Making Sense of Gravity

Peter Lamb

The current theory of gravity, General Relativity, explains gravity as a distortion of the geometry of the fabric of space-time. The one-hundred-year-old theory has had some mighty successes, so any improvement or revision needs strong justification. The first challenge is to reproduce the key experimentally confirmed predictions and to help resolve outstanding issues. Confirmation comes from the alternate theory providing a deeper understanding and making successful new predictions. The details of such an alternative theory, Full Relativity, are presented. It explains gravitational attraction as a decrease in the stored energy (mass) of matter when closer to other matter. The arguments of how and why such an alternative is possible and can meet the challenges are set out. Its many advantages such as the removal of singularities and removal of the need for the ad hoc hypotheses of dark matter, dark energy and cosmic inflation, together with its new explanations and successful predictions, provide strong evidence for its underlying validity. Nevertheless, critical analysis and further development are needed.

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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.

"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)."

Contents

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 space-time. 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 the same amount 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 new predictions have been developed which appear to be in good agreement with observation and a number of experimental tests are set out. 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 may still be 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, Chris King, Sandy Macintyre, Robert Niall, David Phillips, Terry Reichl, Peter Robertson, Peter Smith, John Tacon and Brian Thompson, and physicists Brian Foster and Richard Hemingway. 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 collaborators at CERN; for their support which enabled me to successfully undertake a D.Phil. in experimental particle physics so many years ago.

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 is 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 space-time. This fabric alters the perceived time and distance of a linked combination (space-time) 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 space-time. An increased distortion of the geometry of space-time between unchanged objects is replaced with an undistorted space due to a background in which high-speed movement slows time and in which the speed of light, mass, frequency and inertia of objects embedded in that space are altered by 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. It arises from a change in the properties of objects due to changes in the surrounding medium (a background field). The work done to lift objects in a gravitational field is stored in the objects as mass, not in a less-distorted fabric of space-time 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 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 atoms that is blue-shifted.

The amount of energy (m) stored by the same matter (which locally stores energy E) varies, so that $m = E / c^2$ implies that the speed of light decreases, and the same clock ticks faster, as the magnitude of the background decreases. It is shown that this surprising change, a variable mass and light speed, is consistent with observations including those that gave rise to Special Relativity. However, it also has some encouraging advantages. It removes the singularity at the centre of black holes and allows black holes to interact gravitationally beyond their supposed event horizon. It also implies that the speed of light was faster earlier in the history of the universe. The adjusted travel time for light from the standard candles of supernova explosions then implies a constant rate of change of redshift, 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 hypothesis of cosmic inflation.

The nature of momentum, the handedness (chirality) of weak interactions and the Higgs mechanism, 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 this asymmetry. One consequence appears to be that most of the 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 not be revealed by annihilation. However, the inverse decrease in gravitational potential with distance rather than distance squared means that the 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 or possibly in galaxy superclusters. The dependence of frequency and inertia on the chiral asymmetry then removes the need to postulate dark matter by explaining both galaxy rotation curves and increased gravitational lensing.

The supernovae data gives a measure of the change of stored energy (galaxy redshift) with changes in light-speed over time. This provides a new understanding of Newton's gravitational constant (G_N) and a prediction of the rate at which clock-rate is increasing with time. The expected change in clock-rate fully explains the observed Pioneer anomaly.

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 the one underlying field; 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; that the values of G_N and Planck's constant reflect the total background and its asymmetry at our position in the galaxy at the current time; 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 Special Relativity (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. The fourth force, gravity, has not been unified 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. Einstein deduced that gravity was a distortion of space-time rather than a real force. 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 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 space-time. The concept of space-time first arose in SR so the derivation and interpretation of the Lorentz transformation (LT), which explained high-speed observations, must be 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, but the space between stationary objects is not altered. This replaces the fabric of space-time linked by a constant speed of light, in which both space and time are distorted by mass and energy, and the distortion acts as the source 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. The re-introduced background field must also be able to explain inertia and the bending of light in an undistorted space. The rest of the book seeks to demonstrate the viability and advantages of the replacement theory.

The subsequent chapters are set out as follows. The postulates and derivation of SR, that led to the idea of the fabric of space-time, are carefully examined in Chapter 2. This is essential if such an established theory is to be in any way challenged. It is pointed out that the method used to derive the LT seeks 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. A priori, such a method cannot yield the time (clock-rate) of the moving clock without the clock being examined unless additional assumptions are made, such as: that the time of identical clocks stationary in their respective frames is the same. The derivation appears to confuse simultaneity and synchronicity. The apparent simultaneity of events is altered by relative motion of the observer during the finite time of signal transmission while synchronicity (the relationship between steady clocks in each frame), once established, is independent of relative movement provided velocity is unchanged. It will be argued that observations can only be explained by a real slowing of time with movement of massive clocks relative to a background. SR also claims a slowing of time together with a contraction of length giving a constant measured speed of light. However, under SR, the apparent slowing and contraction with relative motion become real for the observed objects, as seen in the slowed decay rates of unstable elementary particles moving at high speed. It is pointed out that matched changes in space (distance) and time (clock-rate) are required if the same numerical value for the speed of light is to be obtained within each relatively moving frame. However, if the scale of distance is not altered by relative movement and the speed of light is independent of the emitting and receiving sources, then a decreased clock-rate (slowing of time) for the moving frame means that the clocks travel further per tick (increased distance). The numerical value for the speed of light, measured within the moving frame, will then be faster.

A real slowing of time can be explained by a frequency and clock-rate of massive objects that is altered by motion relative to the background from all other massive objects. The inverted interpretation in SR of time dilation relative to length contraction has allowed the incorrect conclusion that space and time are linked into a fabric of space-time that keeps the underlying speed of light constant. Such a linkage requires that larger time intervals, giving slower time (time dilation), be matched by larger length intervals (meaning less distance). This contradicts observations which require time dilation to be matched by length contraction. The revised understanding 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 affects the energy stored as mass via the change in the speed of light. It is not due to differences in mass/energy density distorting the geometry of space-time (the metric) nor is it independent of a uniform, stationary background (as claimed by GR).

The origin and many consequences of this core difference between a background dependence and a distorted space-time, are set out in Chapter 3. The speed of light is 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-time intervals (synchronisation) and clock-rate; that mass does not distort distance; and that the strength of gravity depends on the size of a uniform background from other mass. The last overcomes a serious unrealised problem. The differential form of Newton's equation, on which Einstein's field equation of GR was based, requires that empty space free of matter (i.e. nothing) acts as a source of gravitation. It is shown that background-dependence can overcome such problems yet mimic GR. It does this using an undistorted space and by having the properties of objects and the speed of light depending on the background. It provides a path for avoiding the ad hoc hypotheses of dark energy and cosmic inflation, but more is needed, and the reasoning and proposals 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, inertia, and to avoid the need for dark matter. The two-component background gives rise to a "clout" that only falls off as $1/r$ from a point source (an excess of stored energy). The clout from the gradient due to a given excess of stored energy is reduced as the background flux from all other sources increases. This total background determines the speed of light and hence the conversion factor between mass and energy. In contrast, GR assumes that gradients in potential from opposite directions cancel. This means that, under GR, mass is independent of a uniform background. The revised theory has gravity, and all energy and momentum, fully dependent on the background which is why it has been called Full Relativity. The start of an underlying physical picture of FR and a set of hypotheses consistent with this picture is given. One postulate is that oscillation frequency of light and matter is altered by any asymmetry in the contributions to the background from matter and antimatter. Matter and antimatter have opposite handedness (chirality). A chiral background that affects the properties of massive and massless objects replaces the distortable geometry of space-time 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 field due to the same amount of matter decreases as the background increases. GR has all energy contributing to the field, including gravitational energy so the field increases non-linearly and gives rise to singularities. Under FR, the stored energy decreases which avoids the singularities. Other benefits include the presence of an equal amount of antimatter and black holes which can interact gravitationally. It is shown that FR can reproduce the standard well-confirmed predictions of GR for the current background. Moreover, it links the value of Planck's constant to our location in the galaxy. This is consistent with and explains the flat rotation curves of our and other spiral galaxies without the need for dark matter.

Key new predictions of FR and their comparison with astronomical observations are presented in Chapter 6. The predictions of FR and GR are expected to diverge with an increasingly different background. Such a difference would arise from an expansion of the universe but can also arise from increased clumping of like matter and antimatter. The background affects the speed of light and clock-rate. It is also postulated that an asymmetry between the chiral components of the background alters inertia and oscillation frequency. The reduced change in the speed of light, when only one component of the two-component background changes, leads 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 does not require an ongoing expansion. No driving force for expansion is needed and there is no requirement for an initial Big Bang.

The change in speed of light with clout entirely removes the claimed accelerating expansion and hence the need for dark energy. The corrected supernovae data then gives a prediction for the current rate of change in time. This change in clock-rate predicts an apparent drift to lower frequency of an earlier signal, from the same clock, that has been delayed before being compared with the current signal. Such a delay can be achieved by sending the signal to a distant spacecraft and back. The prediction accurately explains the observed drift to lower frequency known as the Pioneer anomaly, as distinct from the slowing speed produced by heat radiation in the direction of motion. Further astrophysical predictions and consequences are outlined in Chapter 7. Other experimental and observational tests that can provide a clear distinction 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. The clearest example of this is the observation that the speed of propagation of electromagnetic fields is also the speed of propagation of gravity. It is proposed that mass can arise from any force (strong, weak, electromagnetic or gravitational) that confines momentum to a location. 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 the nature of the photon, massive particles and quantum mechanics are developed, together with an examination of particular implications and predictions for particle physics (Chapter 9). 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.

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 space-time. 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 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 see as heat and 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 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 interferes with another beam of 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 carried 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. 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 changed because of 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 space-time, 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 space-time 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 of motion 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 $W^{\pm}$ 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 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 $W^{\pm}$ 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 space-time. Such a force would appear incompatible with the other forces. Moreover, under GR, mass and energy increase the distortion of space-time 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 showed that space and time are not fixed and instead are part of a linked "fabric". In GR, Einstein showed that the geometry of space-time is also not fixed. Space-time is distorted by matter (via its energy and momentum): it tells matter how to move and matter tells space-time how to curve. Under GR, gravity is not a force. It is just the curvature of space-time. The more massive an object the more space-time is bent, which appears as a stronger gravitational acceleration.

The path to GR is 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 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 an undistorted (flat) space of SR,

i.e.: $ds^2 = c^2t^2 - (dx_1{}^2 + dx_2{}^2 + dx_3{}^2)$ 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 space-time 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 during a solar eclipse. The positions of the stars were compared with normal photographs 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. For this to work, 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 would not work. So the predictions are good.

A fourth prediction, 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 black holes, an expanding universe and gravitational waves. 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. This is therefore called a black hole. Such a feature has been imaged in a relatively close galaxy with a very large, compact, concentration of mass at its centre. There is also very strong evidence for a similar, very compact, object at the centre of our galaxy where the orbits of nearby stars indicate an object smaller than our solar system but with millions of times the mass.

Gravitational waves are caused by the movement of massive objects but only become significant in catastrophic cosmic events like colliding black holes. According to GR, the waves are ripples in the fabric of space-time that fan out through the universe at the speed of light. Einstein's equations predicted gravitational waves would exist. The first evidence was from the motion and frequency of pulses from binary pulsars (rapidly rotating neutron stars). The changes in their orbits and timing 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.

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 The current understanding of the Cosmos

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 quite 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 mass increased with distance, so that the galaxy was 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 GR (or twice the supposed Newtonian value). It is found that large diffuse clouds of additional invisible mass are again needed.

Additional lines of evidence for dark matter are the higher-than-expected speed of galaxies within clusters and simulations of galaxy evolution. The simulations, covering the time between the anisotropies observed in the CMB and now, 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 size. 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 the energy density would be expected to decrease in the same way that the matter density decreases. Instead, the amount or importance of this energy increases as the density of the universe decreases.

It turns out that the 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 space-time. 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 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 of the order of 20 orders of magnitude in the first 10^{-35} seconds after the Big Bang.

A final aspect of the current understanding is that the <u>visible</u> 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 perspective

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 space-time.

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, rather than from an increase in the distortion of space-time 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 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 only trapped energy corresponds to mass, then photons will not gain or lose energy 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 nearer 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 gravity) the measured speed of light is the same for all observers and that time and space can be unified into a space-time. However, although the speed of light is constant within an inertial frame, it does not have to be the same constant 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. 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 position with 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 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. 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 space-time a step further than SR by explaining gravity as a space-time 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 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 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 space-time 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 space-time) is directly proportional to the energy/momentum tensor.

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 gradients in opposite directions cancel, removing any dependence on a uniform background potential. However, the distortion (curvature) arises from an antisymmetric tensor of second derivatives of the potential. Cross-terms in the gradients of the potential, like tidal forces from opposite directions, can then add. 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.

Under FR, the background field whose gradient gives rise to gravitational acceleration is the negative of the 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 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 space-time. If the energy gained by the object in falling in a gravitational field comes from the field, rather than the object, then an undistorted space-time 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 space-time) 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 space-time 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 due to the very large gradient in potential.

The understanding that mass decreases as the magnitude of the field from all other matter increases reveals that Newton's law is a scalar, energy-balance equation with no time dependence. The time dependence of events is associated with the speed of movement of particles and fields. 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 space-time 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 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 constant, 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 the same 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.

SR, which appears to give consistency with observed behaviour, is based on a constant speed of light. However, a variable speed is not forbidden because SR applies to inertial frames, and so to regions without gravitational acceleration due to gradients in matter 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 will not be the same. These are clocks based on mirrors the same distance apart. The ratio of time intervals follows $dt' / dt = c / c'$. If light travel-time varies then causality must take this into account. The concept of absolute simultaneity, that there exists an underlying absolute time for sets of simultaneous events throughout space, needs to be refined. The ability to influence events at another location depends on the fastest time any interaction can be transmitted. The underlying time 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, the time intervals between ticks of identical massive clocks do not change in the same way as the time intervals of light-clocks.

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 moving between 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 of FR implied by $m = E / c^2$, is to have c 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 increase in stored energy implies that the length of the same rod (the separation distance between connected ends) will decrease 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.

1.6.2 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) 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 tick at different rates. Both FR and GR attribute this to differences in the gravitational potential. However, the potential of GR comes from the integral of the gradient in the field and so removes any contribution of a constant uniform background. Such a contribution has no effect on mass or c, whereas FR has mass and c dependent on the magnitude of the total background potential. FR has it that the laws of physics are only equivalent after correction for the background.

Under FR, changes in the speed of light (c to c') 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 the assumptions of GR, as will be seen and challenged. 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. In addition, it is difficult to measure local differences in the speed of light as they are so small, matching the difference seen in clock-rate with altitude. The fractional change in mass ($\Delta m / m$) with distance from a spherical object of mass M, is $G_N M / rc^2$.

Thus, under FR, the gravitational potential, the change in energy per unit mass ($\Phi = \Delta E / m$), is the fractional change in energy or mass (i.e. $\Delta E / E = \Delta m / m = (\Delta E / c^2) / m = \Phi / c^2$) 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 of the energy held by a small amount of matter when it moves closer to a large source of mass. Because it is a derivative, a small fractional change will arise when the total background is large. The fractional change in clock-rate with altitude is also $\Delta\Phi / c^2$. It is the change in time from the change in energy stored in the atoms of the clock. It is seen as due to the change in Φ, which, under GR, is independent of the background and c is constant. Under FR, it is due to the change in c from a small change in 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.

1.6.3 Special Relativity does not eliminate background dependence

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, and 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. 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, i.e. that there is no need for a background against which speed of motion has an effect.

SR holds that a background is superfluous and there is no need for an absolute stationary space. 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. The replacement theory FR is background-dependent and movement relative to this background causes time to slow for massive objects. This is a big issue because, 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. independent of a constant background).

So, what is meant by a background? The simple answer is a field that permeates 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 space-time 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 space-time 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 space-time 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 space-time 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).

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 (constant) but inertial mass and gravitational attraction depend on the rest mass plus the kinetic energy, with the kinetic energy depending on speed relative to the observer. Under GR, the amount of warping of space-time depends on the inertial mass. FR must also explain inertia and its increase with speed as well as the bending of light.

FR proposes that the energy of a photon is not changed in moving through a gravitational field so that light does not slow down (fall backwards) in a gravitational field. If bending was caused by light falling, then light would be predicted to be bent by a gravitational field, but by only half as much as predicted by GR because GR claims a distortion of both space and time. However, FR has no distortion of space and so it needs to be explained how it gives rise to the observed bending of light.

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 arises 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 may imply that asymmetry has little or no effect on gravitational mass, but it could still be correlated with inertial mass or 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. The changes in inertia with asymmetry will be proportional to changes in gravitational potential (a $1/r$ dependence from each point source) and so will be partly absorbed into the apparent value of the gravitational constant (a $1/r^2$ dependence on the gradient). The speed of movement of massive objects under the expected gravitational force would, however, differ in regions of significantly 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 while inertia is proposed to arise from asymmetry (not its gradient). 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 with will decrease 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. However, the change in the asymmetry of a two-component background should always be much larger than the change in total background which, FR proposes, gives rise to gravity.

1.8 Gravity as a scalar, vector or tensor field

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 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 are the same to high accuracy. A post-Newtonian theory therefore needs to be able to explain changes with speed of movement and the vector nature of momentum. GR introduced the finite speed of gravity via space-time and via inertia (which increases with the rate of change) but equated inertial and gravitational mass. In SR, the link between space and time had the speed of light a universal constant in a flat Minkowski space-time. In GR, mass and energy can alter this link by distorting the geometry of space-time.

FR also needs to introduce a relationship between space and time in terms of the finite speed of propagation of the gravitational field. However, the requirement is that this relationship be consistent with $m = E / c^2$, with a variable speed of light/gravity. The immediate implication is that Newton's scalar gravitational potential (the stored energy per unit of matter) should be the field which propagates at the speed of light. On the other hand, in formulating GR, Einstein equated acceleration with gravity. This meant that the vector force fields, the gradients of potential (energy) fields, were equated. Therefore, a brief introduction to gravity in terms of both a scalar and vector field is given as a prerequisite to the understanding 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 $\partial Q/\partial V$, 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:

$$\vec{F} = m\vec{g} = G_N Mm\hat{r} / r^2 \qquad (1.1)$$

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), <u>held</u> at that location, that can be given to objects. The energy given to objects is kinetic energy of motion which reflects inertial mass (the difficulty of changing momentum). Under GR, inertial and gravitational mass are seen as the same property (m). The force resisting acceleration and the force of gravitation are equated.

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 rotating binary stars, or black holes, can also be carried away by gravitational waves, and these are assumed to be made up of gravitons. 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 field is altered by the movement of the charge with the change in the field propagating at the speed of light.

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, about 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 $\sum(\delta M / d)$. If there is a large uniform background, then the gradient of this field will appear to depend only on nearby sources.

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. However, the fractional change from the same nearby excess of energy (mass) will be smaller if the background is larger. The proposed scalar background of FR will alter the speed of light and hence the energy stored by matter. The effect of a large background on energy (per unit mass) will therefore be proportional to minus the potential (or minus the potential divided by c^2, for energy per unit energy).

A potential field has a magnitude at all points in space and the force will depend on the fractional change in magnitude with distance. The magnitude of the potential is the sum of all contributions from sources of excess stored energy. Each contribution is in direct proportion to its stored energy divided by its distance. In this sense it reflects a linear energy density, rather than a volume density. However, the term "clout" will be used to represent the magnitude of the background which determines the speed of light and to distinguish it from minus the potential of the stored energy that 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 gravity and acceleration could both 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 distort the geometry of this space-time fabric in which all things move, but the (rest) mass of objects is unchanged. (This background, and also relative movement of object and observer, change perceptions. It is claimed that the fabric just expresses a relationship between space and time and it has no substance.) 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]. Einstein's field equation is a generalisation of equation 1.2. The curvature, and gradient of the acceleration, are directly proportional to the stress-energy tensor, the generalisation of mass density to the density of energy and momentum. The appearance of mass density and energy density in the gravitational field equations (of both Newton and Einstein) is why the terms have become familiar, but their meaning needs careful examination.

The fabric of GR is distorted according to the derivative of a generalised Newtonian potential (in which the properties of tensors allow distortions from opposite directions to cancel). It alters the space and time in which objects are embedded and so can alter their apparent energy and momentum (via velocity) but does not alter their mass (because c observed at the object is kept constant).

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 space-time, 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. 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 space-time can be replaced with a different sort of background. The background affects the properties of objects rather than the space-time 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 Special Relativity (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, gravitational 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 space-time 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 escaping the Earth's gravitational field is inconsistent. Massive objects should also lose energy in escaping a gravitational field. Time going faster should also mean that the frequency of a constant-energy 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 is true within any inertial frame, but only after allowing for changes in signal arrival time due to relative motion during transmission. 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) arises because electromagnetic fields propagate at the speed of light and 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 space-time 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.

Time, in terms of the clock-rate of stored energy (massive objects) does depend 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 the size of this background, affects the magnitude of physical laws. The speed of light has a scalar dependence on the background. The energy that can be held by massive objects, and hence clock-rate, reduces as c increases. Space is not distorted, although the size of objects will change as the background changes. The distance between separated objects, not in relative motion, is constant. 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 space-time (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 derivations require that the radiation of light from a stationary source will, to a moving observer, also be measured to spherically expand at the same speed, independent of relative motion at constant speed. This requires real, rather than imagined, matched distortions of space and time. However, consistency with observations requires that a dilation of time (larger time intervals) goes hand-in-hand with shorter distance intervals (expanded lengths). The opposite of matched distortions. 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 increase in inertia by the factor γ and a decrease by $1/\gamma$ in decay rates. FR achieves this by having inertia and frequency of the same amount of stored energy dependent on an additional aspect (an asymmetry) of the background.

Under FR, space and time are not linked into a space-time. So, gravity cannot arise from a distortion of the geometry of space-time 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 space-time 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 space-time, 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 argued that it is impossible to use the claimed procedure, equivalent to an examination of reflected signals, to deduce the time experienced by a moving object. The distinction between “apparent” and “real” effects then becomes blurred. This is encapsulated in the subtle differences between the postulate that the “measured” speed of light is independent of the speed of the observer and the observation that (in a constant gravitational field) the speed of light is independent of the speed of the emitting object. 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 contradictory conclusions: that the aether is mechanically independent of ponderable matter, but the effects of the then 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 space-time 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 space-time 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 space-time with a locally constant local 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 space-time 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 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 introduced the concept that the perceived time and distance of a moving object, seen and measured by a stationary observer, were flexible. They were dependent on the relative speed, but the measured speed of light was a constant. This was because (when signals took time to propagate) a rod of fixed length, moving towards a stationary observer would appear shortened, while the arrival time of signals from clocks would increase with distance from the observer. Thus, the time difference (simultaneity relative to an initial zero difference) between identical clocks at the two ends of the rod, ticking at the same rate as each other and at the rate of the stationary clock, appeared to increase with the length of the rod.

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.

He then considered a ray of light, emitted from the origin of system k at time τ_0 along the *x*-axis to x' and at time τ_1 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:

$$\tfrac{1}{2}[\tau(0,0,0,t)+\tau(0,0,0,t+x'/(c-v)+x'/(c+v))]=\tau(x',0,0,t+x'/(c-v))$$

However, although events at time τ_0, τ_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 revised equation:

$$\tfrac{1}{2}[\tau(0,0,0,t)+\tau(0,0,0,t+\Delta x/(c-v)+\Delta x/(c+v))]=\tau(\Delta x,0,0,t+\Delta x/c)$$

will hold approximately for any Δx, and accurately in the limit that Δx goes to zero. However, the replacement of x' with Δx in the time of each event removes the effect of the $x'=vt+\Delta x$ and the incorporation of 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 forced equality of the original equation 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. [It will be shown (Section 2.3.3) that the timing of return signals relative to the actual instantaneous position at reflection is increased by the scale factor $1/(1-v^2/c^2)$.]

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. Using $x'=x-vt$ this becomes $\tau=a\gamma^2(t-vx/c^2)$ where $\gamma=1/\sqrt{1-v^2/c^2}$. This expression for τ was then used to derive expressions for ξ,η,ζ by assuming that the velocity of light was *c* when <u>measured</u> in the moving system. So that $\xi=c\tau,\ \eta=c\tau,\ \zeta=c\tau$. For the ξ - axis, 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 similar argument for light propagating along the y-axis gave $\eta=c\tau=ac(t-vx'/(c^2-v^2))$, which was claimed to hold for $y/\sqrt{c^2-v^2}=t$ and $x'=0$. However, $t=0$ when the light ray is at $x'=0$ so the relationship between y and t is arbitrary and undefined. The deduction appears to have been made on the basis of the claim that light is always propagated along these axes, when viewed from the stationary system, with the velocity $\sqrt{c^2-v^2}$. The reason for the claim is not clear but seems to imply an instantaneous awareness of where a light ray would be.

The arbitrary relationship can be ignored by absorbing it into the value of a to give:

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

Einstein replaced a with the factor $\phi(v)$. If $\phi(v)=a\gamma$ and $x'=x-vt$ the equations become:

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

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.

The analysis then examined a third frame (K') relative to which the origin of system k was moving in the opposite direction with 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 the frames are not at rest relative to each other. 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 $\phi^{-1}(v) = 1/\phi(v)$ and all dependence on the unknown clock-rate in the moving system is removed.

The claimed derivation is remarkable because it is 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 introduces a dependence of time (clock-rate) in the moving frame that is related to vx/c^2. The amount will be quantified later in this chapter. 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.

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 $\xi = \gamma(x - vt),\ \eta = y,\ \zeta = z$ then 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 analysis included the assumption that a ray of light emitted at $\tau = 0$ would obey $\xi = cd\tau$ and $\eta = y,\ \zeta = z$, so the constancy of "observed" c, using the supposed time and distance coordinates of the moving system, was built in. The distances and times had (ostensibly) been deduced from the distances perceived by the stationary observer using times that absorbed part of the transmission delays due to the finite speed of light but did not access the clocks in the moving frame.

Subsequent derivations of the LT, by Einstein [15] 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, 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. 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 $x' = x - vt$, builds in a variable scale (a distortion) between the positions in the primed and un-primed systems of coordinates. The requirement of a constant observed value of c, despite differences in distance the light rays travel, then forces a distortion in time proportional to vx / c^2 which reflects the difference in light travel time when there is movement during the time required 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 magnitudes of the distance and time distortion are forced to match by inserting the requirement that the observed speed of light be constant.

The equivalence of the space-time 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, being taken as a real slowing of time in the moving frame. The matched changes keep the 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 value in 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 give an apparent 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 interpretation of the LT in SR is as follows. 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). However, this is not physically correct. It is based on the assumption that the LT indicates that real distances and times are changing. 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 $t' = \gamma t(1 - v^2 / c^2) = t / \gamma$. However, the expression $x = vt$ applies to a separation x that is decreasing when $t < 0$ and increasing when $t > 0$. The sign of the $(v / c)(x / c)$ term, which reflects the (mistakenly included) change in arrival time of signals due to relative motion during transmission, changes sign at $t = 0$. If the scale factor increases by γ in one direction, then it must decrease by the same factor in the opposite direction.

Thus, the interpretation arrived at $x' = \gamma x$ and $\tau = t / \gamma$. Next it took $x = x' / \gamma$ as the length that moving objects of length x' 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, Einstein took the time (τ) of a clock in the moving system as "nothing else than the summary of the data of clocks at rest in the system" when its clocks were synchronised with those of the stationary system [9]. Therefore, $\tau = t / \gamma$ was taken to be the time of the moving clock (viewed in the stationary system) and, since $\tau < t$, time was slowed. The elapsed time within a frame is the sum of time intervals so that a smaller amount of time had elapsed. Minkowski [16,17,18] made the same interpretation, that total time was $\int dt$. However, this leaves out the inversion used in interpreting lengths. Alternatively, 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. 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 in the treatment of length and time means that lengths and times change in unison keeping 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.

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 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.

2.2.4 Comment on a recent derivation

Lectures on SR and GR that are readily available on the web include a derivation of the LT [19]. 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. The reader is invited to examine the lecture and ascertain any hidden assumptions before reading further.

The statement 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 space is distorted).

2.3 An alternative perspective on relativity, space and time

It is proposed that events have an existence at a location (space) and 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 for the transmission of sound relative to a near-instantaneous location seen with light signals. The expectation is also 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 any motion of the medium) has to take into account the relative motion of the observer between emission and reception.

There is no requirement from this proposal that time (clock-rate) is the same for identical clocks that are each stationary relative to the emitter and receiver, but 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 can depend on the magnitude of a background (field) but the light self-propagates at the maximum speed allowed by the medium, independent of an 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 analogous to the LT that is consistent with observations and all the successful predictions of SR.

2.3.1 The derivation of the 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 of $\Delta x/c$, 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 $t' = t(1-v^2/c^2)$. However, this Δx is not the distance the frames move apart with time. Instead, it is the extra distance travelled by the light by the time it reaches the observer.

Under the revised hypotheses, the transformation relating time and <u>apparent</u> 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. Technically, 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 $x'^2+y'^2+z'^2=c^2t'^2$ is a result of a misinterpretation of x in the vx/c^2 term and the assumption that $t'=\gamma t$ applies to all points when $v=0$. It 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 $t=t'=0$. The invariant intervals remain under the revised perspective. The distance squared is unaltered but the time in the moving frame is slowed, meaning the LHS is constant but apparent distances travelled and the measured speed of light will increase. There are no constraints on the speed of light from the proposed alternative perspective. The value is not constant (as observed) but 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 based on returned signals is 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 by sending pulses to the object and examining the time intervals between returned pulses, with the pulses moving at speed c, independent of the direction of travel.

The time interval between pulse emission and return increases linearly with the instantaneous distance (x') to the object at the time the pulse is reflected (t'). This is the time at the object on a clock ticking at the rate of the stationary observer's clock. It is the time on the object's clock when the pulse is reflected 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 $t_e=t'-x'/(c+v)$ and received back at $t_r=t'+x'/(c+v)$, if c is independent of the speed of the emitting object. The total time for the round trip is $t_r+t_e=2t'+2vx'/(c^2-v^2)$.

Half this value, the average time for one-way signal transmission (T), is: $T=t'+vx'/c^2(1-v^2/c^2)$ and substituting $x'=vt'$ gives: $T=t'/(1-v^2/c^2)=t'\gamma^2$ where $\gamma=1/\sqrt{1-v^2/c^2}$.

This time interval is larger than the time needed for light to travel the distance $\Delta x = x'$, i.e. t', because $t_r - t'$ is larger than $t' - t_e$, due to the changing distance between the observer and the object during transmission of the signal. The factor γ^2, by which time intervals increase, is also the factor by which the average of the distance to the object at emission and receipt of signals by the observer is greater than the distance at the time of reflection. It is a scale factor that multiplies both time and distance relative to the instantaneous time and distance. The time, in terms of the sum of stretched round-trip time intervals, is γ^2 greater than the original time and the average distance at the time of receipt of the signals is also γ^2 greater.

The longer time (increased by γ^2) for a signal to reach and return from a more distant object means that it appears to be going further per tick of the observer's clock (whether moving towards or away). The average distance changes more than that expected from the known velocity at the instance (t') of reflection. 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 $\gamma t'$, which is T/γ. 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 returned signals, including the returned time of the moving clock, will appear consistent with the LT.

For an approaching object, the apparent velocity will also 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 of their return 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.

Only the new hypothesis is consistent with a real time dilation and with the real changes in time 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.

The increase in apparent time intervals by the factor γ means the elapsed time, observed after correction for the γ^2 increase in return transmission time with increasing distance, is reduced by the factor $1/\gamma$. Hence, 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 (at reflection) and distance (based on round trip times) 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. The reduction in apparent time intervals needs to be assumed to correspond to a real slowing of time. Only the second interpretation is consistent with a real time dilation 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 space-time 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 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 <u>massive</u> 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 <u>massless</u> 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 the oscillation between them 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 space-times and velocities) as there are observers moving at constant relative speeds. This interpretation requires that the space-time in which objects and clocks exist is 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 then 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 [15], 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. Time in the moving frame is dilated meaning a slower clock-rate, which corresponds to longer intervals between ticks. A contraction in the length of rods means that length intervals are smaller. However, larger time intervals matching smaller length intervals is inconsistent with the altered postulate of SR, that the speed of light always measures the same (in the transformed coordinates). This requires $c = dx / dt = dx_0 / dt_0$, so that dt increases when dl increases and vice-versa. The altered postulate requires increased time intervals (dt), i.e. longer between ticks, to be matched by increased length intervals (dx), i.e. longer rods. The opposite to length contraction. Consistency with observation and an LT (after substituting $x = vt$) requires that slower (less) time, which corresponds to larger time intervals (between ticks), goes with greater distance per unit time, which corresponds to smaller distance intervals (between length marks).

The invariant space-time interval of SR is based on $dx = cdt$ and the assumption that c always measures the same. Hence, $dx^2 + dy^2 + dz^2 - c^2dt^2 = constant$. This is true for any c when dt is, by definition, the time interval, taken to travel a constant distance. The claim that light leaving the origin of a stationary system will propagate spherically with coordinates $x^2 + y^2 + z^2 = c^2t^2$ and that the same light seen from a moving system will also be seen to propagate spherically is incorrect. The coordinates $x'^2 + y'^2 + z'^2 = c^2t'^2$ of the second sphere only match the first sphere when the stretching or contraction in distance and time intervals are matched. Both must be increased or both decreased. The propagation of light (if made visible) will only appear spherical because distance and time are stretched in proportion to the adjustment needed for the delay/advance due to movement during the transmission time of the signals. The alternative is that space is undistorted, that the time of moving (massive) clocks is slowed by $1/\gamma$. The underlying speed of (massless) light will be 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 space-time 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 space-time

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 space-time 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 space-time 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. Therefore, 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 space-times and decay rates for another 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 space-time, under GR, is even stranger than under SR. GR has it that matter distorts the geometry of space-time, 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 is not observable. It is claimed to be present because of the bending of light. Moreover, if time intervals are larger then so should be distance intervals if the speed of light is to remain constant.

Under GR, the distortions of time and space go to zero far away from other massive objects and increase in proportion to the change in potential. The distortions also increase the kinetic energy of objects (accelerate them) when there is a gradient. Because all energy contributes to gravitational attraction, this means that the distortion is increased by the energy given to the object. The distortion effectively becomes easier. Beyond a certain point, the size of the distortions and the total energy of the system head to infinity, giving rise to a singularity. The fabric needs to hold an enormous pool of energy when undistorted. It also means a gradient in the distortion of the fabric bends the direction of the light travelling in the fabric but does not alter the locally measured speed of propagation.

2.4.5 The fabric of space-time is an illusion

A common argument used to support the reality of the changes in space-time 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. The observation of spherical radiation requires that the movement of the observer, during the propagation time of the signals, be taken into account. If this is not done, then the supposed coordinates in the moving frame can only appear to indicate spherical propagation at c if both distance and the time-taken for an unchanged distance are reduced (contracted) or both increased (expanded).

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 space-time 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 keeps the background isotropic.

The frequency of signals emitted by objects was not part of the thought experiment. Einstein's 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 space-time 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 space-time, 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 space-time, 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 space-time 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, there is a real decrease in clock-rate which is 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 $x = ct$. SR assumes that $p = \gamma m v$ means that energy and momentum increase by the factor γ because c is constant. However, it is the apparent velocity γv (due to the time delay from the finite speed of signals) that appears non-linear. If the actual velocity is known, then the increase in apparent energy is seen to be 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.

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. 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 space-time 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 space-time, 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. Space is not locked into a 4-D space-time 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.

Chapter 3

Background dependence versus General Relativity

The deduction of SR of invariant intervals of space-time and energy-momentum does not constrain the speed of light or mass to be constant. However, this framework with its inversion of space relative to time intervals was taken over into GR. It has the distortion of the fabric of space-time (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.

The proposed background (of FR) alters properties of objects with the rate of events (time) decreasing with its 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.

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 if allowed to fall freely) 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.

The core difference between a background-dependent theory and both Newtonian gravitation and GR is that, under FR, mass and inertia are dependent on the background and 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 amount is independent of the absolute level. The distortion is only dependent on gradients in energy/momentum. The gradient of the gravitational potential affects 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. This incorporates the weak equivalence principle – that inertial and gravitational mass are equivalent (have a fixed relationship). There is also an assumption 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.

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, 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 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 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 current interpretation treats gravitational acceleration as a vector field, so contributions from opposite directions cancel. In addition, the force is per unit mass due to another nearby mass. A similar dependence on a uniform background of both the nearby source and the test mass is then 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 a tensor formulation based on gradients. Gradients from opposite directions cancel so there is no contribution from a uniform background. The lack of an effect of a uniform, isotropic background (or constant mass density) 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 be different even if there is no local gradient in matter 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, and how far light travels in a given time increases. Clock-rate, as determined from 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 ($E = \hbar\omega$) 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 and momentum. 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 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. 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 were observed to occur at the same rate for the same objects in two locations, remaining synchronous (if there was no relative movement), 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. Alternatively, oscillation frequency for a given energy may vary with the background. The discussion of the next sub-section ignores these possibilities, as the inertia per unit mass appears to be constant 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 space-time. 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 (time slows, the spacing between ticks increases) in moving to a region (ϕ_2) of more negative 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 $dt_2 > dt_1$. This is what is expected if the amount of mass (stored energy) decreases in proportion to $1/c^2$.

GR has the gravitational time dilation, based on the apparent redshift of the photon, proportional to [23]: $dt_1 = (1 + \frac{\phi_1 - \phi_2}{c^2})dt_2$, [note the change in sign] so that clock-time intervals are larger at a higher gravitational potential. However, the assumption is made that time (clock-rate) is $\int dt$, i.e. the sum of time intervals. A smaller sum is taken as meaning less time has occurred, whereas it means that the same number of events has taken less time. Thus, GR agrees on the slowing of time, but only because of the faulty expectation that clocks go more slowly in a region with shorter intervals between ticks. The decrease in clock-rate at a more negative potential corresponds to an increase in time intervals. This emphasises the need to distinguish between light-speed time intervals and massive clock time intervals. Light-time intervals reduce, as $1/c$, when the speed of light increases, while massive clock intervals increase by c (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 [24] recognised that the time and distance intervals of SR transformed like the rotation of an invariant interval in a 4-dimensional space-time 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.

Clock-rate varies with speed relative to the background. However, clocks in two moving frames will behave identically if they are sent off in opposite directions relative to the stationary frame [25]. The intervals $dx^2 + dy^2 + dz^2 - c^2dt^2$ and $dx'^2 + dy'^2 + dz'^2 - c^2dt'^2$ of the two moving frames will be equal. So, a background-dependent theory can give the appearance of Minkowski space-time.

This dependence of clock-rate on movement relative to a background rather than only on relative motion is consistent with experimental observation. The only speed that is changing relative to the local background is rotation relative to the centroid of the Earth. The experimental results for changes in time intervals between clocks flown in opposite directions around the equator [26] are consistent with this revised perspective and the lack of any contraction in length intervals [27].

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 matter. 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. $E = mc^2$ [28].

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. A gravitational field (apparently due to a gradient in flux density from mass) was explained as a distortion of time and space, and it was assumed 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 formulation assumes that the properties of matter, including mass, are independent of a homogeneous, uniform, stationary distribution of surrounding matter. All locations in space-time 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 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. A cancellation occurs in electrodynamics because the effect of electric and magnetic fields, from opposite directions, cancel due to the vector nature of the electromagnetic force; but identical scalars, such as pressure, in opposite directions, 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 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 space-time 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).

The background-dependent theory (FR) has gravity arising from changes in the energy that can be stored by particles (as mass) when the background changes. There is no distortion of the geometry of space-time between massive objects. Distances are not altered but the time of clocks will depend on the background because their mass will change.

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 postulate that the Einstein equivalence principle (EEP) holds. It 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 $\vec{a} = -\vec{g}$ [29]. 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 rather 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 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 matter density) equates to mass and gravitational acceleration being unchanged even if there is a different but uniform background from surrounding matter. Keeping c constant, in empty space, then requires a distortion of length and time, for stationary objects in a gravitational field, that depends on the gradient in gravitational potential. It also means that all clocks, not subject to a gradient in the field, tick at the same rate. Why should this be expected? If photons do not lose energy in a gravitational field, then atoms (miniature clocks) have higher energy levels, and clock-rate will be faster, when clout (or the density of surrounding matter) is smaller. It makes more sense that the background determines clock-rate whether or not a gradient is present.

GR proposes a constant space-time in a location without a gradient in the gravitational field from massive objects. The geometry of this space-time 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. The gravitational properties at a given location are determined by the background clout. A lack of gradient does not imply that there is no background. Space is not distorted, and time (clock-rate) and size are properties of massive objects, not of the space-time between objects. These properties 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 space-time 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.

There is a common rubber sheet analogy for GR in which massive objects distort the sheet (fabric of space-time) 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 increases the greater the density of the same amount of mass, 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.

Newton's law is based on a scalar gravitational potential. Scalars from opposite directions do not cancel, distortions from opposite directions should not cancel. Gravity should not be gauge invariant.

3.6 Background-dependence can appear consistent with SR and mimic GR

Einstein appeared to derive the known equations of the Lorentz transformation (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 γ) 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 $ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2$ [16]. If time is placed along an imaginary axis, then the Lorentz transformation corresponds to a rotation in this new space-time combination. The interval is 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 adds to zero, if time interval is $distance / c$. This means that changes in length and time intervals 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 [16] 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 space-time 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 space-time in a manner consistent with the observed change in clock-rate with changing gravitational potential and the frequency (of photons) is proportional to the inverse of the local (proper) time interval, i.e. $\omega \propto 1/dt$ [23]. 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 more reasonable 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 has time and space intervals distorted, so that slower time is an increase in time intervals and cdt, and shorter distance is a decrease in length intervals. It is suggested that this inconsistency explains why in GR a geodesic, the shortest (minimum) path between two points in a curved space, maximizes proper time (the time of a clock that is stationary relative to the observer). Whereas it would be reasonable to expect that the shortest path should take the minimum time.

If the energy of a photon is unaffected by a gravitational field, then $E = pc$ would seem to imply (under FR) 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 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. 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 space-time and energy-momentum four-vectors requires a faulty treatment of time intervals. There is an alternative to a warped space-time 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).

If the fractional reduction in a small test mass m is the same as the fractional increase in background due to a large mass M, then their product will be constant. The strength of the force will appear to be directly proportional to the product Mm. If the background, for both masses, changes by the same amount and if these local changes are small relative to the total background, then the changes in energy will appear to be independent of the total background. The fractional changes in stored energy given to objects, as kinetic energy, in the gravitational fields observed locally are tiny. Hence, it should be expected that the two perspectives (GR and FR) will give similar results when the total background is similar to that currently observed locally and when changes in background are small.

3.7 Background-dependence overcomes problems with space-time

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 Lorentz transformations (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 space-time 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 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 in any direction appear slowed? Consistency with observations necessitates a real slowing, dilation of time, of signals emitted by the moving object by γ, 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 such clocks. Under SR, time and distance are subjective, only their combination is constant. Apparent effects (those observed in measurements that do not correct for 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, was proposed 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 space-time 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 space-time 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 space-time 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 [30]. 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 and 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 space-time can either act on objects or be acted upon, leading to space-time being labelled as a glorious non-entity [31]. Another is that the concepts of time in quantum field theories and GR appear incompatible [32]. 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 space-time. However, the local dynamical space-time 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 space-time 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, and gradient (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 this differential form is that mass is independent of surrounding mass density.

Its derivation uses the observation that someone accelerating in a gravitational field no longer feels the force of gravity. Einstein had therefore proposed the equivalence principle: physics in a frame freely falling in a gravitational field is equivalent to physics in an inertial frame without gravity. This is an analogous step to SR's assertion that physical laws, including the constancy of the speed of light, are unaffected by motion at constant velocity. The magnitude of stored energy is unchanged even if the falling object and observer are continually moving into a region of higher mass density. If acceleration can exactly cancel a uniform gravitational field leaving no means of ascertaining either, then physics in a nonaccelerating frame with gravity $\vec{g}$ is equivalent to physics in a frame without gravity but accelerating with $\vec{a} = -\vec{g}$. Inertial and gravitational mass are then the same and constant. This led to the malleable space-time of SR being distorted for the observer in a field of gravitational acceleration while the local speed of light (using proper time) is constant.

Newtonian gravity gives rise to a force field, that maintains its existence while mass is present, according to $\vec{F} = m\vec{g}$. This appears analogous to electrostatics where an electric field ($\vec{E}$) due to a static distribution of charge gives rise to a force on another charge (q), i.e. $\vec{F}(\vec{r}) = q\vec{E}(\vec{r})$. The derivation of the differential form of Newton's equation 1.2 follows from applying Gauss's law, as done for electromagnetic fields [33]. The first step 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:

$$\vec{g}(\vec{r}) = -G_N M\hat{r} / r^2 \qquad (3.1)$$

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 assumption, however, is that mass is conserved, just as charge is conserved. 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 total mass of an arbitrary matter distribution 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).

The divergence theorem, that 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 a 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 equality (and hence equation 1.2) does not hold if the density of surrounding mass alters the mass held by a constant amount of matter. The value of G_N will also change 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. The concept of mass density is extended to a volume adjacent to, but outside, any source of mass. This region of empty space can alter the energy of objects in that region and the amount altered, the size of the source, depends primarily on nearby sources, because the $1/r^2$ dependence means these dominate.

A vector field that arises from mass (a form of energy) and provides energy to matter at a distance, without losing energy, is inconsistent. It means that the surrounding space acts as a source of negative energy (reducing the size of the sink) even when no mass is enclosed. It is something from nothing. The inconsistency arises because the acceleration field is not a conserved flux. The strength of the field, the energy stored per unit matter, decreases as the density of matter increases. The source of energy must come from a change in energy (mass) of the object per unit matter, not from the surrounding empty space.

GR is based on an equation that does not apply if mass, stored energy, is dependent on the background. Under Newtonian gravity and GR there is an enormous pool of energy that can be given to matter, as kinetic energy, when the density of matter increases. This pool exists when there is no distortion (no mass) and is given to matter as the distortion (from mass/energy) increases. Under GR, the total energy and strength of a gravitational field, arising from the same amount of mass, increases as the mass/energy density increases with a decrease in volume (leading to black holes). Conversely, the amount of negative energy provided by the surrounding empty space increases when mass/energy density decreases. Thus, both the singularities within black holes and the hypothesis of dark energy arise from GR being based on the differential form of Newton's gravitational equation which assumes mass is constant. The non-zero value of the divergence can then be attributed to an imagined source of negative energy (i.e. dark energy) that appears to increase with a reduction in density due to the expansion of the empty space between galaxies.

Thus dark energy is an unsatisfactory artifact of the assumption of constant mass. The apparent amount will be consistent with the alternative understanding that space is undistorted and that the change in energy stored by matter has a $1/r$ dependence on distance to all other sources of mass. The amount needs to be consistent with a value of the cosmological constant in Einstein's equation that yields a current universe with a flat space-time (under GR) from the total mass/energy density of ordinary matter, dark matter and dark energy. This appears consistent with observation and should be taken as evidence that a cosmological constant is not needed in a revised theory. It also suggests that dark matter may be explained by a background that alters the ratio of inertial to gravitational mass which gives rise to the appearance of an invisible dark matter.

3.9 Summary

A background whose magnitude determines the mass of objects and strength of gravity replaces the distortion of space-time proportional to the energy-momentum density.

It has been shown (Chapter 2) that space-time is an illusion. The combination into a fabric that can be distorted by matter, but with the speed of light constant, is based on faulty assumptions, a misinterpretation of experimental observations, and an inversion of space intervals relative to time intervals. Gravitational time dilation then corresponds to shorter time intervals between ticks of a clock. This explains why, in GR, a geodesic, the shortest path in a curved space, maximizes instead of minimizes proper time.

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 cannot 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 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.

The proposed background (whose magnitude is the negative of the 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.

A background-dependent theory has effects due to motion of massive objects relative to a stationary or free-fall background, a space that is inherently flat, and clock-rate being distinct from the time interval associated with the finite speed of light. Gravitation does not arise from a distorted space-time, but from a reduction in the energy that can be stored, as the background field and the speed of light increase. The lost energy appears as kinetic energy. 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. 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. Yet it is observed 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.

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 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.

4.1 A different sort of background

Newtonian gravity can be 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: $\Delta E/E = \Delta m/m = -G_N M/rc^2$. Newtonian gravity is instantaneous and static. This energy balance equation is dimensionless and so does not depend on how fast gravity propagates. 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. The mass of objects is assumed constant independent of a uniform, isotropic background from other masses. GR, like Newtonian gravity, has acceleration constant per constant unit of matter. The assumption of constant mass per unit of mater equates to independence from the absolute value of an isotropic background. Changes in the force are then due to nearby masses (local anisotropy). Changes in a large uniform background can be hidden because potential and clout are per unit mass, and the influence of the nearby mass will be changed in the same proportion as the test mass.

The brightness of a light source falls off as $1/r^2$. If all the mass of distant galaxies was in stars similar to our Sun, and there was no blocking of the light, then the total illumination from galaxies and our Sun should be comparable to their relative brightness contributions. If the contribution of the mass of galaxies had the same $1/r^2$ dependence and was similar to that of the Sun, then the night sky should be as bright as day. It is an approximate argument as there may be a larger amount of mass in neutral gas clouds than in stars and it assumes that the light is not significantly blocked or redshifted. However, it indicates that a background from mass must have a different dependence on distance if it is to dominate than that from our Sun.

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. In 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 if the contribution to stored energy from distant sources 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 6×10^8: 4×10^5 : 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 Replacing the metric – the distortable geometry of space-time

As explained by Maudlin: 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 [34].

SR has the observed scale of space-time 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 motion. Time (clock-rate) reflects an underlying concept of the rate of events (involving the motion of massive objects) against constant distance (meaning a fixed separation) that is independent of the speed at which massless information flows. The space between objects 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 which has an M/r 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 implies that the contribution to potential 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 with the gravitational force per unit mass dependent only on the gradient of the potential. The distortion of the metric depends on the second derivative of the gradient of a generalised potential. This is equivalent to the effect of masses from opposite directions cancelling.

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 of a sphere enclosing the source, as occurs for light.

4.1.2 The need for time dependence and oscillation

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, 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 interactions between massive particles ($\frac{1}{2}mv^2$) depends on velocity squared because the momentum that can be exchanged also depends on the rate of change of momentum, which depends on relative 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 its oscillation (after the photon has been emitted) will not be 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 rotational alignment 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 a difference (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 [35], with the observed mass depending on the particle's "energy absorbing" ability, and on the strength of the Higgs field [36,37]. If this is the source of mass then we must be living in a world where the basic scalar interaction between elementary particles and their surroundings, that gives rise to their mass, is 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 GR which is a tensor theory and gauge invariant.

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 the mass of particles 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. The argument that most mass is associated with gauge invariant interactions can also be construed as meaning that only a small part of all interactions of massive particles has a 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). This suggests that the background has contributions from both matter and antimatter, but the chirality does not lead to trapping of energy 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. 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 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. The Higgs is just one member of this set. 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 & 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 might be provided by having a pair of rotating components that are aligned with the current direction of motion. Combining this with the arguments of Section 4.2, implies that there are rotations of chiral components in all objects that are sensitive to changes in the speed and direction of movement. Inertia could 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 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 clock-rate of massive objects based on frequency will depend on inertia (because it depends on frequency) and on the speed of light (because it affects energy). 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, might 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 $(A + \delta A - \bar{A}) / (A + \delta A + \bar{A})$, where δA is a small change in one component (A) and $\bar{A}$ 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 and chirality) with the effect of their contributions to light-speed and stored energy the same. However, inertia and its time dependence involve a difference between the two chiralities. 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 removes 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 isolated galaxies might explain 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 be altered by the local gradient in potential (based on kinetic energy), but 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 space-time 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 space-time 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 $\gamma^2 = 1/(1-v^2/c^2)$.

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.

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).

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. 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, but Newtonian gravity and GR have the source mass 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 a 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 (but not inertia per unit 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 properties of objects with velocity. The magnitude of this inertia depends on (the momentum vector 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 affects the frequency of opposing rotations but that the stored energy is unchanged. The fractional alignment will then affect inertia (the difficulty of changing velocity) but not the stored energy. 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 directions 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: "Space-time tells matter how to move; matter tells space-time 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 space-time and space is not distorted.

Under GR, the pseudo-medium between objects is the fabric of space-time. 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 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) in three dimensions (plus 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 the local contribution would have to approach 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 state of 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 background density, is constant. However, if the same measurement instrument (based on the length of massive rods) was moved to a region of increased clout, then a constant separation distance would appear to be (i.e. 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 $(1 + \delta\rho_1 / 2\rho_1)$ for $\rho_1 \simeq \rho_2$.

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. The rotation curve has already flattened significantly not far from the central bulge of spiral galaxies, which implies that the asymmetry from the galaxy is the prime source of the background asymmetry from matter and antimatter. 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 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, the latter variation will be invisible to the observer, unless the value of h is measured, because the frequency of an emitted photon, but not its stored energy, also changes with the local asymmetry. 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 The nature of clout

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 a 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. This is a start to explaining how and why clout has a $1/r$ dependence on distance.

The $1/r$ dependence of clout is somewhat similar to the total rotation of a stretched spring with distance from the opposite end. However, such a dependence would seem to imply two components, analogous to the spring being held in two places. Clout would seem to require 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.

4.4.3 A background that does not flow away

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. It is observed that 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. It would seem that if the field had only one (unbalanced) component, then the change should propagate away altogether.

GR has a persisting gravitational field in the form of a constant distortion of space-time, that can impart energy to objects, and propagating distortions (gravitational waves) that can impart energy to a detector. It is not clear how such a distortion could both propagate as a moving distortion at constant speed, that imparts energy, and maintain a constant distortion without movement.

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 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.

Energy can be carried away by propagating oscillations of the field (photons) even though they do not seem to carry stored 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. Momentum (including in the form of photons) can be transported to new locations, by 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 photons are absorbed. An electromagnetic field can arise from either/both of a pair of opposite charges and can remain even in the absence of visible photons. It appears to be the same with gravity but with just attractive sources because they alter stored energy. The persistent field of FR does seem to imply that there must be two components to the background that enable an equilibrium to be established.

The observation of gravitational "waves" that travel at the speed of light does not confirm that they are travelling distortions of space-time, 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. This would seem to be consistent with changes in the strength of gravity being like photons of zero frequency. Changes in a persisting background must involve both the chiral components and this is consistent with the speed of light being determined by a 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 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 changes in inertia as they move 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 [38]. He proposed an alternative that depends solely on the general-relativistic equations of motion and the Einstein equations. If this is the case, then it should also be possible to show that FR is able to reproduce the apparent loss of energy, but this needs to be demonstrated.

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 observed. In SR, the postulate corresponding to this observed behaviour was replaced with the postulate that the measured or apparent 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 the faulty interpretation that shorter time intervals meant that less time elapsed. The inverted interpretation between time and distance intervals was incorporated into the concept of invariant intervals of space-time and used in GR where gravity was attributed to a distortion of the geometry of space-time. 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 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 space-time 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 space-time. The increase in the difficulty of changing speed and direction (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 lecture 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 [28], "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 only (at low speeds) within the same inertial frame and not between frames with different backgrounds. He went on to conclude in 1907 [15], 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 [39], 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 [40].

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 speed of oscillation between the electric and magnetic fields of a photon and charged particle is sensitive to their relative motion. This enables the difference between the relative velocities of source and receiver to be conveyed by the photon. The energy of a photon is carried in rotations perpendicular to the direction of motion. The relativistic 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, 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 the magnitude and asymmetry of the background. The photon is seen to resist changes in 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 one or more of the three neutrinos (spin ½) are massless then it or they are also freely travelling states with zero net oscillation along the direction of motion. Any 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 may increase. Moreover, if mass did increase, then decay rate would be expected to increase rather than decrease.

As explained in Chapter 2, the Lorentz transformation arises from the finite transmission time of electromagnetic fields provided the time of the moving object is slowed by $1/\gamma$. However, 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, it is proposed that 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 is indicative of the changes in the pair of counter-rotating components. The amplitude and speed of rotation of these components reflect the amount of stored energy but it is proposed that 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 arises 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 is 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, $p = \gamma m v$ is interpreted as the apparent mass increasing with relative velocity, because of changes in time. If the actual mass increased, then so should the decay rate. If the increase is only apparent, then the decay rate should be unchanged.

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 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 (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. This 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 will need to take inertia into account if the clock's mechanism is based on the speed of movement of massive objects. An energy clock-rate will only apply to the movement of massive objects if inertial mass maintains the same relationship to gravitational mass. However, FR proposes that the magnitude of inertia varies with speed relative to the background and with asymmetry of the background. If the ratio of inertial to gravitational mass varies, then an inertial clock-rate based on movement of massive objects will not be the same as an energy clock-rate based on the energy of a given atomic transition.

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 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 and so with the total amount of dark matter required by GR.

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. As seen in Section 4.3.2, a fractional asymmetry $(A - \bar{A}) / (A + \bar{A})$ will tend to $\delta A / 2A$ as $A - \bar{A}$ tends to zero. It is proposed 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 7.2.

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 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 [41]. 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 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 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. It appears likely that the 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 strength of clout that propagate at the speed of light.

Some consequences appear to 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 space-time (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 the field and all energy contributing to gravitational attraction, while FR has the energy coming from a reduction in the mass of particles, but with the energy of massless particles unchanged after emission. The speed of massless particles but not the magnitude of their momentum is altered by a gravitational field. Their direction can be altered by a gradient in asymmetry.

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 space-time between objects can expand and contract without the speed of the light or the properties of objects, travelling or embedded in that space-time, changing. Gravitational effects should be attributed to changes in the properties of objects (i.e. FR) rather than to changes in the space-time 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 space-time in which photons and massive objects travel. The change in time accounts for half the bending. It also claims 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 space-time incorporates the faulty inverted distance versus time interpretation of the LT. Without the inversion GR would not predict the bending of light. The tensor formulation of GR using gradients also means that space-time 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 rotation in the plane perpendicular to their direction of motion but the oscillation drives the motion 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 being put forward. Firstly, 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 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 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 to work (change of energy) being 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), and the speed of light directly proportional to total clout which will appear as an increase in wavelength as stored energy decreases. However, inertia 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:

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

The same force per unit of inertial mass m_i defines the gravitational acceleration as: $\vec{g} = \vec{F} / m_i$. The force is the gradient of a potential, an energy per unit of gravitational or inertial mass.

Under GR, the units of gravitational and inertial mass are equated. Under FR, the ratio m_i / m_g is small and nearly constant within our solar system because inertia is determined by the asymmetry in the large but nearly balanced contributions from matter and antimatter.

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 and about one hundredth that of the core of the galaxy. Changes in asymmetry that alter inertia, and hence kinetic energy (KE), still give rise to a gradient in the ratio m_i / m_g within the solar system but the magnitude of this ratio is reduced by the larger galaxy asymmetry. If m_i and m_g are equated then it will be absorbed into the value of G_N with $G_N{}' = (m_i / m_g) G_N$, where $m_i = m_g$ for the current local background. The value of G_N therefore includes a nearly constant factor from the background asymmetry due to our galaxy.

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:

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

with distance r from a point source of mass M,

and $$\Delta KE / m_i = \Delta(m_g c^2) / m_g = -G_N M / r + constant \quad (5.2)$$

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

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

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

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 and c .

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:

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

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:

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

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

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} $m^3/kg.s^2$.

The value of KE absorbs the ratio of inertial to gravitational mass (of the same amount of matter) into the proportionality factor between stored energy and the inertial energy needed to overcome resistance to changes in movement. If m_i/m_g decreases, then the value of G_N for the same acceleration will appear to increase. The dependence of the current, local value of G_N on inertia will incorporate scale factors determined by the background asymmetry at our location, primarily from the excess of matter over antimatter within our galaxy, and from the total clout.

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 depending on 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 latter is hidden because the acceleration per unit mass is used. The NG and GR predicted gravitational force assumes a fixed ratio of inertial to gravitational mass. FR proposes that the asymmetry of a two-component background is dominated within an isolated galaxy by that galaxy. Our galaxy dominates the asymmetry at our location but the small gradient in asymmetry within our solar system is determined by the Sun and planets. The effect of the asymmetry of the Sun possibly 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 (and the value of asymmetry is constant). 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 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 asymmetry is constant.

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 are hardly changing within the periods of time and the differences in location being examined. However, under FR, there will be a fractional change of energy stored as mass giving the same change in kinetic energy of $G_N M / rc^2$ because the local values of inertial and gravitational mass have been equated. This change in mass of $G_N M / r$ will, because of conservation of momentum, alter the speed. This mimics the correction factor of GR due to distortion of time that causes the advance in the perihelion of Mercury. Any change in the background value of asymmetry within our solar system is likely to be small. However, the background asymmetry must be much larger than that from the Sun or the value of G_N will appear to change with distance from the Sun. Until the local asymmetry becomes dominant the change will be in approximately in proportion to M / r and so may just be 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 matter (currently of 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 space-time. Consequently, under GR, equal distortions from equal masses in opposite directions cancel, and 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 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 [42], 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 expands, the mean background decreases, so the stored energy per unit of matter would increase via loss of kinetic energy. Orbital radii would therefore 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 would oppose the decrease from any 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. The redshift of distant galaxies indicates that clout is decreasing over time rather than confirming expansion.

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 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 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. Meanwhile it does not contribute to clout. If the background reduces then objects can be expected to move closer together by just the amount needed to maintain the same standing wave patterns and conserve energy under an altered speed of light.

The local change in the sum of clouts due to clumping, of distant groups of sources of constant mass, at approximately the same mean location is negligible. However, clumping increases asymmetry and it appears that this will increase inertia within the clump, which will slow (inertial) time based on the movement of massive objects. The stored energy per unit of matter will decrease as matter concentrates within regions even if the total amount of matter and average matter density is constant within a stationary (non-expanding) universe. This is because the clout appears to arise from stored energy and the amount per unit matter and per unit of inertial time decreases with increased clumping, 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 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, then a change in the value of h is hidden. The local value would be the same independent of the value 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. Therefore, the contributions of the different components of the background to changes in energy, asymmetry and frequency can be resolved and need 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 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 space-time 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 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) [43]. 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 [44]. 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 galaxies beyond closer galaxies or clusters of galaxies. However, the amount of bending from galaxies and galaxy clusters has been larger than expected. This has been used as evidence for the gravitational attraction of 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 space-time 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 [45]. This follows an earlier conjecture by Schiff [46] 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 [47] and a Newtonian special relativistic analysis of redshift, light-bending and Shapiro delay [48]. 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) [49].

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 identical predictions for a similar background and by incorporating aspects of SR such as time dilation.

It is not proposed that these alternatives are realistic or correct as they still assume a fabric of space-time 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

Under GR, the advance in the perihelion of Mercury arises from space-time being distorted, while energy/momentum is conserved and the ratio of inertial to gravitational mass is fixed. Under FR, the mass of objects changes (as $1/c^2$) giving rise to changes in kinetic energy and a velocity altered by inertia. The energy balance between kinetic and stored energy of Newton's equation is per unit of stored energy. Any change in gravitational mass has no effect on the force per unit of gravitational mass and hence no effect on the radial acceleration for a given distance. However, the change in inertial mass induces a change in velocity (in order to conserve momentum) with distance from the Sun. The velocity when the inertia is lower will therefore be faster than expected giving rise to a faster rotation of the more distant part of the orbit and an advance in the perihelion.

The amount predicted under FR can be compared with that of GR based on the supposed distortion of spacetime. The latter assumes that mass and angular momentum are conserved and introduces an additional energy term of $G_N M / rc^2$ into the energy balance equation (per unit mass) [50]. Under GR, this term is the change in time with change in gravitational potential ($\Delta\Phi / c^2$).

The Kepler radial equation of motion is:

$d^2 r / dt^2 = -G_N M / r^2 + J^2 / r^3$, where $J = r^2 (d\Phi / dt)$ is the conserved angular momentum.

This corresponds to a closed orbit with no advance in the perihelion. It is replaced by:

$d^2 r / d\tau^2 = -G_N M / r^2 + J^2 / r^3 + 3G_N M J^2 / c^2 r^4$, where τ is the proper time and does not contribute to orbital advance [51].

The additional term in the equation of motion acts like a r^{-4} type of force with the factor of 3 arising from the differentiation of $1/r^3$. The GR distortion of distance has negligible effect on orbital advance. The fractional change in velocity under FR is due only to the change in asymmetry, as the attraction is per unit gravitational mass, so there is also no additional effect of distance. The gradient in inertia will be $G_N M / rc^2$ with distance from the Sun (in the limit that the asymmetry is dominated by a constant background from our galaxy). This gives rise to the same change in speed as the change in time with difference in potential of GR. Thus, the predictions will be in agreement.

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 (or the mass equivalence of the photon's energy) that bends 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. The claim is that the same amount of bending arises under FR because two components change, the amplitude of oscillation of both the electric and magnetic fields.

It has been claimed, under GR, that the time delay is caused by space-time 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). Under FR, the slowing of time (clock-rate) is irrelevant for massless photons, and instead their speed increases. FR and GR have opposite contributions from the changing speed of light. Under both GR and FR, most of the delay arises from the increased path length, relative to the straight-line path, due to bending. This delay has a logarithmic dependence on the ratio of the path length to the distance of closest approach. The logarithmic dependence has been used to fit the experimental data and therefore determine the delay. The extra delay (GR) or 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 difference in speed varies only slowly and steadily around the path across the orbit between source and receiver. For measurements within our solar system, the extra change will be absorbed into the calculated orbital parameters. It is therefore claimed (under FR) that the measured delay, which is in good agreement with GR, is only that due to the changed path length. This is confirmed by the fact that it is twice that expected from Newtonian gravity which has half the amount of bending and no space-time dilation. The predicted delay for FR and GR is the same because they agree on the amount of bending. The experiments need to be reviewed to see if the other part of the delay/advance, due to different light speed, can be separately measured.

At first sight the increased 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 to 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 reduction of speed 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 along, but not across, a path in space or materials should not affect the direction of the photon. Under FR, the amplitude of oscillation of both electric and magnetic fields, in the plane perpendicular to the direction of motion, will decrease in proportion to the difference in potential, and hence in proportion to twice the difference. Under GR, the local speed of light is constant and the bending apparent to the external observer is doubled due to the distorted space and time along the path travelled.

It is observed that the speed of light, within a region of space of constant clout, is independent of the frequency of the photon. It is also observed that the amount of bending of light passing close to a massive object appears to be independent of frequency. 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 are conserved. Thus bending does not arise from changes in energy of the photon. Instead, the fractional change in direction (bending) must arise from a fractional change in amplitude that is independent of energy. Any change in background that alters amplitude (independent of frequency) perpendicular to the direction of motion will cause bending. Gradients in the total background will change frequency because of the change in the speed of light. Changes in the local asymmetry will modify this in proportion to the size of the change in asymmetry relative to the local total background asymmetry. Thus, under FR, gradients in the amplitude of photon oscillation in the plane perpendicular to its direction of motion determine the amount of bending.

The direction of a photon will be bent by a gradient in amplitude of both the electric and magnetic oscillations in the direction of decreased amplitude (increased frequency from increased asymmetry). 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 the fractional change in clout adjusted for an inertia that changes with background asymmetry. This asymmetry is primarily determined by our location within our galaxy. Using the local value of G_N elsewhere will lead to disagreement with the observed bending.

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 if a galaxy is an isolated excess of matter in an approximately uniform background of matter and antimatter. The amount of bending relative to that expected will vary in proportion to the disagreement between the value of G_N (deduced for our solar system) that incorporates a fixed ratio of inertial to gravitational mass (i.e. constant asymmetry) and the value needed to explain the galaxy rotation curve.

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 matter 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 [52]. 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.

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 will alter the inertia of masses and hence their rate of change of velocity (i.e. acceleration).

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.

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 but 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 near and within galaxy clusters and isolated individual galaxies. These lead 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 is not needed.

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.

Separated regions of surviving matter and antimatter should have been formed early in the universe. 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.

The standard predictions of GR appear 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

Unexpected 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 [53]. 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'" [54]. 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 local background clout from the stored energy of matter and antimatter and these change with location and are changing 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.

The redshift could also arise from an increase in recession speed with distance. This can give rise to a Doppler shift proportional to the speed of separation. However, the wavelength is not stretched by the increased separation of the source and receiver. This unusual property of empty space and the wavelength of signals expanding as the Universe expands is a claimed characteristic of GR. 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 would imply 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 $c_0 / c = \rho / \rho_0$. 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 inverse proportion to the ratio of the clouts at reception to emission.

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 [55,56]. 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 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 [57] for type 1a supernovae in terms of the distance calculated from the luminosity versus the redshift, $Z = \Delta\lambda / \lambda$, is given in Figure 1. 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.

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 2 & 3) 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 2. For just the data out to Z <0.3 (Figure 3) the actual distance is 4518 x 1.5 Megaparsec (for $Z = 1$ at the time of emission).

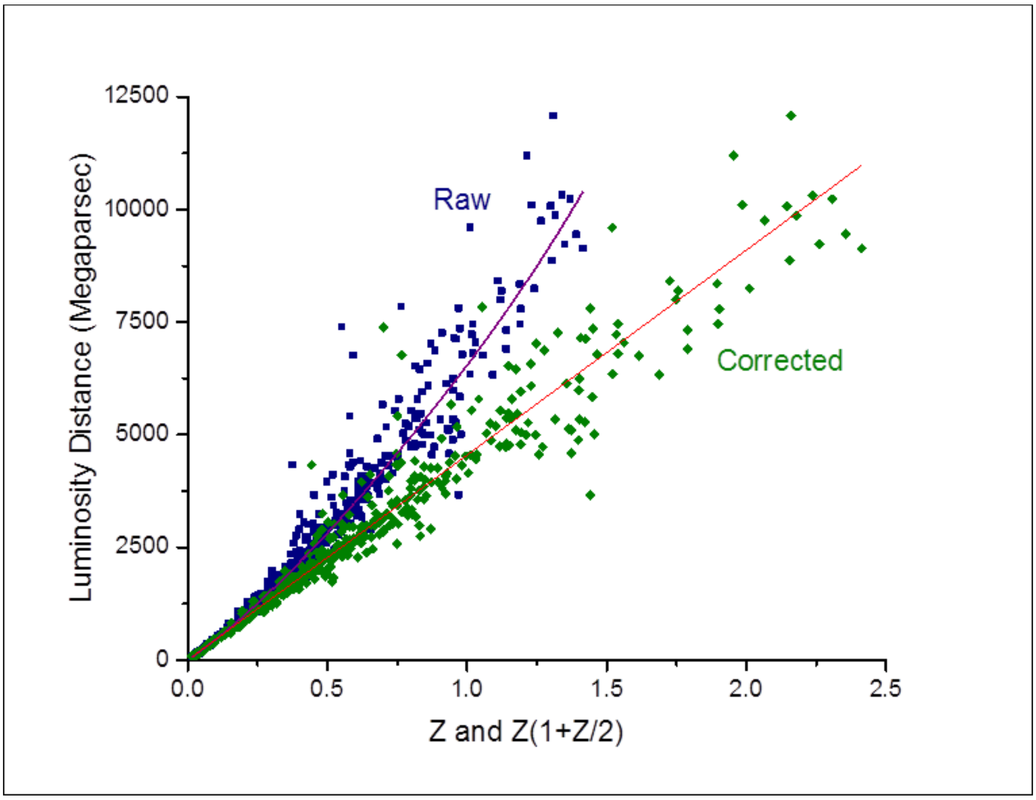

Fig. 1. Type 1a supernovae luminosity distance versus raw (Z) and adjusted ($Z(1+Z/2)$) redshift.

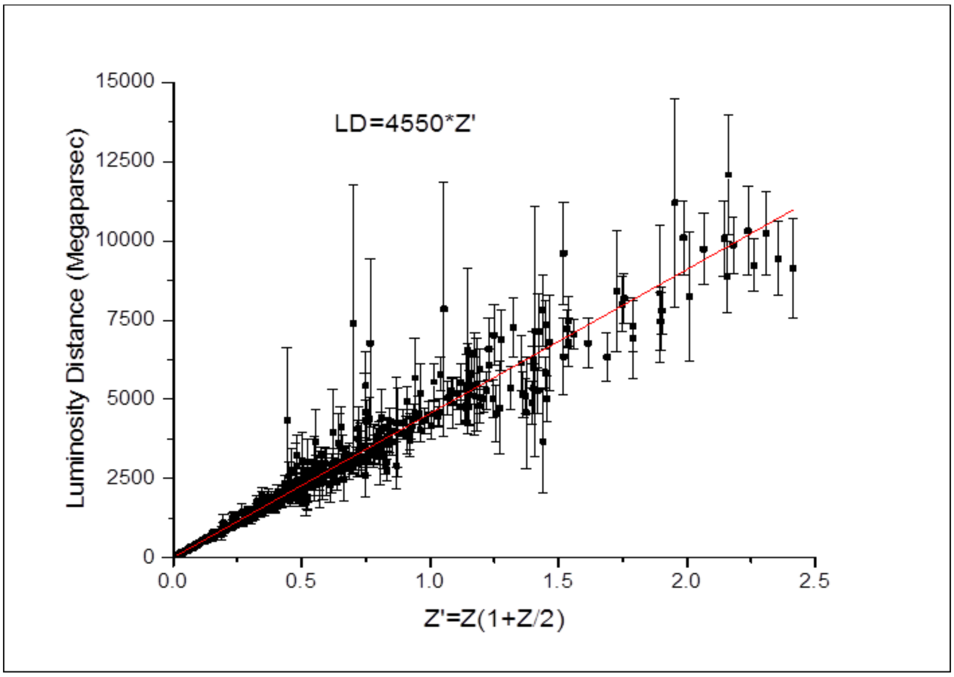

Fig. 2. Luminosity distance for type 1a supernovae with error bars (all data).

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} [58]. 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.

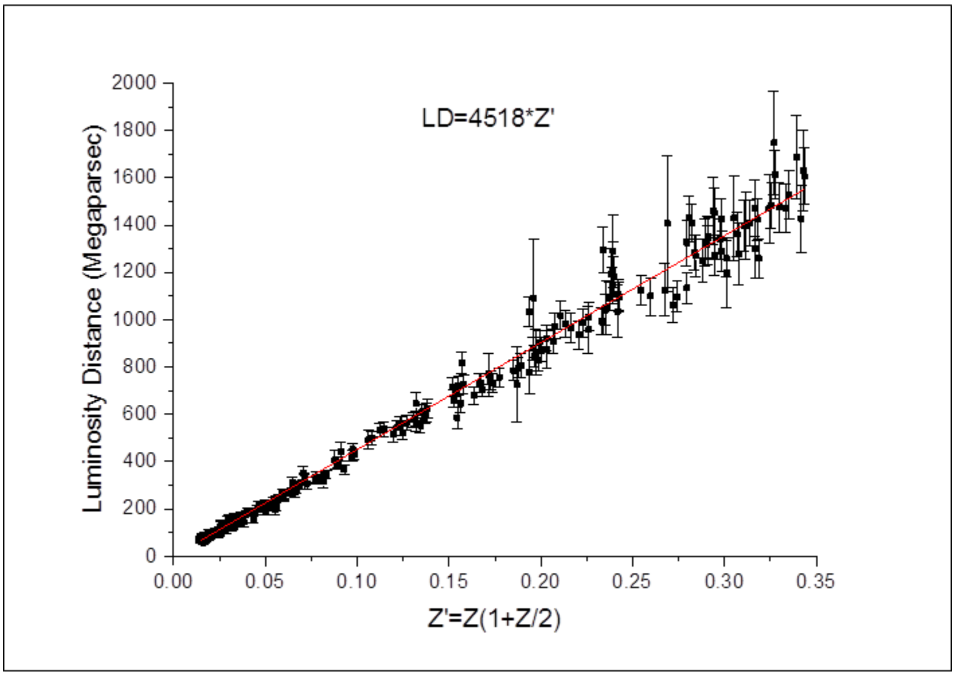

Fig. 3. Luminosity distance for type 1a supernovae with error bars ($Z < 0.3$).

A better way of looking at the data is to plot the u-time since the light was emitted against the Z -shift (Figure 4). 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. Clock-rate has doubled in the u-time that light took to reach from $Z=1$ and so is currently changing at a fractional rate of 2.137 x 10^{-18} per second (if local inertia is constant).

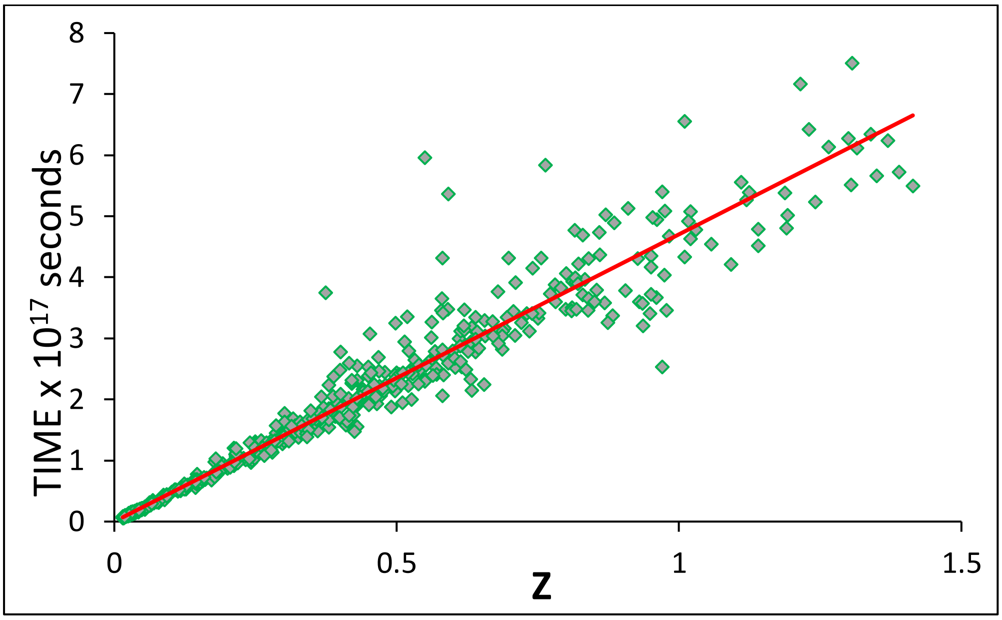

Fig. 4. Time in seconds since light was emitted for type 1a supernovae.

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).

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 energy of the emitting atoms. 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 per particle 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 can lead to an increase in clout from nearby matter but a decrease in the total stored energy 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.

The asymmetry of the local background will increase if the size of the galaxy decreases. Rotational velocity will decrease with contraction if inertia increases and angular momentum is conserved. If the asymmetry in the contribution to clout from matter relative to anti-matter becomes large, then the motion of stars near the central black holes at the core of galaxies will be greatly slowed. The cores will then contain much more matter than indicated by the nearby stellar orbits. Within the galaxy the strength of gravity per unit matter will appear to decrease as inertia increases with increasing asymmetry closer to the centre.

Normally, the supernovae data are plotted assuming a linear velocity-distance law which applies quite generally in expanding and isotropic models under GR [59]. 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" [59]. 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 increases and the stored energy (mass) decreases as a function of background energy clout.

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 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 inertial 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. In addition, just as in 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. They will also alter the rate of change of stored energy, or trapped momentum, with position after taking into account the arrival time of 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 momentum and velocity (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:

$$\frac{F_g(m_i/m_g)}{m_g c^2} = \frac{\partial E_i/\partial r}{E} = -\frac{\partial}{\partial r}\left(\left(\frac{G_N M}{rc^2}\right)\left(\frac{m_i}{m_g}\right) + constant\right) \qquad (6.2)$$

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

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 m_i is actually proportional to $m_g \times asymmetry$, but m_i and m_g have been equated so the value of G_N applies to the local, nearly constant, value of asymmetry.

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. It will vary between regions of the same clout, but different asymmetry, if the units of stored energy relative to movement energy are assumed constant.

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 in the outer 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 space-time always flat and no need for dark matter or dark energy. It should be 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 leading to little change in the apparent 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 at 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 change in clock-rate and Pioneer anomaly

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 change in clout equal to the current clout. From the fit, 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 doubled in 4.68 x 10^{17} seconds (of u-time).

The constant slope of the supernovae data as a function of u-time yields the rate of increase in clout. 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 increase means that a signal of supposedly fixed frequency, 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. However, changes in asymmetry may also need to be taken into account.

The change in frequency with time for returned signals will reflect any change in emitted energy, during the time of signal transmission, of the reference transition used in the stable clock. It will also reflect any change with time in the frequency per unit energy of the clock. The photons of the returned signal will still have the unchanged energy of their emission. However, changes in frequency from changes in both energy and asymmetry 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.

The change in energy clock-rate (time based on energy held) derived from the supernovae data will reflect the change in speed of light when the background decreases with u-time. The change observed in the supernovae data should be that due to the effect of equal changes in the background components from both matter and antimatter and so corresponds to that for no change in asymmetry. Within a region of only matter (or only antimatter) the local matter will move closer together by just the right amount to increase the light speed by the amount needed to compensate for the reduction expected from equal rates of decrease in the contributions from matter and antimatter. However, this must be achieved by altering only one component. Therefore, instead of both components being altered by ½, they will be altered by ½ + ⅙ and ½ - ⅙, that is by ⅔ and ⅓. If just the one component is altered then it must be by 4/3 times that needed if both components are altered because the speed of light results from a balance between the components and this must be restored. This means that the frequency shift should be $\Delta f / f$ = 2.849 x 10^{-18} s^{-1} rather than 2.137 x 10^{-18} s^{-1}.

A signal, of locally constant frequency, was sent out from Earth then back from the Pioneer spacecraft at a frequency locked to a fixed large fraction 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 signals returned from the Pioneer spacecraft were observed to show a steady downwards drift in frequency of approximately 6 x 10^{-9} Hz/s or 1.51 Hz in 2.11 GHz in 8 years or 2.84 x 10^{-18} s^{-1} [60]. This is in remarkable agreement with the predicted drift in frequency. It also confirms that clock-rate is increasing consistent with underlying time running slower and the speed of light being faster earlier in the history of the universe.

Under GR, a gravitational (acceleration) field leads to a time dilation, so that clocks on Earth run slower than the clocks of the GPS satellites which are in a weaker gravitational field. The Pioneer drift has therefore been attributed to an anomalous deceleration towards the sun of approximately 8 x 10^{-10} m/s^2. A more recent analysis has suggested that the anomalous deceleration decreased with time [61], from an early value of 10 x 10^{-10} m/s^2 down to a level of 7 to 7.5 x 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 [62]. Such a deceleration is 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 [63].

The observed decrease in time of the generated heat energy enabled a fit to the navigational data (position with time). The fit 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, it was not explained why the earlier paper [60], using a least-squares fit over the whole orbit, showed the <u>steady</u> drift in frequency (corresponding to an anomalous deceleration of 8.65 ± 0.03 × 10^{-10} m/s^2 under GR), which is inconsistent with the claimed decreasing thermal deceleration with time.

It is not disputed that preferential heat radiation would slow the spacecraft. Based on the navigation data the velocity of the spacecraft was definitely slowed. However, such a slowing will not give a drift in frequency (if clock-rate is constant). Movement away at constant speed produces a fixed fractional drop in frequency (redshift) of a reflected signal whose value does not grow with time. A deceleration reduces speed and so would lead to a smaller drop in frequency over time. The idea, under GR, that an acceleration or deceleration slows time for a moving object is irrelevant because the time at the moving spacecraft was not used or examined. The signal was essentially a reflected signal and completely independent of the time of any clocks on the spacecraft.

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% [64]. 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 $\rho_c = 3\mathrm{H}_0{}^2 / 8\pi G_N$ [65]. 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 area surrounding a 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 $\mathrm{H}_0{}^2$

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 $\mathrm{H}_0 = Zc/r = v_{esc}/r$. The FR-implied critical mass per enclosed volume (r^3) predicted for GR is then also $\rho_c = 3\mathrm{H}_0{}^2/8\pi G_N$. 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 rate of change of time. This enables a prediction of a change in frequency that is in remarkable agreement with the observed drift to lower frequency dubbed the Pioneer anomaly. Although selective heat radiation can explain why the spacecraft were decelerated, the drift cannot be explained by deceleration because signals that were essentially reflected, and did not use the time at the spacecraft, were examined.

The concept of a new form of energy whose influence grows as the space between objects increases, should always have been seen to be suspect. Moreover, under GR, there is no understanding of why dark energy is becoming dominant now 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 an expansion. This removes 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, the size of the empty vacuum between massive objects increases, without the objects moving. This is hard to comprehend and relies on the concept of space-time being a distortable fabric (metric), a relationship and "not a thing".

7.2 No need for dark matter and antimatter is not missing

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 a 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 [66], while others maintain that there is a crisis [67]. 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 are predicted within the Standard Model of particle physics. Similarly, there is no persuasive theoretical explanation for the existence or magnitude of dark energy [68].

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 [69]. 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 [67,69,70].

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 [41]. 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 consistent with $m_i \propto E / c^2$ at high asymmetry and $m_i \propto E / c$ at low asymmetry.

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. This appears consistent with the observed rotation curves if $c \propto (A+\bar{A})$, because the force, due to the ($1/c^2$) increase in mass with decreasing speed of light, would be accelerating objects whose inertial mass was decreasing in proportion to c. The effect is to decrease inertia, at large distances from a point source of like matter, by a similar amount to that by which the gravitational attraction from that same matter reduces. The gravitational force depends on the gradient in total clout while the inertial force also depends on the asymmetry between the matter and antimatter contributions. The latter depends on the excess of the sum, from all directions, of just one component. 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, while the gradient from a nearby single star or planet can be large. The background asymmetry and inertia will reduce, leading to an apparent change in G_N, with decreasing isotropy of the source of asymmetry.

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 the 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. However, it will decrease with distance from the central core but the decrease will only approach a $1/r$ dependence at large distances. This appears broadly consistent with the observed rotation curves of isolated galaxies and the position of our solar system within our galaxy appears 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. Modelling of this explanation is needed which must include the increase in inertia in the central core and the potential impact on the mass present within the central black holes.

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 energy densities 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 [71], 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.

Under FR, as set out in section 5.5, the amount of bending is determined by the gradient in clout and the asymmetry of chiral components because they affect the frequency of oscillation. If the background chiral density from antimatter is constant over the region of interest, then the fractional asymmetry would be proportional to the gradient in clout. Under GR, the amount of bending is determined by the gradient in potential which, because of background independence, goes to zero far from an isolated massive object. Hence, GR and the effect of clout under FR will give the same predicted amounts of bending in our local region of the galaxy where asymmetry is constant. FR will give different predictions elsewhere, but these will agree with the rotation curves of galaxies, because both oscillation frequency and inertia have the same dependence on asymmetry.

The theory indicates that 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 is 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 [43]. A potential test of the revised model is whether it can predict the current ratio of nucleons to gamma rays of approximately 10^{-9}.

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 revised theory and GR both seem to require that antimatter will fall in the gravitational field due to an increasing density of matter or antimatter. This and the associated clumping lead to changes in mass and inertia per unit of matter and the separation into regions of matter and antimatter. The effects need to be modelled in terms of their impact on the evolution of galaxy shapes and the large-scale structure of the universe with time.

7.3 Tully-Fisher relationship

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 [72]. 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 $m_i / m_g = 1$. The decrease in inertia as $1/r$ means $v^2 = G'_N M$ so that the square of the asymptotic velocity (amplitude of the rotation curve) reflects the mass of the galaxy. The inertia for the same distance from a single source of asymmetry will also be proportional to the mass of the source and the clock-rate of energy emission should increase as inertia decreases. Hence, the luminosity of an extended spiral galaxy should depend (roughly) on the number of stars (if they are on average the same) and their rate of emission and hence on mass squared. From which it follows that $L \propto W^4$.

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

The Sachs-Wolfe effect [73], 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 will vary because the speed of light and inertia will be altered. 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 space-time 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 space-time 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 [74]. 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 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 predictions from baryon acoustic oscillations [75], 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.

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 consequences need investigation.

7.5 Summary

FR avoids the need for dark matter and cosmic inflation and appears capable of explaining other observed phenomena while reproducing further predictions of GR. Some of these explanations need further examination including careful modelling and simulation.

Chapter 8

Experimental tests of the changed understanding of gravity

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 [76]. 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 offers 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 [77]. 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 [78]. 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 of both the electric and magnetic fields which gives twice the Newtonian bending. In both cases it also appears that the timing should be altered by the changes in the speed of light but the changes will not be seen by the methods used with the fitting seeking 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.

The delay (GR) or 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 change in light-speed should match the GR change in path length due to the distortion of space. An increase in light-speed will appear like a contraction in distance, but if the actual path length is known then 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 the Earth's orbit. Seen from the Earth, they would then 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 positioning of the spacecraft means that signals exchanged between them should have a constant amount of bending and the same integrated light-speed. Alternatively, it should be possible to use the changes in timing of the signals from multiple pulsars (as has already been done) but using a modified analysis.

The additional change in timing, from that due to bending, will depend on the path to the Earth through the potential of the Sun. After correction for path length changes, the orbit of the Earth, based on timing, will appear to decrease relative to a pulsar (or spaceship) on the far side of the Sun. These changes would appear to be difficult to separate from those due to an eccentric orbit, but timings to multiple sources and/or spacecraft should enable separation of such effects.

8.2 Time dilation with speed relative to the background

The FR explanation of time dilation due to motion differs from that of SR. SR has it that time dilation depends 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 proposes that time is slowed for massive clocks moving relative to the background from all other matter (which will appear stationary when the observer is in free fall). The FR claim is that the most accurate of current tests of time dilation, so far, 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) needs 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 space-time interval of SR it can be used as a test.

The proposed experiment is to examine the signals from three spacecraft carrying identical highly stable clocks. One central spacecraft would be passed simultaneously by the other two spacecraft going at high-speed but constant velocity in opposite directions and the clock-rates compared. The clocks would emit pulses rather than continuous frequency signals. However, their relative motion would also be determined using continuous frequency signals. The spacecraft should be in as weak a gravitational field as possible and moving perpendicular to any gradient in the field. The ability of the clocks to remain synchronous despite acceleration and deceleration would also need to be confirmed.

8.3 The change of time with time

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 supernovae data correctly predicts the drift observed in the two Pioneer spacecraft. The previously proposed explanation of a slowing of the spacecraft due to preferential heat radiation can explain the change in position but is not tenable as an explanation for a drift to lower frequency of the returned signal. This is unaffected by the time at the spacecraft because the returned signal is independent of this time.

A new mission, with careful and adjustable control of thermal radiation, would rule out the faulty explanation. Although it should also be seen to be ruled out by the lack of an effect of the acceleration in circular particle accelerators on the observed time dilation. The key change would be to remove any preferential direction in the radiation of heat. It might also be useful to have returned signals locked to different percentages of the received signal and to have an ultra-low-drift on-board clock to provide additional comparisons.

8.4 The effect of background asymmetry on inertia and G_N

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 inertial mass depends on the product of stored energy (gravitational mass) and asymmetry. It is claimed that within our solar system the ratio is approximately constant with the asymmetry from our galaxy being larger than the background asymmetry except, possibly, near the Sun. Such a contribution to asymmetry will slightly increase the total asymmetry and so increase inertia and lead to an apparent reduction in the value of G_N .

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, this estimate does not allow for the increasing inertia towards the centre of our galaxy and the consequent underestimate of its mass, or for the contribution from stars in all directions. 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 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 other 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 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.

The correct prediction of the frequency drift in the Pioneer data based on the rate of change of time includes an additional factor of ⅓ due to the change in frequency with asymmetry, so a repeat of the Pioneer experiment will help confirm this effect of the background.

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 to speed relative to the background arises from unequal effects on the 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 changes in the value of Planck's constant are likely to be too small to provide useful tests.

Nevertheless, it should be possible to estimate the background clout from observations of the number and distance of galaxies. The reduced mass and increased distance 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. A unidirectional gradient could then be expected to give rise to a pair of spiral arms. This, together with the approximately flat rotation curves, might explain the existence of spiral arms and why they are not wiped out rapidly by the differential rotation with distance from the galaxy centre. The shape of the spiral arms should be predictable from the measured rotation curve and a knowledge of the surrounding distribution of galaxies.

The implications of FR for the evolution of the universe requires modelling. It needs to be shown that the effect of asymmetry on inertia can either duplicate the claimed effects of dark matter or otherwise provide a satisfactory picture of the observed large-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 means that all the properties and interactions of objects 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 gluons of strong interactions are also understood to travel at the speed of light, but not the massive weak bosons.

Under FR the propagation of the gravitational field does not appear to carry energy or angular momentum and so should not be quantized. However, for simplicity a propagating change in clout will still be referred to as a graviton. Stationary states that include rotation of components are quantized. States that propagate freely are massless and 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, but rather the stationary states of objects embedded in a background that allows oscillations.

However, the kinematic behaviour of massive particles 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 space-time 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 (of a point source), as indicated by the uncertainty principle.

The revised understanding emphasises that all particles (massive states as well as photons) are oscillating states, as put forward by Born [79]. 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 predict 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. The 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 [80]. In 1994 Veltman pointed out that the many unknowns included the origin of the particular symmetries of the SM, 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". Thus, the SM 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 when the laws of physics appear 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 neutrinos may be massless. FR also removes the problem of the GR claim that gravity is not a force but a property of space-time. Such a force is incompatible with QM and the SM behaviour of the other forces. However, 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).

The quanta of the interactions (photons and presumably gluons and the gauge bosons of the weak interaction) and massive particles 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. Hence, a model of the nature of the exchange bosons (graviton, photon, gluons, $W^{\pm}, Z_0, H$) and massive (or massless) fundamental fermions (neutrinos, leptons and quarks) in terms of 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. 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 [81].

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 the particles 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 broken, 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 the part of one underlying field that is primarily associated with the massive bosons containing different chiral components.

Under the SM, it is the interactions of the fields of elementary particles (both fermions and bosons) with just the background Higgs field that gives rise to their mass and to the strength and symmetries of their interactions. Under FR, all interactions that involve the one background field can potentially lead to mass and broken symmetries when chiral components interact in a background from unequal chiral contributions. 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 photons

A collection of seemingly relevant information is put forward with a view to establishing a physical model that is consistent with and that can explain the properties of the SM. The properties of 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 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 speed relative to the speed of light but FR indicates that helicity is determined by speed relative to the background.

A graviton 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 Δk Δk 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 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 it can split into a pair of oppositely charged fermions and anti-fermions. The effects of such virtual particles 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 should be 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 ($\mathrm{r\bar{r}}$, $\mathrm{g\bar{g}}$, $\mathrm{b\bar{b}}$) 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 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, so that movement relative to the background has the same effect on each chirality. 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 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 and leptons corresponds to one of (apparently) only three possible sets of components in three spatial dimensions that can give rise to stationary 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.

These postulates are highly speculative but 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. This 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 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 might then 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 would be the “missing” ninth gluon (with three equal pairs of orthogonal components) and the bosons of the weak interaction would be 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 although the mass could still be sensitive to chirality. The $W^{\pm}$, 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.

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 ($W^{\pm}$, 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 antiparticle state. Thus, the Higgs is one of three boson pairs in which chirality and rotation trap energy (except for the photon) which gives rise to their mass. 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 [82], compared with the measured 125.09 ± 0.24 GeV/c^2 [83] and the latest value from the CMS collaboration of 125.35 ± 0.15 GeV/c^2 [84]. 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 [85]. 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. Another possible explanation might 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 massless neutrinos. They are massless because the net angular momentum is purely in the plane perpendicular to the direction of motion. However, it is proposed that the number of components differs for the three families. 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 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.

9.3 The mathematical realisation of Full Relativity

It is highly desirable that FR be put in a mathematical form similar to Einstein's equation in GR. Newton's gravitation is a static equation with no time dependence so it does not include the finite propagation time of changes in the gravitational field. Einstein's equation combined the differential form of Newton's gravitational equation with Newton's equation of motion and built in the finite propagation time via a constant speed of light, constant mass and a constant ratio of inertial to gravitational mass. The starting conditions, in terms of an initial distribution of mass, energy and momentum must be input. The time evolution of the gravitational field and the movement of matter and energy is then investigated. Many exact solutions have been found for simple initial conditions.

It would seem that an analogous procedure could, in principle, already be implemented for FR using Newton's original universal law of gravitation and an initial location and velocity distribution of the nearby masses present, which would include some simplification of the mean background field from both matter and antimatter. The time evolution would be examined by computer simulation that allowed for the finite propagation speed of the components of the field and the effect of the changes of the field on the mass and inertia of the masses. However, at this stage, the relationship between inertial and gravitational mass has not been clearly defined.

Part of the problem would seem to be that we do not have a satisfactory physical model for the number and character of the fields present including how they interact with each other. To make progress we need to be guided by past experience constrained by consistency with observed behaviour. It is desirable to have an understanding of mechanisms, but such mechanics involves our macroscopic experience with interactions of solid, massive objects, at point locations with properties that are independent of any invisible background. These constraints do not apply to interactions via electrodynamics or gravitational fields.

Nevertheless, there has been success from pictures/models based on analogies and metaphors or similar behaviour, such as wave motion in massive media. The models and mathematical formulation are also guided by 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, and that included whirling vortices [86].

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.

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. This photon that can deliver energy E from its momentum travelling at c. This energy has come from the release of the trapped angular momentum held in the particle or from the mass released in a transition of a massive state. Under FR, this angular momentum gives rise to the observed resistance to changes in momentum with time (i.e. inertia) of a given amount of stored energy. 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 counter-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 Possible variation in the fine structure constant

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. The movement of stored energy appears sensitive to motion relative to other local sources of stored energy and thus of motion relative to the mean flow of 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. Measurements of the spin of two particles that came from a state of zero spin will always indicate opposite orientations of spin 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. Entanglement involves fixed phase relationships (constant relative phases) between components but the phase is 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 all the components have a fixed phase relationship, 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 can be fixed). Nor does it mean that the same answer will be obtained under a different interrogation.

9.7 Summary

The aim of this chapter has been to provide an outline of where the revised understanding of gravity and its needed consistency with the Standard Model of particle physics including quantum mechanics points to an underlying physical model that encompasses all known forces. The tentative suggestions for aspects of the model need critical assessment, further development and to be put into an acceptable mathematical form.

The outline appears to remove most or all of the current suggestions for observations that indicate the need for new physics beyond the Standard Model.

Chapter 10

What has been learned and where to next.

The simple expectation that the energy of a photon, with no mass, should be unaffected by 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 space-time, with no dependence on the absolute value of the background in the space between objects, have inherent inconsistencies.

FR introduces new perspectives on the nature of time and space. 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 energy 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 on the inertia of massive objects due to any 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 asymmetry from our Sun.

The speed of light depends on the total clout from all other 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 lead 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 rather than with changes in the misleading concept of flux density from mass. 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. However, FR reveals that the Strong Equivalence Principle does not hold. The apparent 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. Gradients from masses in opposite directions can lead to a flat region in the field (magnitude of clout), so that there is no gravitational acceleration, but the contributions to the clout add, and affect both mass and the speed of light.

A photon does not gain or lose energy in a gravitational field. In cannot, because it has no mass. 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 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 spacing between ticks will decrease), so that 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 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. The unit of conversion between stored energy (mass) and 'free' energy is altered by changes in the speed of light, as encapsulated in $m = E_0 / c^2$. This relationship was derived from the interconversion of energy and momentum, with relative velocity of the observer, in any region of constant c. It indicates that the energy of all atoms and atomic transitions increases in inverse proportion to the square of the speed of light. Thus, there is a "time" that is $1/c$ less than the interval for light to travel a fixed distance and that is a factor of c greater than clock-rate rate (for a constant ratio of inertial to gravitational mass). The relation $m_g = E_0 / c^2$ holds for all c, with the energy stored per particle decreasing as c increases. However, the ratio of inertial to gravitational energy m_i / m_g can change. In contrast, GR keeps both $m = m_g = m_i$ and c constant, independent of the background density, and has opposite interpretations of time and distance intervals.

The inverted interpretation is present in Einstein's formulation of background-independent Special Relativity and Minkowski's inclusion of the effects of motion and momentum into the concept of space-time. 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 interpretation helps hide the dependence of mass on $1/c^2$ and also appears to explain why, in GR, a geodesic, the shortest path between two points in a curved space, maximizes rather than minimizes proper time.

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 space-time between them (as in GR). Space is always flat. There is no fabric (metric or geometry) of space-time 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, the changes in space and time of FR give observationally equivalent predictions to those from the distortion in the underlying geometry (curvature) of space-time 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.

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. Decay rates slow and momentum increases in proportion to γm.

If there is a large background clout, then the increase in clout at a surface around a source of stored energy (ΔE above the background at 1 metre) will be $\Delta E / rE_C$, with distance r metres. The fractional change in total clout (E_C) 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, in inverse proportion to distance from other matter, then explains the existence and strength of gravitational attraction.

10.2 Durationless time is dead

The philosopher Henri Bergson and Albert Einstein engaged in a heated controversy about time in 1922 [87]. Crease has recently discussed the different perspectives [88]. 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 space-time. 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 space-time in which space and time vary but produce an invariant space-time interval because the speed of light is a local constant. However, the logic behind Special and General Relativity 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. The predicted drift in frequency accurately explains the observed anomaly in the returned signals of the Pioneer spacecraft.

Although, an additional change in frequency due to changes in asymmetry with time must be incorporated. The current explanation of the Pioneer anomaly as due to a deceleration of the spacecraft is untenable as the frequency of the returned signal is independent of the clock-rate at the spacecraft and a slowing of the spacecraft would lead to a reduced frequency shift.

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, 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 space-time was real. Gravity was then a distortion of this fabric of space-time by massive objects, but this turned out to be an illusion.

The resultant 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 its density reduced, an invisible dark matter, and cosmic inflation. This included the claim that the entire universe could expand faster than the speed of light without violating current laws because "space was not a thing" and could expand without the objects in that space moving.

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 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 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 desirable. 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, just more complex, and 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 space-time. 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. This needs to be confirmed.

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 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 need 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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