

$$\int \vec{\nabla} \cdot \vec{g} dV = -4\pi G_N \int \rho dV \qquad (3.3)$$

If this equality holds for any volume, the integrands on both sides must also be equal. Hence:

$$\vec{\nabla} . \vec{g} = -4\pi G_N \rho \qquad \text{(1.2 above)}$$

However, the equation does not hold if the density of surrounding mass alters the mass held by a constant amount of matter, because this will alter the magnitude of the flux. The equation will also require modification if the background affects the ratio of inertial to gravitational mass.

Given $\vec{g} = -\nabla\phi$ this becomes:

$$\nabla^2 \phi = 4\pi G_N \rho \qquad (3.4)$$

The divergence of a vector field ($\vec{\nabla} . \vec{g}$ here) is the extent to which the vector field flux behaves like a source at a given point. It is a local measure of the extent to which there is a larger flux exiting an infinitesimal region of space than entering it. Technically, the acceleration field corresponds to a flux entering a region, a sink rather than a source but it is still proportional to the size of the enclosed sink.

If the magnitude of a radial vector field about a point source reduces as $1/r^2$, then the divergence of a field that does not include a source is zero because the surface area around a source increases as $4\pi r^2$. Thus, if the gravitational acceleration falls off as $1/r^2$, as is observed, from a constant source of mass, then the RHS of equation 1.2 should be zero. The implication, of the non-zero value of equation 1.2, is that the reduction in mass density from including an increased volume of empty space surrounding the constant source, reduces the magnitude of the sink. Thus empty space outside any matter reduces the negative divergence in the gravitational field and therefore acts as a source of gravitational repulsion. Contributions to the flux of gravitational acceleration come from a volume outside any visible source of mass. This background of empty space appears to alter the strength of the gravitational field by an amount that depends on the enclosed mass density.

A vector field that arises from mass (a form of energy) and provides energy to matter at a distance without losing energy appears inconsistent. The nonzero divergence implies that the surrounding space can act as a source of energy, even when no mass is enclosed. This is something from nothing. GR is based on an equation that does not apply if mass (stored energy) per unit matter is dependent on the background. It necessarily leads to an apparent increase in repulsion, if the mass of the same amount of matter decreases when the density of matter increases. This gives the appearance of an invisible, repulsive energy. Such dark energy is not required if the total clout affects the energy held by matter by an amount consistent with the change in speed of light needed to remove the apparent accelerating expansion.

3.9 Summary

The fabric of spacetime is an illusion based on faulty assumptions, a misinterpretation of experimental observations, and an inversion of space intervals relative to time intervals. Under GR, such an illusory fabric can be distorted by matter while keeping the speed of light constant. This cannot be the basis for a theory of gravity. Amongst other problems it requires that gravitational time dilation corresponds to shorter time intervals between ticks of a clock.

The "principle of relativity" and the Einstein equivalence principle do not hold. At one moment in time, or one location, an accelerated frame can have a fixed relationship to an inertial frame with gravity, but the magnitude of the relationship changes. Gravity can appear to be transformed away by free-fall, but this only means that the force of gravity matches the force due to acceleration.

Under FR, the effects from matter in opposite directions add. Gradients can disappear but the total strength of the field increases. If matter distorts space and time, then the effect of masses in opposite directions <u>cannot</u> cancel (unless the direction of time changes with spatial direction). The slopes can cancel but not the magnitudes. A uniform background from masses in all directions changes the magnitude of what happens inside. For energy and the speed of light, there is a scalar (direction independent) theory of gravity (FR) that is background-dependent (i.e. not gauge invariant).

GR has assumed that gravitational acceleration is a vector field with a conserved flux. Such a conserved flux is based on the assumption that mass is constant. Newton's and Einstein's field equations then require that empty space free of matter can act as a source of gravity. This will give the appearance of an invisible dark energy that pushes objects apart as the Universe expands. It should be seen as unacceptable along with a number of other problems with GR including singularities, "quantum foam", block time, decay rates being subjective dependent on movement of the observer, and other inconsistencies. All these problems can be overcome by a background-dependent theory.

A background-dependent theory has effects due to motion of massive objects relative to a stationary or balanced background, a space that is inherently flat, and clock-rate being distinct from the time interval associated with the finite speed of light. The background (whose magnitude is the negative of the total gravitational potential) acts like a scalar field and does not involve a flux or flow if the sources are stationary. A gradient in the field means that its magnitude is changing with position. An increase in the background leads to an increase in the speed of light, and objects cannot store as much energy. The resultant gradient in stored energy means objects are accelerated in the direction of the increase in magnitude of the background. In contrast, Newtonian gravitation and GR incorporate the assumption that mass has no dependence on the absolute level of the background potential. Under GR, the (rest) mass of objects is unchanged in moving between regions of different potential.

The many successes of SR and GR should not be taken to mean that their postulates hold, and the inconsistencies can be ignored, particularly if an alternative theory reproduces the successes and overcomes the deficiencies.

However, the background must do more than explain the time-independent strength of gravity, it must also explain inertia and the bending of light, be consistent with existing observations, and be able to reproduce the many successful standard predictions of GR.

Chapter 4

Full Relativity

A desirable objective for a theory of gravitation is that it should be fully relative. That is, for a local object, gravitational and inertial effects should be influenced by, and therefore relative to, the positions and magnitude of all other massive objects. This is consistent with the idea that motion can only be judged relative to other objects. A full relativity allows the energy content and motion of other objects to affect the local energy content and motion. Hence, if the only objects in the universe were a feather and the Earth, the feather should be sensitive to the much bigger mass of the Earth relative to the feather and vice-versa. This appears true for gravitation, under GR, where the gravitational force depends on the gradient of the energy density and inertia and mass are constant (at low speeds). However, Newtonian mechanics and GR, as currently formulated, are not fully relative in that both gravitational and inertial behaviour are independent of a uniform, stationary background density of matter. However, if motion can only be judged relative to other matter, it seems reasonable to expect it to depend on the influence of all other matter according to its energy and distance. This is consistent with the observation that an oscillating pendulum keeps its plane of oscillation constant relative to the background of stars independent of the rotation of the nearby Earth about its axis, or (as seen in gyroscopes) its orbit about the more massive Sun. GR, being independent of a uniform background, does not fulfil Mach's Principle that inertia is a result of all the other matter in the universe.

4.1 A more complex background

Under FR, gravitational attraction can be explained by a reduction in the amount of energy (a scalar property) that can be stored in objects when the "density" (or rather the "clout") of surrounding matter increases. It gives rise to an acceleration of the object in which the energy lost from mass appears as energy of motion. The speed and direction of the induced motion remains constant if the force is removed. However, changes to the velocity of motion, i.e. acceleration of the object, are resisted. This resistance to change, inertia, is sensitive to changes in direction even at constant speed, when the amount of energy is unchanged.

This means that a more complex dependence on the background is needed than a simple scalar effect on the energy that can be stored. This more complex reality is part of FR. Clues to the needed further properties are available in the nature of energy, momentum, and inertia, of massive and massless particles. Any proposed background must also be compatible with the origin of mass according to particle physics, i.e. the Higgs mechanism. These clues will be considered so that a physical picture of the nature and operation of a suitable background can be proposed.

Under FR, Newtonian gravity is explained by conservation of energy and momentum. The energy lost as mass appears as kinetic energy (KE) of motion. The KE gained by falling objects comes from a loss in their stored energy. Energy is conserved but a massive object cannot store as much energy when the speed of light increases as the background increases. The gain in stored energy per unit mass in raising an object distance dx against F is:

$\int (F/m)dx = \Delta E/m = \Delta mc^2/m = -G_N M/r$, with distance r from a point source of mass M.

Hence, the fractional change in energy or mass over distance dx is: $\Delta E/E = \Delta m/m = -G_N M/rc^2$, if there is a fixed relationship between inertial and gravitational energy. This energy balance equation is dimensionless and so is independent of how fast gravity propagates. Newtonian gravity is instantaneous and static. Mass, as stored energy, is independent of time if the background does not change with time. It is a sort of "frozen" energy, yet it can give rise to kinetic energy which is an energy of motion which has a time dependence through velocity.

The background-independent perspective of GR has arisen from treating gravitational acceleration as a vector field in which the contributions from a uniform flux through a closed surrounding surface cancel. Time and the mass of objects are assumed constant independent of a uniform, isotropic background from other masses. GR, like Newtonian gravity, has the acceleration per unit force, of all objects, constant per unit of matter. The assumption of constant mass per unit of matter equates to independence from the absolute value of an isotropic background. Changes in the force are then due only to nearby masses (local anisotropy) and their movement. Changes in a large uniform background can be hidden because potential is per unit mass, and the influence of the nearby mass will be changed in the same proportion as the test mass.

If the effects of gravitational fields behave like light, then the flux contribution of a mass M would be expected to fall off as M / r^2. Gravitational acceleration has this dependence. If this is the field that determines behaviour, then local matter should have a large effect on the total background and therefore on mass via the speed of light. However, the effects are tiny. The M / r dependence of clout and potential, but a gravitational force that has an M / r^2 dependence within our solar system, requires a revised understanding. It is not possible for the visible distant sources to dominate if their contribution to stored energy falls off as the inverse square of their distance. Based on their mass and distance, the relative contributions to the background (at the surface of the Earth) from the Earth, Sun and our own galaxy would be expected to be in the ratio of 6 x 10^8: 4 x 10^5 : 1.

Newtonian gravity has the potential (energy that can be given per unit mass to a tiny test mass from a point source of mass M) falling off as $1/r$. The field giving rise to gravity must be associated with the potential. It provides a steady force that is present while the source mass is present. It does not involve a flux or flow if the sources are stationary. This implies that there is no absorption or dissipation of energy in maintaining the background. However, massive objects need to take in (or release) energy in moving to a region in which the speed of light is slower (or faster).

The conclusion is that the observed dependence of the background potential on $1/r$, as seen in Newton's law, is both necessary and real. The clout must arise from the presence of other matter but not in terms of a flux that carries energy to a new location (as per light). Such an energy flux, or dependence on density, would appear to demand a $1/r^2$ dependence.

4.1.1 A background structure that replaces spacetime

As explained by Maudlin [36]: The inherent nature of space, under Newton, was Euclidean and there existed an absolute space and time. Newton believed in a three-dimensional space that exists at every moment of time and that identically the same points of space persist through time. Space was homogeneous and isotropic and so the behaviour of objects was independent of position and direction of travel. This, his first law of motion, requires a metric, a geometric structure, of both space and time. Absolute space without relation to anything external remained always similar and immovable. Absolute time proceeded equably without relation to anything external. In Newtonian space and time, objects travel in straight lines at fixed speed unless acted on by a force.

SR has the observed scale of spacetime dependent on the relative motion of observer and object. Space is still Euclidean, but space and time are linked via a constant measured speed of light. SR has a deeper level of geometric structure than Newton's perspective. GR takes the linked space and time (metric) a step deeper in proposing that gravity is a distortion of the geometric structure of SR.

Newtonian physics and Relativity therefore include the concept that there is a background structure, in the sense of a geometry of space and time, which governs the rules for the relative location and rate of change of location with time of objects embedded in that space and time. FR replaces the notion of a structure or geometry of space and time that exists undistorted in the absence of objects but is distorted by objects whose properties are unaltered. Under FR, a relative space and time persists but the properties and movements of objects are dependent on all other objects. The motion of bodies and their properties persist but vary with the background due to all other bodies and their movement.

FR proposes that space reflects a constant distance of separation if there is no relative motion between objects (independent of observer motion). Time (clock-rate) reflects an underlying rate of events (involving the motion of massive objects) against a constant distance scale (meaning a fixed separation) that is independent of the speed at which massless information flows. The space between objects (i.e. their separation distance) cannot expand or contract without there being motion. However, the size, energy, and resistance to motion of massive objects changes with the background. Time, in the sense of propagation of causal interactions over constant separation varies with the speed of light. Simultaneity of separated events must take into account both the finite and variable speed of propagation of massless interactions. Time, in the sense of changes in the ongoing synchronicity of similar events, involving the movement of massive objects in different environments, needs to take into account changes in both inertia and stored energy. A clock-rate based on the frequency of massless photons from atomic transitions of known energy may differ from a clock-rate reflecting the rate of change of position (and hence inertia) of massive objects.

GR is built on the gradient of a potential. The gradient has an M / r^2 dependence on distance from a point source. The force, and acceleration per unit mass, falls off as the gradient of the sum of all contributing potentials. The energy gained by objects falling in the field is per unit distance and the potential is the integral of the force per unit mass. The M / r dependence of potential implies that the contribution from distant sources is much larger than expected from their apparent lack of contribution to the local gravitational acceleration. However, GR assumes a constant background potential has no effect on mass. Therefore, gravitational force per unit mass depends only on the gradient of the potential. The distortion of the metric depends on the second derivative of the gradient of a generalised potential, and the mass of the same matter remains constant.

FR has the potential (clout) falling off as M / r and mass decreasing as the total background increases. Clock-rate and the speed of light vary in an undistorted space that does not carry energy. This $1/r$ dependence needs to be better understood but cannot be due to a flux (flow) of energy because it should then fall off as $1/r^2$ with the increase in the surface area ($4\pi r^2$) of a sphere enclosing the source, as occurs for light.

4.1.2 Time dependence, oscillation frequency, inertia and asymmetry

Energy and mass are scalars whose combined energy appears to be constant, that is conserved, over time. Velocity and momentum are vector properties that have direction and are dependent on time interval, even though conserved over time. If the conversion between energy and mass depended on position, but not time, then a scalar theory of gravity, with constant c, might suffice. However, the appearance of time (via the speed of light) in the conversion ($E = mc^2$) and the fact that a loss of stored energy can appear as energy of movement, imply that there must be aspects of the background that introduce a dependence on, or sensitivity to, movement (via velocity) per unit time.

Under Noether's theorem, conservation of energy arises from the invariance of physical laws with time. The conservation of momentum arises from invariance with position. If both the energy and momentum of a photon are conserved in a gravitational field, even though the speed of light changes, then i) the energy delivered per unit time must increase in proportion to the decrease in time interval; and ii) the photon momentum must be independent of position/location (if distances are undistorted). The energy of the photon is then proportional to pc, as observed, and only the time component of the speed of light (not distance) changes with the magnitude of the background.

If conservation of energy holds for the same matter within any constant background and $E = mc^2$ also holds, then clock-rate time interval (Δt_C) should be $(c / c_0)^2$ times the light-clock time interval Δt_L. On the other hand, how fast the speed of a (massive or massless) object can be altered depends on momentum and its relationship to inertia, the resistance to changes in velocity. The time taken for events (involving movement of massive objects) to occur will change if the inertia of the same amount of energy depends on a different aspect of the background to that which determines mass.

If the distribution of matter were entirely uniform, then a scalar interaction that depended only on the magnitude of the background should not impede changes in motion. If the background was constant and completely uniform, then linear and angular motion (translation and rotation) would leave the appearance of the background unchanged. This is consistent with objects maintaining constant velocity in the absence of a force. However, if the apparent background is unchanged by motion, then it is hard to see how it could give rise to inertia, i.e. impede changes in linear motion or rotation at all velocities. Force is needed to impart a change in velocity but, after the change, the velocity and momentum remain constant (when there is no further input of energy). This cannot arise from interaction with a direction-independent (scalar) background unless the background appears still, relative to every object as soon as a new velocity is achieved. Otherwise, the effect will not be independent of the object's speed or direction. A scalar background that is stationary relative to every moving object, but resists changes in velocity, does not seem possible. A scalar interaction with the background could give rise to gravitational mass but is insufficient to account for momentum. Momentum requires an additional contribution to inertial behaviour which depends not only on gravitational mass but also on the rate of change of movement relative to the current position and direction of movement. There must be at least two components to the background, with different or opposite sensitivities to direction of movement, and/or an internal oscillation sensitive to changes in speed and direction.

An input of energy is required to change momentum, including changing the direction (of massive objects and massless photons) without changing speed. Moreover, the force required depends on the rate of change with time. If the properties of a massive object only depended on the magnitude of the background independent of (or insensitive to) direction, when moving with constant velocity, then energy should not be needed for a change in direction without a change in speed. A massive object must carry properties that enable it to store energy and all objects must carry information that allows identification of changes in movement relative to their current movement. If there is a similar resistance to a change in motion in any direction, but no resistance to constant motion, then the object must carry with it some information that is not spatially and temporally located only at its centroid. This implies an oscillation or rotation about that centroid, that resists changes to its alignment with the direction of motion. If the rotation is only in the plane perpendicular to the direction of motion, then the object can travel at constant speed but still be sensitive to changes in direction.

If massive states oscillate relative to a central location, they carry with them a sense of current location. Energy needs to be transferred into this pattern to alter the oscillation about the current central location. It then moves at the new constant velocity without further input of energy. The energy needed to change the current position depends on the energy already stored and its rate of change relative to the current location and direction, so that momentum will be a vector. The kinetic energy of massive particles ($\frac{1}{2}mv^2$) depends on velocity squared. This would appear to be because kinetic energy is cumulative. The total depends on the integral of the changes in velocity.

Inertia should depend on the mass and both its rate of change of movement relative to its current state and relative to the background. By analogy with gravity, the state might be expected to lose mass if movement increased the sensed background. However, it is observed that inertia and apparent mass increase, rather than decrease, with speed and that the increase is non-linear. These observations imply that mass, and hence inertia, depend on the speed of light, and also that inertia but not mass increases with increasing speed relative to the stationary background.

The speed of massless particles is observed to be independent of the velocity of the source. Hence, this speed depends on the magnitude of the background components but not on their direction or movement. However, high-speed movement of massive objects is observed to increase resistance to acceleration and to slow time (as seen in decay rates and clock-rate). Thus, the motion of stored energy (massive objects) does seem to depend on velocity relative to the background that arises from the position, magnitude, and movement of other massive objects. However, massive objects moving at high speed do not slow unless an external force is imposed. It is only the resistance to changes in speed and direction that increase (following $p = \gamma mv$). This implies that changes of the internal components of a massive object, relative to each other and relative to the components of other massive objects via the background, are important.

Massless photons also resist changes in direction of motion in proportion to their momentum. However, they move at constant speed, relative to their previous position, within a constant background. The speed is independent of the energy carried, but the energy carried is proportional to a frequency of oscillation. This seems to imply that the amplitude of the oscillation, transverse to its direction of motion, decreases in inverse proportion to the increase in frequency (for the same background). The energy (E) it can deliver is proportional to the magnitude of the angular momentum carried in its oscillation(s) multiplied by the relative speed of motion. The momentum of the oscillation of the emitted photon is not altered by changes in the magnitude of the background (although the frequency or wavelength might be altered). The energy equivalence of this momentum will be proportional to the speed of the photons (i.e. of light).

The hypothesis is therefore that all particles carry an angular-momentum-based memory of their current orientation and position which can also be sensitive to the current background. For massive particles, the sensitivity depends on relative velocity and the magnitude of the background. For massless particles, the magnitude of the background determines their speed. It takes energy to alter the memory but not to maintain it. If it is sensitive to changes in direction relative to the current direction, then it must have a component of rotation aligned with the current direction. It is proposed that the speed of massless quanta is proportional to (some combination of) the magnitudes of the background components, and that the frequency of oscillation is proportional to an asymmetry between components times the momentum carried. The speed of light is independent of the speed of the emitting object because it involves massless self-propagating quanta whose speed of oscillation in the direction of motion is independent of transverse oscillation frequency. The momentum carried in the rotation/oscillation perpendicular to the direction of motion is constant after emission but its frequency will vary with any change in the asymmetry. However, the energy that can be delivered depends both on the speed of light and on the relative velocity between source and receiver.

4.2 Reconciling the Higgs mechanism with mass as stored energy

In particle physics, the mechanism for giving all fundamental particles (electroweak bosons, quarks, and leptons) mass, is called the Higgs mechanism. This mechanism was based on the idea of a "spontaneously broken" gauge invariance. The exchange particle (a scalar boson) then becomes "charged", i.e. massive. The discovery of the scalar Higgs particle is strong evidence that the mechanism for giving elementary particles mass is a broken gauge invariance that includes a background-dependent scalar interaction. The masses of all particles in the Standard Model (SM) arise from their interaction with this field [37], with the observed mass depending on the particle's "energy absorbing" ability, and on the strength of the Higgs field [38,39]. If this is the source of mass then we must be living in a world where there is a net interaction between elementary particles and their surroundings, that gives rise to their mass, which is scalar and so not gauge invariant. The initial gauge invariance has been broken. Hence, the Higgs boson implies that mass, and hence gravitational attraction, arises from a background dependence. The gauge invariance of the source of gravity has been broken, which is inconsistent with Newtonian gravity which is gauge invariant and GR which is locally gauge invariant over small distances and times.

It has been suggested that the Higgs mechanism may only account for something akin to the bare masses of particles such as quarks because the mass of nucleons includes enormous energy from the motions of their component quarks. Numerical calculations based on Quantum Chromodynamics (QCD), the theory of strong interactions, give self-consistent and accurate predictions of the masses of all hadrons based on the masses of individual quarks and the strengths and mixing angles of the interactions. It is found (under these QCD calculations) that for the basic, most stable, nucleons (the proton and neutron) most of their mass comes from the trapped kinetic energy of relatively light quarks inside these composite particles. The argument is that only a very small amount of mass is associated with broken gauge invariance, because QCD and Quantum Electrodynamics (QED) are gauge invariant interactions.

This is a strange argument because it is the attraction between positive and negative charges of QED that generates a force which confines charged particles to a location and the force needed is dependent on the trapped mass (via momentum or KE). Similarly, QCD confines coloured quarks inside nucleons. The force per unit mass of the trapped particle may be independent of a uniform background of charge or colour, but the trapping gives rise to additional mass. The mass of a body is not a constant; it varies with changes in its energy [2]. FR proposes that there is only one type of mass; that is "stored energy". Any force that confines movement (momentum) to a limited location gives rise to mass. This is already appreciated in the understanding that confining a gas inside a container increases its mass, and the increase depends on the temperature (speed of movement) of the gas, because a force is exerted to match the pressure of the gas. If most of the mass is associated with gauge invariant interactions (QCD and QED) then it must be that their gauge dependence is hidden, with matched contributions of opposite parity giving zero visible (net) broken gauge invariance.

If mass is a result of a background-dependent theory, then mass should change if the amount of background matter (with its stored energy) changes. Hence the stored energy of particles should change if the background changes. Reconciling this with $E \propto mc^2$ requires that the magnitude of c be background dependent. Thus, electromagnetic fields (including photons) move at a fixed speed when the background is constant, but the speed varies with the background.

The SM is a chiral model. Massive particles come in left-handed and right-handed forms and some of the interactions are different depending on the handedness of the interacting particles. In particular, only the left-chiral electron, charge -1, can interact with the W^- and only the right-chiral positron, charge +1, can interact with the W^+. The handedness is the relationship between spin and the direction of motion. For massless particles, the apparent handedness is fixed. However, for massive particles the apparent handedness depends on motion, the velocity relative to the speed of light. The "spontaneous breaking" of gauge invariance, which gave rise to the Higgs mechanism for giving particles mass, arises from this underlying dependence on chirality. It follows that chirality must be involved in the background-dependent interactions that give rise to mass and determine inertia.

Thus, the chirality of both particles and the background should be involved. However, the chirality of "space" is seen only in weak interactions and it is the bosons that mediate this interaction that are massive (whereas the gluons and photons of the strong and electromagnetic interactions are massless but contain a component and anti-component of colour or charge). This suggests that the background has contributions from both matter and antimatter, but the chirality does not lead to trapping of energy (at a stationary location) for the massless bosons. If particles as well as "space" (i.e. the background) can possess chirality, then the lack of visible chirality implies that photons have no, or equal, components that carry chirality, while the eight gluons of the strong interaction in total have no or equal components. The neutrinos and vector bosons of the chirality-sensitive weak interactions must carry chirality. If neutrinos are massless, then the chirality that they carry does not trap energy (or the trapped energy they carry does not resist a change in speed). The three flavour families of massive leptons and quarks (with the top quark being more massive than any of the weak or Higgs bosons) must have three mixtures of chiral components and/or rotation patterns with different ability to trap energy (or resist movement). Every massive particle has an antiparticle which, if charged, has the opposite charge but identical mass. For these pairs of particles, the magnitude of chirality for (the sum of) all the interactions that give rise to the storage of energy must be equal.

The revised understanding, proposed here, is that the strong, electromagnetic, weak, and gravitational interactions are all parts of the same fundamental set of interactions that generate forces that can confine energy of motion to the current location. It would seem misleading to consider just the Higgs particle interactions, the so-called Higgs field, as the source of mass. The Higgs is just one member of this set of interactions, probably all of which are due to one underlying field that includes two chiral components. The massive bosons of the weak interaction have manifest chirality, and their interactions with particles that have opposite chirality (particles and antiparticles) can exhibit this chirality. However, massless bosons (photons and gluons) have an equal mixture of chiralities and the sum of their interactions will not show a chiral asymmetry. The mass of elementary particles (including leptons and quarks) arises from confining energy to a location and the masses of composite particles arises from the masses of the components and the confinement of the total energy to a limited location. The strengths of the interactions depend on the properties of the particle and on the number, type, distance, and direction of the fields from surrounding particles. The implications for the SM of particle physics will be explored further in Chapters 8 and 9.

4.3 A chiral background as the source of inertia

The considerations of Section 4.1 lead to the proposal that resistance to changes in movement is sensitive to the magnitude of the energy carried, and to changes in magnitude and alignment relative to the current speed and direction of motion. This can be provided by having multiple components with opposing rotations that trap momentum. Changes in direction of movement require a force to re-align the direction. Changes in speed have a larger effect on components in the direction of motion than against. The arguments of Section 4.2, imply chiral components. Inertia should then depend on the amount of angular momentum, its velocity relative to the background, and on its rate of change (i.e. have $F \propto d\vec{p} / dt$). The magnitude and frequency of the oscillation reflect the magnitude of the momentum carried and any differences in the number and magnitudes of the chiral components of the background and the object. Inertia will depend on oscillation alignment and frequency as well as stored energy; and the ratio of gravitational to inertial mass (m_g / m_i) will not be constant.

4.3.1 Variation in the ratio of inertial to gravitational mass

If energy and momentum interconvert in a gravitational field but the total is conserved, then the loss in stored energy (gravitational mass, m_g) must balance the gain in momentum (proportional to inertial mass, m_i) from the work done by the gravitational force, even though the mass has reduced. The force needed for a change in momentum depends on the rate of change with time. The measured clock-rate changes by (c/c') and the tick interval by (c'/c), while the light-speed interval changes by (c/c') in a gravitational field. The change in the ratio of time intervals is in the same proportion as the change in the ratio of masses, so the ratio of inertial to gravitational mass will appear constant unless the inertia of the same mass changes with the background.

If measurements are within a region of similar asymmetry, then the visible effects of an inertia that depends on the product of gravitational mass and asymmetry may be small. However, the fractional change in inertia should be much larger than the fractional change in gravitational mass. Thus, inertial mass, the speed of movement of massive objects and the apparent strength of a given gradient in clout will be primarily determined by asymmetry. This seems to be consistent with the small amount of energy needed to accelerate a 1 kg object that contains enough energy to destroy a city.

If inertia does not alter stored energy, then the frequency per unit of energy will depend on the asymmetry at the place of measurement and be independent of the asymmetry at the source. The visible effect of asymmetry on behaviour will then depend on whether differences in stored energy, or time, or inertia, are being examined. The local frequency of massive clocks will decrease as the speed of light increases (because it reduces stored energy) but the magnitude of this frequency per unit of energy will increase as local asymmetry increases. The change in distance travelled by light will depend on the methods used to measure time and distance. The size of any measurement rod used by the clock will change if its mass changes.

Time (clock-rate from photon frequency) is observed to increase with gravitational potential (Φ), with the change consistent with the change in potential energy ($\Delta\Phi/c^2$). Planck's constant (h), which relates frequency to energy, would vary with asymmetry of the background if this influences the rate of oscillation but not the photon energy. Such an oscillation frequency, per unit of momentum, would be expected to be the same for both photons and massive objects at the same location but vary with location. It would then not be readily visible unless the value of h was compared between locations.

4.3.2 The effect of chiral asymmetry

A first proposal might be that the frequency of oscillation, per unit of energy, depends on the fractional asymmetry in the components of opposite chirality, whereas the energy stored depends on a mean value via the speed of light. The change in fractional asymmetry will be $(A+\delta A-\overline{A})/(A+\delta A+\overline{A})$, where δA is a small change in one component (A) and $\overline{A}$ is the component of opposite chirality.

The masses of leptons and antileptons and baryons and anti-baryons, and the energy levels of hydrogen and anti-hydrogen match very closely, and the pairs can annihilate releasing all the stored energy as photons that carry momentum but with the vector total of momentum unchanged. This seems to imply that matter and antimatter are exact mirror images (in a background of equal charge but non-zero chirality) with the effect of their contributions to light-speed and stored energy the same. This would seem to be consistent with the mass of baryons and leptons being independent of asymmetry. However, the resistance to a change in the current velocity (i.e. inertia) could still involve a difference of the two chiralities about their mean.

The apparent weakness of gravity relative to the other fundamental forces implies a large background. This strongly supports the hypothesis that a scalar interaction that provides a large background is involved. A vector interaction would remove the effect of a homogeneous, isotropic background. The small ratio of inertial to gravitational mass then explains why the enormous amounts of energy stored in objects as mass are so relatively easy to accelerate. A large contribution to asymmetry from our galaxy relative to that from nearby objects (Sun and Earth) and a small asymmetry away from an isolated galaxy explains why the strength of gravity in the solar system appears consistent with a $1/r^2$ dependence while the rotation curve far from the centre of isolated galaxies has a $1/r$ dependence.

If $\bar{A}$ is similar to A, then the fractional asymmetry $(A-\bar{A})/(A+\bar{A})$ will change by approximately $(\Delta A+\delta A)/2A$. If the asymmetry ΔA is already large, the fractional change in asymmetry due to δA will tend to zero. If the background clout from each chirality is similar, then a gradient in one component will have a much bigger effect on fractional asymmetry than when the asymmetry is already large. The rate of change in fractional asymmetry will alter the gradient in potential (determined from the kinetic energy due to a given change in mass). The proportionality factor will reduce as the background asymmetry increases, e.g. in moving towards the centre of a galaxy of only matter or only antimatter. For small changes in total clout, any dependence on total clout is hidden by using the force per unit mass. If the contribution of local objects to asymmetry is small relative to the background asymmetry, then the local change in inertia will be small.

This introduction of a rotation/oscillation whose frequency, and hence resistance to change in angular momentum (giving inertia), depends on the asymmetry of chiral components, is partly motivated by the desire to explain the bending of light as well as the flat rotation curves of galaxies. If the space between objects is not bent, then there needs to be an effect of the background on the properties of particles (massive and massless) embedded in that background. FR needs a replacement for GR's distortion of the geometry of spacetime that leads to effects on momentum (vector) as well as gravitational energy (scalar).

4.3.3 Oscillations and rotations with movement

The observation that no energy is lost in the movement of an object at constant speed (in a constant gravitational field) means that the background should not exert any force or torque that requires energy if there is no change in speed. This equilibrium state of the object should also not be free to release energy by slowing. For GR, a spacetime with constant c would always be in equilibrium. Changes in space and time would always match, so it is hard to understand why differences (distortions) would propagate. For FR, the background has chiral components, corresponding to the opposite sense of rotation relative to the direction of movement. However, increases in inertia with speed relative to the background appear to go hand-in-hand with decreases in oscillation frequency (as seen in decay rate) per unit of energy. If mass depends only on the speed of light and this speed is determined by the magnitude, but not movement, of the background then the amount of stored energy should not be affected by movement.

FR requires a slowing of mean oscillation frequency by $1/\gamma$ with movement, but an increase in momentum by the factor γ. This implies an increase in inertia of γ^2 per unit frequency. If the increase was in stored energy, then the frequency should increase. If movement has the opposite effect on a pair of balanced oscillations in the object it should lead to a small effect at low speeds but a large effect at high speeds. The competing effects of a change proportional to $c/(c+v)$ and one proportional to $c/(c-v)$ will give a change in the mean value by the factor $\gamma^2 = 1/(1-v^2/c^2)$.

The dependence of momentum on $\gamma = 1/\sqrt{1-(v/c)^2}$ is also suggestive of a two-fold dependence on the speed of rotation, since $\gamma = 1/\cos\theta = 1/\sqrt{1-\sin^2\theta}$ with $\sin\theta = v/c$, where θ measures the degree of alignment with the direction of motion via the fractional velocity (v/c).

A massive stationary state might constrain a force to a location by matched counter-rotations. If the magnitudes of the chiral components of the background were equal (i.e. arose from equal contributions from matter and antimatter) then there would be no net rotation of the oscillations of such stationary states. The force needed for a new alignment (inertia) would tend to zero.

4.3.4 How can clout depend inversely on distance?

The surface area of a sphere surrounding a source increases by a factor of four when distance to the sphere doubles. The surface area is $4\pi r^2$, where r is the radial distance from the source. The flux or flow through a surface, of light or heat or particles emitted by the source, falls off as $1/r^2$ per unit area. This is what we are used to and perhaps explains why the force per unit mass, the gravitational acceleration, of Newton's equation was seen as the relevant field for GR. The acceleration field is the derivative of the gravitational potential with distance. The potential only falls off as $1/r$. However, a flow implies movement and a source that emits light, heat or particles is continuously emitting energy. This appears inconsistent with Newtonian gravity and GR because the source mass is unchanged even though energy is imparted to objects by the field. As pointed out in Section 3.8 the differential form of Newton's equation (1.2) assumes that mass is constant independent of the background mass density. The assumption gives rise to the inconsistency that an invisible mass density outside any matter can act as a source of gravitation. FR demands that clout falls off as $1/r$, but how can this be?

If there is a boundary that limits the flow away from a source then the volume fills up until the amount coming in stops, as with air in a tyre. The amount is then constant independent of distance. It appears to be essential to have a boundary for a static situation to develop. If there is no boundary any effect from a source would be expected to flow away until there is nothing left of the source.

If springs are held tight at the boundary of a sphere and pulled/stretched towards the centre, then the tension is constant and the cumulative amount of stretch decreases linearly out to the boundary. If a helical spring or a thick rubber rope is wound up at the centre, then the cumulative number of turns decreases linearly out to the boundary. What such an analogy seems to suggest with gravity is that there is something equivalent to two types of springs (left-handed and right-handed) and there is a boundary where they are both twisted the same amount. It is proposed that the sources due to matter and antimatter act as a boundary to each other. If one gets stronger ("twisted" more), then the other is wound up more until they re-balance.

If the background chiral components are ρ_1 and ρ_2, and their contributions are to balance then the effect on the components must be complementary. The larger chiral component (ρ_1) could reduce in frequency and/or amplitude by the factor α while the smaller component could increase by $1/\alpha$. This would mean $\rho_1\alpha = \rho_2/\alpha$ and $\alpha = \sqrt{\rho_2/\rho_1}$, which is reminiscent of light-speed being $c = 1/\sqrt{\mu_0\varepsilon_0}$. Since chirality is associated with opposing directions of rotation it seems plausible to have a conceptual model based on balanced torques, or angular momenta, whereby the larger component can only induce an increase that is proportional to the square root of the excess in stored energy above the mean. This is because a balance requires an equal and opposite change in the opposing chiral component. The proposal appears to be a promising step towards having a persistent field that, once established, does not involve a flux or flow. It also seems to be consistent with a $1/r$ dependence, rather than $1/4\pi r^2$, with distance from the source.

These are initial comments and speculations on how the two components of a chiral background might combine to produce rotations/oscillations that determine the speed of light and inertia. A decision on how they combine needs further experimental investigation and theoretical modelling including making sure the proposed background is consistent with electromagnetism and with gravitational observations.

4.3.5 Consistency with a chiral background

Movement of objects with time-varying chiral components relative to a chiral background can be sensitive to changes in the magnitude and direction of rotation of the components relative to the magnitude and direction of motion. This is proposed as the mechanism by which an object carries resistance to changes in velocity (orientation and speed) relative to the current values and increased resistance to changes in speed relative to a stationary background.

The size of the background affects mass via the speed of light. Gravitational forces arise when there are changes in the background with position. Inertial forces arise from a resistance to changes in the movement (velocity) of objects because of internal rotations. The magnitude of this inertia depends on the momentum vector relative to the direction of motion of the energy carried, its speed relative to the stationary background and the asymmetry of that background. A force, proportional to the energy carried, is also required to change the direction of massless particles (photons) but their speed of motion is independent of the energy carried.

If particle mass is determined by the speed of light, according to $m = E/c^2$, then movement at constant speed in a region of constant background clout should leave the mass, for a given speed of light, constant. However, it is observed that relative movement at high-speed causes time, inherent to the moving massive object (e.g. decay rate), to run slower by the factor $1/\gamma$. Such a slowing of time suggests that movement reduces the mean oscillation frequency of the wavefunction by this amount. If this arose from the object "seeing" a larger background, then it might be expected to lose gravitational mass (as occurs under FR in moving into a region of higher background density) and, thus, have reduced inertia. However, it is observed that resistance to acceleration (proportional to inertial mass), and therefore momentum (mv), increases in accordance with γmv, with velocity v.

The sensitivity of momentum/inertia to speed has suggested, under GR, that mass is increased by acceleration. However, it should then be able to be released by deceleration. In addition, similar particles moving at high speeds ($v/2$) from opposite directions relative to the stationary observer, need less energy for their acceleration than one particle delivering the same energy (moving at v) to a similar stationary particle. More than double the energy is needed for acceleration of the particle moving at v, over that moving at $v/2$, relative to the observer, because of the factor γ. These observations strongly suggest that stored energy is not increased by movement relative to the background. Instead, the difficulty of changing the velocity is increased. The increase in energy is not stored in the particle. There is an increase in inertia with speed relative to the approximately (or effectively) stationary background of the observer, but the stored energy is unchanged.

The increased difficulty is also reflected in a slower rate of oscillation of the same amount of stored energy. Consistency with time dilation and with the increase in inertia with speed then requires that rotational frequency slows by $1/\gamma$ while resistance to changes in the frequency of the rotation increases by γ with speed relative to the background. However, the increase in resistance is not associated with an increase in stored energy (gravitational mass) as this would increase the frequency of (quantum oscillations of) massive particles. Thus, it appears that movement has opposing effects on chiral components leading to an increase in inertia but no change in mass. Speed relative to the background alters the ratio of inertial to gravitational mass and so, presumably, alters the apparent asymmetry of the background. Such a scalar difference will not show up in an Eötvös experiment which compares the ratio of inertial to gravitational mass (of different materials) at a single location.

The "small" asymmetry in the cosmic microwave background and in the isotropy of the redshift of galaxies indicates that we are approximately stationary relative to the historic average distribution of massive objects. This is a fairly generous definition of stationary. If the dipolar asymmetry seen in the NASA COBE satellite cosmic background radiation observations is due to movement, then "approximately stationary" corresponds to a speed of 365 ± 18 km/s! However, this is still only about one eight-hundredth of the speed of light, so will have a negligible effect on the decay rates of particles travelling at close to the speed of light.

We are also in free-fall, accelerating by just the right amount for any gradient in the background to disappear, i.e. for the background to appear isotropic. The forces are, presumably, still present but balanced. If inertia is altered by speed relative to a stationary background, then there would be a small dependence of its magnitude on the velocity of the Earth around the Sun or the velocity of the solar system around the galaxy. However, the first dependence of inertia is on the change of movement relative to the current movement so any effect would not seem to be readily observable. Observation of such a change in magnitude would seem to require a comparison of gravitational effects seen by well-defined systems moving at markedly different speeds relative to the same stationary background.

4.4 The proposed background

Full Relativity proposes a two-component energy-free chiral background interacting with oscillating wave/particles that contain chiral components which can store and carry energy. The speed of propagation of both gravity and the quanta of electromagnetic radiation are determined by the magnitude of the background, which increases with the clout from surrounding matter. An increase in the speed of light reduces the energy that can be stored by matter. This strongly indicates that electromagnetism and gravity are related aspects of the one background field. The gravitational force per unit of stored energy arises from a gradient in the scalar magnitude of this background. An electrostatic force on a charged object arises from a gradient in the vector electric field from any charges embedded in the background. A magnetic force on a moving charged object arises from a field generated by the movement of charges. This includes a directed magnetic field from the rotation of charges about an axis or by an alignment of the spins of elementary particles or atoms. FR has strong, electromagnetic, weak, and gravitational interactions all being part of the one fundamental set of interactions that generate forces and enable stationary states that confine energy to the current location, i.e. give rise to mass. The one background embodies all these aspects.

For massive particles, the degree of helicity is a measure of the alignment between spin and the direction of motion. The spin could be clockwise or anti-clockwise for an observer dependent on the direction of viewing. If an observer catches up to the particle, then the apparent direction of rotation will change as the particle is passed. Hence, under SR and GR, the helicity of a massless particle is along or against the direction of motion and cannot change because no observer can exceed the speed of light. Under FR, the helicity of particles reflects the degree of alignment of opposing components of angular momentum with the direction of motion. The helicity gives rise to a sensitivity to speed relative to the background. It is proposed that the fraction of the angular momentum aligned with the direction of motion does not resist changes in frequency of opposing rotations and that the stored energy is unchanged by movement relative to the background. The fractional alignment will then affect inertia (the difficulty of changing velocity) but not mass. Inertia will also depend on the asymmetry of the background which will affect rotation frequency for a given stored energy. Momentum will depend on the relative velocity of stored energy, and on its inertia, which will vary with velocity relative to the background and with background asymmetry.

This picture would seem to provide an explanation for the properties of momentum. There is an effect on the energy exchanged due to the relative velocity of interacting quantities of constant stored energy. There are also opposite effects on inertia and oscillation frequency, proportional to γ, with speed relative to a stationary background. The contributions to clout from both matter and antimatter from distant galaxies should be approximately isotropic due to the large-scale homogeneity of their distribution. In addition, free-fall motion should lead to an apparently isotropic background. However, the degree of asymmetry could vary markedly with position within, and distance from the centre of, an isolated galaxy. Changes in velocity are resisted in proportion to inertial mass times the change in velocity relative to the current velocity. Inertial mass depends on stored energy (gravitational mass) and speed relative to a stationary background, and on the size of the asymmetry in the chiral components of the background.

The more complex background impacts on the wave properties of matter inherent in quantum mechanics. Firstly, clock-rate depends on the energy levels of the (massive) clock, which reflects the stored energy of its particles, and varies with the background clout. Secondly, the observed frequency/wavelength and inertia, of both photons and massive objects, are dependent on the asymmetry between the contributions to clout. These come from matter and antimatter, the left and right-handedness of the bodies that give rise to, and are affected by, the background. Matter and antimatter have opposite chiral components and clout is related to the way a balanced combination determines the speed of light. The wave properties of all objects and the amplitude and frequency of the waves, and speed of transmission, are affected by the two components of the background field.

Inertia and oscillation frequency reflect the amount of stored energy, the asymmetry of the background and speed relative to a stationary background. Light speed depends on the magnitude of the background, but not on the speed of the emitting object. The total energy of massive and massless objects is conserved but their speed and direction of travel can be altered by gradients in the background because they can affect their mass (if any), oscillation frequency and wavelength. If the background is constant, then the direction and speed of objects is constant. If the clout of a homogeneous background changes, then the speed of light and speed of massive objects will change.

Under FR, the mass/inertia and speed/frequency of massive and massless particles/waves change in response to the background and the mass and movement/oscillation of massive objects change the background between objects and also their wave interactions. The statement echoes, but is quite different from, John Wheeler's famous description of GR: "Spacetime tells matter how to move; matter tells spacetime how to curve". Under FR, the clock-rate (time) of massive objects (including us) changes and the speed of information flow changes, but there is no curvature of a linked spacetime and space is not distorted.

Under GR, the pseudo-medium between objects is the fabric of spacetime. Gravity is a distortion of this fabric which is why gravitational influences travel at the speed of light. Under FR, the medium (a field) arises from the magnitude and asymmetry of the background clout due to the stored energy of matter and antimatter. Therefore, the explanation of why changes in gravitational attraction travel at the speed of electromagnetic fields must be that both speeds of propagation are determined by the same field, the clout of the medium.

4.4.1 The underlying physical picture

Further details of the underlying physical picture, embodied in the background-dependent theory of FR, are set out below. They may not be fully correct but are put forward as a step towards both qualitative and quantitative predictions and experimental tests of the theory.

A finite two-component background leads to a finite speed of light and the possibility of stationary states in which energy is confined to a localised region (i.e. they have mass) and to states travelling freely at the maximum speed (massless) that carry energy to a different location (have momentum). "Stationary" here has both of two meanings: i) not moving relative to the surroundings (confined to a location), and ii) a standing wave in which the component amplitudes can be oscillating but in which the same pattern is repeated, and the centre of the time-averaged pattern is fixed. [The concepts of "fixed" and "not moving" will need clarification to handle movement at constant velocity.] The oscillations have a handedness (chirality) of rotation with movement in three dimensions (and hence with time) that is opposite for matter and antimatter. This chirality means that the phase relation between expansions and contractions in orthogonal directions determines the sign (direction) of the expansion or contraction (with time) in the third orthogonal direction. Thus, there are two contributions (of opposite handedness) giving rise to a clout that falls off as the inverse of distance from an excess of one type of matter. The stored energy of that matter is determined by the speed of light as $1/c^2$. The speed of light depends on the clout, which is determined by matched chiral contributions. However, the visible chirality of space (sensitivity to handedness) depends on the excess of one chiral component over the other, and on the pattern and handedness of the components of the particular stationary state (elementary particle).

Massive particles are stationary states containing balanced opposing components with anti-particles having the opposite chirality. These components can counter-rotate and thereby confine a net force and net stored energy to a mean location. Patterns of the same chirality as the locally dominant chirality correspond to matter. If the background contributions from matter and antimatter were the same, then states could have a stationary pattern that did not have a net rotation. An increasing excess of either chiral component increases the frequency of the net rotation, for a given amount of stored energy. Speed relative to the background alters the balance of the counter-rotating components in the direction of motion (and so alters the helicity) but does not alter the stored energy. A change in speed requires a force but there is no force opposing movement at constant speed in the direction of a constant angular momentum vector. A change in the direction of the angular momentum also requires a force. For a particle without orbital momentum, the spin angular momentum of chiral components can still provide a resistance to acceleration. Inertia will be related to the helicity of the state and the frequency of oscillation.

The relative oscillation frequency and momentum of two particles will depend on their speed relative to the background as well as their speed relative to each other. This slightly alters the current concept of helicity relative to chirality.

If all elementary particles are standing wave states with chiral contributions due to backgrounds of matter and antimatter, then the pattern of their standing waves is determined by the number, magnitude, and relative phases of the components. It is known that the frequency of oscillations of both photons and massive objects increase with energy, and wavelength decreases, for a given speed of light. The kinetic energy that can be delivered by a constant amount of trapped momentum will increase with c, and the stored energy can be expected to increase the more the momentum is confined in space. These are consistent with stored energy varying as $1/c^2$. If force is proportional to the rate of change of momentum with time, then it is consistent with conservation of angular momentum and time intervals (u-time) being distance divided by the speed of light.

It is proposed that the stored angular momentum of a given stationary standing-wave pattern (i.e. specific particle of matter) will vary in inverse proportion to the change in speed of light. The speed of light is hypothesised to be proportional to clout due to the combination of the two chiral contributions. Within regions of predominantly one chirality of matter, the speed of light could have a weaker dependence on changes to the dominant contribution (but this would not be seen until the local contribution approached that of the enormous background). However, the frequency and inertia of the stored energy will decrease as the fractional asymmetry of matter over antimatter decreases. A massive object gives rise to a region in which the contribution of that chiral component is increased. The contribution decreases inversely with distance rather than distance squared, implying that the second component limits the rate of change of the first. The second component then has to increase by the inverse amount to maintain a balance.

A fractional increase in the magnitude of a balanced background clout of ρ' / ρ means the speed of light increases in the proportion $c' / c = \rho' / \rho$, and the same particle cannot trap as much momentum in proportion to c / c'. The size of the same standing wave will increase in proportion to the speed of light. A state of the same momentum, but reduced energy, is then less confined. Massive objects become larger so the distance between stationary, unconnected objects, measured with massive rods, would appear to decrease. The ratio of energies is proportional to $(c' / c)^2$. The separation of charged components increases by c' / c, but light travel-time intervals per unit distance decrease by c / c', so that c appears constant for the same, but shorter, object. The distance between unconnected stationary objects, not in relative motion but in regions of different clout, is constant. However, if the same measurement instrument (based on the length of massive rods) is moved to a region of increased clout, then a constant separation distance would appear to be (measure) smaller by c / c'.

Planck's constant h (in $E = hv = pc$ and $p = h / \lambda$) has units of angular momentum and the de Broglie wavelength (λ) applies to both photons and matter. The value of λ is the wavelength of a photon that can deliver energy E from its momentum travelling at c. This energy has come from the release of part of the trapped angular momentum of a stationary massive state. If there are background components due to matter and antimatter then it might be expected that there will be stationary states in which the torques, from opposite directions of rotation with respect to forward motion, are balanced. This will require the angular momenta to balance which will involve changes in amplitude. If the backgrounds are markedly different then changes in the dominant background component can be expected to have less effect on a balanced average. If only one component (ρ_1) changes then the fractional change in speed might be expected to depend on the fractional change in the balanced combination $\sqrt{(\rho_2 + \delta\rho_1 / 2)(\rho_1 + \delta\rho_1 / 2)}$. This factor is approximately $\sqrt{1 + \delta\rho / \rho} \simeq (1 + \delta\rho / 2)$ for $\rho \simeq \rho_1 \simeq \rho_2$.

An explanation for the flat rotation curves requires that a galaxy, near its centre, has a significant excess of like matter and that this affects inertia. Even for large isolated spiral galaxies, the rotation curve has already flattened significantly not far from the central bulge. This implies that the asymmetry from the galaxy is modest but is also the prime source of the background. The asymmetry depends on the amount of surrounding matter independent of direction while the gravitational force depends on the gradient in the clout of the surrounding matter.

The stored energy, or trapped momentum, can have contributions from strong, electromagnetic, and weak interactions. Momentum and inertial resistance will depend on the effect of movement on the oscillations of the opposing chiral components and so have a dependence on stored energy and its rate of change with time. The extent (amplitude) of the particle state depends on the confinement of trapped energy, and the (quantum) oscillation frequency of the state depends on both the energy of the state and the asymmetry between matter and antimatter components. These hypotheses need careful examination but appear consistent with all particles (including photons) having a wave nature (oscillation wavelength) dependent on momentum as seen in their de Broglie wavelength.

Under these hypotheses, the frequency of the light from the same transition of an atom will vary according to the transition energy (determined by the atom's energy via the speed of light) and the local asymmetry. However, changes in asymmetry at a remote location will be invisible to the distant observer, unless the remote value of h or time is measured, because the frequency of an emitted photon, but not its momentum, changes with location. The speed of light depends on both chiral components, but the same clock holds more energy when clout decreases with increasing distance away from, and with decreasing energy stored in, the surrounding matter/quanta. Local frequency and the inertia of a given stored energy decrease with decreasing asymmetry, with distance from an excess of one chirality. Differences (between GR and FR) will appear when comparing regions with different total clout, or differences in asymmetry, where there are means of assessing relative clock-rate, or local frequency, or energy.

4.4.2 A two-component clout that does not flow away

If $m = E_0 / c^2$ holds then the impact of clout on the energy stored by matter reflects the way it changes the speed of light. For a massless photon $E = pc$, so that the energy exchanged depends on the relative speed at which the interaction occurs times the amount of momentum carried. For massive states, the amount of momentum that can be trapped also reduces (as $1/c$) when the speed at which changes propagate increases. This suggests that momentum is trapped when it takes time for a fluctuation to be balanced, and hence cancelled, by a complementary fluctuation in another component. If chiral components are equal, then there will be no resistance to changes in this momentum because the change in one component will be matched by an equal but opposite change in the other. Inertia only occurs when changes in motion require a net force. Inertia will depend on fractional asymmetry but the stored energy will depend on clout.

The $1/r$ dependence of clout on distance from a concentration of stored energy implies that the total "flux", in terms of an influence per unit area, grows with distance from the source. This would appear to conflict with the everyday experience of fields including electromagnetic and pressure fields. It is proposed that the difference arises because the familiar fields involve an unconstrained movement (flow) of energy. The implication is that a gravitational field does not carry energy, instead it affects the amount of momentum that can be trapped by rotating or oscillating states and the speed of propagation of those oscillations.

The $1/r$ dependence of clout is somewhat similar to the total rotation of a stretched spring with distance from the opposite end. Such a dependence implies two opposing components, analogous to the spring being held in two places. The opposing components provide a "soft" barrier that reduces the rate at which the influence of an excess in one component decreases. If the field had only one (unbalanced) component, then the change should propagate away altogether. Clout requires something equivalent to the balancing of "torques" from opposite chiralities at every location in space. A rotation in two dimensions only has chirality with respect to a third perpendicular direction. For electromagnetic fields, the third direction is defined by the direction of motion. Thus, it is proposed that the effects of the handedness of the two sources of background appear when there is movement.

A gravitational field of constant strength at constant distance appears to surround a massive object and, when the object moves, the change in the field propagates at a finite speed. A constant speed of movement of such a massive object, and its field, in a steady, uniform gravitational field does not require an ongoing input of energy. This would seem to require that changes in the field do not carry energy, otherwise the amount of energy gained by a new region must always be matched by the energy lost by the old region, independent of the speed of the object and despite the finite speed of gravity. It also requires that the underlying background can reach a new equilibrium, that persists at the new level, immediately upon the arrival of the propagating increase or decrease in the field.

How can a non-zero background field be maintained under FR? Light comes in quanta that travel and carry energy away from the source. When the source stops emitting energy, it goes dark. The background seems to disappear. If gravitational fields arise from quanta carrying gravitational energy, then all massive objects that project a gravitational field should be losing energy. However, massive objects appear to maintain a constant field without radiating energy. Similarly, stationary charges can provide an electric field and moving charges a magnetic field that persist and affect charged objects. In the case of electromagnetic fields work is done in establishing the field and energy can be extracted or removed from the field by moving charged objects or photons. However, no energy can be extracted from a stationary balanced electromagnetic field without the movement of charge.

It is claimed that the orbits of binary pulsars lose energy at a rate that is consistent with the loss expected from gravitational waves of GR that are distortions of spacetime but this will be disputed (see below and Section 5.5.3).

Energy can be carried away by propagating oscillations of the field (photons) even though they do not seem to carry <u>stored</u> energy in the form of mass. The energy is in the form of trapped momentum, perpendicular to the direction of motion. The photon does not appear to have mass and, under FR, the magnitude of its "stored" momentum is not altered by a gravitational field. However, the energy of the same momentum will increase according to $E = pc$. A photon carries energy to a new location and can impart momentum if its velocity is altered in magnitude or direction. Massive and massless particles carry an unchanging momentum to a new location but the energy delivered will depend on the speed of travel including that from relative motion between the emitter and receiver.

The energy and momentum travel freely (at the speed determined by the background) in the direction of motion. The momentum of propagating quanta can be transported to new locations, as oscillations sustained by the background, but total momentum is conserved. The stored energy (mass) of the emitter is reduced at the source with the kinetic energy and momentum of the source being altered. The stored energy is recovered elsewhere when the quanta are absorbed. An electrostatic field can arise from stationary charge and can remain even in the absence of detectable photons. However, charge and energy are conserved and the field must lose energy if it is to impart energy to a charge. Gravity appears similar, but has just attractive sources. Under FR, movement of a mass will alter the stored energy, and the field remains constant if there is no relative movement. A persistent field does seem to imply that there must be at least two components to the background that enable an equilibrium to be established. If gravity imparts movement energy to objects, then it should be expected that the energy stored in the objects and/or the field will be correspondingly reduced.

GR has a persisting gravitational field in the form of a constant distortion of spacetime, that can impart energy to objects, and propagating distortions (gravitational waves) that can impart energy to a detector. The persistence of the field implies a balanced multi-component field. Under GR, the propagating distortion imparts energy and this energy increases the distortion as objects move closer together. Hence, the field provides energy as spacetime becomes more distorted. So undistorted space, empty of mass, must contain an initial enormous pool of energy.

The observation of gravitational "waves" that travel at the speed of light does not confirm that they are travelling distortions of spacetime, or that they carry energy. Changes in the level (clout) of gravity of the proposed background will change the energy that objects can store and would be expected to also travel at the speed of light if the change does not carry energy. Changes in the strength of gravity would involve the propagation of the degree of balance of opposing (e.g. chiral) components that make a persistent background possible. The speed of propagation would be determined by the magnitude of the balanced combination of the two components.

Time, in terms of the speed of light and oscillation frequency will change with background magnitude but it appears that the total energy/c and momentum of objects is conserved. The background field can then be seen as a balanced two-component chirality that enables the existence of states that trap momentum and can transport energy but the field does not itself carry energy. Propagating changes in the background will still be observable and will appear like the gravitational waves of GR.

If this is to be consistent with the apparent loss of energy of rotating pairs of neutron stars, then the apparent loss in energy must be due to changes in the energy stored in the stars as they move closer and, possibly also, to changes in inertia as they move closer and faster, rather than due to radiation of energy as gravitational waves. Duerr has argued that textbook arguments commonly taken to establish that gravitational waves carry energy-momentum are either contentious, or incomplete [40]. He proposed that an alternative is that GR does not require conservation of energy. FR proposes that propagating changes in clout, putative gravitational waves, do not carry energy, but that momentum is conserved. An outline of why FR is able to reproduce the apparent loss of energy, predicted by GR, is set out in Section 5.5.3, but the arguments need to be carefully examined.

4.5 Changes in understanding

The differences between FR and GR are more than just a change from a pseudo-background to a real background. Many aspects of the accepted understanding are called into question.

There is very good experimental evidence that the speed of light is independent of the speed of the source and receiver. For example, if the speed of light varied with the speed of stars in a rotating binary system, then, in principle, for a distant observer the light from an approaching part of the orbit could overtake light emitted earlier from a receding part. This is not seen. In SR, the postulate corresponding to the observed behaviour of light was replaced with the postulate that the measured (observed) speed of light is constant independent of the movement of the observer (see Chapter 2). This gave rise to Special Relativity's subjective distortion of space and time by the speed of relative motion which, in turn, required that distance and time be reduced by matched amounts. The inverted interpretation between time and apparent distance intervals was incorporated into the concept of invariant intervals of spacetime and used in GR where gravity was attributed to a distortion of the geometry of spacetime. It then appeared consistent with photons losing energy in a gravitational field whereas, under FR, photon energy is unchanged. Instead, massive atoms store more energy when the background decreases, time (clock-rate) runs faster, and the speed of light is slower.

But how can the classical Doppler shift of light, the change of frequency with relative motion, be explained if the speed of light (based on the actual distance travelled) is independent of the motion of the source and receiver? The answer is in the transverse oscillation of the photon. The angular momentum carried by a photon is proportional to its frequency divided by c, so inversely proportional to wavelength, while the speed of the photon is independent of the momentum carried. The photon then carries the "fixed" amount of momentum that was emitted but the apparent amount of energy of this momentum is altered by the change in frequency due to relative motion.

A speed of light that is dependent on the background means more than that mass varies. It also means that the relationship between momentum and energy changes ($E = pc$). Thus, "energy" is a relative concept. The amount of energy carried by photons, once emitted, does not change but the amounts of energy and momentum that are transferred depend on relative speed. At high speeds, the amount of energy of the observer and the system being observed will both depend on their speed relative to the background of all other matter. The conversion factor between energy and momentum varies with the speed of light and with speed relative to the background. This changes the understanding of the weak equivalence principle: that inertial and gravitational mass are "equivalent". Einstein's proposal that c was constant meant that there was no difference between inertial and gravitational mass. Instead, it should be seen that they have a fixed relationship for the same background and the same velocity relative to that background, but the relationship changes with the background. The so-called relativistic Doppler shift then arises from the motion of the massive source and/or receiver relative to the background, rather than a distortion of spacetime by relative motion of the source and receiver.

The rejection of "the principle of relativity" (Chapter 2) means that the increase in momentum of massive objects with speed ($p = \gamma mv$) is not due to a linked spacetime. The increase in the difficulty of changing velocity (inertia) seen with high-speed movement does not mean that mass increases with velocity. This should not be possible with a background-independent theory (SR and GR) unless apparent effects become real. However, it is stated as fact in many texts, including Feynman's lectures in physics. If an object stores more energy when accelerated, then it should be expected to freely release this energy by slowing. The inertia of the same amount of energy must be what changes.

In his 1905 paper [30], "Does the Inertia of a Body Depend upon its Energy-Content?", Einstein derived $E = mc^2$. The derivation is based on the claim that, for a relatively moving observer, energy and momentum transform into one another. This assumes that the "principle of relativity" holds. However, the principle holds (at low speeds) within any inertial frame, but not between frames with different backgrounds. He went on to conclude in 1907 [16], that the inertial mass and the energy of a physical system are equivalent (for all frames). Consequently, there is a widespread acceptance of the fallacy that the mass of a body increases when its velocity increases (following $p = (\gamma m)v$). Okun has pointed out [41], that only a small minority of physicists know that Einstein's true formula is $E_0 = mc^2$, where E_0 is the energy contained in a body at rest, and that the mass of a body is independent of the velocity at which it travels. However, the faulty belief is widespread [42].

A notable difference for FR relative to GR is that, under FR, photons will travel faster, rather than slower, when nearer to a massive object. This seems to contradict the experience with refraction in materials where light is bent in proportion to the slower speed through the material of higher refractive index. However, in refraction the bending arises at the boundary and is determined by the length of path parallel to the direction of motion, per unit time of the wave-function, with distance perpendicular to the direction of motion. In cosmology, the comparison is between the bent paths of separated photons emitted in different directions, as they travel through a massless medium free of large gradients in electromagnetic fields from arrays of charged particles. The oscillations of a photon are transverse to the direction of motion, so an increase in speed perpendicular to the light path should cause a bending towards the direction of the increase in speed. The GR-predicted Shapiro delay of signals passing near a massive object should be sensitive to a change in the speed of light. The delay has been well confirmed. However, it can be shown that the experimentally determined delay is that due only to the change in path length due to the bending. The method used hides changes in signal arrival time with light speed which can be absorbed into the estimated orbital path. This claim is more fully examined in Section 5.5.2.

4.5.1 Mass, energy and momentum re-visited

It is hypothesised that the nature of elementary particles follows from the interactions of wave components (oscillations) associated with a two-component chiral background. The photon is a freely oscillating travelling state of a balanced set of opposite chirality components (spin 1) which carries energy of movement to a new location. The movement energy that can be transferred to a massive particle depends on the relative velocity of the source and receiver of that photon, as per the classical Doppler shift. This shift in frequency with relative velocity implies that, although photon speed is independent of the speed of the emitting and receiving object, the spacing between the electric and magnetic fields of a photon, in the direction of motion of the photon, is set at emission but can be altered by relative motion of the receiving object. This enables the difference between the relative velocities of source and receiver to be conveyed by the photon. The momentum of a photon is carried in oscillations/rotations perpendicular to the direction of motion, but the amount that can be delivered depends on relative motion. The relativistic (i.e. high-speed) Doppler shift arises because the inertia of a massive particle's trapped momentum depends on its velocity relative to the background. The apparent mass of the photon is zero because there is no resistance to motion at the speed of light. This, in turn, is because there is no trapped momentum in the direction of motion, not because there is no energy of movement being carried to a new location.

Massive particles confine movement to a location. The confinement necessarily involves balanced forces, maintained by opposing rotations, about a mean position. A change of this mean position, relative to its movement at the current velocity, i.e. a change in the pattern with time, requires a force. The size of the force depends on the rate of change of position and on the speed of the current movement relative to c, and the mass and inertia, determined by the magnitude and asymmetry of the background. The photon is seen to resist changes in its speed and direction by imparting momentum in electromagnetic interactions, and so has inertia, but has the constant speed of a free oscillation in the direction of motion.

If the three neutrinos (spin ½) are massless then they are also freely travelling states with zero net oscillation along the direction of motion. Any net rotation is confined to the plane perpendicular to the direction of motion. A massless graviton (if it exists) must also be a freely travelling state, although FR would have it as spin-less rather than spin 2 (and not oscillating and not carrying energy).

It appears that energy and momentum are both conserved for a photon (even though c varies). Hence, $E = pc$ and the energy that can be delivered depends on the relative speeds of the object and photon that interact. If this was also true for massive objects then the observed momentum and energy would always be proportional to v. However, the momentum of massive objects is observed to increase non-linearly with velocity ($p = \gamma mv$), even for a constant background (no field of gravitational acceleration), and the decay rates of unstable states decrease by $1/\gamma$. The necessary conclusion is that massive objects are sensitive to speed of movement relative to a background.

This behaviour is observed for both charged particles and for neutral particles produced by charged particles. The change in inertia and decay rate depend on velocity, and their values are independent of how the velocity was achieved. Knowledge of changes in decay rate with velocity is primarily limited to decays involving weak and electromagnetic interactions but is presumed to also apply to strong interactions. Decay rates are proportional to the change in stored energy levels between the initial and final states. However, the increase in momentum with velocity does not require gravitational mass to increase with velocity if the inertia of the same amount of energy increases. Moreover, if mass did increase, then decay rate would be expected to increase rather than decrease.

As explained in Chapter 2, the LT arises from the finite transmission time of electromagnetic fields provided the time of the moving object is slowed by $1/\gamma$. If inertia is determined by, and proportional to, the frequency of oscillation, then mass would have to increase by γ^2, to give $p = \gamma mv$, and the increase in available energy would be expected to increase the decay rate. Instead, under FR, the amount of stored energy of a particle state does not change with movement relative to the stationary background, but the resistance to change (inertia) increases with velocity. The slowed frequency (clock-rate) of the moving object indicates changes in a pair of counter-rotating components. The amplitude and speed of rotation of these components reflect the amount of stored energy but their alignment with the direction of motion depends on speed relative to the stationary background.

Massless electromagnetic fields propagate at a speed that is independent of the velocity of the emitter, but the transfer between source and receiver of the energy carried by a photon depends on relative motion. However, if the photons are emitted by a massive object, then the frequency of emission corresponding to a given change in momentum of the object can be different. This will occur when the inertia of massive objects changes because of speed relative to a stationary background. It is proposed that a stationary position in this background corresponds to a location where opposing components of the background are equal. Equality can also be achieved if the object is free to accelerate. This will generate a force that matches any gradient in the clout of the background. The energy stored by the particle reflects the momentum trapped by the opposing oscillations of the components that make up the particle. A change in movement relative to the current balance induces opposite effects on the counter-rotating components. Energy is required to change the orientation and magnitude of these components relative to the direction of motion, but they retain their new values if speed relative to the balanced background subsequently remains unchanged.

The reduction in decay rate of particles moving at high-speed relative to the background is then a real effect from rotation frequency of massive objects being sensitive to motion relative to a balanced background. The effects on apparent distance and velocity due to relative motion and finite signal speed, plus the real change in decay rate, mimic the effects of the changes claimed by SR. In the limit of high speed, compared to the current speed needed to obtain a balance, the clock-rate of massive particles moving in any direction is reduced by the factor gamma. This is a radical change in perspective. Under SR, $p = \gamma mv$ is interpreted as the apparent mass increasing with relative velocity, because of changes in time.

4.5.2 Space and time re-visited

The new physical picture changes the understanding of space and time and the way in which they are linked. The relationship between time and space is now more fluid but, individually, time and space have clearer meanings in terms of the rate of events and the distance between objects. Clock-rate indicates the relative rate of events involving the energy, movement and interactions of the same massive objects in different environments. Observers can relate measurements at different locations, with different backgrounds, in terms of relative rate and separation (u-time and distance). The magnitudes involved in the laws of physics depend on the background.

In Section 3.2 it was proposed that, although mass and the speed of light are variable, a relative underlying rate of passage of time exists and that spatial distances are undistorted. The distance between separated objects that are stationary relative to each other, with vacuum in-between, remains fixed (even if atoms change size). A change in such a constant spacing requires a force giving an acceleration. Space exists in terms of a constant separation and direction of objects if they initially move at the same velocity and neither accelerates (assuming the backgrounds experienced by the two objects are the same or stay in a fixed ratio). Constant distance is not the same as constant size because the latter depends on using massive rods whose length varies with the background.

The underlying time (u-time) is distance divided by the speed of light. Time can also be seen in terms of the clock-rate of events, e.g. the ticks of a massive clock. An "energy clock-rate" allows for changes in the stored energy of the "same" massive object with changes in the background according to

$m = E / c^2$. If identical sets of events, centred on two locations at a fixed separation, remain synchronous, then time, in terms of clock-rate, is the same. Such an "energy clock-rate" will vary with the energy of stationary atoms but an "inertial clock-rate" will need to take the asymmetry of the background into account if the clock's mechanism is based on inertia or speed of movement of massive objects rather than just the energy of atomic transitions. The same energy clock-rate will only apply to the movement of massive objects if inertial (i.e. kinetic) energy maintains the same relationship to gravitational energy. However, FR proposes that frequency and the magnitude of inertia vary with speed relative to the background and with the asymmetry of the background. If the inertia of gravitational mass varies, then the "inertial time" based on movement of massive objects must correct for speed and asymmetry to yield the underlying energy clock-rate based on atomic transitions.

There is very strong evidence that the ratio (m_i / m_g) is fixed, independent of the nature of the materials, but this is for the identical amount of stored energy at the same location. On the other hand, the rise-and-fall times of the light curves of distant type 1a supernovae appear to vary markedly yet the total energy emitted (the area under the light curve) is nearly constant. The rise-and-fall time will depend on the rate of movement and decay rates at the supernova location and so is strong evidence that inertial clock-rate can vary with location, even where there is no field of gravitational acceleration. According to FR, the rate should depend on the magnitude and asymmetry of the background at that location. Changes in asymmetry will appear like a change in the strength of gravity.

4.5.3 A path to avoiding the need for dark matter

The inertia and oscillation frequency of a photon appear to reflect its energy and the asymmetry of the background. The energy of massless objects is conserved but their direction of travel can be altered by gradients in the background because they affect their oscillation frequency and wavelength. If the background is constant, then the direction and speed of massive and massless objects is constant. If the clout of a homogeneous background changes, then the speed of light will change but the mass of photons will remain zero. The asymmetry of the background will decrease with distance from a concentration of matter or antimatter in a uniform background, so the local frequency and (transverse) inertia of photons can change although the magnitude of momentum is conserved.

The approximately flat rotation curves of isolated spiral galaxies require the force of gravitational attraction to be matched by the centripetal acceleration force. Hence, $G_N Mm / r^2 = mv^2 / r$ and $M = (m_i / m_g) r v^2(r) / G_N$, where $m_i / m_g = 1$ for the current, local background. The conventional explanation of the constant speed independent of r, under both Newtonian gravity and GR, is that the enclosed mass $M(r)$ is increasing linearly with distance from the centre of the galaxy. The alternative, under FR, is that inertia (m_i / m_g) is decreasing as $1/r$.

The change in mass with the speed of light accounts for gravitational attraction and the decrease in inertia can account for the flat rotation curves of isolated galaxies. The $1/r$ dependence of clout means that distant matter (that from our and other galaxies) provides most of the background that determines the speed of light. However, it is proposed that the asymmetry within an isolated galaxy can be dominated by that galaxy. A fractional asymmetry $(A - \bar{A}) / (A + \bar{A})$ will tend to $\delta A / 2A$ as $A - \bar{A}$ tends to zero (see Section 4.3.2). FR proposes that the frequency of wave-functions depends on the magnitude of the asymmetry and that the speed of the oscillation determines the resistance to movement. The effect is to decrease inertia, at large distances from a concentration of like matter, by a similar amount to that by which the gravitational attraction from that same matter reduces. This removes the first reason for postulating dark matter. The explanation is elaborated in Section 7.3.

The observation that the rotation curve of our solar system is so different from the flat rotation curve at large distances from the centre of our and other galaxies implies that the background asymmetry must be little affected by distance from our sun, but significantly affected by distance from the centre of our galaxy. It also means that the amount of matter in the super-massive black hole at the centre of galaxies is underestimated from the rotation of nearby stars because of the increase in inertia, although the stored energy per unit of matter will be lower due to the increase in the speed of light.

The second reason for postulating dark matter lies in the larger than expected gravitational lensing of galaxies and galaxy clusters. Under FR, this is also removed because the bending of light is from changes in oscillation frequency. It is argued that it should be twice that expected from the change in gravitational potential (see Section 5.5.2), and so will mimic the prediction of GR based on both time and space being distorted. There will be discrepancies in the predicted amount of bending when regions with different background asymmetries (to that observed locally) are compared. If inertia is proportional to the frequency of oscillation and the frequency is determined by the asymmetry, then the putative amount of dark matter needed to account for gravitational lensing will match that needed to explain the flat rotation curves.

Evidence against the need for dark matter comes from a study of the rotation rate at different distances from the centre of spiral and irregular galaxies. It was found that the radial acceleration is strongly correlated with the amount of visible matter attracting it – but the relationship does not match that predicted by Newtonian dynamics [43]. The strong correlation implies that, if dark matter exists, its distribution is fully determined by the baryonic matter. The change in inertia, under FR, provides a simple explanation of the relationship with visible matter without the need for dark matter. Further aspects of this explanation are set out in Chapter 7.

4.6 Elaboration of the changed perspective and hypotheses

It is proposed that observations are consistent with the following set of hypotheses.

1. Gravity and the Strong, Electromagnetic and Weak interactions all arise from the same background.

2. Gravity is much weaker because the magnitude of trapped energy/momentum depends on the speed of light which is proportional to the magnitude of a scalar background (clout). Therefore, the contributions from all sources add so fractional changes in the total background are generally small.

3. All forces involve exchange of momentum (vector) components, in which total momentum is conserved, between states that arise from multiple oscillating components of the background. For gravity, the opposite direction of motion of attracted masses enables momentum to be conserved.

4. Momentum, energy and mass are, in total, conserved; but their relative magnitudes depend on the size of the chiral components of the background via their effect on the speed of light and inertia.

5. Distance, as a constant measure of separation (dx) between stationary objects (and those not undergoing relative acceleration), exists independent of the background.

6. A constant time scale exists in which energy and momentum are conserved, and in which the speed of light varies (time intervals decrease as dx/c) and clock-rate increases in proportion to c, but in which c depends on the magnitude of the background, and inertia and speed of movement also depend on asymmetry.

7. The particle states of both bosons and fermions are determined by the number, amplitude, phase, and orientation of components sensitive to the background from matter and antimatter.

8. Inertia arises from, and depends on, the difficulty of changing the pattern of trapped momentum, with inertia proportional to trapped momentum times an asymmetry factor dependent on the contributions to the background from matter and antimatter.

10. The speed of light depends jointly on the magnitudes of the pair of background components.

11. The chiral components become balanced with the angular momentum due to the weaker component needing a larger amplitude and increased frequency to match the stronger component.

12. The chiral components of the background and the resulting oscillations that give rise to stored energy and inertia are present for photons and massive objects and so must be equated with the wave-functions and time dependence inherent in Schrödinger's equation and QM.

13. Gravitational "waves" are changes in the magnitude of clout that propagate at the speed of light.

Some consequences include:

The $1/r$ dependence of clout requires that the background field does not carry energy but affects the energy that can be carried and stored by the oscillations of the field (i.e. of the objects embedded in the field). Thus, gravitational "waves" do not carry energy but the energy of objects and the speed of light are altered by the change in clout from the changes in mass and distance of objects.

Although the stored energy of the same amount of matter increases in proportion to $1/c^2$, the conversion between inertial and gravitational mass will change with asymmetry. Inertia will decrease steadily at large distances from the centre of an isolated concentration of matter in an otherwise uniform background of similar densities of matter and antimatter. However, the speed of light will change in proportion to the fractional change in clout.

The strength of gravity in terms of changes of stored energy (gravitational mass) will vary as $1/c^2$ and as $1/c$ in terms of changes of momentum. However, the concept of momentum needs to include the dependence of inertia on the asymmetry of the background. Energy will be required to change the balance of the oscillating components relative to the background but there is no change in the energy relative to the centroid.

The decrease in stored energy with increasing speed of light strongly suggests that the trapping of momentum is dependent on the time taken for a component fluctuation in the medium to be cancelled by the fluctuation of another component. This will relate to the chiral nature of the background, the type of components and the nature of the periodic oscillations that can be sustained. Ultimately, this must tie in with the Standard Model of particle physics (see Chapter 9).

4.7 Summary

GR has the fabric of spacetime (the metric) between objects of constant mass distorted by gradients in the surrounding amount and movement of energy, while the speed of light is constant. FR has space undistorted but massive and massless objects altered; with the speed of light, mass, momentum, time, and size varying according to the amount and movement relative to a surrounding clout from both matter and antimatter. For a small change in gravitational potential ($\Delta\Phi$) GR has $\Delta\omega_p / \omega_p = -\Delta\Phi / c^2$ for the <u>photon</u> redshift, while FR has $\Delta\omega_a / \omega_a = \Delta\Phi / c^2$ for the <u>atom</u> blueshift. The two theories give similar results for small changes to the current background energy density and speed of light. GR has the kinetic energy of gravitational acceleration coming from a distortion of spacetime by the field of gravitational acceleration and all energy contributing to gravitational attraction. On the other hand, FR has the change in energy from gravitational acceleration coming from a reduction in the mass of particles, while the energy of massless particles is unchanged after emission. For massless particles, their speed, relative to c, and the magnitude of their momentum are unaltered by a gravitational field. However, their direction can be altered by a gradient in asymmetry and the value of c is determined by the value of the total background, not its gradient.

The many successful predictions of GR have led to the strong belief that only a metric theory of gravity is possible. However, it should also be accepted as unlikely that the spacetime between objects can expand and contract without the speed of the light or the properties of objects, travelling or embedded in that spacetime, changing. Gravitational effects should be attributed to changes in the properties of objects (i.e. FR) rather than to changes in the spacetime between them (i.e. GR). This echoes the change in perspective from a photon being redshifted as potential increases to that of massive objects being blueshifted as clout decreases. The two gravitational theories yield similar predictions when the background and its asymmetry are similar to those currently observed locally.

The revised perspective requires changes in the understanding of time intervals and clock-rate, beyond that set out in Chapters 2 and 3. GR has the time interval dt of clocks at a higher gravitational potential being larger and interprets this as more time occurring (faster clock-rate). The smaller time interval at a lower potential, nearer to a massive object, is taken to mean that light waves will not travel as far, so that light is bent towards the massive object. Thus, GR assumes that there is a dilation of "time" (clock-rate) that applies to the spacetime in which photons and massive objects travel. The change in time accounts for half the bending. GR also claims that there is a matched decrease in the size of space (distance between objects) so the combined distortion gives twice the earlier predicted bending. The distortion of the invariant interval of Minkowski spacetime incorporates the faulty inverted distance versus time interpretation of the LT under SR. Without the inversion GR would predict no bending of light. The tensor formulation of GR using gradients also means that spacetime distortions are independent of a uniform, stationary background.

Under FR, the change in stored energy, as the field of clout from surrounding matter and antimatter changes, provides an explanation for gravity. However, the background must have additional effects if momentum and inertia are to be understood and if light is to be bent by a gravitational field. The Higgs mechanism and the observation of the Higgs boson confirms that mass and inertia are associated with a breaking of chiral symmetry. The observed nature of elementary particles and their interactions indicates that they and the background arise from two components of opposite chirality. Such a background appears to be able to explain observations including the properties of momentum. This claim and the nature of the background need careful examination.

It appears that the strength of clout, the magnitude of the background, arises from a balance of the fields due to the trapped momentum in matter and antimatter. The speed of light is proportional to this magnitude. However, the resistance to changes in constant motion (inertia) depends on the asymmetry between the chiral components. The speed of movement of trapped momentum, in response to a given force, then depends on asymmetry as well as the speed of light. It also depends on speed relative to a balanced background. Thus, inertial clock-rate depends on asymmetry via inertia, and the ratio of inertial mass to gravitational mass will not be constant.

The changed perspective is from a pseudo-background that alters the perceived time and space of events to a real background that affects the properties of objects. Momentum is conserved but the apparent energy depends on the speed of light (i.e. $E = pc$) and the motion of the observer and object relative to the background. The mass of an object is equivalent to its rest energy (E_0) and mass does not increase as the object gains kinetic energy. Massless objects have rotating components in the plane perpendicular to their direction of motion but the oscillations propagate at a constant velocity.

The assertion, under FR, that gravity arises from the energy stored by all forces means that all the properties and interactions of objects arise from different aspects of the one background. Ultimately, it means that the observed properties of gravity must be related to those of the other three forces. This leads to many new predictions, including for the effect of changes in the distribution of matter on the strength of gravity and rate of change of time; then for other aspects of cosmology. The properties of all elementary particles, notably their masses, should also be predictable from a knowledge of the current background. Models of the nature of photons and leptons should also give rise to a relation between the magnitude and asymmetry of the background seen in gravitational and inertial parameters and Planck's constant for the current background.

Immediate consequences of FR for our understanding of the cosmos and how it can reproduce so many of the successful predictions of GR are set out in the next chapter. New astrophysical predictions due to FR, that are not expected from or explained by GR, are set out in Chapters 6 and 7. Some possible experimental tests for distinguishing FR from GR are set out in Chapter 8. The unification of gravity with other forces via the shared background means that the quantum mechanical interactions of particle physics and the properties of gravity must be related. The implications and some predictions for particle physics are set out in Chapter 9.

Chapter 5

Consequences for our understanding of the cosmos

The revised theory, with particle and photon properties and the speed of light dependent on a two-component background, but with photon energy unaltered by a gravitational field, has many consequences for our understanding of the nature of the cosmos and interpretation of observations.

Clout is proposed to arise from the energy stored in both matter and antimatter with an increase in the clout from mass M in a region of only one type of matter falling off as M / r with distance. The de Broglie wavelength of matter and photons obeys $p = h / \lambda$ within a constant background in which, under FR, distance is not distorted. If energy and momentum are both conserved, then the concepts of the quantity of movement energy ($E = pc = mvc$) and stored energy ($E = mc^2$) must be adjusted for different dependencies on a variable speed of light. This occurs naturally if both v and c are distances per unit of u-time. A given change in the momentum per unit u-time then corresponds to the same force and work (change of energy) remains the integral of the force over the same distance, i.e. $F = dp / dt = dE / cdt$ and $W = \int Fdx$. The amount of trapped momentum is then expected to be inversely proportional to background clout (for constant inertia), with the speed of light directly proportional to total clout. The wavelength increases as stored energy decreases. However, the inertia of a given amount of trapped momentum will depend on the asymmetry between matter and antimatter components.

5.1 A revised understanding of Newton's law of gravitation

Newton's law has the gravitational force on a mass m_g due to a point mass (M) at distance *r* as:

$F = G_N M m_g / r^2$.

This force per unit of inertial mass m_i gives rise to a gravitational acceleration of $\vec{g} = \vec{F} / m_i$. The force is the gradient of a potential, an energy per unit of gravitational or inertial mass.

Under GR, gravitational and inertial mass are considered equivalent and their units are equated. Under FR, inertia is determined by the asymmetry in the large but nearly balanced contributions from matter and antimatter. If G_N is assumed constant, then the apparent ratio m_i / m_g will increase when inertia increases. This will occur near isolated concentrations of matter such as the Earth, Sun or our galaxy, if the backgrounds from distant matter and antimatter are nearly equal.

The asymmetry should be approximately constant within our solar system to the extent that the contributions from the solar system are modest relative to the contribution from our galaxy. If the core of our galaxy has 150 billion solar masses at a mean distance of 8 kpsec, then the contribution of the Sun at the Earth's orbit is about ten times that of the Earth at the Earth's surface but only one hundredth that of just the core of the galaxy. Changes in asymmetry that alter inertia, and hence kinetic energy (KE), can only give rise to a small gradient in the ratio m_i / m_g within our solar system because the magnitude of the variation in this ratio is reduced by the larger galaxy asymmetry. If the locally observed values of m_i and m_g are equated then the effect of the local asymmetry on inertia has been absorbed into the value of G_N with $G_N' = (m_g / m_i) G_N$. F' is then the apparent value of F at another location. The ratio F' / F will be in proportion to (local asymmetry)/(asymmetry there).

Under FR, total energy and momentum are both conserved, with the energy lost as mass appearing as KE of motion. The KE gained by falling objects comes from a loss in their stored energy. Energy is conserved but a massive object cannot store as much energy when the speed of light increases as the background increases. The gain in stored energy per unit of gravitational mass in raising an object distance dx against F is:

$$\int (F / m_g) dx = \int G_N M / r^2 dr = -G_N M / r + constant \qquad (5.1)$$

with distance r from a point source of mass M,

and $\quad \Delta KE / m = \Delta(mc^2) / m = -G_N M / r + constant \qquad (5.2)$

if the gain in KE per unit of mass comes from the loss in stored energy.

Hence, the fractional change in energy or mass over distance dx is:

$$\Delta E / E = \Delta m / m = -G_N M / rc^2 + constant \qquad (5.3)$$

The acceleration of an object arises from the gradient per metre, of the fractional change in its energy with distance (d metres), from a point source of mass M, i.e. $-G_N M / dc^2$.

The clout from a point source of M kg at d metres, is M / d times the clout of 1 kg at 1 metre, for the current local value of the background that determines G_N via c and asymmetry.

If the clout (ρ_B) from surrounding (i.e. background) sources is much larger than the clout from M kg at d metres, and is constant and uniform, then the local fractional change in total clout is:

$$\Delta\rho / \rho_B = (M / d) / \rho_B \qquad (5.4)$$

For small changes, the fractional change in mass should be minus the fractional change in the background clout (ρ_B) that causes the change in mass. Hence:

$$(m + \Delta m) / m = \rho_B / (\rho_B + \Delta\rho) \text{ and } \Delta m / m \cong (-\Delta\rho) / \rho_B \qquad (5.5)$$

and: $\quad G_N M / rc^2 = M / r \rho_B \qquad (5.6)$

giving a local background clout of $\rho_B = c^2 / G_N$ = 1.3467 x 10^{27} times the local clout from 1 kg at 1 m, using G_N = 6.67408 × 10^{-11} $m^3/kg.s^2$.

Equating local KE and gravitational energy removes the ratio of inertial to gravitational mass (of the same amount of matter) from being included in G_N. If inertia decreases elsewhere, then m_i / m_g decreases and the apparent value of G_N (i.e. G_N') will appear to increase. The dependence of G_N' on inertia will be determined by the fractional change in asymmetry relative to that at our location. This asymmetry should primarily be from the local excess of matter over antimatter due to our galaxy.

Newton's law of gravitation reflects changes in energy of a small, massive object with distance from a concentration of stored energy. A changing clout with distance from a source of stored energy produces a gradient in mass (stored energy) and a gradient in inertia of the small test mass. The observed gradients reflect the fractional changes in mass and inertia of the object due to the effect of a fractional change in total clout (determining the speed of light) and to the change in asymmetry when only one of the two background contributions changes. These gradients give rise to the gravitational field and the resultant forces and acceleration experienced by all massive objects.

There are some subtle differences between FR and both Newtonian gravity (NG) and GR. The latter two have the strength of gravity related to the gradient in flux density from mass but independent of a uniform, isotropic background of mass. However, under FR the clout from a uniform background affects the strength of clout from a local anisotropy due to the same amount of matter. NG and GR effectively assume that there is no contribution to the potential (which arises from changes in clout) other than from the difference that gives rise to the gradient in the potential. This removes the contribution of a constant background. FR has the value of G_N and mass determined by the total background via the speed of light. NG and GR have a constant speed of light and mass independent of the total background. The variation of mass is hidden because the acceleration per unit mass is used. The expected gravitational force, under NG and GR, assumes a fixed ratio of inertial to gravitational mass. FR proposes that the apparent force at another location is determined by the asymmetry of a two-component background, and is dominated within an isolated galaxy by that galaxy. The small gradient in asymmetry within our solar system is determined almost exclusively by the Sun. The effect, at most, rivals that of the galaxy close to the Sun but further away should be almost negligible.

The dimensionless energy equation 5.3 should apply to all regions in which energy is conserved, i.e. is independent of time. This implies that G_N / c^2 in m/kg, i.e. when the unit indicating the amount of matter is kg, will be nearly constant locally if distance and time are in units which are independent of background. If both energy and momentum are conserved, then the equation should be independent of time and distance, provided the values of G_N and c (which incorporate time) are based on the correct understanding of energy and of time versus clock-rate. This implies the use of u-time which is independent of c. The equation incorporates the relationship between energy and momentum which depends on c, but assumes that the clock-rate used is independent of asymmetry.

This (Newtonian) equation appears to hold fairly accurately within our solar system because the large background values of stored energy and the speed of light hardly change within the periods of time and the differences in location being examined. Under FR, there will be a fractional change of energy stored as mass giving a change in kinetic energy of $G_N M / rc^2$. However, the value of G_N must incorporate any differences in asymmetry with time or location. The change in mass of $G_N M / rc^2$ will, because of conservation of momentum, alter the speed. This mimics the correction factor of GR due to the distortion of time ($\Delta\Phi / c^2$) that causes the advance in the perihelion of Mercury. Any change in the value of asymmetry within our solar system is likely to be small, because the background asymmetry should be comparable to or larger than that from the Sun. If not, the value of G_N would change with distance from the Sun. However, if the change in asymmetry due to M is in proportion to M / r, then its effect on G_N may be hidden by being absorbed into an altered value of M.

The gravitational acceleration, $g = F / m = \nabla\Phi = G_N M / r^2$, applies to the inertial force per unit mass because the equation $\Delta E / m = G_N M / r$, or $\Delta E / mc^2 = (G_N / c^2) M / r$, deals with changes in kinetic energy from overcoming inertial forces. $G_N M / rc^2$ reflects the fractional difference in stored energy due to movement of a massive object towards a point source of mass. This energy appears as the kinetic energy of the object, which reflects its resistance to changes in velocity. Thus, the relationship between kinetic energy and stored energy will depend on inertia but the value of $G_N M / rc^2$ solely reflects the ratio of the background from mass M to that from all other masses (within the limit that the measurements are made within a region of constant asymmetry).

The gravitational potential (Φ) is the work done, per unit mass, to move that mass (unit distance) into a region of reduced clout. The gradient, of Φ / c^2, is the fractional rate of change of stored energy with distance. Under GR, the gradient of Φ gives rise to a force and the integration of the gradient means that a constant can be added to the potential. The force therefore appears independent of the absolute value of the potential. The observed accuracy of Newton's equation seems to imply an independence of background energy. However, this is because the potential is per unit matter and the effect of an amount of nearby matter (with current mass M) is influenced by the much larger background in the same manner. GR therefore appears consistent with Newton's law of gravitation being due to differences (gradient) in potential, i.e. appearing independent of an absolute background.

A consequence of full background dependence is that the gravitational effect of distant galaxies is much more important than previously thought. GR assumes that mass is constant and the force of gravity arises directly from the acceleration field due to the distortion of spacetime. Therefore, the effect of a source decreases inversely as distance squared. However, FR has the total background determining behaviour, but it is so large that its slope appears independent of the total. The contribution of each mass (M) to the large background only declines inversely with distance, not distance squared. The force appears to arise from a gradient proportional to M / r^2 and the contribution of the enormous uniform, background is not noticed. However, the magnitude of the force depends on the background.

There is strong evidence for such an M / r dependence, rather than the M / r^2 dependence inherent to GR. An example, is the behaviour of a large, nearly frictionless, oscillating (Foucault) pendulum. Its oscillation arises from the interchange between the kinetic and potential energy of its massive bob in the Earth's gravitational field. If the responsible field varied as M / r^2 , then the Earth would dominate over the Sun, and over distant galaxies, and the plane of oscillation would be expected to remain fixed relative to the Earth. However, the plane of oscillation remains constant relative to the distant stars, and changes as the Earth rotates. An M / r dependence reverses the order of importance.

The new concept is that there exists a two-component background field that allows oscillations with a sense of handedness. Opposing oscillations can trap energy and resist changes in the movement of this energy (i.e. accelerations). The background field affects the speed of light, the oscillation frequency of waves, and the stored energy of massive objects embedded in the background.

FR and GR can be consistent with the various tests that indicate that G_N does not vary with time because the amount of matter (kg) is conserved in the tests [44], and distance (space) is undistorted.

5.2 Implications for the development and expansion of the universe

FR has mass per particle reducing when the background clout increases. It also appears to predict that inertia and rotation frequency will drop to zero when the two chiral background contributions are equal. Therefore, there would have been rapid movement and annihilation of matter and antimatter near the boundaries of equal contributions early in the life of the universe. This appears likely to have led to separated regions of the remaining matter and antimatter. Modelling is needed to determine whether it would lead to interlaced regions within which matter and antimatter were gravitationally bound to like matter. In this case an annihilation signal would no longer occur while most of the initial matter and antimatter particles would have annihilated during the formation of the separate regions. This might explain the photon to proton ratio of approximately one billion. The amount of matter and antimatter would always be equal but exist in separate locations.

If the universe was expanding, the mean background would decrease, so the stored energy per unit of matter would increase via loss of kinetic energy (which would oppose the expansion). Orbital radii would also decrease, moving matter closer together. Hence, galaxies (concentrations of matter) would be expected to shrink and the existing matter become more strongly bound. However, the increase in clout per unit of matter from local clumping would oppose the decrease from any general expansion. If there was a boundary to the universe then gravitational attraction should strongly oppose expansion, and it is not clear that ongoing expansion would occur. Under FR, the redshift of distant galaxies indicates that clout is decreasing over time. However, the redshift does not confirm that an expansion is causing the decrease in clout.

The clumping of matter, within a uniform background, decreases the stored energy per unit of matter and the speed of light will increase within that clump but decrease outside the clump. Objects moving closer gain KE and lose mass. However, the gain in KE from the reduction of stored energy can cause the masses to move past each other and apart again. If the background is constant over time and there is no dissipative mechanism, then the situation reverses as the objects subsequently separate, as occurs with elliptical planetary orbits. If there is a dissipative mechanism then the KE is randomised (becomes heat), is absorbed (becomes mass) or is radiated, which will eventually be absorbed elsewhere. (It is not clear whether massless radiation would contribute to clout.) If the background reduces then objects can be expected to move closer together or shrink by just the amount needed to maintain the same standing wave patterns and conserve the trapped energy of motion.

The local change in the sum of clouts, due to clumping of sources of constant mass about a mean distant location, is negligible. However, clumping increases asymmetry and, under FR, this will increase inertia within the clump, which will slow the time and movement of massive objects leading to contraction of orbits. The stored energy per unit of matter will decrease as like matter concentrates within regions even if the total amount of matter/antimatter (and, hence, average matter density) is constant within a stationary (non-expanding) universe. This is because the clout arises from stored energy and the amount per unit of matter, and per unit of inertial time, increases with increased clumping of like matter, because the inertial resistance to movement increases.

Hence, the clumping of matter can reduce the background clout, even if there is no change in total matter. Thus, it appears that clout should decrease as the universe evolves, leading to an increasing redshift going back in time, without expansion being required. A concentration of like matter would contract more rapidly in a region where the change in inertia with asymmetry is maximal per unit of inertial clock-rate. A galaxy might then evolve into a disk with a core where the asymmetry was so large that changes in inertia with changes in clout became small. The strength of gravity between objects rotating about each other (within a region of large asymmetry) would appear to decrease but would most likely be attributed to a lower-than-expected mass of the components. The mass and amount of matter of the black hole at the centre of a galaxy would then be greatly underestimated.

If the background clout is decreasing, then the energy and frequency of massive objects would also be increasing over time. Larger clout at emission relative to now would lead to redshifts in the light from distant galaxies with increasing travel time of the light. However, comparisons of theory and experiment must also take into account that an increase in asymmetry is proposed to lead to a faster oscillation frequency per unit energy. Thus, if asymmetry was increasing over time at our location within a galaxy of like matter, then the frequency of light of the same energy would be increasing. Increasing asymmetry would change the local relationship between energy and frequency, i.e. the value of Planck's constant. However, if stored energy is independent of asymmetry and photon energy is unchanged, differences in the value of h at the source are hidden. Photon energy would be independent of the value of asymmetry and h at the time of emission. The observed redshift will be due only to the change in energy with the change in the speed of light. This potentially enables the contributions of the different components of the background to changes in energy, asymmetry and frequency to be resolved. It needs to be tested.

The implications for the structure and distribution of galaxies and the rate at which galaxies should have formed, and the distribution of galaxy velocities with degree of clumping, requires modelling to see if it accords with observation. The changes in distant clout also take longer (u-time) to propagate because the mean speed of light, away from the clump, reduces as clumping increases. Clumping means that, for an isolated galaxy, there will be an ongoing decrease in surrounding background clout with time. The redshift of distant galaxies can be expected to increase in proportion to the mean rate at which the speed of light changes due to clumping. Therefore, the galaxy redshift does not seem to require an expanding universe, which presumably means that a Big Bang was not necessary. Moreover, time (in terms of the clock-rate applying to energy of the same objects) is getting faster.

5.3 Black holes are not as currently envisaged

Under FR the energy of an already emitted photon is not changed by a gravitational field. An increased clout, arising from a gradient in the background from other matter, will mean the energy of the same transition will decrease (and clock-rate will slow), but, if they can be emitted, photons will not be trapped by losing energy. For a black hole there will be no event horizon at which time goes to zero or that information travelling at the speed of light cannot cross. However, photon direction can be altered (see Section 5.5.2) in moving through a gravitational field. Under FR, the stored energy and energy levels of all particle states reduce with increasing background, avoiding the GR-predicted singularity at the centre of a black hole, and the matter can still exert a gravitational influence outside the (GR) event horizon of a black hole.

Under GR, the distortion of spacetime becomes so great that the passage of time goes to zero at an event horizon, from beyond which no signals or information travelling at the speed of light can ever escape. However, GR (and FR), and observations, have it that gravitational waves (or influences) travel at the speed of light, so no gravitational change could propagate out of the GR-hypothesised black hole. Any external distortion of space should disappear at the speed of light as soon as an event horizon formed. If it is claimed that the distortion remains, but the internal gravitational field does not propagate across the horizon, then the external distortion can no longer change and hence cannot move. Yet putative black holes are observed with a revolving star, and in binary black hole systems.

The observed propagation of gravity outside a black hole is evidence against the strength of gravity being redshifted, as claimed for light under GR. Under GR, the redshift of a wave travelling at c becomes infinite at the event horizon. The propagation of gravity would then imply that gravity does not have an oscillating wave nature and therefore should not be quantized or have spin 2. Under FR, propagation of light and gravity at the same speed implies that propagation of an increase in background clout (a change in gravity) is also independent of any energy carried (as with light). The observation of the coincidence in the arrival time of light and gravitational waves from a distant source then implies negligible difference in their bending along the path travelled.

Under GR, the enormous density of the early universe would have also meant that matter started off inside a black hole. The galaxies of the current universe could never have escaped unless the laws of physics have changed. Our existence and black holes are inconsistent with the GR postulate that the laws of physics are independent of time and place.

This is not to say that extremely dense concentrations of matter do not exist. However, the evidence that they are "black" holes hiding singularities is all indirect. There is good reason to believe that objects denser and more massive than neutron stars exist, but they should not be black due to redshifting of light after emission. Under FR, the concept of a black hole as an object dense enough to trap light by loss of energy is faulty. Light (if generated) could still escape, except that a sufficiently strong gravitational field would bend light paths back on themselves. In addition, there would be no atoms only a quark/gluon plasma or some unknown low mass (stored energy) state of matter, so light might no longer be emitted. The gravitational field felt by massive particles will also be altered by high-speed rotation which may provide a mechanism that allows charged particles to be ejected along the axis of rotation. The speed of light would be faster near a supermassive object so, if distance scale was known, electromagnetic radiation might appear to propagate faster than our local speed of light. A gravitational "wave" signal from the formation of a "black hole" might also not disappear as suddenly as implied by crossing behind an event horizon.

5.4 Antimatter

If gravitational mass is trapped energy relative to a locally dominant background energy, then it could be an increase or decrease relative to the mean. The inertial mass, a reflection of the difficulty of changing the velocity of the increase or decrease, would be expected to be positive for both cases. However, a region of reduced energy would then appear to have a negative gravitational mass as it would need to release energy if the total background decreased. Thus, if antimatter gives rise to a region of reduced energy relative to the local dominant background energy, then the expectation would be that it be repelled (i.e. such antimatter would rise in the Earth's gravitational field). This would have the advantage that uncharged regions of matter and antimatter (e.g. galaxies) would repel, preventing an annihilation signal from collisions of matter and antimatter galaxies or clouds of gas. However, an annihilation of matter and antimatter would then have the energies cancel, leaving nothing to be carried away by photons. Thus, matter and antimatter with opposite values of energy is not consistent with observation. However, it is proposed that the background field does not carry energy so repulsion is not yet ruled out.

A repulsion would have appeal because it could provide an explanation for the observational conclusion that regions of matter and antimatter are separated on scales at least as large as galaxy clusters, while allowing the possibility that the universe is symmetric (equal amounts of matter and antimatter) [45]. However, FR may offer an alternative explanation of why antimatter is not observed via collisions between gravitationally attracted matter and antimatter galaxies. Early in the history of the universe, when the clout was much higher and more uniform, the mass and inertia of particles would have been much smaller. Any particles approaching a region of zero asymmetry would move at very high velocity. Moreover, as the matter clumped more of the kinetic energy of motion would have been stored as mass and the matter within galaxies would have retracted towards the centre. This would have led to the rapid removal of all matter in the region between dissimilar galaxies, so that galaxies of each matter type might now be locked into regions of similar matter via gravitational attraction. However, this possibility needs modelling.

The flat rotation curves of spiral galaxies appear consistent with the hypothesis that they, and our spiral galaxy, are surrounded by a remarkably uniform sea of matter and antimatter. The apparently identical energy levels of anti-hydrogen and the dependence of the speed of light on clout, but not asymmetry, also suggests that both matter and antimatter would lose energy in moving deeper into a region of increased contribution from either source. Therefore, antimatter would fall in the gravitational field of matter and vice-versa. The inertia of a galaxy will drop if it approaches a region of equal contributions but the gravitational attraction back to the nearer galaxies of like matter will increase. It seems that the momentum towards boundaries will also have been removed by the initial annihilation and further reduced by the subsequent contraction associated with clumping.

Antigravity, of antimatter, is in conflict with a GR in which photon energy changes in a gravitational field. The argument has been that, if a positron rises in a gravitational field (with the same magnitude of acceleration as an electron falls), then a positron/electron pair can be raised to a higher altitude without work, and then annihilate into photons [46]. If, as supposed in GR, a photon loses energy with altitude, then conservation of energy is violated. Hence the conflict. Under FR, a similar argument can be used. If the photon energy of annihilation is unchanged, then an antiparticle must lose mass when raised in a gravitational field, in which case the antiparticle will lose energy (or store more negative energy) and a mass difference between matter (electron) and antimatter (positron) would appear.

5.5 Agreement with the standard predictions of General Relativity

GR has led to a large number of successful predictions. The first was the observed, but previously unexplained, discrepancy in the advance in the perihelion of the orbit of Mercury. The second was in the correct prediction of the amount of bending of the light from stars as it passed close to the Sun. Such bending has also been seen in the multiple and distorted images from distant quasars and galaxies beyond closer galaxies or clusters of galaxies. However, the amount of bending from galaxies and galaxy clusters has been larger than expected. This is seen as additional evidence for unseen dark matter. Other predictions have included the gravitational redshift of light and the (Shapiro) delay in light signals passing massive objects, the Hubble expansion of the universe, and gravitational waves. The many successful predictions have been taken as strong confirmation that GR is correct.

GR claims that gravity corresponds to a distortion of the Euclidean geometry, of the flat Minkowski spacetime with c constant, of SR. Recently, special relativistic (i.e. SR) calculations of gravitational redshift, of light deflection and of the Shapiro delay, have been extended to include perigee advance [47]. This follows an earlier conjecture by Schiff [48] that the "classical" experimental tests of general relativity might be derived from simpler postulates, such as SR or the equivalence principle, and not require the full apparatus of GR. Subsequent papers have reproduced GR predictions via a special relativistic analysis of the gravitational redshift [49] and a Newtonian special relativistic analysis of redshift, light-bending and Shapiro delay [50]. Thus, it has been shown that all the standard, experimentally confirmed, predictions of GR can be reproduced to lowest order in the gravitational coupling constant using just Newtonian relativistic mechanics (NRM) in Euclidean space. Somewhat similar work has been set out in a theory called Relativistic Newtonian Dynamics (RND) [51].

NRM has the gravitational force at distance r from a stationary, spherically symmetric, source of mass M, proportional to $\vec{F} = d\vec{p} / dt = -\gamma G_N m\hat{r} / r^2$, where $E = \gamma mc^2$, $\vec{p} = \gamma m\vec{v}$, and $\hat{r}$ is the unit radial vector. RND has relativistic length contraction and time dilation due to the escape velocity of the location in a gravitational field. The space increments in the direction of the gradient of the gravitational potential and the time intervals are altered by the Lorentz factor. Thus, both theories introduce a change in time by the factor γ. In addition, NRM has a variable speed of light and no length contraction. Thus, NRM effectively duplicates key aspects of FR which demands a real slowing in time by the factor γ and has no length contraction. That both NRM and RND can mimic GR provides strong support for the claim that FR can also reproduce all the standard predictions of GR, using a real time-dilation for moving objects and no spatial distortion. The mathematics can give similar predictions by incorporating the effects of a finite light-speed and the time dilation of SR into Newtonian gravity.

It is not proposed that these alternatives are realistic or correct as they still assume a fabric of spacetime with a universal speed of light in the absence of a gravitational field, i.e. a constant potential. They are just evidence that the enormous predictive success of GR does not confirm its validity or imply that a radically different theory (FR) cannot give the same standard predictions.

5.5.1 Advance in perihelion of Mercury

GR's prediction of the advance in the perihelion of the eccentric orbit of Mercury arises from the distortion of time with distance from the sun. The distortion of time is claimed to alter the speed of objects as well as how fast their clocks tick. The claimed additional distortion of distance has a negligible effect on the rotation of the point of closest approach of a planetary orbit. Under FR, there will be a fractional change in velocity due to the change in mass, but conservation of momentum. The change in velocity is the same as that attributed to GR's distortion of time. The change in mass does not change the eccentricity of the orbit because the central mass is dominant and the orbital speed relative to the speed of light is negligible. The radial gravitational acceleration with distance is independent of the size of the small mass, because the gravitational force (being a fractional change in mass) is per unit mass. The predicted orbital advance is the same because, in this case, the effect of GR's distortion of distance is negligible.

GR assumes that mass and angular momentum are conserved and introduces an additional acceleration term into the Newtonian energy balance equation (per unit mass) [52]. Under GR, this term is the change in time with change in gravitational potential ($\Delta\Phi / c^2$).

The Kepler radial equation of motion (acceleration per unit mass) is:

$d^2r / dt^2 = -G_N M / r^2 + J^2 / r^3$, where $J = r^2(d\phi / dt)$ is the conserved angular momentum per unit mass and $J^2 / r^3 = V^2 / r = V(d\phi / dt)$ is the centripetal acceleration per unit mass.

The equation corresponds to a closed orbit with no advance in the perihelion because the forces are per unit mass and central. GR replaces it with the second derivative against proper time (τ) [53]:

$d^2r / d\tau^2 = -G_N M / r^2 + J^2 / r^3 + 3G_N MJ^2 / c^2r^4$, where τ is the proper time

However, 'the physical interpretation of τ does not enter the calculation' [53], and so does not alter the predicted orbital advance. The additional term in the equation of motion acts like a r^{-4} force.

Under FR, the released kinetic energy is $-G_N M / rc^2$ with decreasing distance from the Sun, which reduces the energy stored as mass by the fraction $1 - G_N M / rc^2$. Conservation of momentum then gives rise to an angular acceleration proportional to the differential of the change in tangential velocity with *r*, leading to a modified expression for the conserved angular momentum. The change in angular frequency ($d\phi / dt$) matches that from GR's change in time (from *t* to τ) where the factor of $3 / r^4$ has arisen from the differentiation of $1/r^3$ in $d(J^2 / r^3)dr = J^2(-3 / r^4)$. This term arises because the change in tangential velocity increases the centripetal acceleration. Thus, the predictions agree.

5.5.2 Bending of light and Shapiro delay

Under GR the bending of light is due to the distortion of both time and space by a gravitational potential. The combination doubled the predicted distortion over earlier calculations. Under FR it cannot be gravity (in terms of an attraction due to the photon's momentum or a distortion of space) that doubles the bending of light because light does not gain or lose energy in a gravitational field, and distance is not distorted by matter. The speed of light does vary with clout so photons going along separated paths will have different speeds. However, under FR, the speed of light increases with clout so it will be faster closer to a massive object. Therefore, photons passing closer to a massive object would arrive sooner if travelling the same distance but, if the amount of bending is the same as under GR, can arrive later (Shapiro delay) because the curved path is longer. FR has photons changing direction in a gravitational field by an amount proportional to the gradient perpendicular to the direction of motion. It hypothesises that the same amount of bending arises because pairs of chiral rotations (i.e. the two components seen in the split into electric and magnetic fields) change with the gradient in clout. The speed of light (total clout) and oscillation frequency (of a pair of components with an unchanged energy) both increase closer to a massive object.

It has been claimed, under GR, that the time delay is caused by spacetime dilation, which increases the time it takes light to travel a given distance from the perspective of an outside observer. The delay is attributed to the slowing of time (clock-rate) and contraction of distance deeper in a gravitational potential. This follows the strange, inverted behaviour claimed in SR (see Section 2.4.2), which means the effects sum rather than cancel. Under FR, the slowing of time (clock-rate) is irrelevant for massless photons, and instead their speed increases. FR and GR have the opposite sign for the contribution from any change in light-speed. Under both GR and FR, most of the delay arises from the increased path length due to bending, relative to the straight-line path. This amount has a logarithmic dependence on the ratio of path length to distance of closest approach. The logarithmic dependence has been used to fit the experimental data. Therefore only this component of the delay is determined.

Any effect of the gravitational potential on the speed of light needs to be integrated over the length of the path through the altered potential. The difference in light speed will cause a change in timing which varies only slowly and steadily with the path between the orbital positions (relative to the Sun) of the source and receiver. For measurements within our solar system, the extra change is likely to be absorbed into the calculated orbital parameters. The predicted delay for FR and GR is then the same because they agree on the amount of bending. This explanation is consistent with a value twice that expected from Newtonian gravity which has half the amount of bending (if photons lose energy) and no spacetime dilation.

At first sight the lack of bending with increased speed of light (proposed by FR) seems to contradict experience. In materials the bending of light is towards the axis perpendicular to the boundary of the material with the slower speed. Snell's law has the ratio of the sines of the angles of incidence and refraction equal to the ratio of the speeds of light in the two materials. However, the speed reduction in a material relative to that in a vacuum is due to the interaction between the electromagnetic fields of the photon and the material. If the crossing is along the direction of travel, i.e. perpendicular to the boundary, there is no change in direction. The bending in the transition from one material to another arises from the different distance covered by the wavefront perpendicular to the direction of motion. Gradients in light speed that are just along, but not across, a path in space or materials should not affect the direction of the photon.

The observed speed of light is independent of the frequency of the photon (even if the speed varies between regions of different constant clout). Similarly, the amount of bending of light passing close to a massive object appears independent of the frequency (colour). However, the energy carried by the photon is directly proportional to frequency for a given speed of light. Under FR, the speed of light can change but photon momentum and energy (relative to c) are conserved. Thus bending does not arise from changes in energy/momentum of the photon along its path. However, a fractional change in direction (bending) can arise from fractional changes in both frequency and wave speed perpendicular to the direction of motion that are independent of photon energy. Changes in two photon components that experience similar fractional changes in frequency are needed to double the amount of bending. Changes in the local asymmetry will modify frequency in proportion to the size of the change in asymmetry relative to the local total background asymmetry.

The direction of a photon will be bent by a gradient in asymmetry in the direction of increased frequency from increased clout and asymmetry. If two components are altered, then the amount matches the distortion in both space and time that gave rise to the doubling of the predicted bending under GR. The change in frequency of a photon perpendicular to the direction of motion should be the same as that which applies to massive objects. Within our solar system the local value of $G_N M / rc^2$ reflects both the change in c and the fractional change in clout. The apparent effect on bending elsewhere must be adjusted for background asymmetry. Using the local value of G_N elsewhere will lead to disagreement with the observed bending.

5.5.3 Gravitational waves and loss of energy

FR has gravitational waves (GWs) in the sense of propagating changes in the field. The values of the field determine the speed of propagation of light/gravity, mass per unit matter and inertia. The changes in mass give rise to gravitational attraction and changes in inertia alter speed of movement. The changes in the field are in the magnitudes of the pair of chiral components which arise from the location and chirality of all massive objects. The balance of the components determines the speed of propagation of changes while the frequency of the changes ("waves") reflects the movement of the sources (e.g. the periodicity of rotations of binary star systems). There are no waves in terms of self-propagating distortions of spacetime. The speed of the field determines the momentum that can be trapped in stationary patterns of oscillations of the field (i.e. their mass). The asymmetry determines the rotation frequency of these patterns which then determines the resistance of the trapped angular momentum to changes in velocity (relative to c).

FR has changes in chiral components travelling freely in an undistorted space. These changes in the field do not carry energy. If they did, then the $1/r$ dependence of clout would mean that the flux (flow) of energy (gravitational potential) through a sphere enclosing the source would increase with distance. Thus, FR contradicts GR which has energy-carrying GWs which are travelling distortions of spacetime. GWs from the merger of black holes and neutron stars have been detected, but this does not mean that they are distortions of spacetime or that they carry energy. GR also predicted that rotating binary pulsars would lose energy via the radiation of energy-carrying GWs. An apparent loss of energy consistent with that predicted has been observed for the Hulse-Taylor binary pulsar system [54], and other binary pulsars [55]. FR needs to explain and reproduce this apparent loss of energy.

The claimed GR loss of energy enables a predicted rate of decay of the orbital period. The prediction uses an expression for the energy flux of a gravitational wave in terms of the perturbation of the metric under GR. It then calculates the wave amplitude due to quadrupole moments and uses this to calculate the energy loss for two equal masses in a circular orbit. Correction formula can then be applied to allow for any eccentricity of the orbit and unequal masses. In the case of the Hulse-Taylor binary system the eccentricity correction is by a factor of over 11. A smaller correction applies for the slightly different masses of the two pulsars and the galactic acceleration of the binary system relative to the Earth/Sun system. The predictions are in remarkable agreement with observations over 28 and 16 years [54, 55].

Duerr critically examined four textbook arguments commonly taken to establish that GWs carry energy-momentum and found them wanting [40]. FR claims that the direct observation of GWs in the LIGO detectors only establishes that propagating changes in the gravitational field can alter the apparent relative lengths of perpendicular paths. Under FR, this is expected from changes in the speed of light. FR therefore needs to demonstrate that the apparent loss of energy via the GWs of GR arises from the difference between the apparent and actual energy held by rotating binary black hole or neutron star systems given the rate at which their orbits change.

Duerr also proposed that, under GR, energy is not necessarily carried away by GWs. Instead, the conservation of energy may not be required. "The special-relativistic conservation laws for energy-momentum and angular momentum depend on the 10 Killing vectors of Minkowski space. Generic GR spacetimes, by contrast, lack any symmetries"[40]. Conservation of energy/momentum comes from symmetries associated with invariance over time and location, yet distortions of spacetime carry time-dependence. FR does not have spacetime between objects distorted, instead the time of objects is changed and distance is undistorted. Conservation of energy/momentum for objects should remain.

The GR predicted loss of energy, via GWs, arises from Einstein's equation and the geodesic equation of motion in the limit of weak fields. Cheng presents the calculation for the rate of change of energy based on the change of the quadrupole moment in the linearized (i.e. weak field limit) of GR [56]. The derived formula is $dE/dt = (128G_N/5c^5)\omega_b{}^6 M^2 R^4$ for a rotating binary system of two equal masses (M) in a circular orbit, of radius R, with angular frequency ω_b (Figure 1).

For a binary system the effects of a finite propagation speed alter the apparent direction and distance of gravitational influences. These must be taken into account. This is done in the GR calculation of the rate of energy loss because it is based on an oscillating energy-carrying distortion of spacetime due to propagating changes in the gravitational potential. The distortion of spacetime incorporates the finite speed of light/gravity via a distortion of distance with time that keeps c constant. These distortions of space and time are assumed to propagate outward in all directions as waves whose amplitude is proportional to the variation in potential seen from that direction. The energy loss is the integral over all directions of the flux of distortions that arises from the quadrupole moment of the orbits of point sources of constant mass. The calculated flux is altered by variations in the arrival time of the distortions from each source and so take into account the retarded positions and the relative velocity of the sources. The change in orbital period and rotation of the periastron are compared with that expected for a constant orbit with no advance of the periastron.

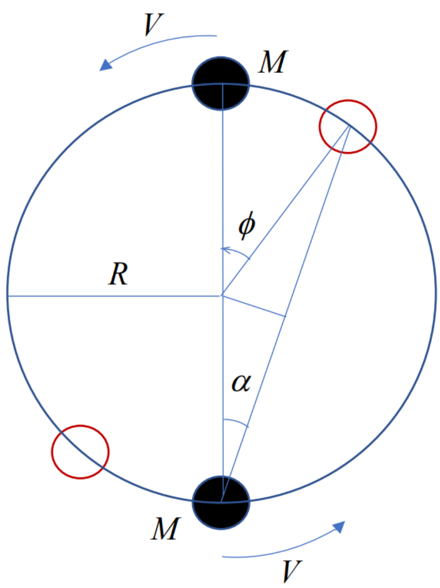

Fig. 1. A pair of equal mass objects in a circular orbit (red circles indicate apparent positions when allowing for a finite speed of propagation of light/gravity).

Conservation of momentum allowed FR to give the same predicted advance as GR in the perihelion of Mercury, when the gravitational attraction remained central and any distortion of distance could be ignored. The speed of light is constant in the weak field limit, so FR should be expected to reproduce the apparent loss via an amended circular orbital equation that takes into account the effects of the changes in mass and momentum and retarded positions. It should provide the same prediction but with the changed energy-momentum stored in the orbits and pulsars rather than being lost by energy-carrying distortions of spacetime.

The GR calculation has been done for a circular orbit of equal masses in the weak field limit. Corrections are then made for the eccentricity of the orbit and unequal masses. The FR calculation therefore needs to consider a circular orbit and assume that these geometric corrections will also match.

The finite speed of light means that the clout observed at another location is that from when other objects were at earlier positions (as illustrated in Figure 1). The rate of change of the clout will depend on the relative velocity (speed and direction) of the objects. Even for circular orbits of a binary pair, the field and its gradient are different to those expected from an instantaneous speed of propagation and not in the direction of the centre of the circular orbit. The non-zero tangential component of the gravitational attraction will increase the speed along the circular path, increasing the centripetal acceleration, and there will also be a small change in radial acceleration. For a constant orbital radius the total radial attraction must match the centripetal acceleration (i.e. that directed towards the centre of the orbit). The effect of non-central forces will cause the orbital parameters to change over time. This will increasingly alter the apparent energy compared to that of a circular orbit with a central force.

In the limit that the changes are small the binary system will take up successive nearly circular orbits, in which a smaller than expected amount of energy will appear to be present, relative to that if the masses and period are assumed constant. The apparent energy held by the orbit will appear to continually decrease. A careful analysis is required to confirm that the prediction of the apparent loss, when changes in gravitational strength (apparent GWs) do not carry energy, matches that of GR with energy-carrying GWs.

The first step is to calculate the amended orbital energy equation, for circular motion, when there is an angle ($\alpha = \phi / 2$) between the apparent and instantaneous direction to the other pulsar. The orbital energy, used in the GR equation [56], is based on the instantaneous position in which the gravitational attraction is radial and the separation distance is $2R$.

The total energy is: $E =$ K.E. + P.E. $= MV^2 - G_N M^2 / 2R$

The Newtonian equation of motion for a circular orbit has the centripetal force matched by the radial gravitational force, so that: $MV^2 / R = G_N M^2 / (2R)^2$ and $V^2 = G_N M / 4R$

This yields: $E = (G_N M^2 / R)[\frac{1}{4} - \frac{1}{2}] = -G_N M^2 / 4R = -MV^2$

The potential energy lost (due to a decrease in mass, rather than an increase in the distortion of spacetime) as R decreases ($1/R$ increases) is twice the reduction in kinetic energy needed to match the larger centripetal acceleration of the smaller circular orbit. For a given change in R, the pulsars will release twice the stored energy from their mass than needed to provide the kinetic energy of the tighter orbit.

The values of α and $\cos\alpha$ follow from the time for gravity to travel the distance between one pulsar and the apparent position of the other pulsar, i.e. $\Delta t = 2R\cos\alpha / c$, and the time for the pulsar to travel the distance around the orbit between the apparent and instantaneous positions when the pulsar speed is V.

$V = R\omega = 2\pi R / T$, where T is the orbital period, and $\phi = 2\alpha = 4\pi\Delta t / T$ in radians.

Hence, $\alpha = 2\pi(2R\cos\alpha)\omega / 2\pi c = (2R\omega / c)\cos\alpha = 2\cos\alpha(V / c) \simeq 2R\omega / c$.

For an isolated system, not losing energy, the total energy does not change. However, the orbit will change if the value of α changes. The tangential acceleration from the off-centre force will be a function of α and will lead to an increase in orbital velocity. An increase in the delay angle with time will cause the total energy to change because the direction and magnitude of the attraction will change with orbital radial separation and relative velocity. The difference relative to that calculated using $\alpha = 0$ will increase, making it appear that energy has been lost.

It needs to be shown that the rate of change of energy loss derived by the quadrupole radiation formalism of GR, i.e. $dE/dt = (128G_N/5c^5)\omega_b{}^6 M^2 R^4$ can be reproduced. By analogy with the reproduction of the advance in the perihelion of Mercury prediction (Section 5.5.1) the assumption of slow changes to a circular orbit should render any effect of a distortion of distance/space (without a change in time) negligible. The way in which a derivative was needed also suggests that $(4G_N M^2/R)\alpha^6 = (1/5)(2^5 R^5/c^5)\int \omega^5 d\omega = (128G_N/5c^5)\omega^6 M^2 R^4$ is relevant.

However, the calculation needs to be completed to confirm that the apparent energy loss numerically matches that claimed for the supposed loss due to energy-carrying gravitational radiation.

5.6 Summary

FR changes the understanding of many phenomena but appears able to produce similar results to the successful predictions of GR. The places where the predictions differ arise where there are large differences in the magnitude and/or asymmetry of the background.

The clout of gravity appears to be a scalar property that carries influence, but not energy, between locations. The size and distance of all contributing masses will alter the energy that can be stored locally. They will also alter the rate of change of stored energy with position and the arrival time of contributions. Any asymmetry between chiral components, giving rise to clout, will alter the inertia of masses and hence their rate of change of velocity (i.e. acceleration). The ratio of inertial to gravitational mass will vary with location relative to concentrations of different chiral components.

The clout will have been larger and asymmetry will have been much smaller when matter was more uniformly spread in the early universe. The annihilation of most matter and antimatter would then have led to separated regions of surviving matter and antimatter. These may now be permanently separated and so not give rise to an annihilation signal. However, the implications of FR for the evolution of the universe requires modelling. Antimatter should fall in a gravitational field.

Black holes are not due to loss of photon energy. If light were trapped by loss of energy, then gravity should also be trapped. Light may no longer be emitted from whatever form matter takes within a black hole and any light that is emitted will be trapped by bending.

FR provides the insight that there is an enormous background field due to the presence of both matter and antimatter. This field behaves like a balanced tension (or a pair of torsional stiffnesses) giving a clout that falls off as $1/r$ with distance from a source of stored energy. An increase in the clout reduces the energy that can be stored in the same amount of matter, so that the gradient in clout gives rise to a force proportional to the fractional change in mass. This accounts for the change in energy that drives gravitational acceleration of massive objects whose inertial resistance to that acceleration depends on background asymmetry.

The local acceleration appears independent of a uniform background but is not. The M/r dependence means that the background field is dominated by distant galaxies There is only a small asymmetry between the contributions from matter and antimatter. This occurs near and within galaxy clusters and towards the centre of individual galaxies. The large nearly balanced background leads to the apparent weakness of gravity and the smallness of the inertial resistance to the movement of the enormous quantities of energy held as mass.

The background field can be expected to decrease over time because of clumping of matter. This will lead to a reduction in the speed of light and an increase in the mass stored per unit of matter. This is the proposed source of the gravitational redshift of galaxies with increasing distance. Expansion of space, or of the distance between galaxies, is not needed.

The current local value of the proportionality factor G_N is not predicted by GR but should be by FR from a knowledge of the background at our location in our galaxy and the required consistency if the same background determines both mass and inertia. The value of G_N should also be consistent with data on changes in mass due to changes in the speed of light at other times and places in the universe. Its apparent value across regions of nearly constant total background will depend on changes in asymmetry because these affect the ratio of inertial to gravitational mass. The framework appears capable of predicting gravitational behaviour within a fully specified set of initial conditions of the background matter.

The standard predictions of GR appear to be able to be reproduced by FR for the current background. However, the details of the theory need further development and comparison with experiment. Some new predictions and improved explanations of existing phenomena are set out in Chapters 6 and 7. Potential experimental and observational tests are outlined in Chapter 8.

Chapter 6

Cosmological predictions of Full Relativity

To be acceptable, a revised theory firstly needs to reproduce all the confirmed observational effects. Secondly, it should have advantages by, for example, making new predictions that can be confirmed by observation or by explaining existing observations in a more satisfactory manner. The status of the experimental tests of GR and of theoretical frameworks for analysing alternate metric theories of gravity have been extensively and systematically reviewed [57]. However, although FR has spatial sizes and time intervals varying, space is not distorted; it always has a Euclidean geometry. FR is not a metric theory in the sense of being due to the distortion of an underlying geometry. At first sight, this appears like heresy because it has been noted that: "If the Einstein equivalence principle [EEP] is valid then gravitation must be a 'curved spacetime' phenomenon" and that "the only theories of gravity that can fully embody EEP are … 'metric theories of gravity'" [58]. However, FR claims only that the weak equivalence principle holds (in the sense that there is a fixed relationship between inertial and gravitational mass in the limit that the asymmetry in the background from matter and antimatter is constant), and not the stronger EEP, because local positional invariance (LPI), and time invariance, of physical laws do not hold. The magnitude of gravitational effects is dependent on the background clout and asymmetry from the trapped momentum of matter and antimatter which change with location and over time. Physical laws depend on position within a background and are not identical unless the magnitudes of their components are adjusted for the effects of the local background.

LPI can be tested by gravitational redshift experiments. However, great care needs to be taken in the interpretation of apparent changes in clock-rate, frequency and wavelength at different locations. The properties of the measuring system will be altered if it is moved between locations with different backgrounds. If the measurement system is not moved then information must be compared using electromagnetic signals whose speed and frequency can depend on location. The two theories predict the same <u>apparent</u> shifts in energy clock-rate and frequency seen in the Pound-Rebka-Snider experiments. This is because GR attributes a gravitational potential to all energy and so gives the photon a redshift when it moves to a higher gravitational potential, whereas FR has the photon energy unchanged by a gravitational potential but the energy levels of (massive) atoms blueshifted.

The predictions of FR and GR can be expected to be the same when changes in the stored energy components are small relative to the present background or if the changes are in proportion to the current, locally observed, values. Hence, the predictions are nearly the same in our region of the solar system, now (i.e. close enough in position and recent enough in time that the background has hardly changed). The equivalence of the changes in time and momentum of the two theories mean that effects such as the precession of the perihelion of Mercury are automatically reproduced. Differences between the predictions of the two theories appear when comparing behaviour in regions or at times with significant differences in total clout, or in the balance of the matter and antimatter components. The differences will show up in mass and the speed of light, and in inertia with asymmetry.

6.1 Energy levels and the speed of light in a changing universe

One situation where marked differences will be seen is going back in time to when, under current theory (GR), the universe was denser. Under FR the background clout was larger and the speed of light was faster. Under FR, the observed redshift of galaxies earlier in time arises from the lower energy of the emitting atoms. If the density of galaxies was greater in the past, then so would have been the speed of light, and the stored energy (mass) per particle would have been lower. However, if the redshift with distance arises from a change in clout due to clumping of matter over time, then it is not necessary that the mean density of matter was higher and, therefore, that the universe has expanded.

FR predicts that energy levels of atomic transitions will be redshifted because of the change in background clout during the transmission time of the signal. The redshift will reflect the lower energy of the atoms at the time of photon emission because the energy of the photon is conserved. The change in redshift with time must allow for the distance travelled by light per unit time because the speed of light will have been faster in the past.

An increasing redshift could also arise from an increase in recession speed with distance. This would give rise to a Doppler shift proportional to the speed of separation. However, Doppler "stretching" is an increase in apparent wavelength by the increased relative speed of separation of the source and receiver. It is not altered by the separation distance unless the emitted wavelength depends on distance. General relativity's claimed expansion of empty space between galaxies, with its supposed stretching of wavelength of propagating signals, as the Universe expands, should be seen as unexpected and unusual. It is based on the claim that the "Copernican principle", that there is nothing special about the position of any location in the Universe, holds. The claimed consequence is that every observer appears to be at the centre of an expanding universe, in agreement with the Equivalence principle where there is no effect from the absolute value of the background. It has been suggested that expanding space is the phenomenon that distance between observers at rest with respect to the cosmic fluid increases with time [59], because general relativity's metric describes a homogeneous universe filled with a fluid of uniform density. A fluid of space-time that can expand while maintaining constant density seems like magic to me. There is no evidence that the phenomenon occurs. The argument just replaces "empty space" with "cosmic fluid". Both are artefacts of the need to explain the redshift of galaxies under the assumptions of general relativity.

Under FR, the space between stationary objects cannot expand and the relative velocity of objects, in a homogeneous background, does not increase unless a force producing acceleration is present. The speed of separation could have been higher in the past which would then appear as an increased redshift with distance, but a significant rate of slowing implies a larger gravitational attraction in the past and an enormous initial source of energy.

6.1.1 Fitting of the type 1a supernovae data

Local type 1a supernovae appear to release the same amount of energy and so their apparent brightness can be used as a direct measure of distance to be compared with the wavelength shift. Under GR, the observed brightness of distant supernovae is lower than expected from their distance based on the wavelength shift of their host galaxy and a constant rate of expansion. This led to the conclusion that the universe is now expanding faster than in the past, the so-called "accelerating expansion". Gravity had been expected to slow the expansion, so dark energy was hypothesised to drive the expansion of the universe faster now than in the past. Hence, this dark energy has the very unusual property of a negative pressure that opposes gravity more strongly as the density of the matter, the number of galaxies per unit volume, decreases!

Under GR, the redshift of the wavelength λ of light from distant galaxies is attributed to the increase in size of the universe, or scale of the fabric of spacetime, between when the light was emitted R and received R_0. Thus $R_0 / R = \lambda_{rec} / \lambda_{em} = 1 + Z$, where $Z = (\lambda_{rec} - \lambda_{em}) / \lambda_{em}$, is predicted by GR.

Under FR, the measured change in wavelength is due to a reduction in the energy of emission when the clout was larger and the speed of light higher. There will have been a decrease in the speed of light (from c to c_0) during transmission. FR proposes that the speed of light is proportional to clout and that measured values can be based on constant underlying distance and time scales in the sense that: i) the separation distance of stationary objects does not change, and ii) the momentum of a photon is conserved independent of the speed of light. The speed of light, distance per underlying unit of time, then changes. The speed of photons of constant momentum will change when the background changes. If the background clout decreases from ρ to ρ_0, then the distance travelled by light, for constant underlying time and distance intervals, will decrease in proportion to $c_0 / c = \rho_0 / \rho$. However, the time in terms of the clock-rate of massive clocks will increase by $(c / c_0)^2$ because the stored energy of the matter that makes up the clocks will have increased. The trapped momentum of the energy levels of atoms when the photons were emitted will have been lower in proportion to c_0 / c, and the energy levels will have been lower in proportion to $(c_0 / c)^2$. So the ratio of the wavelengths at emission to receipt of photons, whose energy and momentum do not change during transmission, will be $\lambda_{rec} / \lambda_{em} = c / c_0 = \rho / \rho_0$, i.e. in proportion to the ratio of the clouts at emission to reception.

For nearby type 1a supernovae, the total amount of energy released (area under the light curve) appears to be approximately constant, although brighter supernovae increase and decrease in brightness slightly more slowly than fainter ones. When the timescales of individual light-curves are stretched to fit the norm and the brightness is scaled according to the stretch, then most light-curves match [60,61]. This would seem to be a way of determining the total energy independent of any difference in local asymmetry. The energy needed to compress electrons into nuclei is determined by the electromagnetic interaction. Electromagnetism is gauge invariant and therefore does not depend on the background density of surrounding charge, but the amount of energy each particle stores does depend on the background density of matter (via clout). The stored energy and inertia per particle should change, but so will the number and size of particles, before gravitational collapse. So, it appears reasonable to expect that the total gravitational energy needed to cause the gravitational collapse would be constant but involve different numbers of particles. Most of the light emitted, after the explosion, is due to the decay of radioactive nuclei synthesized in the explosion and the rate of light emission will depend on the frequency of quantum oscillations. The apparent rate of decay of the light curve, and the inertia of the expanding gases, will depend on the asymmetry and so the width will increase with decreasing asymmetry, but the product of the number of particles available to decay and their reduced energy levels will be independent of width. The light curves of supernovae would then scale to the same brightness, when stretched so that the timescales of the light curves match.

Since the speed of light was faster in the past, the light will have travelled further during intervals of constant time. The brightness (total energy emitted) of a source of fixed energy gives a direct measure of distance, independent of the speed of travel. Hence, the relationship between distance, based on brightness (emitted energy) and Z, based on wavelength shift, will not be linear. In order to plot how distance has changed with time, the luminosity distance must be divided by the integral of the speed of light over time. If the shift in wavelength were due entirely to the change in clout, then the luminosity distance (with no correction for expansion) will have been increased by a factor of $1+Z/2$ due to the linear increase in average light speed, and hence path length, per unit increase in $1+Z$. This can be tested by plotting the luminosity distance against $Z(1+Z/2)$, as done below.

The Union 2.1 data [62] for type 1a supernovae in terms of the distance calculated from the luminosity versus the redshift, $Z = \Delta\lambda / \lambda$, is given in Figure 2. The distance is first plotted against Z, then against $Z(1+Z/2)$ which allows for the integrated change in speed of light. A linear fit (red line) shows a nearly constant slope and so removes the lower-than-expected brightness that necessitated the hypothesis of an accelerating expansion and the need for dark energy. A constant slope indicates that, once the distance is corrected for a speed of light proportional to the increased clout going back in time, the rate of change of clout with u-time is constant. The observed redshift can be explained by a fractional increase in wavelength for the same transitions of the emitting atoms that is proportional to the fractional increase in background clout, and a speed of light that is directly proportional to clout.

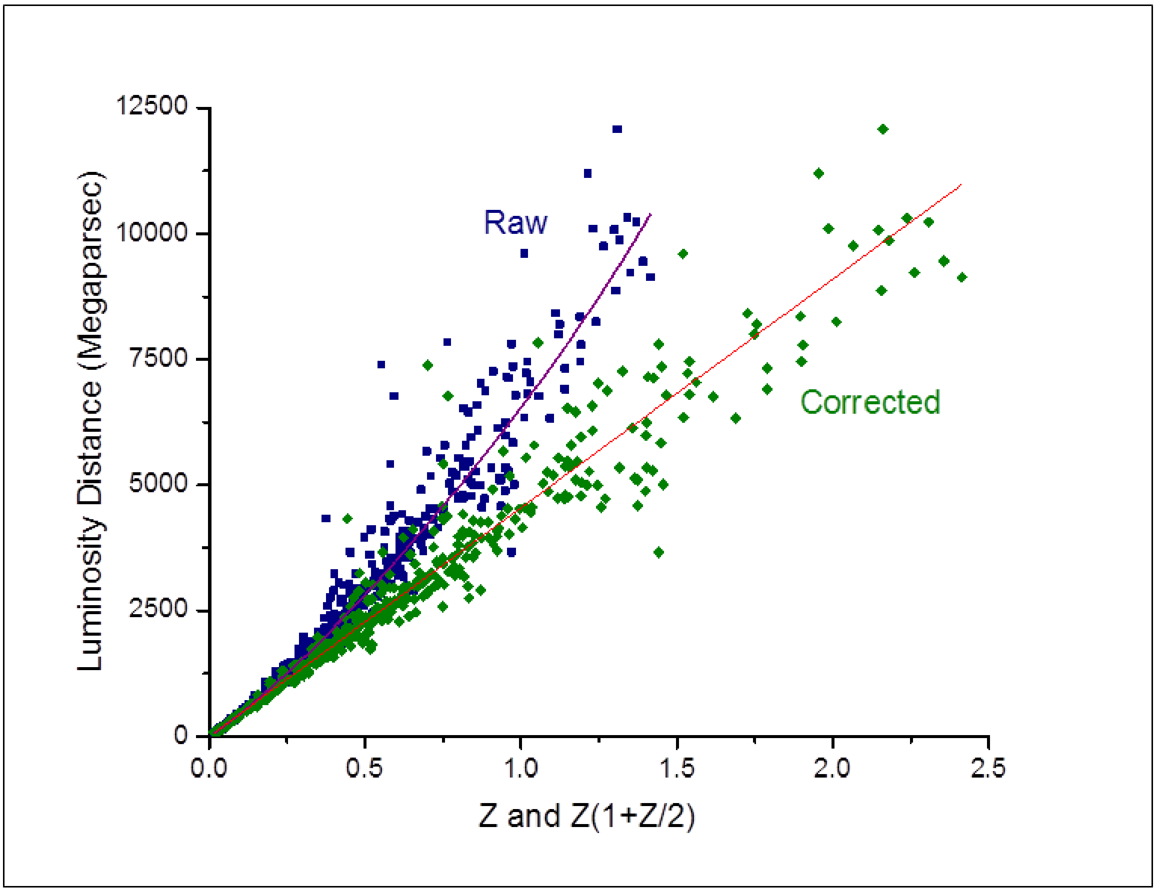

Fig. 2. Type 1a supernovae luminosity distance versus raw (Z) and adjusted ($Z(1+Z/2)$) redshift.

The plot indicates that the behaviour is approximately the same for all regions at a given epoch when averaged over the directions to the supernovae. The scatter appears to be about that expected from the quoted measurement errors, with roughly two-thirds of the points lying within their error bars for the straight-line fit (see Figures 3 & 4) except possibly at low Z. There is a slight suggestion of regions of similar low Z where there are groups of data points above or below the fit. It is speculated that this might indicate a lack of isotropy and homogeneity over the nearer regions of space due to the large-scale structure in galaxy distribution.

The luminosity distance to a supernova that exploded at a redshift of one will reflect the distance the light actually had to travel even though the speed of light has decreased during the journey. The actual distance is 4550 x 1.5 Megaparsec (for $Z = 1$ at the time of emission) from a linear least-squares fit (weighted by the quoted error on each point) to Figure 3. For just the data out to Z <0.3 (Figure 4) the actual distance is 4518 x 1.5 Megaparsec (for $Z = 1$ at the time of emission).

The distances of 4550 and 4518 Megaparsec are close to the recent value of the Hubble length of 4422 Megaparsec based on the data of the Planck space observatory, which corresponds to a value of the Hubble constant (H_0) of 67.8 km/(s.Mpc) or 2.198 x 10^{-18} s^{-1} [63]. The is because the current recession velocity ($v = H_0 D = cZ$) is given by the asymptotic slope of distance (D) vs. Z-shift at low Z.

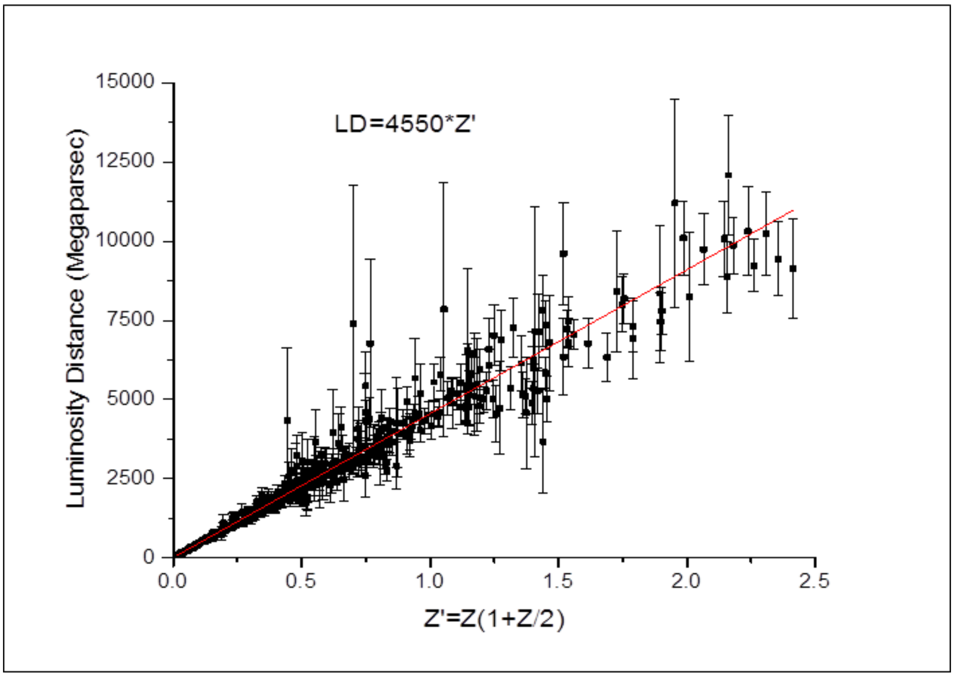

Fig. 3. Luminosity distance for type 1a supernovae with error bars (all data).

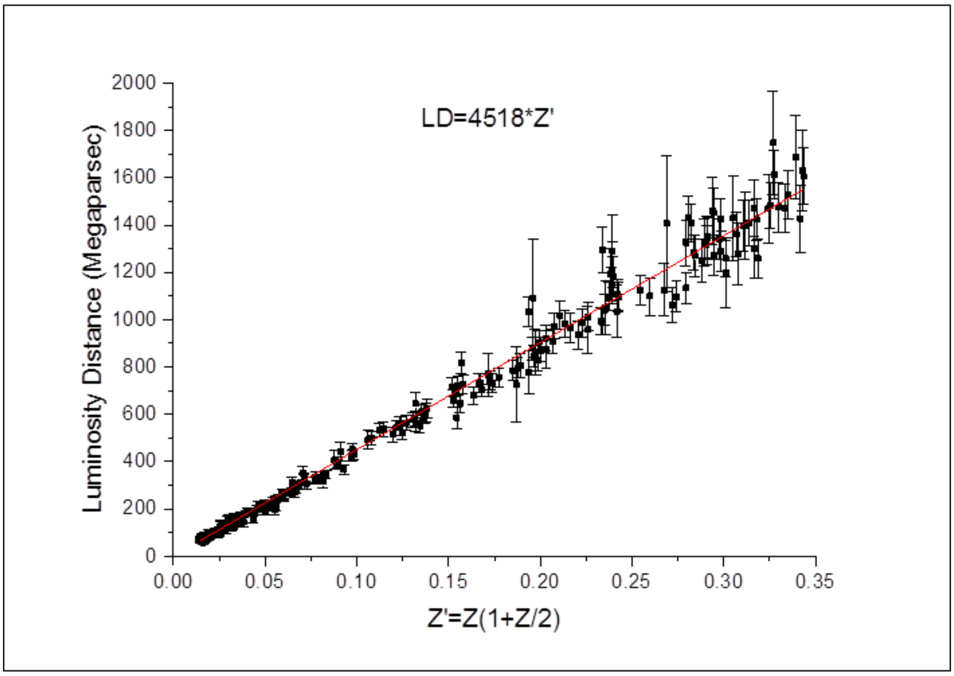

Fig. 4. Luminosity distance for type 1a supernovae with error bars ($Z < 0.3$).

A better way of looking at the data is to plot the u-time since the light was emitted against the Z-shift (Figure 5). The time taken is the luminosity distance divided by $c(1+Z/2)$ to correct for the changing speed of light. The straight-line fit indicates the underlying connection between the speed of light and the energy of atoms. The u-time taken for light to reach from $Z=1$ is 4.68 x 10^{17} seconds. Energy and local clock-rate have doubled in the u-time that light took to reach from $Z=1$ and so are currently changing at a fractional rate of 2.137 x 10^{-18} per second.

Recent values from the Hubble space telescope, based on Cepheids and the cosmic ladder for distance scale have indicated a value of about 74 km/(s.Mpc) and the disagreement with the Planck data appears to be worsening as more distant galaxies are included. This suggests that the Cepheid data and parameters such as the size of galaxies are being biased by the increase in size, and decrease in momentum, with increasing background density going back in time (i.e. with increasing distance).

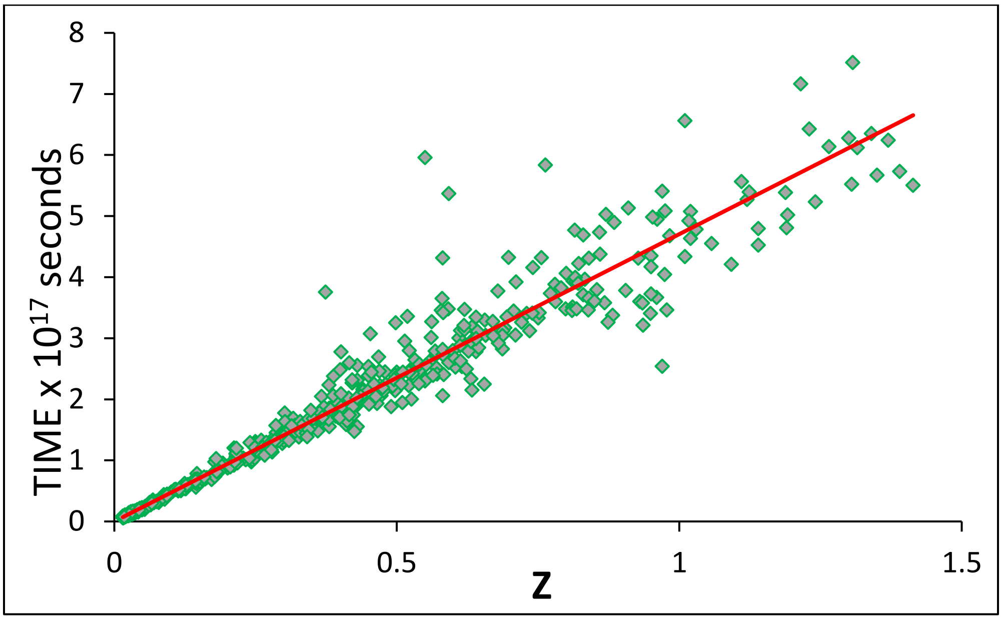

Fig. 5. Time in seconds since light was emitted for type 1a supernovae.

A decrease in density from an expansion in the spacing of galaxies would lead to a decrease in clout. However, supernovae could be expected to have zero average velocity relative to the background at the time of emission and our observation position appears approximately stationary relative to the current background. Therefore, an expansion should not lead to an additional redshift of the photons due to relative velocity. The redshift should solely reflect the change in the momentum of the atomic transitions. The average spacing between galaxies could be increasing but it does not seem to be required. Moreover, it would be at a very much slower rate than that derived under GR.

Under FR, the energy per particle increases if the background reduces, but a decrease in only one component of a background that involves a balance between two components will have a different effect to that from an equal reduction in both components. Clumping of matter leads to increased clout from the increase in nearby matter but a decreased background clout for distant matter because the amount per unit of matter will reduce. Mass can be gained from a decrease in kinetic energy (temperature) but this will be lost when the kinetic energy is recovered, as in an eccentric orbit about the Sun, unless inertia is increasing with time.

The asymmetry of the local background will increase if the size of the galaxy decreases. Rotational velocity will increase less than expected with contraction if inertia increases over time. The loss in mass reduces angular momentum but circular orbits, at a given inertia, are independent of mass when there is a large central mass. However, if the asymmetry in the contribution to clout from matter relative to anti-matter becomes large, near the central black holes at the core of galaxies, then the velocities of stars will be greatly slowed. The cores will contain much more matter than indicated by the speed of these nearby stellar orbits. At large distances from the galaxy core, the strength of gravity per unit gravitational mass will appear to increase as inertia decreases with decreasing asymmetry.

Normally, the supernovae data are plotted assuming a linear velocity-distance law which applies quite generally in expanding and isotropic models under GR [64]. In this case, "… spatial homogeneity and isotropy imply a preferred (universal) space, and the time invariance of homogeneity and isotropy implies a preferred (cosmic) time. In the co-moving frame, space is isotropic, receding bodies are at rest, and peculiar velocities have absolute values" [65]. Under FR, co-moving coordinates arise from the faulty assumptions of GR including that a uniform background density of matter has no effect.

The linear velocity-distance law is based on the assumptions of GR, including constant c, and leads to recession velocities that exceed the speed of light. The invariant Robertson-Walker line element corresponds to the assumption of an invariant rate of (cosmic and proper) time. These assumptions must be rejected and instead distance versus redshift (adjusted for a changing speed of light) should be plotted, as done here. It applies to a homogeneous universe where the speed of light decreases and the stored energy (mass) increases as the background energy clout decreases over time.

Correcting the Type 1a supernovae distance data for the change in light speed yields an accurately constant apparent rate of expansion, thereby eliminating the need to hypothesise an invisible dark energy to drive that expansion. The concept of an energy whose influence grows as the space between objects increases, should always have been seen to be suspect.

6.2 Consistency of clout and asymmetry with gravitational observations

Correcting the Type 1a supernovae distance data for the change in speed of light yields an accurately constant relationship between u-time and the energy stored in matter. However, the change in redshift with change in clout, and changes in asymmetry, must be consistent with the changes in stored energy with changes in background (gravitational potential) seen in our solar system. The supernovae data must be consistent with a local Newtonian gravitational behaviour whose strength is determined by the average mass and mean distance of massive objects, mostly galaxies, responsible for the background. In addition, the contributions of various sources to asymmetry must be consistent with a flat rotation curve of the outer regions of our galaxy but a $1/r$ curve within our solar system.

Under FR, the energy levels of the atoms emitting the photons decrease as the surrounding background increases. A changing clout corresponds to a gradient in gravitational potential. This gradient in energy given to objects can be equated with the gravitational field, which gives an acceleration, or force per unit mass, experienced by all massive objects. A positive gradient in clout with location means that the speed of light is increasing, which reduces the stored energy (the potential) of the same amount of matter (the same massive object). A constant, positive gradient going back in u-time means the speed of light was higher and has been decreasing at a constant rate.

6.2.1 The underlying gravitational equation

The equation that incorporates the effects of clout and asymmetry is the form of Newton's gravitational equation embodied in equations 5.1 to 5.3.

Equation 5.3 can be rewritten as:

$$(\Delta E + E)/E = (-M/r + c^2/G_N)/(c^2/G_N) \qquad (6.1)$$

where c^2/G_N is the constant large local value of the background clout and $(M/r)/(c^2/G_N)$ is the fractional change in clout at distance r from an excess in mass of M kg.

Equation 6.1 is a time-independent energy balance equation. The units of time appear in the equation via the speed of light but the units of c^2/G_N are kg/m which no longer includes time. Thus, as known for Newtonian gravity, the finite propagation time of gravitational effects is not incorporated. The clout of gravity appears to be a scalar property that carries influence, but not energy, between locations. The size and distance of all contributing masses will alter the clout and hence the energy that can be stored locally. The rate of change of stored energy, or trapped momentum, needs to take into account the magnitude, direction and arrival time of all contributions.

The gravitational force $F = \partial E / \partial r$ depends on the gradient of the total clout. Again there is no link with time (unless the unit of energy varies with time). The time-dependence arises when the gravitational force is equated with the inertial force of Newton's second law. Under FR, a time-dependence will then arise from two sources. The first is from a change in total background clout which increases in proportion to the speed of light. The second is from a change in asymmetry between chiral components which will alter the inertia of masses and hence their rate of change of velocity per unit of inertial time (i.e. acceleration) for a given force. If the units of the gravitational force are equated with the acceleration force, then the derivative of equation 5.3 gives:

$$\frac{F}{mc^2} = \frac{\partial E / \partial r}{E} = -\frac{\partial}{\partial r}\left(\left(\frac{G_N M}{rc^2}\right) + constant\right) \qquad (6.2)$$

So that: $$\frac{\Delta KE}{E} = \frac{M / r}{c^2 / G_N} \qquad (6.3)$$

The expression yields the kinetic energy released per unit of stored energy in moving to a region with an increase in clout of M / r from an excess of stored energy of M kg relative to a large constant background clout of c^2 / G_N kg/m. The value of inertia changes with asymmetry, but the local units of m_i and m_g have been equated so the value of G_N applies to a clock-rate based on energy. The observed velocity squared of the same kinetic energy at another location will differ by the inverse ratio of inertias.

As set out above, Newton's universal law of gravitation reflects changes in kinetic energy of a massive object with distance from a concentration of stored energy. Under FR, this leads to the expectation (see Section 5.1) that the current background clout is:

$\rho_B = c^2 / G_N$ = 1.3467 x 10^{27} times the local clout from 1 kg at 1 m, using G_N = 6.67408 × 10^{-11} m^3/kg.s^2.

The value of G_N is a fractional change in kinetic energy and includes the effect of the local asymmetry that changes inertia but not stored energy. The resultant velocity (change in distance with time) from the same change in energy will vary between regions of the same clout, but different asymmetry, because the change in inertia alters a "time" based on speed of movement rather than energy.

6.2.2 The local value of asymmetry

The position of our solar system in a spiral arm of our galaxy suggests that our location is one of finite but not large asymmetry as the flat rotation curve of similar galaxies begins to appear not far out in the spiral arms. If background clout reduces, then the orbits of the stars of the galaxy will shrink in order to try and maintain the same speed of light. This will increase the like matter component of the total clout and so increase the asymmetry and inertia. Hence, the absolute rate of change of inertial time should be related to the rate of change of asymmetry and position in a galaxy in terms of the rotation curve. FR has spacetime always flat and no need for dark energy. It will be shown (Section 7.3) that the needed amount of dark matter can be explained by the degree of asymmetry at our location in the universe. The amount of asymmetry is small at our location but is dominated by the asymmetry from our own galaxy. Therefore it is nearly constant within our solar system leading to little change in the apparent local value of G_N via changes in the ratio of inertial to gravitational mass.

Based on accepted masses, distances and constant inertia, the value of the clout from Earth at its surface is 9.4 x 10^{17} kg/m, the value from the Sun at its surface is 2.85 x 10^{21} kg/m, reducing to 1.34 x 10^{19} kg/m at the Earth. The mass of our galaxy has been determined to be 1.5 x 10^{12} solar masses but the calculations are based on the rotation curve and include the supposed dark matter of GR with it being estimated at 90% of the total. The mass of the core of our galaxy has been estimated to be between 100 and 400 billion solar masses. If its mass is 150 billion solar masses at a mean distance of 8 kpsec, then the clout from the core of our galaxy at our solar system is about 1.22 x 10^{21} kg/m but the total clout could be ten times higher if the total mass is ten times the core at a similar average distance. This latter amount would dominate that from the Sun and the Earth at the Earth's surface by factors of roughly 10^3 and 10^4. However, the smallness of all three values relative to the background clout (1.3 x 10^{27}) suggests that the enormous number of distant galaxies contributes almost all the background and therefore that the asymmetry away from an isolated galaxy is likely to be small. If the background asymmetry towards the edge of our galaxy is small, then the variation in asymmetry with distance from the centre of the galaxy will significantly influence the rotation curve while the asymmetry at our position will be dominated by that of both the core and bulk of the galaxy, except possibly for a modest additional contribution very close to the Sun.

The value of G_N, however, indicates that the local background clout due to a balanced contribution from matter and antimatter corresponds to the effect of an amount of energy of 1.3467 x 10^{27} kg at 1 m or 10^5 to 10^6 times the estimated clout from the matter of our galaxy. The local asymmetry due to our galaxy is therefore estimated be of the order of 10^{-5} to 10^{-6}. The value of asymmetry should be approximately constant for the planetary orbits within our solar system because the contribution to asymmetry from the Sun at the orbit of Mercury would be significantly less than the background value from our galaxy. The correct prediction of the bending of light by the Sun would also suggest that the total asymmetry is hardly altered close to the Sun (see Section 8.4).

6.3 Prediction of an effect similar to the Pioneer anomaly

The constant slope of the supernovae data as a function of u-time yields the rate of decrease in clout. The fractional increase in energy of atoms with u-time should reflect the decrease in speed of light with decreasing background clout since the light was emitted. Hence, $Z = 1$ will correspond to a reduction in background clout (from that at the time of emission) equal to the current clout. The elapsed time for this change, in constant units of u-time, i.e. after allowing for the speed of light being faster in the past, is 1.404 x 10^{26} m or 4550 Megaparsecs divided by the current speed of light. Hence, the clout has decreased by the amount of the current clout in 4.68 x 10^{17} seconds (of u-time).

The momentum trapped in massive objects is inversely proportional to the speed of light. Hence, clock-rate increases (time intervals reduce) if the background clout decreases. Under FR, the fractional rate of change of clout and of the current speed of light with current time is the distance light travels in a second divided by the slope of the supernova data, i.e. 2.137 x 10^{-18} per second. This change means that a signal of supposedly fixed frequency and wavelength, using an atomic clock, will actually be increasing in frequency over time. If a signal of nominally constant frequency is sent to a distant spacecraft and back it will appear to drift lower in frequency, because local time (energy clock-rate) will have increased during the time taken for the signal to make the round trip. The observed frequency should uniformly decrease by $\Delta f / f$ = 2.137 x 10^{-18} per second, if the frequency per unit energy is constant and the local speed of light is changing at the same rate as it is for the total background from equal changes in clout from matter and antimatter. Changes in asymmetry with time or location should be invisible because the signals are compared at the same time and location.

The change in frequency with time for returned signals will reflect any change in the energy, during the time of signal transmission, of the reference transition used in the stable clock. The rate of change in energy will reflect the rate of change with time of the local speed of light. This will reflect the rate of change of the components of the local clout whose balance determines light speed. The photons of the returned signal will still have the unchanged momentum of their emission. Changes in frequency from changes in emission energy will be visible if a delayed signal is compared with a newly emitted signal. If the background was larger at the time of emission, then the speed of light will have been faster and the emission energy smaller. If the asymmetry at emission was smaller than at reception then there will be an additional decrease in frequency. However, this change should not be visible because the frequencies of the signals are being compared under the same (current) asymmetry.

A signal, of locally constant frequency, was sent out from Earth then back from the Pioneer spacecraft at a frequency locked to a fixed ratio of the received signal. Such a procedure is equivalent to a reflection and is independent of clock-rate at the spacecraft. By the time of return, the frequency of the signal from the time of emission will be lower than the new reference frequency. Therefore, the returned frequency will appear to drift lower with increasing elapsed time of the journey. The rate of drift should be constant and the amount should be proportional to the return journey time of the signal. The difference between the measured and predicted returned signals from the Pioneer spacecraft equivalent to a steady downwards drift in frequency “of about 6×10^{-9} Hz/s, or 1.5 Hz [in 2.29 GHz] over 8 years (one-way only)” [66], where it was stated that it equated to a clock acceleration of -2.8×10^{-18} s/s^2 . This appears to be in moderate agreement with the predicted drift in frequency. It may be that the current, local, rate of change in background is less than the average over time and distance.

The Pioneer drift indicated an anomalous deceleration towards the Sun of approximately 8×10^{-10} m/s^2. Therefore a substantial effort was put into finding the source of the deceleration. A more recent analysis suggested that the anomalous deceleration decreased with time [67], from an early value of 10×10^{-10} m/s^2 down to a level of 7 to 7.5×10^{-10} m/s^2, and that the deceleration could be explained by the selective radiation of heat energy, from the radioactive power sources, in the direction away from the Sun [68]. Such a deceleration appears plausible because more than 2 kW of waste heat was generated throughout the mission and an anisotropy in the flow of energy of less than 2% away from the Sun would be sufficient to produce the claimed deceleration [69]. The observed decrease in time of the generated heat energy enabled a fit to the navigational data (position with time). The fit indicated that the spacecraft had definitely not travelled as far as expected. The reduced distance was consistent with the slowing from thermal radiation and it was concluded that once the thermal recoil force was properly accounted for, no anomalous acceleration remained.

However, that is not the end of the story because the predicted position of the spacecraft was based on GR. The calculation of the expected position of the spacecraft used a parameterized post-Newtonian (PPN) approximation of modern theories of gravity, which includes GR. Thus the modelling includes the effects of both time dilation and distance contraction. As pointed out in Section 5.5.1 the calculation of the advance in the perihelion of Mercury was based solely on the slowing of time, closer to the Sun. It was effectively independent of GR’s contraction of distance (closer to the Sun) because the mean orbital distance of the eccentric orbit was close to that of the circular orbit. FR gave the same prediction without having a contraction of distance. However, FR predicts a decrease in velocity due to the slowing from the effect of increased mass on momentum. This matches the prediction that GR attributes to the change in time. Therefore, FR might be expected to predict that the position of the Pioneer spacecraft should change by only half that of the GR prediction with its matched changes in both time and distance with gravitational potential. However, FR has an increase in apparent distance because the speed of light is slower further from the Sun. This will appear as a real increase in a distance based on timing of returned signals that uses a constant speed of light. Thus, in the absence of a slowing via preferential heat radiation, the FR and GR predictions should agree, except for FR’s frequency shift from the rate of reduction in the total background with time.

A careful comparison of the predictions of the two theories should be made that includes an examination of the arguments that the predictions of GR are incorrect because of the inversion of time versus distance intervals. It should also examine whether the method used, of phase-locking the returned signal to received signal, removes any effect of clock-rate at the spacecraft so that GR's supposed change in time with location has no effect on the returned signal. This will void the need to take the change in clock-rate at the spacecraft (from differences in gravitational potential) into account. However, changes in momentum will need to be taken into account.

6.4 Consistency with data from cosmic microwave background

The WMAP data of the cosmic microwave background (CMB) also provides information about dark matter and energy independent of supernovae results. The data are consistent with a flat universe to better than 1% [70]. A fit to the data using the ΛCDM model (based on GR) then gives the percentage of baryonic matter as 4.56%, cold dark matter as 22.7%, and the rest as dark energy. If the universe is spatially flat the asymptotic value of the Hubble parameter (H_0) and GR can then be used to determine that it has a critical density of 9.30 x 10^{-27} kg/m^3, using $\rho_c = 3H_0^{\ 2} / 8\pi G_N$ [71]. The observed density of baryonic matter appears consistent with the fit to the CMB data and much lower than the needed critical density, which is taken as further evidence for dark matter and dark energy.

Under FR the universe is necessarily flat, and the current background clout is $\rho_B = c^2 / G_N$ = 1.3467 x 10^{27} times that from 1 kg at 1 m using the measured value of G_N . The gradient giving rise to gravity then corresponds to the clout (Mc^2 / r) at the surface of a surrounding 1 metre sphere of volume $4\pi / 3$ containing a given mass (kg) of matter. This gives rise to a factor of $3/4\pi G_N$. The value of $H_0^{\ 2}$ in GR is based on the value of the apparent Hubble expansion under which galaxies are moving away at a velocity (v/c) proportional to redshift. The escape velocity for a mass (m) can be determined by equating the potential and kinetic energy, so that $\frac{1}{2}m(v_{esc}/c)^2 = G_N m M_C / rc^2$. The Doppler redshift from galaxies moving away is $Z = v/c$ in the asymptotic limit of low Z , with $H_0 = Zc/r = v_{esc}/r$. The FR-implied critical mass per enclosed volume (r^3) is then also $\rho_c = 3H_0^{\ 2} / 8\pi G_N$, as predicted by GR. However, under FR, there is no expansion and the apparent value of H_0 corresponds to the reciprocal of the Hubble time for light to travel the distance since $Z = 1$ as determined from the fit to the supernovae data. The value is $c/4550$ Megaparsecs or 2.137 x 10^{-18} s^{-1}. The predicted critical density is then 8.17 x 10^{-27} kg/m^3 which appears reasonably consistent with observations.

This prediction may be suspect but it shows that the claims of the ΛCDM model, based on GR, have quite a different interpretation under FR. They simply reflect the effect of the background in determining G_N and c in a flat universe (no distortion of distance) with no expansion. There is no need for dark energy or dark matter and the changes in the energy and inertia of matter over time and with location mean that conclusions about the amount of baryonic matter need re-examination.

6.5 Summary

FR explains the supernovae data without the need for an accelerating expansion or dark energy. The linear change in redshift with time can then be used to predict the mean current rate in change of time. However, this may not also be the local rate of change of time. The changes in position and signal frequency referred to as the Pioneer anomaly need re-examination. Selective heat radiation can explain why the two Pioneer spacecraft were decelerated relative to their expected positions. However, it appears likely that a review of the predictions of both GR and FR will enable either an alternative explanation for the anomaly or a means of distinguishing between the theories.

The concept of a new form of energy, the dark energy hypothesised to explain the apparent accelerating expansion, should always have been seen to be suspect. The influence of this energy grows as the space between objects increases. Moreover, under GR, there is no understanding of why it is just now becoming dominant and will drive the universe away from its observed flatness.

FR provides a potential explanation for the discrepancy between the Planck data and the cosmic ladder-based data because the size of galaxies and the oscillation frequency of Cepheid variables will have changed with background magnitude and redshift.

FR not only removes the accelerating expansion and dark energy, it removes the need for any expansion, and hence the need for an initial hot, dense state and a Big Bang.

Chapter 7

Further astrophysical predictions and consequences

Full Relativity has wider implications than just changed observations when the background magnitude and asymmetry were different. It alters many perspectives such as the early nature of the universe, how it evolved and why it appears as it does now.

7.1 No need for cosmic inflation

The converse of clock-rate increasing with time is that clock-rate was progressively slower and the speed of light faster, earlier in the history of the universe. Moreover, the increasing redshift of galaxies with distance does not require any expansion or even an initial hot, dense state. These changes remove the need for "cosmic inflation" which was hypothesised to explain why the observed universe could be so uniform and isotropic if distant regions had not previously been in thermal equilibrium. The suggestion that the universe expanded by 20 orders of magnitude in the first 10^{-35} seconds after the Big Bang should have always been seen as untenable, when the existing laws of physics say that infinite energy is needed to get even the smallest amount of matter moving at the speed of light. Moreover, under GR, the density of the early universe would have been such that it would have been inside a "black hole" from which nothing, including our galaxy, could escape. The incredibly rapid expansion would have to have been much greater than the speed of light, violating SR and GR. This has been claimed to be allowed because it is "space itself" that expands rather than that the objects move! That is, distance, the size of the empty vacuum between massive objects increased, without the objects moving. This is hard to comprehend and relies on the concept of spacetime being a distortable fabric (metric), a relationship and "not a thing".

7.2 Overcoming the worst prediction in physics

The value of the vacuum energy density based on the value of the cosmological constant, determined under the assumptions of GR, is in marked disagreement with theoretical predictions based on the value of vacuum energy implied by quantum field theory. Depending on assumptions, the discrepancy is as high as 120 orders of magnitude. This has been described as "the worst theoretical prediction in the history of physics" [72].

FR overcomes this disagreement. First, there is no need for a cosmological constant. The universe is inherently flat and the assumptions of GR are faulty. Second, the apparent vacuum energy does not exist in the space between objects but in the stored energy trapped within objects.

Under GR, the cosmological constant (Λ) corresponds to a force that increases with distance. It can be expressed as: $g_\Lambda = -\nabla \phi_\Lambda = \Lambda c^2 r / 3$. Under FR, this behaviour can be understood as arising from using gravitational acceleration instead of gravitational potential (clout) as the source of gravity. The ratio of volume to surface area is $\frac{4}{3}\pi r^3 / 4\pi r^2 = r / 3$. The implication would seem to be that the needed value of dark energy should be three times the apparent amount from matter (i.e. dark matter plus ordinary matter) and add to the amount needed to achieve a flat universe required by FR. This would suggest 75% dark energy to 25% dark plus ordinary matter. This is in moderate agreement with claimed amounts of 72.7% versus 22.7% + 4.56%, although in poorer agreement with more recent claims of 68% to 32%, but the values potentially incorporate errors from the ladder of the cosmological distance scale. The apparent amounts of dark matter and dark energy are approximately consistent with that expected from the faulty assumptions of GR. More importantly, FR removes the need to explain why the present values of dark matter and dark energy are just right to yield the observed geometrically flat universe. GR does not explain why the accelerating expansion due to dark energy, which would rapidly drive the universe away from a flat geometry, should just happen to give a flat geometry now.

7.3 No need for dark matter

The rotation speed of stars in the disk portions of spiral galaxies is observed to be in poor agreement with that expected from Newtonian gravitation and the observed mass distribution, based on assumptions for the luminance to mass ratio of matter in the cores of galaxies. The rotation curves do not decrease as the inverse square root of distance but are nearly constant outside of the central bulge. Under GR, this discrepancy is thought to betray the presence of an unseen halo of dark matter. This extensive halo of invisible matter provides additional gravitational attraction. Diffuse dark matter haloes have also been put forward to explain the observed gravitational lensing of distant galaxies and galaxy clusters, and the evidence for dark matter is considered by some to be compelling [72], while others maintain that there is a crisis [73]. The proposed dark matter can neither absorb nor emit electromagnetic radiation and cannot be attributed to neutrinos. Despite extensive searches no candidates for this non-baryonic dark matter have yet been observed and none is predicted within the Standard Model of particle physics. Similarly, there is no persuasive theoretical explanation for the existence or magnitude of dark energy [74].

The existing theory, based on GR, that has best explained cosmological observations is the ΛCDM model which incorporates a non-zero value of the cosmological constant (Λ) and cold dark matter (CDM) and seems to be in agreement with detailed observations of the cosmic microwave background [75]. However, it is also claimed that there is poor agreement between ΛCDM and observations of galaxies and dwarf galaxies and that an explanation of the Tully-Fisher relation is needed [73,76-77].

FR firstly proposes that gravitational mass depends on the background via the speed of light. This means the theory maintains consistency with Newton's law of gravitation if inertia is constant. The additional effect of the background that is needed, that allows dark matter to be avoided, is that oscillation frequency/wavelength, and therefore inertia, of both photons and massive objects are dependent on the asymmetry between matter and antimatter contributions to the field. There are chiral components sensitive to the background from matter and antimatter. The asymmetry will decrease with distance from concentrations of matter or antimatter in a uniform background.

A study of the rotation rate at different distances from the centre of spiral and irregular galaxies found that the radial acceleration is strongly correlated with the amount of visible matter attracting it – but the relationship does not match that predicted by Newtonian dynamics [43]. The relationship between predicted and observed gravitational acceleration was found to be linear at high accelerations. This meant that the acceleration was directly proportional to the visible matter in regions of large asymmetry. However, $g_{obs} \propto \sqrt{g_{pred}}$ was seen at low accelerations, i.e. in regions of low asymmetry. This appears potentially consistent with m_i / m_g constant at high asymmetry so that $F_g \propto 1/r^2$ and $m_i / m_g \propto 1/r$ at low asymmetry, so that $F_g \propto 1/r$, but is examined in more detail below.

For a galaxy surrounded by an approximately uniform sea of clout from matter (A) and antimatter ($\bar{A}$), the matter asymmetry will be $(A+\delta A-\bar{A})/(A+\delta A+\bar{A})$, where δA is an increase in clout from matter. An inertia that depended on the asymmetry would be proportional to $\delta A/2A$ when $A=\bar{A}$, far away from an isolated galaxy in a uniform background. The M/r dependence of clout should mean that the enormous number of background galaxies, that are relatively large compared with their spacing, would dominate over any one galaxy. Hence, the background should be large but its asymmetry small. The gradient in stored energy would be accelerating objects whose inertial mass was decreasing in proportion to the fractional decrease in asymmetry. The effect is to decrease inertia, at large distances from a point source of like matter, by $1/r$ while the gravitational attraction from that same matter reduces as M/r^2. The coefficient of the $1/r$ dependence of inertia is not known for certain and needs to be observationally tested. The gravitational force depends on the gradient in total clout while the inertia depends on the fractional asymmetry relative to a background with near zero asymmetry. The latter depends on the excess of the sum, from all directions, of just one component (either matter or antimatter). Within an extended uniform distribution of stars in a galaxy the asymmetry from the surrounding galaxy can dominate and be nearly constant near its centre, so the gradient in asymmetry from a nearby single star is small. The background asymmetry and inertia will reduce away from the galaxy centre, leading to an apparent increase in G_N with decreasing isotropy of the source.

Our galaxy has an extended distribution in a single plane but with a marked concentration in the central core. The position of our solar system is a modest way out from the central core. The estimates given in Section 6.2.2 suggest that the asymmetry at our position will be dominated by our galaxy with components from both the central core and the bulk of the galaxy. These are likely to be some hundred or more times larger than an additional contribution very close to the Sun. The value of asymmetry, and therefore inertia, will be nearly constant within our solar system. It will decrease with distance from the central core of our galaxy, but the decrease will only approach a $1/r$ dependence at large distances (when the gradient in asymmetry follows that expected from a point source). This appears broadly consistent with the observed rotation curves of isolated galaxies and the position of our solar system within our galaxy. It is proposed that it is likely to be able to explain an apparent need (under the assumed constant inertia of GR) for five times as much dark matter as ordinary matter. This would seem to imply that the total clout from our galaxy at the location of the solar system is some five times the vector sum of the clout from the region within the sphere surrounding the core out to our Sun (which determines the gradient). Modelling of this explanation is needed which might also need to include the increase in inertia in the central core and its impact on the estimated mass present within the central black hole.

Under FR, the rotation curves of spiral galaxies do not require a surrounding cloud of gravitationally active but invisible dark matter, provided galaxies reside in a background of roughly equal clouts from matter and antimatter galaxies. Dark matter will appear to be necessary because the asymmetry in chiral densities will vary within an extended distribution of like matter and decrease markedly with distance from a large central concentration of matter. A diffuse galaxy will appear to need little dark matter within the diffuse region [78], because there will only be a small gradient in asymmetry with position. An apparent need for dark matter can also be expected to be seen within galaxy clusters.

If the background chiral component from antimatter is constant over the region of interest, then the fractional asymmetry is proportional to the gradient in the matter component of the clout. The asymmetry will change <u>within</u> a galaxy if it is an isolated excess of matter in an approximately uniform background of matter and antimatter, because the asymmetry has contributions from all directions. The amount of bending and change in inertia relative to that expected will vary in proportion to the disagreement between the apparent value of G_N (deduced for our solar system) that incorporates the local ratio of inertial to gravitational mass.

Hence, GR and FR will give the same predicted amounts of bending in our local region of the galaxy. FR will give different predictions elsewhere, but these will agree with the rotation curves of galaxies, because oscillation frequency and inertia have the same dependence on asymmetry. The putative amount of dark m G_N atter needed to account for gravitational lensing will match that needed to account for the apparent velocity of matter (e.g. galaxy rotation curves). That is, the amount needed by the locally observed gravitational acceleration when inertia is assumed independent of asymmetry.

The revised understanding voids the claim that the distribution of matter, and supposed dark matter, seen in the Bullet Cluster (1E 0657-56) of two colliding galaxy clusters, constitutes a "direct empirical proof" of the existence of dark matter [79]. It is claimed that the bulk of hadronic matter is at the location of the visible plasma while the gravitational bending indicates that the location of the centres of gravitational attraction are at the centres of the galaxy clusters, which is where the (electromagnetically) non-interacting dark matter should be expected to reside. The suggestion that the plasma should indicate the location of the dominant source of mass appears to be based on tenuous evidence. Most of the stars should pass through unless the cores of the galaxies actually collide. More importantly, the inertia of the cores of the galaxies (any region with asymmetry significantly larger than that in our solar system) will be much larger than expected using our value for G_N . Their momentum will be correspondingly greater for a given velocity.

The larger than expected momentum for a given velocity will alter the apparent dynamics and clusters of galaxies of like matter will also give rise to gravitational lensing that depends on the surrounding galaxies and not just the enclosed matter. It is highly desirable that the observed gravitational lensing be fitted using the revised theory to confirm that dark matter is also no longer required to explain the observed lensing.

The requirements on the shape of the hypothesised clouds of dark matter and that they extend far beyond the boundaries of the visible matter, yet interact gravitationally with it, has always appeared suspect. FR implies that there is a similar amount of antimatter in the universe, consistent with the observed symmetry of physical laws, but appears able to remove (see Section 5.4) the expectation that the distinctive annihilation signal from a merger of matter and antimatter galaxies would still be common. The lower mass of particles in the high density of the early universe and the reduction in inertia in regions of low asymmetry, at the boundaries between regions of matter and antimatter, has the potential to avoid the complete annihilation of baryons and antibaryons which is a prediction of the current big-bang model if symmetric [45]. A potential test of the revised model is whether it can predict the current ratio of nucleons to gamma rays of approximately 10^{-9}.

7.4 Tully-Fisher relationship and MOND explained

An empirical relationship between the intrinsic luminosity (L) and asymptotic rotational velocity (amplitude of the rotation curve W at large distance) of spiral galaxies has been observed [80]. The relationship $L \propto W^4$ applies over several orders of magnitude. Since the intrinsic luminosity is inherently independent of dark matter, but dark matter (if it exists) should have an effect on the rotational velocity, the relationship is actually evidence that dark matter does not exist. The relationship appears to be explicable by FR.

The approximately flat rotation curves require the force of gravitational attraction to be matched by the centripetal acceleration force. Hence, $G_N Mm / r^2 = mv^2 / r$ and $M = (m_i / m_g) rv^2(r) / G_N$, where $m_i / m_g = 1$ is for the location of the solar system within the local excess of matter, i.e. our galaxy. However, the value of G_N in our solar system, per unit of stored energy, includes the fractional asymmetry at our location in the galaxy. This value of asymmetry, from the galaxy, is much larger than that due to the Sun so inertia appears constant. Across a region as small as our solar system, that is also within the near-field of the galaxy, changes in inertia will be small. Moreover, the calculated force is based on the gradient of the potential and a small additional change in inertia could be absorbed into the estimated mass of the Sun. The decrease in inertia as $1/r$ at large distances (r) from the centre of an isolated galaxy means that $m_i / m_g \propto 1/r$. However, this $1/r$ dependence is locally hidden. The rotation curve becomes flat as the source of attraction and inertia becomes point-like.

As set out in Section 4.3.4, if the background chiral components are ρ_1 and ρ_2, and their contributions are to balance then the effect on the components must be complementary. The larger chiral component (ρ_1) could reduce in frequency and/or amplitude by the factor α while the smaller component could increase by $1/\alpha$. This would mean $\rho_1\alpha = \rho_2 / \alpha$ and $\alpha = \sqrt{\rho_2 / \rho_1}$. Since chirality of matter and antimatter is associated with opposing directions of rotation it seems plausible to have a conceptual model based on balanced torques, or angular momenta. It is therefore proposed that an excess of one type of matter induces an increase that is proportional to the square root of the excess in stored energy above the mean. This is because a balance requires an equal and opposite change in the opposing chiral component.

The gradient in clout from a point source of mass M, within a large and constant background from equal quantities of matter and antimatter, will be proportional to M / r^2. The fractional decrease in inertia with distance, when the background asymmetry is small, will be proportional to $\sqrt{M} / r$ so that $v^2 \propto G_N \sqrt{M}$. (The value of G_N incorporates the local value of inertia, because m_g / m_i was set to 1.) The asymptotic velocity (amplitude of the rotation curve) raised to the fourth power will be proportional to total mass. If luminosity is proportional to mass, it follows that $L \propto W^4$.

Further evidence against the need for dark matter has been found in an even tighter relationship between the radial acceleration traced by rotation curves (not just the asymptotic velocities) and that predicted by the observed distribution of baryons. The correlation holds across 153 galaxies with very different morphologies, masses, sizes, and gas fractions. The correlation persists even when dark matter dominates. Hence, the dark matter contribution is fully specified by that of the baryons [43].

The observed asymptotic velocity is used to calculate the observed acceleration $g_{obs} = v^2(R) / R$. This is compared with the acceleration expected from the sum of the baryonic components $g_{bar} = \left|\partial\Phi_{bar} / \partial R\right|$, using their gravitational potentials Φ_{bar}. These are determined from solving Poisson's equation $\nabla^2\Phi_{bar} = 4\pi G\rho_{bar}$ for the observed distribution of each component. In all galaxies, the data exceed the lines $v_{bar} = \sqrt{Rg_{bar}}$, i.e. that expected if $g_{bar} = v_{bar}^2 / R$. The excess over that expected is, under GR, taken to indicate the need for dark matter. The observed acceleration is compared with a predicted acceleration that adjusts the expected baryonic acceleration according to $g_{obs} = F(g_{bar}) = g_{bar} / (1 - e^{-\sqrt{g_{bar}/g_\dagger}})$, where the one parameter is the scale factor $g_\dagger$. Under FR, this scale factor substitutes for the acceleration value at our location in our galaxy, because this represents the value of asymmetry incorporated into G_N by equating inertial and gravitational mass.

MOdified Newtonian Dynamics (MOND) is the unusual idea that the strength of gravity levels off at very low accelerations. Why is not explained but, as seen in the above study, it appears to be in better agreement with the rotation curves of galaxies which correlate with the distribution of visible matter (stars and gas) [81]. The idea of a "dynamical law" in which the strength of gravity maintains a constant value independent of distance is difficult to accept because it requires that the total background field, and the change in energy that it can induce, increases with distance from the source. The observations of MOND can be simply explained by incorporating an inertia that arises from an asymmetry due to an excess of one component in a two-component background.

FR has inertia proportional to fractional asymmetry, with asymmetry being very small except near or within a large source of clout. The asymmetry within a galaxy, an isolated region of just matter or just antimatter, has contributions from all directions. Therefore, it will only decrease as $1/r$ at sufficient distance outside a source that it appears point-like. Both the gravitational potential and asymmetry depend on the sum of clouts that reduce in proportion to $1/r$. The gravitational force depends on the gradient of the clout from matter on a large, and therefore nearly constant, background due to equal contributions from matter and antimatter. The total background determines the speed of light which determines the mass per unit matter. The gravitational force will therefore be small but will appear to just depend on the gradient and so vary as M/r^2 outside the near field of a circularly symmetric distribution of mass M. The fractional asymmetry determines the frequency of oscillation, and therefore the inertia, per unit of stored energy (mass). The inertia from each isolated source of just matter will decrease as $\sqrt{M}/r$. However, the background asymmetry is very small. The gradient in fractional asymmetry is therefore normalised by the total clout from just the local excess of matter independent of its direction.

The needed rate of change of direction (acceleration) for a circular orbit decreases as $1/r$. Therefore, the rotation curve will become flat as a function of the degree to which the mass distribution, and therefore the asymmetry, becomes point-like.

For circularly symmetric galaxies with the same shape of radial density distribution the needed fraction of dark matter (under the assumption of constant inertia) with distance from the centre should be expected to scale, i.e. be identical after adjusting for the size (diameter).

Within the galaxy (before there is a significant need for dark matter) the speed of rotation should approach that expected for the visible matter as inertia within a uniform extended source will approach a constant value.

These deductions seem to be consistent with observations [81]. The next step is to use the understanding to show, given our position in our galaxy, that it is in agreement with the observed levelling off of gravitational acceleration at a value of approximately 1.2×10^{-10} m/s^2.

7.5 Galaxy evolution, Sachs-Wolfe, Lense-Thirring and other effects

The Sachs-Wolfe effect [82], in which photons from the CMB are gravitationally redshifted, causes the CMB spectrum to appear uneven. Under GR, this effect is the predominant source of fluctuations in the CMB for angular scales above about ten degrees. However, under FR, variations in the wavelength of the cosmic microwave background cannot be attributed to losses or gains in energy of photons as they move through gravitational potentials.

Under GR, there is a non-integrated Sachs-Wolfe effect caused by the gravitational redshift at the surface of last scattering. The amount varies due to differences in the matter/energy density at the time of last scattering. There is also an integrated Sachs-Wolfe effect caused by gravitational redshifting after emission, i.e. on the way to us. Under GR, a photon gains energy entering a potential well (a supercluster) but regains it on leaving. The opposite happens with a supervoid. Thus, there should not be significant change if the potential energy wells and hills do not evolve. However, accelerated expansion due to dark energy would cause potential wells to decay over the time it takes a photon to travel through them. A signature of the effect is a cross-correlation between observed galaxy density and the temperature of the CMB, and such a correlation seems to have been detected.

Under FR, such changes in photon energy after emission do not occur. Instead the variations in wavelength must reflect different mean energies of emission or changes in wavelength during the journey. Differences at emission arise directly from large-scale variations in the background.

Differences that arise during transmission need more careful examination. Variations in the density during transmission do not directly affect photon energy. They would affect the speed of light so the time taken for the light to travel from the surface of last scattering would be different, but this would not matter if the surface of last scattering occurred at a fixed time and the same distance and background density. The dimensions of space are not changed by expansion, nor is the energy of already emitted photons, but the relative values of clout in regions of initially different density and from changes in density from clumping would seem likely to grow over time. The rate of clumping in a galaxy cluster and void may vary because the mean speed of light and inertia will be different. This might lead to increasing differences in redshift from large-scale differences in mean background clout.

It should be noted that variations in the temperature of the CMB predominantly reflect variations in redshift due to differences in clout with differences in mean density of regions. Therefore, there should be a correlation between subsequent galaxy density along the line of sight and the temperature of the CMB. The strength of the correlation would depend on how inhomogeneities evolve over time. Modelling of the evolution of structure in the distribution of galaxies is needed.

GR predicts that a massive object will distort spacetime so that the spin of an orbiting rotating body will precess (geodetic effect). It also predicts that the rotation of a massive object will distort the spacetime metric, making the orbit of a nearby test particle precess (Lense-Thirring or frame-dragging effect). These effects have been recently confirmed to good accuracy [83]. They are due to the finite propagation speed of gravity so that different parts of a rotating or moving object see a different direction in the gradient or magnitude of the clout. This produces a torque in a rotating object or a sideways force in an eccentric orbit. They are thus inherent to theories that have gravity propagating at the speed of light. The magnitude of the effects will depend on the magnitude of the force at the distance of the test object before taking these relativistic effects into account. FR has the same propagation speed of gravity and if the force is the same then so will be the predictions.

The contraction of galaxies as kinetic energy is converted to stored energy (mass) appears to have interesting consequences. It should lead to isolated white dwarf stars, with no companion from which to gain material, crossing the mass limit and exploding as Type 1a supernovae. Similarly, the contraction would mean that more matter would be drawn into the large concentrations of matter (black holes) at the centre of galaxies. This could explain the observed special relationship between supermassive black holes and their host galaxies. The amount of matter in these concentrations would also be grossly underestimated from the dynamics of nearby stars because the asymmetry and inertia would be much greater than observed in our region of our galaxy. This could help explain why the current baryon density appears to be much less than that deduced from nucleosynthesis.

The consequences of the revised theory for many other astronomical observations, such as for the predicted distribution and evolution of stars and galaxies, for nucleosynthesis, and for the separation of matter and antimatter, need deeper investigation. The changes in mass and inertia per unit of matter with clumping and the separation into regions of matter and antimatter needs to be modelled to explore their impact on the evolution of galaxy shapes and the large-scale structure of the universe with time. FR implies that the amount of matter in the central region of galaxies including inside the core of any black holes should be much larger than currently modelled, because of the increase in inertia with increasing asymmetry. The predictions from baryon acoustic oscillations [84], periodic fluctuations in the density of the visible baryonic matter of the universe, also need to be re-examined in light of the revised theory. However, the oscillations should also exist under FR. In fact, they are also the proposed source for the appearance of galaxies.

7.6 Summary

FR avoids the need for dark matter and cosmic inflation and appears able to explain other observed phenomena, including galaxy rotation curves and why the current universe is accurately “flat”, while reproducing the predictions claimed to establish GR. The further consequences and explanations need detailed examination including careful modelling and simulation.

Chapter 8

Experimental tests of Full Relativity

FR asserts that the there is a real background from the mass stored by all other objects and that mass and the speed of light vary with changes in this background. GR asserts that mass is constant but that the observed speed of light and clock-rate decrease when examined from a higher gravitational potential. FR also asserts that frequency and inertia should depend on the asymmetry of the background. A number of experimental tests are put forward to distinguish between the theories.

8.1 Speed of light

The GR predicted slowing of time (clock-rate) lower in a gravitational potential is a confirmed effect seen in the faster clock-rate of the GPS satellites. In the language of gravity being a curved spacetime, the light trajectory in the curved spacetime will be different to that in a flat spacetime [85]. The dilation of time and contraction of space causes light to take a longer path giving an increase (delay) in the time it takes light to travel a given distance from the perspective of an outside observer. Under FR, the slowing of time (clock-rate) is irrelevant for massless photons, and instead the speed of light increases closer to a massive object. The difference may offer a means of distinguishing FR from GR.

The Shapiro delay of signals passing near a massive object is an observationally confirmed prediction of GR. Electromagnetic signals follow a curved path in spacetime which combines the changes due to the distortions of space and time, with both reducing/slowing near a massive object. The effects of many alternatives to GR, that are still metric theories (unlike FR), have been formalised in terms of their effects on a finite set of parameters [86]. The relevant parameter for path length is γ (which is unrelated to the use of the same symbol in SR). The parameter measures the amount of curvature of space (only) relative to that predicted by GR $(\gamma = 1)$. The contribution of time to curvature, known from the dilation of time with gravitational potential, is set to 1. The accuracy of the predictions of different metric theories has been examined in terms of the value of $\frac{1}{2}(1+\gamma)$. Observations are consistent with the GR value of 1, for both the deflection of light and the Shapiro delay, to within 0.01 percent [87]. However, it needs to be recognised that the value of the Shapiro delay, as currently determined, is solely a measure of the amount of bending. The delay from the increased path length in spacetime is predicted to have a logarithmic dependence on the ratio of the path length to the distance of closest approach. All observations appear to have used this logarithmic dependence to remove effects from uncertainties in orbital movements and from distortions due to the solar corona.

Under both FR and GR, the path is determined by the bending and the predicted amount of bending is the same and in excellent agreement with observations. For FR, the amount of bending is determined by changes in oscillation frequency which give twice the Newtonian bending. For FR, the timing along the bent path should also be altered by the changes in the speed of light but such timing changes will not be seen by a fitting method that seeks only the logarithmic dependence.

FR has the speed of light increasing. Under GR, the speed of light appears slower when seen from a higher potential but, arguably, should be constant along the paths taken by the signals because the path is not at the observer's potential. Yet, it is this change in the apparent speed of light that already leads to half the bending. (Under GR, this includes the notion that the real decrease in clock-rate deeper in a gravitational potential means that light will take longer to traverse a given distance even though, to the local observer, the speed is unchanged.) This underlying inconsistency is a carryover from the inverted interpretation of time intervals relative to distance intervals that was necessary to keep the speed of light constant in SR. If light speed is actually slowed along the bent path, then there should be an additional delay. However, under GR, a slower time is taken to mean that light will take a reduced time to travel a contracted distance, so there should not be an additional delay.

The possible delay (GR) or definite advance (FR) due to the effect of the gravitational potential on time or the speed of light is integrated over the length of the path through the altered potential. The change in time or light-speed varies with the change in potential/clout along the signal paths. The FR increase in light-speed will appear like a contraction in distance. Therefore, if the actual path length is known, FR can be distinguished from GR by the difference in travel time. A difficulty of determining this by observation is that distance measurements usually assume a constant speed of light. The effect of any increase in light-speed would potentially be hidden by faulty distance measurements or easily absorbed into orbital parameters using a decreased orbit, a decreased path length.

The proposed experimental test is to have at least two, and preferably three or more, spacecraft spaced equally in the same circular orbit around the Sun and in the same plane, but at a different radius to Earth's orbit. Seen from the Earth, they would pass behind the Sun at intervals but maintain their same relative spacing and remain at the same gravitational potential so that there was no gravitational time dilation. Timing signals would be passed between all the spacecraft and the Earth and, ideally, there would be low-drift clocks on the spacecraft synchronised with each other. The matched orbits of the spacecraft is to ensure that signals exchanged between them have a constant amount of bending and the same integrated light-speed.

Alternatively, changes in the arrival time of signals from multiple pulsars could be examined (as has already been done), but using a modified analysis. The additional changes in timing, beyond those due to bending, will depend on the path to the Earth through the potential of the Sun. After correction for path-length changes due to bending, the distance between the Earth and spacecraft or pulsars, based on timing, will appear to decrease if the light speed along the path increases. However, this will just duplicate the supposed matched contraction of space (distance).

8.2 Time dilation with speed relative to the background

SR has time dilation dependent only on relative motion. The clock rates of identical clocks, each stationary with respect to their local observer, but with the observers moving relative to each other, will both be slowed when seen by the other observer. FR has time slowed for massive clocks moving relative to the background from all other matter. The most accurate current tests of time dilation, so far, appear to have examined oscillatory or circular motion relative to a stationary mean. Less accurate Hafele-Keating type experiments have compared clocks with uncertain drifts which have spent different lengths of time at varying gravitational potential. A more accurate test of reciprocal time dilation (i.e. of SR's relativity) requires low-drift clocks at similar gravitational potential.

A test that distinguishes between changes in time due to movement is not a direct test between the two theories of a gravity, both of which have time running slower higher in a gravitational potential. However, since GR is built on the invariant spacetime interval of SR it can be used as a test.

The proposed experiment is to examine the signals from three pairs of equidistantly-spaced spacecraft carrying identical highly stable clocks. All pairs would maintain a similar distance from the Sun. One central pair would be passed simultaneously by the other two pairs of spacecraft going at a constant high-speed, but in opposite directions, and all clock rates would be compared. Each pair would have their clocks synchronised, and all pairs would maintain the same fixed separation based on signal return time.

The clocks would emit both pulses and continuous frequency signals. Their relative motion would be determined using the Doppler shift of the continuous frequency signals. The spacecraft should be in as weak and as nearly constant a gravitational field as possible, and moving (nearly) perpendicular to any gradient in the field. The changes in clock rate and simultaneity of the passings would test both reciprocal time dilation and length/distance contraction with relative movement.

8.3 Changes in time relative to distance

FR predicts a slowing of time going back in time consistent with the increase in speed of light that explains the supernovae data without the need for dark energy.

The previously proposed explanation of a slowing of the Pioneer spacecraft due to preferential heat radiation can explain a change in position and signal frequency. However, GR and FR would appear to give different predictions for changes in position and frequency. The method used does not need to take time at the spacecraft into account because the frequency-locking of the returned signal is independent of this time. The current predictions of position appear to take the claimed changes of distance and the observed changes in frequency in a gravitational potential into account by different means. GR uses a distortion of space and time between the observer and spacecraft while FR has frequency altered by stored energy and no change in distance.

A new mission, with careful removal of any preferential direction in the radiation of heat, is required. Ideally, a second pulsed signal would also be sent containing a time signature that would enable a calculation of distance since time of launch despite any breaks in signal contact. It would also be useful to have at least one, and preferably two, ultra-low-drift on-board clocks to send separate signals of constant frequency back and to provide additional comparisons at the spacecraft.

8.4 The effect of background asymmetry on inertia

FR proposes that the current local ratio m_i / m_g has been included in the value of $G_N M$. The ratio of inertial to gravitational forces has been set to one even though apparent inertial mass depends on the product of stored energy (gravitational mass) and oscillation frequency via background asymmetry. FR claims that within our solar system the ratio is approximately constant with the asymmetry from our galaxy being larger than other sources of asymmetry except, possibly, near the Sun. Such a contribution to asymmetry will slightly increase the total asymmetry and so decrease the fractional change in inertia. This will lead to an apparent reduction in the value of G_N near the Sun.

The value of c^2 / G_N indicates that the local background clout, due to a balanced contribution from the matter and antimatter of distant galaxies, corresponds to the effect of an amount of energy of 1.3467 x 10^{27} kg at 1 m or 10^5 to 10^6 times the estimated clout from the matter of our galaxy. If the local asymmetry is primarily due to our galaxy, then it should be of the order of 10^{-5} to 10^{-6}. The value of asymmetry should be approximately constant for the planetary orbits within our solar system because the clout from the Sun at the orbit of Mercury is 3.43 x 10^{19} kg/m which is about 1/35th that of the estimated background value of 1.2 x 10^{21} kg/m from just the core of our galaxy. However, the apparent need for five times the amount of dark matter to ordinary matter when inertia is assumed constant suggests that the background from the entire galaxy is at least 6 x 10^{21} kg/m. This would mean that the orbital periods of Mercury and other inner planets would be marginally slower, relative to the outer planets, than that predicted by Kepler's third law. A more stringent test would seem to be in the bending of light by the Sun as the clout at its surface (assuming constant inertia) is 2.86 x 10^{21} kg/m. This is likely to be a significant fraction of the background from the galaxy and so may be enough to increase the asymmetry and amount of bending close to the Sun by an observable amount.

The FR hypothesis that the asymmetry of the background affects inertia means that the rate of movement of massive objects will also vary with location within a galaxy and possibly within a supercluster of galaxies. Such a variation would appear to be an explanation for the variable rise and fall times of the light curves of supernovae while the total energy emitted is approximately constant. FR predicts that rise and fall times should depend on the local asymmetry. This could be tested by searching for a correlation between the location of supernovae within galaxies (and galaxy superclusters) and the width of their light curves. The narrowest light curves should be observed for the most isolated supernovae.

8.5 Linking Planck's and Newton's constants

For massive objects travelling at high-speed relative to the background both inertia and the time (clock-rate) inherent to the object (seen in the emitted oscillation frequency) are reduced by the factor γ. This is the oscillation seen in the de Broglie wavelength $p = h / \lambda$ of matter and light. If Planck's constant depends on the local clout and asymmetry of the background, it suggests that the sensitivity of inertia to speed relative to the background arises from unequal effects on the rotation frequency of opposing chiral components.

If a photon has two components of opposite chirality that rotate at speeds dependent on the energy density for their respective chirality, then the frequency of oscillation will depend on the energy of the photon (as seen in $E = hf$) and the asymmetry in chiral contributions. So, it would be expected that h will change according to the local asymmetry in matter over antimatter. However, if the frequency of oscillation of both matter and photons change in unison, the observer will be unaware of changes in local oscillation frequency at a distant location unless there is an independent measurement of inertia, or of energy with frequency.

In moving away from a region containing a concentration of matter, e.g. the centre of a galaxy, that lies within a large background of similar contributions from matter and antimatter, the fractional asymmetry will decrease. Hence, the frequency of a photon carrying the same energy will decrease and the value of Planck's constant (which relates energy to frequency of oscillation) will increase with movement into a region of smaller asymmetry, and the inertia of objects will decrease. The value of m_i / m_g will change in proportion to the change in fractional asymmetry.

The value of Planck's constant, local frequency for a given energy, should depend on the size of the asymmetry of the chirality from matter and antimatter, relative to the total clout. For a constant energy photon, the change in frequency will depend on the fractional change in asymmetry. In our region of only matter, the energy of a photon from the same transition will increase in proportion to $1/c^2$, from the decrease in c due to the decrease in the clout from a change in one component. The value of h should decrease by the increase in gravitational potential (because changes in clout affect c and inertial time) which is dominated by the fractional decrease in asymmetry. Hence, the value of h will appear constant in terms of local inertial time within a region of large, constant background asymmetry but, if it could be measured at different locations in a galaxy, should vary in line with the change in asymmetry implied by the galaxy rotation curve. Thus, local (i.e. within our solar system) changes in the value of Planck's constant are likely to be too small to provide useful tests.

It should be possible to estimate the total background clout from observations of the number, size and distance of galaxies. The reduced mass of more remote (earlier) galaxies due to the faster speed of light in the past should mean that their contribution decreases significantly at high Z. The asymmetry of the background in our solar system should also be able to be estimated from observations of the distribution of stars and the rotation curve of our galaxy. These estimates should link and be consistent with the observed values of h and G_N , and allow the size of any resulting discrepancies in bending of light and planetary orbits near the Sun to be predicted.

8.6 Galaxy distribution and evolution

Clusters of galaxies, and large-scale separation of regions of matter and antimatter, could lead to modest variations in the asymmetry of the background with direction. This would mean that inertia would vary along the gradient in background asymmetry. It would lead to a periodic variation in rotation velocity with direction, for the same distance from the galaxy centre. Any small anomaly in density from circular symmetry should also lead to a gradient in inertia. The gradients in velocity could then be expected to give rise to spiral fluctuations in density away from the core consistent with the observed stellar velocity with distance. At large distances, where speed is constant, the arms should wrap by the ratio of the circumferential paths. In addition, the contraction of all galaxies as the speed of light decreases, would seem likely to produce, and determine the width of, spiral arms. The width would relate to the ratio of galaxy rotation speed to contraction speed. Thus, it appears that the hypothesis on the origin of inertia can explain not only rotation curves but also the existence of spiral arms and why they are not wiped out rapidly by the differential rotation with distance from the galaxy centre. The morphology and distribution of the spiral arms should be consistent with the mass distribution of the galaxy, the measured rotation curve and the rate of change of light speed. They may also be influenced by the surrounding distribution of galaxies.

The implications of FR for the evolution of the universe requires modelling. It needs to be shown that the effects of the decreasing speed of light and of asymmetry on inertia can explain the rate of formation and the observed large and small-scale structure and distribution of galaxies, including the apparent voids.

Ideally, modelling might confirm that separated regions of surviving matter and antimatter should have been formed early in the universe and that these are now permanently separated and so do not give rise to an annihilation signal.

Modelling might also enable a clearer picture of the synthesis of light elements and enable agreement with their observed abundances and with the observed photon to baryon ratio.

8.7 Summary

There are many opportunities for both observational and experimental tests that can distinguish between FR and GR. The suggested tests are probably just the tip of the iceberg.

Chapter 9

Linking gravity to particle physics and quantum mechanics

The assertion that gravity arises from the energy stored by all forces suggests that all the properties and interactions of objects may arise from different aspects of the one background. Ultimately, this means that the observed properties of gravity must be related to those of the other three forces. The observation that the speed of propagation of light, the quanta of electromagnetic interactions, is the same as the speed of propagation of gravity should be seen as strong evidence of the underlying unity of electromagnetic and gravitational fields and forces. The massless gluons of strong interactions are also understood to travel at the speed of light, as do the neutrinos but not the massive weak bosons of the weak interaction.

Under FR the propagation of the gravitational field does not appear to carry energy or angular momentum in the form of a confined (but oscillating) wave, and so should not be quantized. Changes in the "field" require changes in the balance of two chiral components. Their sum determines the speed of light and their fractional difference determines inertia. (However, for simplicity a propagating change in clout will still be referred to as a graviton.) Stationary states that include matched rotations of components are quantized. States that propagate freely are massless because the components match in the direction of motion. They resist changes in other directions and in magnitude and so can carry energy to a new location. The amount of energy remains constant after emission, but the rotation frequency of states that carry energy varies with the local asymmetry. A quantum theory of gravity is not needed. Space and time do not need to be quantized. Instead the stationary states of objects embedded in a background that allows oscillations are quantized.

However, the kinematic behaviour of quantized massive particle states experiencing gravitational forces must also be consistent with QM. Under FR it is proposed that inertia is related to oscillation frequency which depends on the clout and asymmetry of the current background. If this is the same oscillation seen in the de Broglie wavelength of matter and the $E = hf = \hbar\omega$ of light, then the value of Planck's constant per unit of energy should also be related to the asymmetry.

Unlike GR, FR appears to be consistent with QM because the strength of gravity does not tend to infinity in the limit of small separations or large energies. It does not have gravity as a continuous distortion of spacetime which goes to infinity as the separation of point sources approaches zero. If such point sources could exist, then their gravitational potential, the induced background, would reduce the mass, avoiding the singularity. Time, in terms of clock-rate, would also slow. Finally, the trapped momentum must not be stationary, so it does not have an infinitely small location in space (as would a point source) or time. This is reflected in the uncertainty principle.

The revised understanding emphasises that all particles (massive states as well as photons) are oscillating states, as put forward by Born [88]. It is proposed that the probabilistic nature of QM reflects this oscillating behaviour of all matter and quanta. The outcome of an interaction depends on the relative phases of the interacting wavefunctions. The phase relationships depend on the relative motions of the component wavefunctions as well as on their inherent phase. An "interaction" is observed if the wavefunctions interfere to produce a different standing-wave pattern that carries the same total momentum. This pattern is made of localised components moving relative to each other. The probability of different outcomes results from averaging over all relative phases according to their overlap. An individual outcome is causal and definite, but cannot be predicted definitively because the relative phases of the wavefunctions cannot be established without altering the phase relationship.

The appearance of the complex conjugate of a wavefunction in calculating the probabilities of particular outcomes in QM appears to be connected with the complex conjugate corresponding to a rotation in the opposite direction (i.e. matched counter-rotating components).

9.1 A physical realisation of the Standard Model

The strong, weak, and electromagnetic interactions have been unified in terms of gauge interactions (QCD, Electroweak and QED) of a finite set of elementary particles in which masses are predictable and linked via a finite self-consistent set of parameters. This is known as the Standard Model of particle physics. This renormalizable quantum field theory, covering all interactions except gravity, can be written down in terms of a Lagrangian that has terms for each of the strong, electromagnetic and weak interactions. High energy experiments, so far, have been remarkably consistent with the SM. However, it has many arbitrary features and all attempts at understanding these features have failed abysmally [89]. In 1994 Veltman pointed out that the many unknowns included the origin of the particular symmetries of the SM, i.e. SU(3) x SU(2) x U(1), why there are three generations of particles, and any explanation of the values of the underlying set of coupling constants and masses. Moreover, in his words: “In the background, as always lurks non-renormalizable gravitation with its black and other holes” (i.e. GR). Thus, the SM and renormalisation should be seen as a valid method for calculations and predictions but in need of an underlying physical explanation of how and why it works.

Many suggestions of physics beyond the SM have been put forward. These include dark matter and dark energy, the lack of antimatter despite the laws of physics appearing symmetric, and that neutrinos have mass (because they oscillate between flavours). FR removes the need for the first two and suggests that an equal amount of antimatter is actually present. In this chapter it will be argued that the oscillations of neutrinos between their flavours does not require them to be massless. FR also removes the problematic claim that gravity is not a force but a property of spacetime. Such a force is incompatible with QM and the SM behaviour of the other forces. FR claims that mass generation is not just due to the Higgs mechanism but to any force that confines energy to a location (as in angular momentum). This provides a link between the forces.

Massive particles and the quanta of all interactions (photons and presumably gluons, plus the neutrinos and the gauge bosons of the weak interaction) have an oscillation whose Compton wavelength is dependent on the energy carried. FR proposes that the chiral asymmetry of the background determines the rotation frequency of the trapped angular momentum seen in this Compton wavelength of quantum mechanics. It would appear to be strong evidence that the massive bosons of the weak interaction, plus quarks and multiple quark states (hadrons), store energy because of the chirality of the background and because of chiral components within the oscillations of their particle state. Hence, a model of the nature of the exchange bosons (graviton, photon, gluons, $W^{\pm}, Z_0, H_0$) and massive (or massless) fundamental fermions (neutrinos, leptons and quarks) in terms of oscillations that include chiral components is needed. The correct model should then allow the values of the SM parameters to be predicted based on the values of the two-component chiral background. It should also explain the modest mass of the Higgs (H_0) when its self-interaction might be expected to make it enormous.

9.1.1 Considerations based on broken gauge invariance

In quantum field theory the wave behaviour means that two numbers are needed for each point in space, a magnitude and a phase. A simple gauge invariance arises for vector fields that have a magnitude and phase at each location and time. It means that the choice of the zero position of the phase is of no importance for interactions, only the relative phase matters. Gauge invariance gives, or results from, conservation of a physical property. For example, QED is associated with conservation of electric charge. Local gauge invariance requires the agent that is carrying the information from one electron to another be a massless vector boson [90].

The development of the SM was based on the realisation that gauge invariant theories involving spin 1 bosons (Yang-Mills theories) were renormalizable. For the strong interaction there were 3 x 3 massless gauge bosons (the gluons) while the electro-weak interactions had the one massless boson (the photon) and three massive bosons ($W^{\pm}$, Z_0). These acquired their mass via the Higgs mechanism – a spontaneous breaking of an underlying gauge invariance, as occurs with the spontaneous alignment of spins in a ferromagnet cooled below its critical temperature. The Higgs mechanism applies to massive bosons and the understanding (under GR) has been that the mass terms preclude chiral gauge invariance for massive fermions (because a massive particle moves at less than the speed of light and its apparent direction of rotation will change when it is overtaken). The gluons of the strong interaction are massless but a (Yukawa-type) coupling between fermions and the Higgs field is introduced to handle and explain the non-zero mass of the fermions.

Under FR, there is an underlying gauge invariance of particle/antiparticle pairs but it is not fully manifest in regions in which there are differences in the contributions from chiral components (matter and antimatter) to the underlying field. The symmetry is not seen for particles with unmatched chiral components, but only in the sum of the interactions of matter/antimatter pairs. The energy that can be trapped increases with a decreasing speed of light providing increased time before differences cancel (allowing trapped momentum), and the asymmetry of the background within regions providing rotations which introduce inertia. The postulated Higgs field is just a manifestation of a scalar (spin 0) component (mass) of differences in properties with relative speed of movement of chiral components in the underlying field.

Under the SM, it is assumed that it is the interactions of the fields of elementary particles (both fermions and bosons) with just a “Higgs field” that gives rise to their mass and to the strength and symmetries of their interactions. Under FR, a particle having unbalanced chiral component(s) in a balanced two-component background field can potentially trap energy as mass. Inertia can arise when unequal chiral components of the background give rise to oscillations of the cyclic pattern of particle states. This underlying understanding of the nature of the field(s) and particles can, hopefully, enable the observed masses, couplings and symmetries to be reproduced.

9.1.2 Considerations based on the nature of spin 1 bosons

Information on spin 1 bosons is relevant to a physical model that is consistent with, and that can explain the properties of, the SM. The properties of the quantized wave interactions, e.g. via the photon, constitute a starting point.

A photon is understood to be a self-propagating oscillation of electric and magnetic fields and the wave equation of Maxwell’s theory of electrodynamics gives the speed of light as: $c^2 = 1/\mu_0\varepsilon_0$, where μ_0 is the magnetic permeability and ε_0 is the dielectric permittivity in vacuum. This splitting into component fields needs to be related to oscillations due to the two components of the background coming from contributions by matter and antimatter. An initial conundrum, that also provides clues, is that the photon is neutral whereas an electric field arises from a distribution of charge and a magnetic field arises from a rotation of charge (including from an alignment of spins). Moreover, the magnetic field acts on moving particles and both fields only seem to act on charged particles.

The chirality of a rotation is relative to the direction of motion and the helicity of a particle is a measure of the alignment of spin with the direction of motion. A particle that moves at the speed of light has a fixed helicity, the spin vector (time-averaged) can only be aligned with or against the direction of motion, and only massless particles can travel at the speed of light. For massive particles, the helicity appears to be proportional to the observer's speed relative to the speed of light but FR indicates that helicity is determined by speed relative to the background.

Under GR, a graviton has spin 2. Under FR, it appears analogous to a non-oscillating photon (zero frequency and unquantized spin) that propagates changes in the field strength but does not carry energy. It corresponds to a gradient in field strength along the direction of motion.

Heisenberg's uncertainty principle arises from the Fourier relationship between the time and frequency domains of a wave. If an arbitrary wave function is confined to a finite location, then it can be represented by a finite range of frequency components. For example, the sound of a very short impact contains a very wide range of frequencies. A wave confined to a region Δx must contain a range of different spatial frequencies $\Delta k\, \Delta k$ such that the product of the two ranges is $\Delta x \Delta k \geq \frac{1}{2}$, where the wave number $k = 2\pi / \lambda$ is the number of full waves that fit into 1 metre. Since $p = h / \lambda = \hbar k$, then $\Delta p \Delta x \geq \hbar / 2$.

The uncertainty relationship, that applies to waves, can be seen in a somewhat different light when considering waves in two and three dimensions rather than in one, i.e. not just along a line. A circular oscillation of constant magnitude in two dimensions can be represented by two (single frequency) sinusoidal oscillations that are 90^0 out of phase. The oscillation is confined to a region and each component has a maxima/minima when the other passes through zero.

The sum of three sinusoidal wave components that are each $2\pi / 3$ (120^0) out of phase add to zero, i.e. $\sin\phi + \sin(\phi + 2\pi / 3) + \sin(\phi + 4\pi / 3) = 0$ for all ϕ.

In seeking to model the photon we are seeking an oscillation pattern involving a two-component background that travels freely at the maximum speed allowed by the background, while this speed is independent of the energy and frequency of the oscillation. There already exists a model in terms of the crossed electric and magnetic fields of electrodynamics which act on massive particles (fermions of spin ½) carrying charge. However, the photon is an uncharged boson (spin 1), although, if it carries sufficient energy, it can split into a pair of oppositely charged fermions and anti-fermions. The effects of virtual particle/antiparticle pairs appear to be ever present even when there is insufficient energy for a permanent split into the pair of states that hold stored energy.

The proposed mechanism for establishing a persistent background field related to the density of matter and antimatter is that the torques from the larger component of the field decreases and that from the weaker field increases until the contributions balance. This should mean that oscillations of the torque about a mean position in space are able to occur, and the oscillation would be associated with a reversal of chirality (sense of rotation relative to direction of movement) about the equilibrium point. An oscillation would involve an increase or decrease in the magnitude or degree of rotation of the component.

It is proposed that a pair of such components corresponds to a gluon of the strong interaction and that the 3 colours of gluons (**r**ed, **g**reen, **b**lue) are associated with the three orthogonal directions of space. It is further proposed that the photon is the missing ninth gluon that is an equal mixture of the three colourless gluons ($r\overline{r}, g\overline{g}, b\overline{b}$) in which the components lie along the same axis. Previously, the ninth gluon has been assumed not to exist because it has no colour and leaves coloured quarks and gluons unchanged under the strong interaction. The photon does this, and so has no strong interactions, but interacts with the electric charge of quarks and merely flips the spin of charged particles.

The model of the photon is therefore an equal mixture of three gluon components that can be resolved into two fields (carrying spin =2 x ½) oscillating in the plane perpendicular to the direction of motion and a third component corresponding to a continuous displacement of the equilibrium point in the direction of motion. The difference in spin between the photon (spin 1) and graviton (no or undefined spin, not 2) suggest that the graviton has no transverse oscillations.

The photon is massless, not because it does not carry energy in the form of angular momentum, but because: i) its angular momentum vector is aligned with the direction of motion, and ii) the pairs or triplets of rotating components have matched chirality (net zero along the direction of motion). There is then no resistance to movement at the natural frequency of the background. These attributes mean that it travels at constant speed independent of movement relative to the source of the background yet resists changes in direction. It also is gravitationally "attracted"/bent perpendicular to its direction of motion.

9.1.3 Initial postulates towards a physical model

1. All particle states and their interactions arise from the one background field with the mass of a particle arising from any mechanism that confines energy to a mean position.

2. A mechanism for confining energy to a time-averaged mean position arises from rotations of oppositely directed components of matched time-averaged chirality.

3. Particle states correspond to standing-wave oscillations in which the pattern around a mean position is cyclic but the mean position may be changing relative to a stationary background.

4. Inertia arises when the angular momentum about the mean position is changed so that the magnitude of this inertia depends on velocity relative to the stationary background and on the degree of asymmetry between the chiral components of the background.

5. Charge corresponds to a net torque (relative to the mean torque that is hypothesised to balance the chiral contributions from matter and antimatter) that a particle state exerts on the background.

6. Each flavour family of quarks, leptons and neutrinos, corresponds to one of (apparently) only three possible sets of components in three spatial dimensions that can give rise to stationary (opposing rotations) or travelling (photon and neutrino) standing-wave states.

7. The pair of quarks of each family correspond to the charged leptons of the same family missing either one or two components, that must be continuously replaced by the exchange of gluons. Each gluon consists of a pair of opposite chirality components.

8. The supposed excitations of the underlying fields of strong, electromagnetic and weak interactions that constitute their exchanged quanta (bosons) are just the manifestations of possible combinations of chiral components that conserve angular momentum. Only photons and neutrinos can exist as real (time indefinite), rather than virtual, states.

These postulates are speculative, but seem plausible. It is hoped that they will stimulate the development of a complete physical realisation. A key missing ingredient is the self-interaction and possible spatial and temporal extent of elementary particles. Finite extent is a method used to avoid infinities, yet leptons and quarks appear to be point-like for their interactions. The avoidance of infinities may be because angular momentum cannot be exchanged at zero separation.

9.2 Implications and predictions for particle physics

The finite speed of light leads to massive particle states in which energy is confined to a localised region and to freely travelling states (massless) that carry energy to a different location. The multiple components that give rise to oscillations have a handedness (chirality) in three dimensions that is opposite for matter and antimatter. The fields of opposite handedness seek to balance, and oscillations and rotations of this background allow standing wave states that trap energy. The frequency of oscillation for a given energy will depend on the number, magnitude, and relative phases of the chiral components of that state.

It is proposed that these states include leptons in which opposite torques correspond to opposite charge states. For leptons and neutrinos, it is proposed that orthogonal components can mix in different proportions to give two groups (leptons with mass, and neutrinos) of three states that oscillate and rotate at three frequencies. The states with opposing components can trap momentum at a constant location but produce a net torque on their surroundings which is seen as charge. Antiparticles then have the opposite chirality, and charge, associated with their torque. It is hypothesised that neutrinos are massless states, as well as photons and gluons, of freely travelling chiral components. The three different quark, lepton, and neutrino (flavour) families have different sets of chiral components. Each neutrino has the sum of the opposite chirality components equal in the direction of motion but a different frequency of rotation in the plane perpendicular to this direction. These three combinations arise from different mixtures of the three underlying orthogonal pairs of components, and so will have different frequencies for the same energy, i.e. different values of $\hbar$. Hence, the three neutrinos can mix even though massless.

The gluons of the strong interaction can be seen as pairs of components of opposite chirality, with the colour property of quarks corresponding to the three orthogonal directions of space. The photon of electromagnetism is the "missing" ninth gluon (with three equal pairs of orthogonal components) and the bosons of the weak interaction are doublets or triplets of mixed chirality components that trap momentum and so have mass. The sum of the chirality contributions in both strong and electromagnetic interactions would balance and so the average interaction would not exhibit a handedness (parity would be conserved) although the mass could still be sensitive to chirality. The $\mathrm{W}^{\pm}, \mathrm{Z}_0$ and Higgs would be the combinations sensitive to chirality, except that the Z_0 pairs with the photon, and the Higgs is effectively a pair of particle and antiparticle states that cannot transform into each other.

It is proposed that this is consistent with massless neutrinos of only one helicity and antineutrinos of only the opposite helicity going forward in time within a region of space carrying an excess of one type of matter.

9.2.1 Higgs mass prediction

The force carrying particles that give rise to mass must include not only the Higgs boson (H_0), but the vector mesons ($\mathrm{W}^{\pm}, \mathrm{Z}_0$) and also the photon and gluons. The mass of particles is determined by the extent to which all the known forces (strong, electromagnetic, weak) act to store energy in a limited location. Any force that acts to localise a particle (a standing wave) stores more energy the greater the confinement of the particle. It is proposed that the sum of the chirality contributions in strong interactions balance and so the average interaction does not exhibit a handedness although the mass of quarks can still arise from chirality.

The photon is the missing ninth gluon, with its interactions leaving quarks and leptons unchanged except for the flipping of their spins (by one unit). This is the same set of interactions as the Z_0 and so the Z_0 / γ form a pair. It is therefore proposed that the three required massive bosons are not the

W^+, W^- and Z_0 (as previously understood) but the boson pairs W^+/W^-, Z_0/γ and $H_0/\bar{H}_0$. The first two are particle and antiparticle and it is proposed that the Higgs also has an opposite state. Thus, the Higgs is one of three boson pairs in which chirality and rotation trap rotational energy which gives rise to their mass (except for the photon in which the rotation is perpendicular to the direction of motion). This enables a prediction for the Higgs mass in terms of other bosons. It suggests that the Higgs mass should be: $(m_{W+} + m_{W-} + m_Z)/2$ = 125.979 ± 0.024 GeV/c^2 [91], compared with the measured 125.09 ± 0.24 GeV/c^2 [92] and the latest value from the CMS collaboration of 125.35 ± 0.15 GeV/c^2 [93]. The division by 2 arises because there is a Higgs and an anti-Higgs boson. Hence, FR gives a borderline prediction, as it is higher than the measured value for the Higgs mass by 4 to 5 σ. However, the CMS result for the $H_0 \to \gamma\gamma$ channel is 125.78 ± 0.26 GeV/c^2, while for the four lepton final states $H_0 \to Z_0 Z_0 \to 4l$ the values for the 4e, 2e2μ and 4μ channels have elsewhere been given separately as approximately 124.4, 126.0 and 125.0 GeV/c^2, respectively [94]. One possibility seems to be that the 4e and 4μ channels may have some contamination, for example, from a mis-identified e or μ and a missing neutrino which shifts the apparent Higgs mass lower. Contamination in the 2e2μ channel would need two missing neutrinos. Moreover, the H_0 mass is considerably less than twice the Z_0 mass, so one or both of them is virtual or off-shell and the broad mass of the Z_0 means the selection is poorly constrained against missing energy. However, the more likely explanation seems to be that electromagnetic (charged) self-interactions have raised the W^+/W^- mass by $\alpha \simeq 1/137$.

9.2.2 Neutrinos are massless

FR supports the SM with its three flavour families and <u>massless</u> neutrinos. The photon is massless because the angular momentum vector points in the direction of motion. It has angular momentum and therefore resists changes in speed and direction (has inertia). However, the angular momentum (rotation) is in the plane perpendicular to the direction of motion. It is proposed that the neutrinos are also massless because their <u>net</u> angular momentum is purely in the plane perpendicular to the direction of motion. Their standing-wave patterns can have components in the direction of motion but these are always balanced by a matched component in the opposite direction. However, it is proposed that the number of such components differs for the three families. It is therefore proposed that, although massless, the neutrinos can oscillate between flavour families because they have different frequencies for a given energy (i.e. different values of h). The rates of oscillation should be predictable once the oscillation states are specified. Another prediction is that a region with a larger background from anti-matter would have right-handed neutrinos and left-handed anti-neutrinos.

The belief that oscillations between neutrino states necessitates that at least two states are massive must be questioned. If right-handed neutrinos or left-handed anti-neutrinos existed, then a photon should be able to decay into pairs of neutrinos.

9.2.3 The nature of quarks

It is proposed that the quarks of the three flavour families correspond to the charged lepton states of that family but are missing one or two components that are continuously replaced by a gluon made of a component and anti-component. Only two-thirds or one-third of the possible photon reactions are then possible making the quarks appear to have the corresponding fractional charges. The quark states cannot exist without the continual exchange of gluons which leads to confinement and asymptotic freedom because a change in momentum requires a torque that acts at a distance. The small difference in mass of the proton and neutron each containing 3 quarks, and the concept of isospin, should then result from the sum of all possible quark and gluon interactions being the same except for the differences arising from the small asymmetry of the background.

9.3 The mathematical realisation of Full Relativity

Einstein's equation of GR combined the differential form of Newton's gravitational equation with his equation of motion and built in the finite propagation time using a constant speed of light, with mass and the ratio of inertial to gravitational mass constant. Predictions in GR from Einstein's equation require that starting conditions, in terms of an initial distribution of mass, energy and momentum be input. This is usually done for simplified distributions with high degrees of symmetry. The time evolution of the metric and the movement of matter and energy can then be investigated.

A similar approach appears possible with FR. Newton's original (static) universal law of gravitation can be used after including the finite propagation speed of changes in the gravitational field. It then needs to be combined with his second law but with the ratio of inertial to gravitational mass determined by the background asymmetry. The initial conditions need to include the location and velocity of nearby masses and some simplification of the mean background field from both matter and antimatter. These would allow specification of G_N and c for any location. The time evolution could then be examined by computer simulation that allowed for the finite propagation speed and the effect of the changes of the field on mass and inertia. (However, the relationship between inertial and gravitational mass as a function of background asymmetry and the speed of light first needs to be verified and quantified.)

The incorporation of FR into the SM requires a satisfactory physical model for the number and character of the fields present including how they interact with each other. The ability to set out a satisfactory gravitational theory appears intimately linked with a deeper theory of particles and fields, particularly in terms of incorporating angular momentum and chirality. It does appear that there is just one underlying field with at least two balanced components. Models are needed for how the various possible standing waves of multiple components in three dimensions correspond to the known particles. It seems to be misleading to consider that a different field is associated with each particle. Instead, the number and phases of the components of each particle determine their interactions with other particles via the underlying field(s).

The "super-symmetry" that relates bosons and fermions is not a new set of additional particle states or deeper structure. They are related by the breaking of the gauge symmetry by the rotation and asymmetry of the components of the particle state and background. The relation is between the possible standing wave states of oscillating and rotating components which trap different amounts of energy (giving different masses) because the relative directions of rotation can be the same or opposite and the magnitudes of the chiral components of the background are slightly different.

It is proposed that the three families of massive fermions (leptons $e^{\pm}$, $\mu^{\pm}$, $\tau^{\pm}$ and quarks) might be explained by a singlet, pair or triplet of opposing but matched oscillations of the background field. These oscillations will also rotate if the axial components of the background are not matched, or rotate in order to match. The possible stationary states depend on the number of components and their relative phases. If two components are out-of-phase by $\pi / 2$, then a third (orthogonal) component can be matched by their rotation. It is proposed that the two directions of such rotations correspond to opposite charge states. Opposing sets of rotations can be countered by a force along the axis of rotation. Rotations which would match except for being of opposite chirality (i.e. matched if asymmetry was zero) will not trap a large force. Rotations of the same or opposite chirality in opposing directions would trap a large force. Massive fermions would have 1, 2 or 3 components opposing a similar set of the same chirality. An apparent half-integral spin would appear to occur if after one cycle the pattern was the mirror-image of the initial pattern. The precession of the components would be at half the frequency of oscillation perpendicular to the precession. The torque associated with the precession might correspond to charge. Massless fermions (neutrinos) would have cooperating rotations (with 1, 2 or 3 pairs of components that are $\pi / 2$, π, $2\pi / 3$ out-of-phase perpendicular to the direction of motion) sustained by unidirectional motion at the speed of propagation of the fields. The massless boson (the photon) would have a triplet of aligned pairs of opposite-chirality orthogonal components giving two rotations (π out-of-phase in the direction of motion and of arbitrary phase perpendicular to the direction of motion). The rotations alternatively cooperate then oppose and are sustained by unidirectional motion, perpendicular to the plane of rotation, at the speed of propagation of the fields. Massive bosons ($\mathrm{W}^{\pm}$, Z_0, H_0) would arise from multiple orthogonal pairs of opposite chirality that trap a large force and strongly resist changes because of counter-rotation.

This picture/model is highly speculative, based on analogy and observations of wave and rotational behaviour extended into three dimensions and a multicomponent balanced field. The correct model and mathematical formulation also needs to be consistent with principles such as causality and conservation laws. Maxwell managed to obtain the correct equations to explain the propagation of light and radio waves in vacuum using a mechanical model, based on wave propagation in a special kind of invisible very stiff ultralight rubber, which included whirling vortices [95]. The proposed picture/model set out, or an alternative, needs to be shown to be consistent with the group structure of the relativistic field theories of the SM. The successful model will explain why renormalisation works and predict the masses and strength of interactions of all particles given the observed clout and asymmetry of the current background of our location in the universe.

9.4 Planck's constant, Compton wavelength and quantum mechanics

Planck's constant (h) gives the change in frequency with energy ($E = hf$) seen in electromagnetic radiation. This energy comes from transitions in massive atoms and so should be expected to relate to the current unit of trapped angular momentum and the de Broglie wavelength ($\lambda = h / p = h / mv$) associated with a massive particle of momentum p. For $v = c$ its value is the same as the Compton wavelength of a particle. This wavelength is equal to that of a photon whose energy is the same as the mass of the particle. The photon can deliver energy E from its momentum travelling at c. This energy has come from the release of trapped angular momentum held in particles. It is typically the mass released in the transition between electronic energy levels of a massive state. Under FR, inertia is this angular momentum's resistance to changes in its value with time. The value of Planck's constant, or energy per unit frequency (applicable to photons), is $h = p\lambda =$ 6.626 x 10^{-34} kg.m^2/s which has units of angular momentum, where λ is the wavelength of a photon of energy E travelling at speed c and having linear momentum $p = E / c$.

Under a model in which the energy stored as mass arises from the force needed to trap rotating components, the amplitude of the relevant rotation (travelling at c) will be the reduced Compton wavelength $\bar{\lambda} = \hbar / mc$ where $\hbar = h / 2\pi$. This reduced Compton wavelength is already understood as the natural representation of mass on the quantum scale that applies to inertial mass and appears in Schrödinger's equation. Thus, FR appears to provide a link consistent with the wave/particle nature of matter under quantum mechanics, with the ratio of inertial to gravitational mass, and with the nature of elementary particles and how clout and the speed of light depend on the combination of the chiral components of the background. Implications include that the magnitude of the violations of the components of CPT symmetry, i.e. of the broken symmetries of charge conjugation (C), parity transformation (P), and time reversal (T) will have a dependence on the asymmetry of the background.

9.5 The nature and progression of broken gauge invariance

Under FR, mass depends on the speed of light which depends on the sum of background components and inertia depends on their asymmetry. Early in the evolution of the Universe, before annihilation of most of matter and antimatter, the number of particles and speed of light would have been very large but the mass and inertia of particles would have been very small. The breaking of gauge invariance would have been progressive and ongoing rather than a sudden change of state. The speed of light would have been almost uniform across vast regions which suggests the epoch of the transition to neutral hydrogen atoms, when photons were no longer scattered, would have been similar.

It would seem that particle states would have gained mass as the speed of light reduced but the chiral splitting associated with the weak interaction would have remained small until regions of significant asymmetry developed.

There is a modest Doppler shift seen in the Cosmic Microwave Background (CMB) radiation which is ascribed to the velocity of our galaxy relative to this background. The CMB presumably reflects the background mass distribution, which was much more homogeneous at that earlier epoch. However, our galaxy is now moving relative to the CMB due to a “relatively small” inhomogeneity that has developed over time in our region of the universe. The Earth, Sun and our galaxy are in free-fall towards the net inhomogeneity in matter and antimatter contributions. However, they may not be moving directly towards the current centre, just as our planet is not moving directly towards the Sun. The presence of inhomogeneities could show up as apparent differences in redshift with location and direction. However, it is not clear that this would lead to variations in physical “constants”, such as the fine structure constant, that apply to gauge invariant interactions.

9.6 Comment on “spooky action at a distance”

A photon carries information on the phase of its components, relative to the emitter, that affects the frequency and wavelength seen by the receiver. The speed of light is constant, within a region of constant background density, and this speed has a scalar dependence on the background. So, it is independent of, and oblivious to, any motion of the massive objects that give rise to the background other than by the amount that they change the magnitude of the background. The movement of stored energy appears sensitive to relative motion, but under FR the sensitivity is to motion relative to the mean flow of the clout from the matter giving rise to the background.

The photon is capable of carrying information about the relative phase of its components to distant locations. This information could have a fixed spatial orientation at, for example, the maximum of a sum of the interfering components. Thus, it seems that a pair of photons emitted back-to-back could carry complementary information on relative orientation even though the phase is continuously varying. This brings out a flaw in Bell’s proof that a hidden variable theory cannot give the same result as QM. The assumption is made that experiments which give a definite result at one orientation imply a fixed property independent of the viewing orientation. A rotating spoked wheel has a fixed direction and magnitude of angular momentum but that does not require that the spokes always point in the same direction. Two spoked wheels may have a constant phase relation between matched spokes even though the phase of each is continually varying. Counter-rotating wave functions of identical speed will also give rise to a fixed orientation of the interference pattern. Measurements of the spin of two particles that came from a state of zero spin will always indicate opposite orientations of spin vectors when both measurements are aligned. The measurements can only yield one of two possible states of the spin, even though all orientations of the rotating components perpendicular to the angular momentum vector occur. Moreover, measurements at right angles always give a random result.

The improved understanding of the properties of particles, including the photon, that arise from a two-component background, appears to indicate that relative phase information can be a hidden variable that relates orientation across the distance of subsequent separation. “Spooky action at a distance” or communication faster than the speed of light are not required. Objects are in definite states with continuously varying phase. Bertlmann may always have a second sock that is not pink when the first one is pink but the colour of each sock before observation can be continuously cycling through a range of complementary colours.

Entanglement involves fixed phase relationships (constant relative phases or constant orientation of the superposition pattern) between components. The phase difference can be fixed but each phase can be continuously varying. The relative phase is altered by measurement. Schrodinger’s cat is not both alive and dead. An array of states (qubits) could be set up in which the components have a fixed phase relationship and interference patterns can have a fixed orientation, but the phase is continuously varying. Interrogation of the array, from a fixed orientation relative to that for the construction of the array, could always give the same answer. Thus, it would seem that quantum computing can give a definite, reproducible answer if always interrogated in the same manner. However, the relative phase of the component qubits being fixed does not mean that all the component states simultaneously contribute (although their time-averaged contributions might be fixed). Nor does it mean that the same answer will be obtained under a different interrogation.

A more detailed exposition is given in Appendix 1.

9.7 Summary

The aim of this chapter has been to provide an outline of where the revised understanding of gravity (FR) and its consistency with the Standard Model of particle physics including quantum mechanics overcomes key problems with current theory (GR). Moreover, the new understanding points to an underlying physical model that encompasses all known forces. It also appears to remove another of the current suggestions, i.e. that neutrinos have mass, for observations that indicate the need for new physics beyond the Standard Model.

The tentative suggestions for a model of particle states, their properties and interactions, need critical assessment, further development, and to be put into an acceptable and quantified mathematical form.

As Einstein insisted, instantaneous action at a distance (entanglement) is spooky. The understanding of the periodic oscillation of particle states with components maintaining a fixed phase relationship means that definite properties of the wave function (i.e. a phase difference) or of the resultant standing-wave orientation does not mean that the phase of the components does not vary. Consequently, the wave function can behave as a hidden variable and Bell’s proof is based on a misunderstanding. This strongly suggests that the potential of quantum computing is over-hyped.

Chapter 10

What has been learned and where to next.

The simple expectation that the energy of a photon, with no mass, should not lose energy in a gravitational field, inevitably leads to a revised understanding of gravity and a replacement theory for General Relativity. The replacement theory appears capable of removing all the worrisome, if not weird, conclusions of current astronomical theory. Gravity now makes sense.

The number of changes to the current understanding, which might be better characterised as an interlocking belief system, is very substantial. The experimental evidence does not support the Einstein equivalence principle, only a limited version of the weak equivalence principle. If EEP were valid, then gravitation must be a 'curved spacetime' phenomenon and a metric theory of gravity would appear essential. However, such theories of a dynamic spacetime in the space between objects, with no dependence on the absolute value of the background, have inherent inconsistencies.

FR restores "common sense" about the nature of time and distance. It proposes an absolute space in the sense that separated objects that are stationary relative to each other remain the same distance apart even if the background, from the surrounding clout, changes. The objects may change in size and energy content but will not move apart without a force being applied. It introduces a time, in terms of energy clock-rate, that varies with the energy held by atoms. The energy depends on the effect of the background on the speed of light and therefore the energy of the atoms of a massive clock. There is also an inertial clock-rate for clocks based on the movement of massive objects. This alters the energy clock-rate by introducing a dependence of rate on the inertia. The resistance to movement of massive objects increases with the fractional asymmetry in the contributions of the chiral components of the background. The asymmetry alters the frequency of quantum oscillations and can change the value of the gravitational (Newtonian) and quantum oscillation (Planck) "constants". However, G_N is approximately constant within our solar system because the asymmetry from our galaxy is much larger than the observable asymmetry from our Sun or the Earth.

The speed of light depends on the balanced total clout from all matter and antimatter. This clout affects the energy stored but does not carry energy and only falls off as $1/r$ with distance from a source of energy. This slow fall-off is because the contributions from matter and antimatter seek to balance. However, any asymmetry in the contributions of components leads to oscillations that affect inertia, the resistance to changes in the motion of stored energy. Therefore, the speed of massive objects due to the same force will vary between regions with the same speed of light but different asymmetry.

It is argued that the evidence already available confirms the key aspects of Full Relativity but a number of new experimental tests have been put forward.

10.1 Summary of the changed understanding of gravity

Special Relativity revealed that mass is a form of stored energy with a conversion factor proportional to the speed of light squared. Gravitational fields occur when there is a gradient in clout which is the negative of the gradient in Newton's gravitational potential. However, the clout is not independent of the contribution from a uniform, isotropic background from the mass held by matter. The gravitational force can be attributed to a reduction in the stored energy held by particles when the background increases. SR was based on the postulate of the principle of relativity, which amounted to the equivalence of physical laws in all frames moving at constant speed. GR extended this to include accelerated frames on the mistaken belief that the effect of free-fall was to remove any effects of gravitational acceleration on the laws of physics. However, FR reveals that the Strong Equivalence Principle does not hold. The magnitudes of forces, energy, and time intervals of the laws of physics depend on the contributions from, and interaction between, the background clouts from both matter and antimatter. The background changes as objects move deeper into a gravitational field. Gradients from masses in opposite directions can lead to a flat region in the field (constant magnitude of clout), so that there is no gravitational acceleration, but the contributions to the clout add rather than cancel and affect both mass and the speed of light.

A photon does not gain or lose momentum (energy relative to c) in a gravitational field. In cannot, because it has no inertial resistance (mass) in the direction of motion. Instead of the photon energy being redshifted, the energy levels of atoms (all massive particles) must be blueshifted. The binding energy of atoms increases, and their size reduces, as the background energy density and the speed of light decrease. Hence, FR has particles gaining stored energy (mass), from the work done in lifting them in a gravitational field and releasing this as kinetic energy when falling. The potential energy is stored in the object not the field. Moreover, the rate of change of mass (stored energy) reduces as the background increases. There is an apparent increase (redshift) in the wavelength of a constant energy photon but this comes from a real blueshift (increase) in stored energy of massive objects when work is done to raise matter in a gravitational field, i.e. take it further from other matter.

Mass is stored energy and the equation $m = E_0 / c^2$ reflects the increase in stored energy of particles in proportion to the work done in moving them to a region of reduced background energy density. The conversion factor $1/c^2$ reduces when the background clout increases. The equation implies that the energy equivalence of mass goes to infinity as the speed of light tends to zero, which would be expected if the speed of light depends on the background and the relative importance of new matter decreases with increasing amounts of other matter. Clocks (massive objects) have higher energy and tick faster in a region of reduced clout.

The proposed second aspect of the background is that a state with the same energy will oscillate faster if the asymmetry in the chiral contributions from matter and antimatter increases. Hence, oscillation frequency of the same amount of energy reduces in moving away from a concentration of matter within a background of both matter and antimatter. For a photon, the energy of a given rate of oscillation (Planck's constant) decreases as asymmetry increases. The rate of oscillation, for constant energy, is a local property that changes for both photons and atoms, so is not directly observed if energy is unchanged. However, faster oscillations relative to the speed of light mean that inertia will be increased. If a galaxy of matter is embedded in a background of approximately equal amounts of matter and antimatter, then the rate of change in asymmetry with changes in the amount of matter will vary with the relative importance of antimatter. The energy of already emitted photons will not change but their frequency will increase with the speed of light and with asymmetry. A gradient in speed and asymmetry in the plane perpendicular to the direction of the photon will cause light to bend. Together, these effects can be used to explain the observed flat rotation curves and gravitational lensing of galaxies and so obviate the need for dark matter.

It is experimentally observed that the clock-rate of massive clocks is not constant for the same clock in regions of different "mass density". GR proposes that clock-rate is the same for a clock in free-fall in a gravitational field and for clocks not subject to any gravitational force. FR proposes that the equivalence is true only instantaneously before the falling clock moves into a different region and loses stored energy. The changes in mass and size depend on both matter and antimatter contributions to background clout, via the speed of light, while the conversion factor between gravitational mass and inertial mass (and also frequency) depends on the asymmetry. The energy levels of atoms increase when an object moves into a region of lower clout (when mass density is lower) with the energy coming from the work done to lift the object higher. Clock-rates, of massive objects, increase (the time interval between ticks will decrease). Time appears to pass more quickly. If matter alters c and clock-rate, then different uniform backgrounds of surrounding matter can lead to different mass, momentum, and time scales even though there is no local gravitational field (i.e. no gradient giving an acceleration). The same local concentration of matter will induce smaller changes if there is more background matter, and the speed of a wave (a freely travelling variation in the field due to clout) will increase by an amount that depends on the balance of both contributions to clout.

FR has both the speed of light and size of objects dependent on the same aspect of the background, so changes in the speed of light using the same rod are not visible. The stored energy increases and the spacing between charges, the size of atoms, decreases when the speed of light and background energy density decrease. The product of the speed of light (*c)* x (light-time interval) is proportional to distance because light-time interval is a relative measure of separation between stationary unconnected objects divided by the speed of propagation of light. So, time-interval (for constant separation) decreases if the speed of light increases. Thus, there is a light "travel-time" that is c/c' less than the original interval for light to travel a fixed distance.

The unit of conversion for the stored energy (mass) of the same matter is altered by changes in the speed of light, as encapsulated in $m = E_0 / c^2$. It indicates that the energy stored by the same matter (and all of its atoms and atomic transitions) decreases in inverse proportion to the square of the speed of light [$m'/m = (c/c')^2$]. This means that that the clock-rate rate we use (which is based on energy) decreases as $(c/c')^2$. GR proposes that distances and time intervals are shortened by an increase in the gravitational force (a decrease in potential), together with shorter time intervals meaning less time (slower clock-rate), so that the "standards" of time are predicted to increase by $t'/t = \Delta\Phi / c^2$. GR keeps both m and c constant, independent of the background density, but its matched changes, but opposite interpretations, of time versus distance intervals reproduce the FR prediction.

The inverted interpretation is present in Einstein's formulation of background-independent SR and Minkowski's inclusion of the effects of motion and momentum into the concept of spacetime. As has been set out in Chapters 2 and 3, time within a region is the sum of time intervals. However, the number of events in a region in which the time interval for an event to occur is shorter, is greater. This means that relatively more events occur. Time runs faster when time intervals are shorter. The inverted interpretation, of SR, allows the Lorentz invariance of massless electromagnetic interactions to appear to be applicable to massive states, whereas the rate of massive clocks increases as their energy increases. The matched predictions hide the dependence of mass on $(c/c')^2$.

The changed understanding of FR is that the background field (clout rather than energy density) of space alters the properties of massive objects rather than distorting the spacetime between them (as in GR). Space is always flat. There is no fabric (metric or geometry) of spacetime that is curved. The Strong Equivalence Principle, that the non-gravitational laws of physics are independent of the place and time at which they occur, does not hold because the properties of matter and the speed of light are background-dependent. However, because the blueshift of atoms is equated with a redshift of photons, FR's changes in distance travelled by light and time can give equivalent predictions to those from the distortion in the underlying geometry (curvature) of spacetime proposed by GR. This holds for small changes and the current local background, while predictions will differ when there are large changes in background clout which will correlate with differences in density. FR predicts that energy levels of atomic transitions will appear redshifted if there is a change in background clout during the transmission time of the signal. The redshift will reflect the lower energy of the atoms at the time of photon emission because the energy of the photon is conserved. However, the distance travelled by light for a given redshift will be increased by the change in speed of light with clout.

Under FR, the redshift with galactic distance arises from the increase in the speed of light going back in time. The decrease in mass (stored energy) arises from the decrease in trapped momentum with increasing c. The supernova data reveals that, after correcting for the increase of c going forward in time, the rate of increase in mass with underlying time is constant. FR attributes the change in mass, and hence the redshift, to the change in speed of light. The mean speed of light will decrease because of the clumping allowed by the increase in inertia as asymmetry increases. These effects not only remove the accelerating expansion and dark energy, they also remove the need for any expansion, and hence the need for an initial hot, dense state and a Big Bang.

FR proposes that: i) mass, the size of massive objects and the speed of light depend on a balance between the clout from matter and antimatter; ii) the frequency of quantum oscillations, and inertia, depend on the stored energy of a state (for a given background) and on the chiral asymmetry arising from differences in matter and antimatter contributions to clout; and iii) the magnitude of the effect of asymmetry will increase with speed relative to the minimum (stationary) asymmetry. It is postulated that this effect relative to the stationary background is because particles retain a memory of their speed in proportion to the inequality of chiral contributions. This leads to a slower oscillation but an increase in inertia with speed. Decay rates slow and momentum increases by γm.

If there is a large background clout (ρ_B), then the fractional increase in clout ($\Delta\rho / \rho_B$) at a surface around a source of stored energy ($\Delta E / E$ above the background at 1 metre) will be $\Delta E / rE$, with distance r metres. The fractional change in total clout will be smaller when the background is larger. The speed of light depends on the combined clout and massive particles cannot store as much energy when c is larger. The fractional decrease in mass with increase in clout, giving an increase in c, then explains the existence and strength of gravitational attraction. However, the conversion between gravitational and kinetic energy will depend on inertia via asymmetry if inertial time is used.

10.2 Durationless time is dead

The philosopher Henri Bergson and Albert Einstein engaged in a heated controversy about time in 1922 [96]. Crease has recently discussed the different perspectives [97]. Bergson considered time as a moving continuity that incorporates and allows surprise, novelty and transformation, while 'scientific time,' on the other hand, 'has no duration'. He argued that it had been turned into an abstract clock time that differs from moment to moment only by measurable distance from another point in spacetime. Einstein curtly dismissed Bergson with the sentence: "There is no such thing as the time of the philosophers". Einstein maintained that there was no absolute space and time and that lengths and time actually dilated. Lorentz and FitzGerald thought there was an absolute space and time in which there were real lengths and time intervals, which contracted and dilated only apparently but not really. Crease considered that these issues were resolved in Einstein's favour.

This idea of "durationless" time can now be seen to arise from equating light-clock time with clock-rate in conjunction with mistakenly assuming that shorter time intervals mean a slower clock-rate. This permits a fabric of spacetime in which space and time vary but produce an invariant spacetime interval because the speed of light is a local constant. However, the logic behind SR and GR is flawed. There is no fabric, space is not distorted and there is a time of massive objects (including philosophers!) that has a duration that is related to the relative speed of occurrence of equivalent events in different environments.

10.3 The advantages and potential of Full Relativity

Full Relativity has the beauty of restoring the Machian philosophy that observed behaviour, both gravitational and kinematic, is relative to all other matter. On the other hand, SR and GR have a misinterpretation of space intervals relative to time intervals, which gives rise to untenable infinities (i.e. singularities), and have inconsistencies between the postulates used and observed behaviour. FR also restores conservation of energy/momentum to the explanation of gravity and enables a philosophical understanding of potentials, momentum, and the relativity of motion.

The supernovae data, corrected for the change in the speed of light with clout, removes all evidence for an accelerating expansion and the need for dark energy. The observed redshift versus distance relationship gives a measure of the change in stored energy with underlying time after correcting for a changing speed of light. This value must be consistent with the changes in gravitational force and stored energy density in our solar system. The constant slope of the corrected supernovae data predicts the current increase in energy clock-rate with underlying time. However, this appears to be outside the potential of current experiments.

FR appears capable of reproducing all the experimentally confirmed predictions of GR while removing the need for dark matter, dark energy, cosmic inflation, the singularities and other problems of black holes, the inconsistency with QM, and all the evidence for disagreement with the Standard Model of particle physics. It appears to provide plausible explanations of the Tully-Fisher relationship and for the Pioneer anomaly, neutrino oscillations and Higgs mass. These successes and the removal of the need for ad hoc, implausible, hypotheses of dark energy, dark matter, cosmic inflation and a cosmological constant (whose value has been labelled "the worst prediction in the history of physics"), should be taken as strong evidence for the validity of the core proposals of the replacement theory. Tests, such as those set out in Chapter 8, particularly a repeat of the Pioneer voyages, should distinguish between the current and new theory.

FR needs to be further developed and modelled, particularly in terms of the implications for the development of the large-scale structure of galaxies and galaxy clusters over time, and with the possibility of separated but co-existing regions of matter and antimatter. An understanding of how matter and antimatter energies contribute to the speed of light and the oscillation states of matter needs to be more fully developed and compared with observations. The consequences of the proposed relationship between Planck's constant and asymmetry need to be better set out and compared with observed values. Ultimately, the linking of all four forces into the aspects and properties of the one underlying field hold promise for explaining the Standard Model and enabling the prediction of the masses and couplings of all elementary particles.

10.4 A comprehensible universe

The most encouraging aspect of the revised theory is that it seems to remove many of the most difficult to understand aspects of the currently accepted point of view without destroying the successful predictions. Motion appeared to alter the perception of space and time so that only a combination into a fabric of spacetime that gave an invariant speed of light was real. Gravity was then a distortion of this fabric of spacetime by massive objects, but this turned out to be an illusion.

Einstein's theory (GR) contained singularities, apparent paradoxes and inconsistencies, and needed ad hoc hypotheses such as a mysterious dark energy that pushed galaxies apart more strongly as their density reduced, an invisible dark matter, and cosmic inflation. The latter claimed that the entire universe could expand faster than the speed of light without violating current laws because "space is not a thing" and could expand without the objects in that space moving.

Einstein's idea that "space is not a thing" appears to have arisen from his conviction that physics laws should not depend on reference frames, which express the relationship among physical processes in the world and do not have an independent existence [98]. A single reference frame is arbitrary in orientation and scale. In Mach and Einstein's view, space and time should not be like a stage upon which physical events take place, thus having an existence even in the absence of physical interactions. However, using "space" rather than "separation distance between objects not in relative motion" appears to be partly responsible for the idea that distances might be malleable by the motion of the observer or the presence and number of massive objects. We observe that physics laws do depend on reference frame. We can tell if an elastic sphere is rotating at constant speed relative to the stars by whether it bulges at the equator. Measurements of motion always involve at least two reference frames and the relationship between frames is no longer arbitrary. An observer falling freely in a gravitational field may not sense the accelerating force but it is still present and their movement relative to the background frame from other objects changes their mass, inertia and time. Distance is a relationship but every constant specific distance relationship is fixed independent of reference frame after correcting for scale and any effects of movement on the measurement. Distances cannot change without movement.

Possibly the strongest reason for questioning GR was that stated by Maxwell before the fabric was even invented! It requires an enormous intrinsic energy that is diminished by the presence of matter. In GR this led to singularities. Taking enormous energy from an initially undistorted fabric as it becomes more distorted and eventually breaking down appears analogous to a Ponzi scheme (a fraud that lures investors by paying interest to earlier investors with funds contributed by later investors, and which breaks down because of the finite limits on investors and funds). It is getting something for, or from, nothing.

Under FR, the nature of the universe becomes inherently much simpler and more comprehensible. It seems likely that the observed values of elementary particle masses, and other constants and mixing angles, will follow directly from the improved understanding. In that case, the current values do not need fine-tuning or multiple universes where we are in the one that suits our existence, or a block time where the past, present and future already exist, or a world where a cat can be alive and dead at the same time. The revised understanding of the photon and QM promises an understanding of spin and removes the need for what Einstein referred to as "spooky action at a distance".

10.5 Where to next?

It is likely that some of the arguments and speculations presented in this document are faulty but setting them out will hopefully allow them to be corrected and improved upon.

Tests of both GR and SR against FR are essential. The decay rate, or other means of measuring clock-rate, as a function of speed relative to a local free-fall background should be tested. This is a definitive test between the FR and SR, and by implication GR.

The new perspectives open up new opportunities and hopefully the expenditure on the search for dark matter, quantum gravity, the nature of dark energy, and even quantum computing might be channelled into new research.

There seem to be exciting opportunities in the further development of the implications of FR for particle physics. The model of the nature of photon, quarks, gluons, and leptons including neutrinos, needs to be more completely set out. This should make it clear how the magnitude and asymmetry of the components of the background determine mass, frequency and inertia and lead to an understanding of spin. The proposed model, presented here, for the nature of quarks needs to be shown to be consistent with quantum chromodynamics, or otherwise rejected. The successful prediction of all lepton and baryon masses, including what are currently arbitrary constants and mixing angles, should then follow. The value of Planck's constant should depend on asymmetry of the background, and a fuller development of FR and a knowledge of the local asymmetry should allow the value of $\hbar$ to be related to the value of G_N.

It would seem desirable if a mathematical formalism for an equation of motion analogous to Einstein's equation could be set out. However, the procedure is essentially the same as under GR, simpler than tensors but with more variables. As with GR, general predictions of behaviour may only be possible for simplified sets of initial conditions. Under FR, the development over time requires that the finite propagation speed of changes in the background, in which the speed changes with the magnitude of the background, and in which the properties of objects including their speed of movement and mass both alter, and are altered by, the background. Handling these feedback mechanisms would seem to necessitate careful computer simulation.

GR provides a calculation of the current mass density from measurements of the cosmic microwave background given that the observations are consistent with a flat spacetime. The explanation of the frequency components present in the temperature variations of the CMB in terms of the quantities of dark matter and dark energy should be consistent with the explanation under FR of the supernovae data if there is no distortion of space by matter and no dark energy. Under FR, there is no expanding universe, so no Big Bang. Clock-rate is slower going back in time and matter held less stored energy but inertia would have been lower. The reduction in the ratio m_g / m_i would appear like an increase in temperature. It needs to be confirmed that this altered explanation of the CMB and its variations in apparent temperature are consistent with their subsequent evolution into galaxies.

The effect of asymmetry on inertia implies the amount of matter in the centre of galaxies is much larger than currently deduced. Quantifying these effects should enable the motions within star systems, galaxies and galaxy clusters to be fully specified, so that the gravitational and kinematical behaviour within any arbitrary distribution and movement of matter should be predictable and comparable with observation.

The consequences of FR for the evolution of the structure of galaxies and their distribution, and the shape of galaxies, needs to be modelled and compared with observations. It would be pleasing if the presence of anisotropies in asymmetry due to surrounding galaxies could explain why the arms of spiral galaxies are not rapidly destroyed by rotation. The ability of FR to avoid there being a current signal from a collision of matter and antimatter galaxies needs to be more rigorously established. The implications of FR for many other related phenomena in the early universe such as the spectrum of the CMB, baryon acoustic oscillations, Sachs-Wolfe effects and nucleosynthesis needs further investigation.

Many details of the revised theory need more work and many consequences need to be examined. Exciting new possibilities include a deeper understanding: of elementary particles in which neutrino oscillations and the apparent dearth of antimatter do not constitute new physics beyond the Standard Model; of the values of fundamental "constants" their calculation; and of quantum entanglement including that it does not constitute the "spooky action at a distance" which Einstein hated.

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Appendix 1 - No need for spooky action-at-a-distance

This is a slightly revised version of a paper submitted for publication in March 2015 but not refereed.

The argument is put forward that the proof establishing Bell's inequalities is faulty because it does not allow for the wave nature of particle states. Superposition of continuously rotating or oscillating components can give stationary standing wave patterns of fixed orientation. The assumption that any hidden variable theory requires a fixed value for all measurement at a particular orientation to mean that there is a constant underlying hidden value of the components is mistaken. A fixed direction of an angular momentum vector does not require that each component perpendicular to the vector has a fixed orientation in space. Instead, it can result from a fixed relative phase of the components. The apparent entanglement of separated particle pairs exists in terms of fixed phase relationships of the components of each particle's wave function. There is no need for superluminal communication.

Abstract It has been claimed that photon pairs can be entangled such that when one is measured the properties of the other are instantaneously determined even if they are too far apart for a signal to travel between them. Einstein famously referred to this as spooky action-at-a-distance. An improved understanding of the nature of quantised states, and in particular photons, reveals that the correlations between pairs of photons can be explained without rejecting local determinism. The confusion has arisen because the statistical nature of quantum mechanical predictions arises from the unknown phase relationship between the wavefunctions of a particle and a measurement procedure. The outcome is fully determined by the phase relationship but the relationship can never be determined without altering it. The standing wave of a quantised state can have a fixed pattern and orientation but the components are oscillating, and hence a determined outcome does not imply additional hidden variables to those of quantum mechanics. Entanglement of separated particles reflects fixed relations between their patterns at the time of separation. The outcome is determined but unknown. This viewpoint overcomes both the Bell and Kochen-Specker theorems against hidden variables that can explain the stochastic behaviour. Quantum mechanics can then be seen as local, causal and complete. Entanglement of separated particles does not involve spooky action-at-a-distance. Neither instantaneous collapse of the wavefunction nor a many-worlds interpretation is needed.

Keywords Bell inequalities · Kochen-Specker theorem · non-locality · hidden variables · entangled states · determinism

1 Introduction

Quantum mechanics has given the most accurate predictions of any physical theory, yet it has some peculiar properties. Firstly, it has been accepted that the experimental violation of Bell inequalities shows that it cannot be local. Separated particles can be entangled such that changes to one can affect the other sooner than it would take for light to travel between them. Secondly, the mathematical apparatus of the theory gives only probabilities. The current formulation of quantum mechanics interprets the wavefunction as representing a probability distribution of outcomes. How or why is not understood and it appears inconsistent with the definite time evolution of Schrödinger's wavefunction.

As Weinberg [1] points out, under the Copenhagen interpretation, a measurement changes the state of a system in a way that is not described by quantum mechanics. If a system is in a normalized superposition $\sum_n c_n \psi_n$ of orthonormal eigenstates of operator A with eigenvalues a_n, then on measurement the state will collapse into a state ψ_j in which the observable is a definite one of the values a_j, with the probability of the eigenvalue being $\left|c_j\right|^2$. This probabilistic interpretation of quantum mechanics appears to be in conflict with the deterministic evolution of the state vector described by the time-dependent Schrödinger equation. The end result of a deterministic process should be some definite state, not a number of possibilities with different probabilities.

Einstein, Podolsky and Rosen (EPR) were unhappy with this uncertainty of outcomes and constructed a thought experiment to suggest that quantum mechanics must be an incomplete theory which required some unknown or additional hidden properties [2]. Bell subsequently showed that a theory involving hidden variables led to predicted results, obeying an inequality, that were different from those of quantum mechanics and therefore open to experimental tests [3]. Many such tests have been carried out examining the correlations between pairs of photons, or spin ½ particles, emitted back-to-back from an initial particle. It has then been claimed that: "The violation of Bell's inequality with strict relativistic separation between the chosen measurements, means that it is impossible to maintain the image '*à la* Einstein' where correlations are explained by common properties determined at the common source and subsequently carried along by each photon" [4]. Therefore: "We must conclude that an entangled EPR photon pair is a non-separable object; that is, it is impossible to assign individual local properties (local physical reality) to each photon. In some sense, both photons keep in contact through space and time." [4]. It has also been claimed that: "The essence of Bell's theorem is that quantum mechanical probabilities cannot arise from ignorance of *local* pre-existing variables. In other words, if we want to assign pre-existing (but hidden) properties to explain probabilities in quantum measurements, these properties must be non-local." [5]. (*Local* meaning that if two particles are separated then measurement of one cannot affect the other sooner than the time it would take for light to travel between them.)

Bell put it this way: "In a theory in which parameters are added to quantum mechanics to determine the results of individual measurements, without changing the statistical predictions, there must be a mechanism whereby the setting of one measuring device can influence the reading of another instrument, however remote. Moreover, the signal involved must propagate instantaneously, so that such a theory could not be Lorentz invariant." [3]. Maudlin put it somewhat more strongly: "What Bell proved … is that the physical world itself is non-local" because "any world that displays violations of Bell's inequality for experiments done far from one another must be non-local" [6].

These statements are part of a widespread acceptance that the experimental observations confirming quantum mechanical predictions, when the measurements are relativistically separated, mean that quantum mechanics is either non-local and/or an inherently stochastic theory with a lack of determinism, i.e. that the state of a system and the result of a measurement are not determined by properties that exist but are unknown. Einstein had earlier rejected the idea that the outcome of experiments could rely on the transmission of information faster than the speed of light, implied by non-locality; as "spooky action-at-a-distance".

Bell's theorem addresses the non-locality. A second theorem, by Kochen and Specker [7], addresses the stochastic nature. It limits the type of hidden variable theories that try and explain the stochastic nature by means of hidden but deterministic properties. The logical deduction from the stochastic nature can be seen in the summary of the EPR argument by Bell which included the statement that: "Since the initial quantum mechanical wavefunction does *not* determine the result of an individual measurement, this predetermination implies the possibility of a more complete specification of the state" [3]. This was the essence of Einstein's concern with quantum mechanics, that a theory that left outcomes to chance was inherently unsatisfactory and incomplete and so required extra (hidden) variables to exist (be physically real). However, the Kochen-Specker (KS) theorem excludes hidden variable theories in which the elements of physical reality are non-contextual (i.e. independent of the measurement arrangement). This means that if there is no spooky action-at-a-distance then there must be an even spookier lack of freedom of choice of measurement settings.

The perspectives presented here, based on a plausible nature of the wavefunction and its measurement, reveal faulty assumptions in the hidden-variables arguments (i.e. the proofs of both Bell and KS theorems). The properties of such a wavefunction provide "hidden" variables that are non-contextual and allow locality. Such variables which exist, but are not known, enable the deterministic evolution of wavefunctions to be consistent with the generation of the observed probabilities. Quantum mechanics can then be viewed as local, deterministic, and complete. This gives a changed understanding of entanglement and impacts on the interpretation and potential of quantum computing. It also allows the Copenhagen interpretation of quantum mechanics, that definite properties do not exist prior to measurement, to be rejected along with the instantaneous collapse of the wavefunction.

2 Measurement and properties of a plausible wavefunction

It is proposed that, although an elementary particle is a stationary state it is not frozen. Just like a violin string, except in three dimensions, the phase of the components of the wavefunction can be continuously varying away from the nodes. If the particle carries angular momentum, then the time-averaged direction of the angular momentum vector will remain stationary unless acted on by an external force. The wavefunction has components that have both amplitude and phase and so can interfere with another wavefunction. Multiplying a wavefunction by its complex conjugate removes the phase information and gives the peak amplitude squared of matched counter-rotating wavefunctions.

A pair of particles, which has arisen from an initial state of zero total angular momentum, will have component amplitudes with complementary phase relationships, which can have a fixed time-averaged direction, even though the components are oscillating. A pair of photons, for example, will have complementary polarisations. The direction of the polarisation cannot be known without a measurement but it exists and can lead to correlations between measurements on pairs of previously connected particles.

The Bell and KS arguments will be examined under the awareness that the wavefunctions of particles (including photons) can have fixed phase relationships that give an orientation relative to stationary directions in space but which arise from rotating amplitudes perpendicular to the eigenvectors. The directions of the orientations will be opposite within each pair of particles but random between different pairs of particles. The latter random distribution should be spherically uniform when averaged over many pairs of particles because the original singlet states had no preferred orientation. This gives rise to the probability distribution of the ensemble of all pairs. However, if a measurement is made along any direction, it will always yield the quantized value and the measured value of the second particle of a pair, if undisturbed, will always be opposite even if the two particles are now far apart. If, for example, one photon is measured to have upward polarization then the complementary polarization of the other photon (going in the opposite direction), measured in the same plane (transverse to the direction of motion) will always give the opposite polarization.

The situation is analogous to the case of the relaxed retiree who was eligible for free rail travel. He was not concerned in which direction he travelled and knew that the same number of trains from each direction stopped at his station (every 10 minutes). Therefore, he resolved to arrive whenever he felt like it and catch the first train that arrived. After many such trips he realised that he was four times more likely to go North than South. Since the time he arrived at the station was completely random he concluded that, in some unknown way, he could sense the train's presence and unknowingly adjusted his arrival times! However, the reason was that, for this station, the train going North always arrived two minutes before the train going South. The fixed phase relationship meant that it was four times more likely that he arrived in the 8 minutes before the North-bound train than the 2 minutes before the

South-bound train. The same fixed phase relationship gave different probabilities at other stations. A traveller on a second train line with trains leaving a central depot at the same time but heading in opposite directions, would observe a complementary probability at every station of matched distance.

The situation is similar for the pair of photons where the polarisation result is an up or down depending on the position (angular direction in space) of the measurement relative to the unknown direction of polarisation. Observing one photon gives definite information about the other photon at a matched measurement orientation and incomplete information away from that orientation. However, there is a subtlety in the amount of information because definite information for one orientation does not imply the state is frozen, a stationary state is still oscillating.

An elementary particle of spin ½ will have an eigenvector of fixed magnitude in what we will label as the $\bar{z}$ -direction. The eigenvector is perpendicular to two components giving a maximum amplitude rotating in the $\bar{x} - \bar{y}$ plane. When a measurement is made and the spin is determined to be, for example, up, it does not mean that the spin was exactly aligned with the (upward) orientation of the measurement apparatus, just that the direction of the vector was in the up hemisphere. This is because the rotation produces an apparent magnetic dipole with the north/south orientation determined by the apparent direction of rotation. The inhomogeneous field of a Stern-Gerlach apparatus senses the relative phase of the components and exerts a force couple that aligns the magnetic poles of the particle with those of the apparatus. If the spin of one particle is measured as up, then when the spin of the second particle is measured in the same direction it will always be measured as down. When the angle between the measurement is non-zero then there are some directions where the relative phases will mean both measurements will yield up (and some where both measurements will yield down).

If the state of a wavefunction is investigated using a photon (any electromagnetic interaction between states that have a relative oscillation) then the result will depend on the relative phases of the two states. However, the interaction will only ever lead to a quantized result. This is because an interaction occurs only when the wavefunctions add (interfere) to give the wavefunction of a new state. The quantum mechanical interpretation of the wavefunction representing a probability density reflects the fact that the phase of the wavefunction(s) can never be known without altering the phase or the orientation of the standing-wave pattern. Consequently, the probability of the interaction must be averaged over all possible phases or orientations.

This is the probability distribution predicted by quantum mechanics. The observed probability distribution based on the angular momentum eigenvectors as the hidden variables gives the same distribution as that predicted by quantum mechanics.

3 Analysis of Bell's theorem

The argument by Bell [3], against hidden variables, has been set out carefully by Brunner *et al.* [8]. To quote them: "The assumption of locality implies that we should be able to identify a set of past factors, described by some variables λ, having a joint causal influence on both outcomes, and which fully account for the dependence between *a* and *b* (where *a* and *b* are the outcomes of measurements, in directions *x* and *y*, on the separated particles). Once all such factors have been taken into account, the residual indeterminacies about the outcomes must now be decoupled, that is, the probabilities for *a* and *b* should factorize:

$$p(ab|xy,\lambda) = p(a|x,\lambda)\,p(b|y,\lambda)\ ." \tag{A1}$$

It is claimed that: "This factorability condition simply expresses that we have found an explanation according to which the probability for *a* only depends on the past variables λ and on the *local* measurement *x*, but *not on the distant* measurement and outcome, and analogously for the probability to obtain *b*."

They go on to say: "The different values of λ across the runs should be characterized by a probability distribution $q(\lambda)$. Combined with the above factorability condition, we can thus write

$$p(ab|xy) = \int_{\Lambda} d\lambda\, q(\lambda)\, p(a|x,\lambda)\, p(b|y,\lambda)\ , \tag{A2}$$

where we also implicitly assumed that the measurements *x* and *y* can be freely chosen in a way that is independent of λ, i.e., that $q(\lambda|x,y) = q(\lambda)$." This argument follows Clauser *et al*. who had pointed out: "we assume that the normalized probability distribution [$q(\lambda)$] characterizing the ensemble is <u>independent</u> of [*x*] and [*y*]" [9].

This *Independence* assumption has been stated as the requirement that any hidden variables be independent of the choice of measurement settings [10]. Put this way, the assumption sounds eminently reasonable. The choice of settings should be governed by the experimenter and free of any hidden information carried by the particles.

The problem with the above argument is that it is assumed that once all hidden factors have been taken into account then the residual indeterminacies are "decoupled". The reality is that there is no residual indeterminacy that is giving rise to the probability distribution (except due to measurement error). Instead, the probability distribution comes from fully determined but hidden and variable properties and the measurement results due to such properties can, and will, be correlated with the angle between the measurements (i.e. they cannot decouple).

The assumptions leading to equation (A2) show up more clearly when the eigenvector is considered to be the hidden variable λ. Firstly, factorability requires that the probabilities be independent of each other. This is only true if λ is perpendicular to the *x*-*y* plane. Secondly, the relationships between λ, *x* and λ, *y* completely determine the results *a* and *b*. The apparent probability arises separately because the measurer does not know the value of λ, which is randomly oriented in space. The probability distribution of the ensemble arises from a sum over definite causal outcomes.

Equation (2) can only be maintained for this hidden variable, and the corresponding fully determined results (i.e. up or down), if $q(\lambda|x,y)$ is used and not $q(\lambda)$. Using $q(\lambda)$ amounts to the assumption that the probability of up for *y*, when up for *x* is observed, depends only on the relationship between *y* and λ and is independent of the angle between *x* and *y*. As shown earlier, this does not hold for such a hidden variable. The assumption actually needed if equation (A2) is to hold is that the probability distribution (the fraction of eigenvectors per unit angle) is independent of the angle between the measurement settings, not that the hidden variable is independent of the measurement settings. The latter is a completely different requirement. The λ could, and should, be randomly oriented in space (free of the choice of orientation of the settings) but it is the orientation relative to *x* and *y* that matters. The probability of the occurrence of a hidden variable that gives particular outcomes *a* and *b* changes with the relationship of λ to the *x*,*y*-plane. The correlations between the measurement results are NOT independent of the angle between the measurement settings.

The assumption of Independence made in Bell's "proof" is the requirement that the effect of any hidden variables be independent of the choice of the combination of measurement settings relative to the hidden variable(s), not the implied qualifier: relative to the choice of orientation in space. The factorisation, inherent in equation (A2), effectively assumes that the eigenvector is at right angles to the measurement plane. The random variation in the spatial orientation of the hidden variable is then uncorrelated with the angle between the measurements which leads to the prediction that all hidden variables must give a flat probability distribution, i.e. that the measured values be independent of the measurement plane. The disagreement of this prediction with experiment has been taken to mean that hidden variables are ruled out. However, it is a faulty prediction. A plausible model of the wavefunction deterministically gives the quantum mechanical prediction. The argument that the perfect correlation between the spins of pairs of particles, when measured in complementary directions, means that the results are pre-determined (at the time of particle separation) is upheld.

The essence of Bell's arguments in terms of hidden variables was encapsulated in the notion of Bertlmann's socks, which always came in pairs of different colour [11]. The pairs of particles (socks) are presumed to possess some variable or variables which predetermine the outcomes of the subsequent spin (colour) measurements. The deductions made are about the probability of observing the same or opposite colour. The experiments are analogous to whether two reddish or two blueish socks or one reddish and one blueish sock will be observed when the underlying colours can be anywhere in the red or blue half of the spectrum (with the second sock always having the anti-colour). The Bell probability calculation assumes that the probability of observing red/blue just depends on whether the randomly chosen measurement colour (used for determining nearer red or blue) was in the red or blue half of the spectrum, and similarly for the blue. However, the additional assumption is made that probability of observing a difference between the socks is only dependent on the difference between the two chosen measurement colours (directions). This is unreasonable. There will also be a dependence on how close the actual (hidden) colour is to the boundary between red and blue. Moreover, the probabilities are an illusion in that the hidden colour and the directions completely determine what will be observed. The apparent probabilities arise because the hidden colour is randomly distributed.

4 Analysis of the Kochen-Specker theorem

The Kochen-Specker theorem has been simplified and clarified by Mermin [12]. It demonstrates the impossibility that quantum mechanical observables represent "elements of physical reality" as set out in the EPR paper [2]. More specifically, the theorem excludes hidden variable theories that require elements of physical reality to be non-contextual (i.e. independent of the measurement arrangement). The theorem shows that there is a contradiction between the assumption that any hidden variables that give rise to quantum mechanical observables have definite values and the sensible expectation that the values are independent of the device used to measure them. The contradiction is caused by the non-commutative nature observed for quantum mechanical observables.

The key premise of the KS theorem is that of value definiteness: all quantum mechanical observables have definite values at all times. More explicitly, it is essential to the arguments that the observable gets assigned the same value in different sets of compatible (e.g. aligned) observations. It is assumed that this will occur if the value assignment is not sensitive to the measurement context. It can be seen immediately that an eigenvector as the hidden variable is not value definite. The fact that pairs of aligned measurements give specific results (e.g. an up and a down) does not mean that there is a unique hidden variable (a definite value) that gives rise to these projections onto matched directions. The assumption is analogous to the faulty assumption in the Bell theorem. The rotation of the wavefunction means that the observed definite values for aligned measurements does not imply a unique value of the eigenvector prior to measurement. The non-commutative relationships of quantum mechanics reflect the wave nature of matter. Angular momentum can be seen as a rotating wave where orthogonal components perpendicular to the angular momentum are continuously varying but maintain a fixed phase relationship or give rise to an interference pattern with fixed orientation.

5 Discussion

The above discussion shows that quantum mechanics can be viewed as local and deterministic for a measurement of polarisation observations of pairs of photons, as in the experiments by Aspect *et al.* [4]. It presumably can be extended to particle spins in a Stern-Gerlach experimental set-up. However, the initial impetus for Born's proposal that the magnitude squared of the wavefunction $|\psi(x,t)|^2$ should be interpreted as a probability (that the particle is near *x* at time *t*), arose from scattering experiments. If a particle is a localised packet of waves, then when it strikes a target the wavefunction radiates out in all directions, with a magnitude decreasing as $1/r$, where *r* is the distance to the target. This seemed to contradict the common experience that, though a particle striking a target may indeed be scattered in any direction, it does not break up and go in all directions [13].

In order to maintain the determinancy it is proposed, as above, that individual particles are standing waves with eigenvectors that have steady directions in space. Then, an electromagnetic interaction between two such particles (which conserves energy and the nature of the particles) requires that their wavefunctions interfere such that each particle after the interaction has a new standing wave pattern with eigenvectors that have new directions in space.

The absorption of a photon on the screen behind a double slit experiment occurs at a single place where the magnitude and phases for the whole of the incident wavefunction matches the difference between the receiving wavefunction and the resultant wavefunction (e.g. of an excited state) plus any residual photon (if there is excess energy).

In a double slit experiment, the phase (or orientation of the standing-wave pattern) of a single photon relative to the slits cannot be determined without changing the phase/orientation and so destroying any correlation. However, the photon wave passes through both slits. The phase of the travelling wave is continuously varying but for each photon there is a fixed orientation of successive elements of the standing-wave at the two slits. A property (the phase relationship) exists for all photons in terms of the number of wavelengths between the slits (for a given energy and direction), but the absolute phase is hidden because it cannot be determined for just one slit without destroying the phase relationship. This fixed relationship gives rise to the interference pattern. However, it is proposed that the stochastic or probabilistic nature of the measurement or observation of a particular photon on a screen behind the slit, i.e. the absorption of the photon, additionally depends on the phase relationship between the wavefunction of the photon and the absorbing particle (atom, electron etc.). In this sense the result is determined by the measurement (the phase of the detecting wavefunction) as well as the wavefunction of the particle.

The revised understanding can now be taken back to the initial explanations of why the EPR argument, for the decay of two particles of a system with zero total angular momentum, led to a paradox [14,15]. The wavefunction of a system of total spin zero consisting of two particles, each of spin one-half was written as $\psi = \frac{1}{\sqrt{2}}[\psi_+(1)\psi_-(2) - \psi_-(1)\psi_+(2)]$, where $\psi_+(1)$ refers to the wavefunction of the atomic state in which one particle has spin +1/2, etc. The paradox arose because measuring the spin of any desired component of one particle immediately gave the value of the same component of the spin of the other particle. The complete determination for any pair of opposite measurements seemed to imply that components of spin in all directions were simultaneously definite. However, in quantum theory, only one component of the spin of each particle can have a definite value at a given time. The paradox is resolved by the understanding that $\psi_+(1)$ indicates that a measurement of this particular wavefunction will yield spin +1/2 because the eigenvector of the wavefunction points in the same hemisphere as the measurement direction. However, the direction of the eigenvector is not unique for a given measurement direction, even though for any pair of particles the eigenvectors will be opposite. The opposite direction of the pairs of eigenvectors leads to the observed correlation as a function of the angle between measurements. The interpretation of an eigenstate in terms of basis states with different probabilities needs to be seen in the context of the unknown direction of the eigenvector (or orientation of the interference pattern) having components in different directions and that components perpendicular to an eigenvector will be oscillating. These components are not the same as the supposed components in the above paradox, which are yes/no results for whether the eigenvector points in the direction of the measurement hemisphere.

It is further proposed, but needs careful verification, that the above hypotheses will yield the results of the existing mathematical formalism of quantum mechanics. The random phase relationship between the detecting and detected wavefunctions would seem to be consistent with the probabilistic interpretation of the wavefunction by Born. It is suggested that it is somewhat misleading to envisage particle states as mixed combinations of component eigenstates that collapse to one of the components on measurement. The apparent mixture arises because of missing or time varying information, for example, the angle of the eigenvector to the measurement direction, or the absolute phase(s) of the wavefunction of the particle relative to the measuring photon, or the orientation (polarization) of the photon arising from co-rotating components. The outcome is fully determined by realistic (pre-existing) properties but these cannot be measured without altering them. The proposed interpretation of quantum mechanics presented here is that the wavefunction is ontic; it has a physical, real existence. This agrees with recent experimental results that strengthen the view that the wavefunction directly corresponds to reality [16]. The Copenhagen interpretation that the results are indeterminate holds only in the sense that they cannot be known and that the outcome is not determined prior to a given measurement. However, the eventual outcome is fully determined by existing real properties and is causal. A many-worlds interpretation is not needed. Schrödinger's cat does not exist as a superposition of alive and dead states. The state is fully determined but unknown.

The EPR argument that because the initial quantum mechanical wavefunction, or state vector, does not determine the result of an individual measurement, quantum mechanics must be incomplete, arises from limitations placed on the state vector and its detection. The wavefunction can be varying in the plane perpendicular to an eigenvector and this variation relative to other wavefunctions (such as that of the measurement photon or particle) gives rise to the stochastic behaviour.

As Maudlin [17] pointed out: “the dilemma posed by the EPR argument: if a theory predicts perfect correlations for the outcomes of distant experiments, then either the theory must treat these outcomes as deterministically produced from the prior states of the individual systems or the theory must violate EPR-locality.” The argument presented here is that quantum mechanics is indeed a deterministic theory. However, the Bell proof fails and so EPR-locality and quantum theory can co-exist. The outcome is fully determined by the time varying wavefunctions but the relative phases (the hidden variables) are unknown and their interference leads to the apparent stochastic nature or apparent lack of determinism. In this sense both Einstein and Bell can be seen to be correct. No parameters have been added to quantum mechanics to explain the statistical predictions but the outcomes are determined and non-locality can be rejected.

The concept that physically separate particles can be entangled, meaning that an action on one can immediately affect another, independent of the time needed for a signal to pass between them, is faulty. The two particles have shared properties determined at the time of separation. The measurement of one does not affect the state of the other. Entanglement just means that there are some fixed phase relationships determined at the time of separation of the particles. This would seem to bring into question the concept of quantum computing if, as it appears, it is based on non-locality i.e. the actions on one separated particle affecting the other. A number of qubits could have fixed phase relationships and so one measurement could be related to, or influenced by, the state of all qubits. However, the absolute phase relative to that of a measurement process will be random and could never be known without altering the phase. It would still seem to be analogous situation to the double slit experiment where the pattern builds up over time but no individual result can be predicted.

7 Conclusions

A plausible picture of the nature of the wavefunctions and standing wave states of elementary particles illustrates that a causal and fully deterministic interpretation of quantum mechanics is possible. The stochastic nature is due to spatially different and time varying phases of both particles and measurement procedure. It is claimed that this interpretation will be found to be mathematically consistent with current theory that interprets the magnitude squared of the wavefunction as a probability distribution. The revised interpretation allows flaws in the assumptions made for hidden variable theories to be clearly seen. The faulty assumption made in proofs of the Bell theorem is that there are decoupled (uncorrelated) probability distributions for each measurement after the hidden variable is taken into account. Instead, the results are fully determined by the measurement directions relative to the angular momentum eigenvector or orientation of the standing wave. Probabilities arise from the random orientation of the eigenvector (or interference pattern) between different pairs of particles but there is a correlation between the eigenvectors or orientations and the angle between the measurement directions.

The likelihood of observing particular outcomes therefore depends on the half-angle of the relative orientation of the detectors in the way predicted by quantum mechanics. The Bell "proof" fails and the violation of the inequalities does not mean quantum mechanics is non-local. Similarly, the time varying or rotational nature of the wavefunction means that the value definiteness assumption of the Kochen-Specker theorem does not hold, so the indefinite hidden variable can have a physical reality independent of the measurement settings. The outcome of any interaction is causal and determined, although the impossibility of obtaining complete phase information of an individual state, without altering that phase, means that the observer is unable to predict the outcome of an individual measurement. Quantum mechanics is a complete theory but its calculations average over unknown (hidden) phase differences or orientations. Non-locality, the spooky action-at-a-distance, is not required and the idea that the wavefunction collapses is unnecessary.

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