Making Sense of Gravity

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Version 8 is the first version of this document to be made available on the internet.

It 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 develop the ideas further.

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

"The important thing is never to stop questioning."

— Albert Einstein

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 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 perspective 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. It is argued that the observed behaviour, encapsulated in the Lorentz transformation, can be explained by an altered understanding of time and distance intervals. The alternative 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 explains gravity as a decrease in mass that can be stored by the same amount of matter as the background from surrounding matter increases. A simple conservation of energy and momentum.

The full implications of this new perspective still need to be investigated. 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 agreement with observation. It 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, christened Full Relativity, were unfortunately riddled with mistakes and inconsistencies, and some 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, particularly Graham; our daughters Caroline, Stephanie, Belinda, and their families; friends including David Anderson, Kevin Essery, Chris King, Sandy Macintyre, David Phillips, Terry Reichl, Peter Smith and John Tacon, and physicists Brian Foster and Richard Hemingway. John Field and Paul Lasky also shared some of their understanding. 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.

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Introduction

The current theory of gravity, Einstein's General Theory of Relativity, is regarded as one of the greatest intellectual achievements of human thought. It explains and predicts how matter and energy will behave. It holds 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. Additions may help 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.

The mathematics of GR is very challenging but the underlying principles can be simply set out. However, the meaning or interpretation of the concepts take some time to master because they challenge common expectations. This has led to claimed paradoxes that have been debated for more than one hundred years.

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 of the Lorentz transformation, which explained high-speed observations, must then be examined. The derivation is found to be suspect. The upshot is that a real background that affects the energy that can be stored by particles, but in which space is not distorted, can replace the fabric of space-time as the source of gravity.

The reader should appreciate that this is an enormous challenge to the current paradigm. Mass and the speed of light are no longer (locally) invariant and the laws of physics are not independent of 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 clock-rate of a moving clock cannot be derived solely from return signals to a stationary observer as claimed in SR. Time dilation of returned signals is an apparent effect from motion during the finite time of signal transmission. It will be argued that the observation of the relativistic Doppler shift in signals emitted by a moving object confirms that there is a real slowing of time. SR also claims a real slowing of time together with a contraction of distance. However, it is not widely appreciated that this contradicts a constant measured speed of light and requires an inverted interpretation of the terms of the Lorentz transformation (LT). This issue is carefully examined.

A real slowing of time means that the frequency and clock-rate of massive objects is altered by motion relative to the background from all other massive objects. It is concluded that there has been an inverted interpretation of time dilation, in which shorter time intervals (between ticks of a clock) has been taken to mean less time has elapsed. This has allowed the incorrect conclusion that space and time are linked into a fabric of space-time that keeps the speed of light constant. Such a linkage requires that larger time intervals (time dilation) be matched by larger distance intervals. This contradicts observations which require time dilation to be matched by length contraction. The revised understanding enables a theory in which the speed of light can vary with the magnitude of the background. Gravity can then be explained by a background that affects the speed of light and the energy stored as mass. 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 the 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 matter. The last overcomes a serious unrealised problem. Newton's and Einstein's field equations (GR) require that empty space free of matter can act 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 falls of as $1/r$. The clout, which is proportional to the total background potential, determines the speed of light and hence mass. 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 and so it has been christened Full Relativity (FR). 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 clout 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 of the many changes in understanding for cosmology 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. The change removes the current problem of singularities. Other benefits include a revised understanding of what happened to antimatter and of the nature of black holes. It is shown that FR can reproduce the standard well-confirmed predictions of GR for the current background.

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 clout. Such a difference would arise from an expansion of the universe but can also arise from increased clumping of like matter. The background affects the speed of light and clock-rate. It is also postulated that there is an asymmetry in the background which affects inertia and oscillation frequency. 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 explains most of the observed drift to lower frequency known as the Pioneer anomaly, as distinct from the slowed speed produced by heat radiation. An explanation of the discrepancy in the prediction is put forward based on changes in the asymmetry. Further astrophysical predictions and consequences are outlined in Chapter 7.

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, or electromagnetic) that confines momentum to a location. Some initial implications for the nature of the photon and quantum mechanics are developed (Chapter 8) followed by an examination of some implications and predictions for particle physics (Chapter 9). The last chapter takes a look back and a look forward.

Chapter 1

The background to, and of, a revised understanding

The revised theory, Full Relativity (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:

$$F = G_N Mm/r^2$$

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 (r). 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 and that the ratio of the masses might be fixed for all objects at any one location 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 were able to 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 (ν) of the light, and inversely proportional to its wavelength (λ), according to $E = h\nu = hc/\lambda$, 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. As a result, Einstein stated: "Concerning matter, we have been all wrong. What we have called matter is energy, whose vibration has been so lowered as to be perceptible to the senses. There is no matter."

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, 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 distance with speed by the factor gamma ($\gamma = 1/\sqrt{1-(v^2/c^2)}$). This could be set out mathematically as a relationship between the space and time coordinates of a frame stationary relative to the observer and a frame stationary relative to the receiver. For movement 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 was taken as strong evidence of the correctness of SR. It will be examined in Chapter 2.

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 independent 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 distance and timing for an object in the stationary frame and that the underlying clock rate for both observers was the same. However, 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 our motion relative to the object we were measuring. 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: $ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2$, with $dx = x_1 - x_2$ etc. and $\text{distance} = \sqrt{dx^2 + dy^2 + dz^2}$ (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 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?

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.

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 worked out that the metric is 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 tests. One was a gravitational redshift. Time would run slower deeper in a gravitational field. The other was about how light would be bent when it travels past a massive object. Einstein predicted the amount of bending of light from distant stars as it passed close to 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, the gravitational redshift or slowing of time deeper in a gravitational potential 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 christened “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 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 supernova 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 were 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 now 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 provide gravitational attraction.

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 the photons had lost 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 blue-shift 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, 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 (blue-shift) 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 lifted in a gravitational field. The beautiful change in perspective is that gravity is simply the conservation of energy. The kinetic energy of gravitational acceleration comes from a loss in the stored energy of objects, rather than from a change in the 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 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 not trapped and does not require a net force. If only stored 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 blue-shift of atoms means that photon energy is unchanged. The gravitational redshift of light is because the energy (and clock-rate) of the emitting atoms is lower when nearer to other matter, i.e. deeper in a gravitational potential. The revised theory, christened Full Relativity (FR), 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 that slower light takes to travel a set distance and the decreased time intervals (clock-rate) between the ticks of a more massive clock. Clock-rate and light-speed time intervals are background-dependent and differ by $1/c^2$.

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. 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 distance in a frame moving at constant speed relative to the observer. He had found that this combination of altered time and distance 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 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 interpreted the apparent increase in distance travelled (contraction in distance intervals for the object) and apparent decrease in time intervals as real and applicable to the object. However, the conclusion is not possible without examining signals emitted by the moving object. Instead, the observed behaviour can only arise from a real increase in time intervals (a slowing of time) for massive objects with increased speed relative to a stationary background, giving an apparent reduction in distance intervals. The claim is therefore that the derivation of the LT in SR is faulty and does not establish either of the postulates actually used. These postulates were that the speed of light is constant, the same for all observers, and that laws of physics 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 by, for example, the arrival time of the light from binary star systems. 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. Observed 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 the background.

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 contradicts the original requirement of the LT of a dilation of time (increase in time intervals) and a contraction of distance (decrease in distance intervals). This has been avoided in SR by interpreting smaller time intervals as less time. However, smaller time intervals between events, e.g. the ticks of a clock, means that the clock is ticking faster (more time passes).

The claim of FR is that the interpretations of both red-shift (to blue-shift) and time intervals need to be inverted. The result is a cancellation that enables FR to reproduce the predictions of SR. It also reproduces the predictions of GR 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 the 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 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 second derivative of this gravitational potential is directly proportional to mass density. 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 corresponds to an infinite 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 the metric by massive objects and their movement builds in a dependence of the apparent speed of light on the size and relative velocity of massive objects. The use of derivatives means that contributions from gradients in opposite directions cancel, removing a dependence on the total 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 is a revised gravitational potential and not the gradient of the potential. The magnitude of this field determines the speed of light and thereby alters the amount of energy that can be stored in the same amount of matter. The corresponding amount of trapped momentum reduces as the speed of light increases. The amount of energy stored by matter decreases with an increase in the background mass causing the potential. The gradient of the potential is the fractional decrease in stored energy with position (distance) as the surrounding density of matter increases. Hence, the gravitational force on a massive object will be proportional to its mass.

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 singularity should be seen as confirmation that a theory has been pushed beyond the limits of its validity. Black holes with a singularity at their centre, which owe their existence to an enormous pool of energy when space is empty, should be of serious concern. Even so, a half-share of the 2020 Nobel prize in Physics was awarded to Roger Penrose "for the discovery that black hole formation is a robust prediction of the general theory of relativity". According to the citation, he "proved that black holes really can form and described them in detail; at their heart, black holes hide a singularity in which all the known laws of nature cease."

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 blue-shift 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 in 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 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, that alters the speed of light, will be required.

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 analysis, 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 correctly describes the observed behaviour of electromagnetic interactions between particles moving at high speed, does not require that c have the same constant value in inertial frames with different 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 $dt = dx/cdt$. In this case it is no longer possible to formulate causality based on the concept of absolute simultaneity. This concept is that there exists an underlying absolute time for sets of simultaneous events throughout space but their ability to influence each other 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 a local constant. Although the apparent speed can be altered if the observer is in a different gravitational field, there is no change in the locally measured value of c from moving between regions. GR has the space and time of the observer altered (distorted) in unison by the difference in gravitational potential. The alternative of FR implied by $m = E/c^2$, is to have c decrease as the background potential from stored energy decreases. Changes in light-time intervals reflect changes in both the separation of objects and the speed of light. 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 object, would then appear constant.

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 mass density tick at different rates. Both FR and GR attribute this to differences in the gravitational potential. However, the potential of GR has no effect on mass or $cc\,c$, whereas FR has mass and $cc\,c$ dependent on the magnitude of the 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 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 $1/c^2$, suggesting the wavelength of the transition (spacing of the charges) decreases by c. The observation that clock-rate increases in proportion to $1/c^2$, 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. This means that 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 but is not, while clock-rate, of massive clocks containing more energy, increases in proportion to $1/c^2$. 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 stationary objects) is unchanged.

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 GM/rc^2. Thus, under FR, the gravitational potential, the change in energy per unit mass ($\Phi = \Delta E/m$), arises from the fractional change in energy or mass (i.e. $\Delta E/E = \Delta m/m = (\Delta E/c^2)/m = \Phi/c^2$). The value is of order 10^{-16}per metre change in height at the Earth's surface. The change in clock-rate with altitude is seen as due to the change in Φ, under GR, but to the change in c, under FR.

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, but observations can also be explained by 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.

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. SR holds that a background is superfluous and there is no need for an absolute stationary space. 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 a volume of gas is unconstrained, then it will expand and cool. 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. However, the time and space of an observer freely falling in the gravitational field, so not feeling any force, is 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. FR must also explain inertia and the bending of light.

FR proposes that the energy of a photon is not changed in moving through a gravitational field and that light does not fall in a gravitational field. If it did then light would be predicted to be bent by a gravitational field but by only half as much as predicted by GR because of its 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 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. 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 the wavelength and momentum, and frequency and energy, of the oscillations are related and dependent on the energy. An oscillation implies that the magnitude or direction of momentum is moving back and forward or rotating and implies that there are at least two components. The frequency of oscillation will depend on the magnitude of the components but any imbalance, asymmetry, between components could lead to an additional rotation/oscillation.

Gravitational mass, which varies with the speed of light (as $1/c^2$), appears to have a scalar (or single component, direction independent) dependence on background. This seems to imply that asymmetry has little or no effect on gravitational mass, but it could still be correlated with inertial mass. The slowing of time and frequency, with speed of movement relative to the background, indicates that a larger force is needed to accelerate a given amount of stored energy (gravitational mass). This suggests that the ratio of inertial to gravitational mass is sensitive to movement relative to a balanced/stationary background.

If fractional changes in asymmetry are small within our solar system, then changes in inertia with asymmetry will be proportional to changes in gravitational attraction and so will be absorbed into the apparent value of the gravitational constant. The speed of movement of massive objects under the expected gravitational force would then differ in regions of significantly different asymmetry. The change in asymmetry in moving away from a concentration of just one type of matter could reduce the ratio of inertial mass to gravitational mass. The required acceleration for a given orbital velocity would then decrease. It would appear like an increase in the strength of gravity. 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 "clout" or a vector 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. However, it is now known that gravity propagates at the speed of light, so a deeper theory is needed. This theory also 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. In SR, the link between space and time had the speed of light a universal constant in a flat Minkowski space-time. In GR, matter could alter this link by distorting the geometry of space-time.

FR needs to also 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 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 north and south poles). The fields have magnitude and direction and effects of like charges (or like magnetic poles) in opposite directions cancel. A small test charge enclosed within a spherical shell of isotropically distributed charge 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:

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

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

can be expressed in terms of a vector field of gravitational acceleration. The acceleration ($\vec{g}$) is the force per unit mass experienced by objects in this field. This force is equal to the gradient of a potential (a scalar), which is the gravitational energy (per unit mass), held at that location, that can be given to objects. 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 (GR implies that they are spin 2 oscillations of the field) called gravitons. The assumption 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. A photon is an oscillation of the components of the electromagnetic field that can carry a fixed quanta of energy to a new location. The stored energy (gravitational mass) 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 increase as massive objects move closer together. For GR, the distortions of space and time, and the energy associated with the 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 mass density is the total mass in an enclosed 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 in an enclosed volume. However, what is meant by mass density or a mass density function outside an enclosed volume? Under equation 1.2, this function is the source of 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. 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 their energy does not flow away or move unless the sources move, and/or massless energy is radiated in the form of wave/particles (gravitons and photons).

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 distort the geometry of this space-time fabric in which all things move, but the (rest) mass of objects is unchanged. (This background changes perceptions but its components just express a relationship and have 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 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 $1/4\pi r^2$. Electric and magnetic fields can be seen as arising from scalar electric and magnetic potentials (whose strength decreases as $1/r$) but, because of the large forces between charges and their ease of movement, it is takes enormous energy to establish and maintain such potentials.

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 according to its distance d, i.e. according to $\Sigma\delta M/d$. 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. The fractional change from the same nearby excess of matter will be smaller if the total background is larger. The proposed scalar background of FR will alter the speed of light and hence the energy stored by matter. Its effect on energy will therefore be proportional to minus the potential divided by c^2. The pseudo-background of GR is a vector field that is the derivative of a generalised Newtonian potential. It alters the space and time in which objects are embedded and so can alter their energy and momentum but does not alter their "rest" mass.

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 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. The amount of each contribution falls off as the inverse of the distance (not the inverse square expected for a flux). Therefore, the term "clout" will be used 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 clout, with the amount of momentum that can be trapped varying as $1/c$ and the stored energy as $1/c^2$.

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 value for the speed of light. Gravitational acceleration then arises from a distortion of the geometry of this fabric by matter and energy. However, GR has required additional hypotheses in order to explain cosmological observations. These include dark energy, dark matter, cosmic inflation, and black holes which have a singularity at their centre. In the past, singularities have always been seen as an indication that a theory has been pushed beyond its limits. In addition, GR appears to be incompatible with another major theory of physics, 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 (FR) 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 the alternative can reproduce the successful, standard predictions of GR.

FR does not require quantum gravity or string theory. The path to the new theory is based on a careful analysis of existing arguments and of the underlying meaning and interpretation of real versus 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, 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 arises from changes in the speed of light.

Under FR, gravitational time dilation 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 smaller background clout (higher potential) and lower c. The claim that $E = h\nu$, as observed for photons, means that the photon has lost energy because of an apparent red-shift in escaping the Earth's gravitational field is inconsistent. Time going faster already means that the frequency of a constant-energy atomic transition would be higher. The frequency of an <u>unchanged</u> photon emitted at a lower altitude, but measured at a higher altitude, will appear slower.

FR has the speed of massless particles, including light quanta, independent of the velocity of the emitting source. This was the original second postulate of Special Relativity (SR) which was based on experimental observation. The speed depends on the magnitude of the background but not the direction. The changes propagate at the speed of light.

The replacement for the 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 delays in signal transmission due to relative motion. 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 medium, due to 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 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 with the analysis assuming that the measured speed of light is constant and that shorter time intervals mean a slower clock-rate. Consistency with the LT proposed by Lorentz requires that a dilation of time (larger time intervals) goes hand-in-hand with shorter (contracted) distance intervals. 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 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. However, FR also allows for the possibility that the frequency of the same amount of stored energy may depend on an additional aspect (an asymmetry) of the background.

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, clock-rate, 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.

It is proposed that FR can overcome many problems and inconsistencies with both SR and GR and avoid the need for the ad hoc hypotheses of dark energy, dark matter and cosmic inflation. However, it firstly 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 seems to support 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 key experimental evidence amounts to the confirmation of the Lorentz transformation (LT). FR maintains the validity of 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 only relative motion is important, that the speed of light is constant, 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 faulty steps 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. The changed understanding means that the LT can be maintained but only with a new understanding of its applicability and the interpretation of terms. 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 length of objects and a dilation (slowing) of time, with relative velocity. 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.

The behaviour of light appeared to depend only on relative motion, 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 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. This 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 will be slowed independent of whether the object, and its frame, is moving towards or away from the stationary 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 viewpoint, with 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 original derivation of the Lorentz transformation in Special Relativity

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 allowed for the possibility that identical clocks in relative motion might not tick at the same rate.

Einstein thus 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 time signals from clocks would appear to increase with distance from the observer. Thus, the time 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. The time τ and distance ξ in the moving frame were allowed to be different from those in the stationary frame. This incorporated a factor $\phi(v)$ which was a linear function of velocity. The analysis demanded that $c = x/t = \xi/\tau$ for light in both frames. [Later, (ξ, η, ζ, τ) was replaced with $(x^{'}, y^{'}, z^{'}, t^{'})$.]

The point $x' = x - vt$ at rest in the system k will have a set of values x', y, z independent of time. A ray of light, emitted from the origin of system k at time τ_0 along the x-axis to x', was at time τ_1, reflected back to the origin, arriving at time τ_2. These times were those in the moving system and it was claimed that $\frac{1}{2}(\tau_0 + \tau_2) = \tau_1$ must hold, so that, using the principle of the constancy of the velocity of light in the stationary system:

$$\frac{1}{2}[\tau(0,0,0,t) + \tau(0,0,0,t + x'/(c - v) + x'/(c + v))] = \tau\left(x^{'}, 0,0, t + x'/(c - v)\right).$$

However, although events at time τ_0, τ_1 and τ_2 are stationary and can be synchronised in the moving frame, events at position 1 (time τ_1) occur with different delays for the observer in the stationary frame. The claimed equality of the equation disregards Einstein's earlier observation that simultaneity, of events at different locations, does not have an absolute significance. The timing of events, using time ttt of the stationary frame, cannot be applied to the LHS and RHS of the equation without a correction to allow for the different separations $(x' - x_0)$ and $(x' - x_2)$ of the event at τ_1 from those at τ_0, τ_2. The size of the correction goes to zero with the separation. The equation introduces a dependence of the ratio τ/t on c and v. Moreover, timing of light rays from and back to the source in the stationary frame cannot give any information about the clock-rate in the moving system since the clocks of the moving frame are not interrogated.

The equation was used to deduce that: $\tau = \phi(v)(t - v/(c^2 - v^2)x')$. The quantities ξ, η, ζ were then derived by assuming that the velocity of light was c when measured in the moving system, i.e. using the time and distance of the moving system via $\xi = c\tau$. This is a remarkable jump from the original postulate that the speed of light in the stationary system is c, whether the light be emitted by a stationary or moving body. It amounts to the assumption that: if the time (τ) of a moving frame appears to proceed at a different rate to that of time (t) in the stationary frame, then the distance scale must be altered in the same proportion, so that the measured speed of light will be unchanged. This requires that the ratio of distance intervals to time intervals ($c = d\xi/d\tau = dx^{'}/dt^{'}$) remains constant for all inertial frames. It was seen to follow from combining the postulates that the laws of physics are the same for all systems in uniform translatory motion and the constancy of c. Thus, time and distance scales for a moving object are taken to be subjective (observer dependent), but the speed of light is real and absolute (observer independent).

The transformation equations relating time and distance coordinates between the two frames, based on $\xi = c\tau$ and the faulty synchronisation in the frame at rest, were found to be:
$\tau = \phi(v)\gamma(t - vx/c^2)$ and $\xi = \phi(v)\gamma(x - vt), \eta = \phi(v)y, \zeta = \phi(v)z$ where $\gamma = 1/\sqrt{1 - v^2/c^2}$. The equations are those of the Lorentz transformation within the multiplicative factor of the linear function. The sum of the time intervals in the rest frame was assumed to be in direct proportion (with the proportionality factor being $\phi(v)$) to the time (τ) of clocks at fixed locations in the moving frame.

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:

$t' = \phi(v)\phi(-v)t$ and $x^{'} = \phi(v)\phi(-v)x$

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. 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 they 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 SR derivation of the LT is faulty. Moreover, it is impossible to derive clock-rate in a moving frame from an analysis using timings only from the stationary frame. These involve reflected signals and do not interrogate, and cannot reveal any information about, the clock time in the moving frame.

2.3 Later derivations of the Lorentz transformation in Special Relativity

In his 1905 paper 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, but distances and times were distorted.

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 to appear the same to observers in both frames). Given that $x' = 0$ when $x - vt = 0$ and assuming $x^{'} = \alpha(x - vt)$, the LT then follows.

However, the claim that a spherical wave of light emitted from a stationary source would also appear as a sphere to the moving observer is misleading. A pulse of light emitted from, for example, a supernova will reach surrounding gases at equal times for equal distance in all directions, if the speed of light is constant. Nevertheless, the reflected light will not appear as a sphere to the observer moving relative to the supernova unless allowance is made for the distance the light has to travel to reach the observer. The allowance must include the extra time taken because the observer moves during the time taken for signal transmission. A moving observer coincident with the supernova at the time of emission will see light returned from gases moving with the observer as propagating spherically, but these are not the same photons or spherically positioned gases seen by the stationary observer.

The claim that $x^2 + y^2 + z^2 = c^2t^2$ applies to photons in one frame and that $x'^2 + y'^2 + z'^2 = c^2t^2$ applies to photons in a second frame is acceptable for one instantaneous flash of light. The photons will propagate spherically if the speed of light is independent of direction. For the next flash, the origin of the coordinates of both frames will not overlap at zero time. The objects or markers in each frame which are used to assess the position of the spherical wavefront must also be stationary within that frame. Otherwise the scale of the axes, the distance between markers, changes during the finite transmission time of the signal. The misleading derivation took the primed coordinates as being the real coordinates of the second (moving) frame rather than the apparent coordinates of events seen from the stationary frame. It then 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 that changes in time be matched by changes in distance, and an imagined (unobserved), distorted, set of distance and time coordinates for the moving frame. Under these distorted coordinates distance and time for light to propagate both shrink making the imagined propagation spherical.

2.4 The altered understanding of the Lorentz transformation

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 at 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.

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 distance Δx refers to the distance in the frame of the stationary observer ($v = 0$), while the time t', of the reflection of the signal, is ostensibly in the frame of the receiver (but in units of the time of the observer). However, the elapsed time (the t' of the moving object in terms of the sum of time intervals) for light to get to the location $x = 0$ is changing with distance, so that t and $t^{'}$ do not remain synchronous. If the clocks are ticking at the same rate in both frames, the time intervals between a synchronous sets of events, e.g. ticks of clocks, will change with time.

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 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 $\gamma x^{'}/c\gamma$ in the time of the stationary frame.

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.

The Lorentz transformation (for constant velocity in the x-direction) still applies but the interpretation is changed. The LT is: $x' = \gamma(x \pm vt), y' = y, z' = z, t' = \gamma(t \pm vx/c^2)$, where the plus and minus signs depend on the convention on the sign of the velocity. The coordinates (x', y', z', t') are the apparent values assessed by the observer on the basis of the increased (by γ^2) time intervals of reflected signals. The sum of returned time intervals is reduced by the factor $1/\gamma$, which should mean that the interval between ticks is reduced so that clock time runs faster. The faulty assumption is made that the sum of reflected time intervals (corrected for transmission delays and multiplied by γ) is the time seen by the observer, whereas it is the sum of delayed time intervals (larger by the factor γ^2) divided by γ. The apparent distance travelled in the observer's time is increased by the factor γ. The experimental observations of the time of moving clocks, assessed from the frequency of timing signals emitted by a moving clock (or decay rates of unstable elementary particles), requires that the clock-rate of the moving object is reduced by the factor $1/\gamma$ (the time intervals are increased by γ).

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 for $t < 0$. The LT with minus signs means the separation distance is $x - x'$ with objects approaching from the negative x direction for $t < 0$.

The LT for the apparent distance and time can be derived from the known relationship $x' = x - vt$ in two ways: i) using $dt = dT$ and ii) $d\tau = \gamma dt$.

Firstly, $x'' = \gamma x - v''t = \gamma(x - vt)$ and $t'' = \gamma^2 T = \gamma t' = \gamma(t - v''x/c^2)$, for the apparent distance x'', the apparent velocity $v'' = v\gamma$ and the time for light to travel the apparent distance $t'' = \gamma t' = \gamma x'/c = x''/c$ consistent with the underlying clock-rate (T) being the same.

Secondly, $x' = \gamma(x - vt)$ and $t' = \gamma(t - vx/c^2)$, for the actual velocity (v), the actual instantaneous distance (after contracting distances, i.e. apparent distance intervals scaled by γ, because time has slowed) and actual time intervals of the moving clock ($d\tau = \gamma dt$) in the stationary frame adjusted for the different distance scale. The actual time intervals ($d\tau$) are consistent with a slowed time τ in the moving frame (i.e. a real slowing of clocks moving away from, or towards, the stationary observer). The elapsed time sent from the moving object, based on the known velocity and actual time of emission, needs to be slower, i.e. that $\tau = t/\gamma$. Larmor appears to have effectively reproduced this derivation of the LT in 1897 [16].

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 (by $\gamma = 1/\sqrt{(1 + v/c)(1 - v/c)}$) with movement relative to a stationary background will change the expected non-relativistic forms of the Doppler shift of $c/(c - v)$ and $c/(c + v)$ into the accepted relativistic forms. The emitted frequency is blue-shifted by $\sqrt{(1 + v/c)/(1 - v/c)}$ for movement towards and red-shifted $\sqrt{(1 - v/c)/(1 + v/c)}$ 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 frame should be seen by the observer that is moving relative to this frame. 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. It is difficult to distinguish between the perspectives by observing shifts in timing signals emitted and received by objects moving at high speed, because the relative differences are the same.

The LT will be observed, for the apparent velocity, time and distance and unchanged clock-rate AND for the actual velocity and distance consistent with a real dilation of time intervals. The latter requires that time signals from the moving object are slowed (intervals increased by γ), independent of movement towards or away from the stationary observer. 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 should be seen. Only the second interpretation is consistent with a real time dilation and matches that seen in the changed decay rates of unstable elementary particles.

2.5 Implications for space-time and Special Relativity

SR is effectively based on a faulty derivation of the LT in which the sum of time intervals of returned signals (stretched by γ^2) has yielded apparent increases (by γ) in the velocity of, and distance to, a moving object. These require that apparent time intervals be reduced by $1/\gamma$. Observations of emitted signals actually require a real increase in time intervals by γ. The required reduction in apparent time intervals has been wrongly assumed to correspond to a real slowing of time. This is why there has been such vigorous arguments over claimed conceptual inconsistencies between apparent and real changes in time and distance. The new interpretation overcomes these. However, it comes at the price of requiring that high speed motion of massive objects, whether towards or away from our approximately stationary position relative to the "background of stars", gives rise to a slowing of clock-rate (of massive objects) by $1/\gamma$. On the other hand, the speed of massless photons is insensitive to the speed of the emitting atom or clock. Invariance of Maxwell's equations under the LT is because the oscillation between electric and magnetic fields depends on their relative motion.

2.5.1 Time and distance are not subjective

Einstein's deduction of the LT included that the clock-rate factor was one, in which case 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 inertial frames. This interpretation requires that the space-time in which objects and clocks exist is altered 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 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 [17]: '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.' This time is the sum of longer time intervals with a correction for the delay in light to travel the apparently shorter (i.e. magnified, distance intervals).

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 one part of 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.

2.5.2 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. For the moving observer $dt = \gamma dt_0$ and $dl = dl_0/\gamma$, where dt_0 and dl_0 are duration and length intervals in the rest frame. This 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. Under the altered postulate, increased time intervals (dt), i.e. longer between ticks, is taken to mean less or slower (dilated) time. It must be matched by increased length intervals (dx), i.e. longer rods. The opposite to length contraction. Consistency with observation and an amended LT requires that slower (longer) time and larger time intervals go with shorter (smaller) distance and distance intervals. The revised postulate, adopted in SR, required shorter time intervals to be wrongly interpreted as less time.

In Einstein's analysis the time τ, of a clock in the moving system, was taken 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]. Minkowski [18,19] made the same interpretation, that total time was $\int dt$. The total elapsed time within any frame is the sum of time intervals. However, when comparing time between frames which have different clock-rates, the time in the frame with the bigger interval between ticks of its clocks is proceeding more slowly. His deduction of $\tau = t/\gamma$ actually meant $d\tau = dt/\gamma$ so that apparent time intervals were shorter, meaning less time between ticks, so that more events occur and the time in the moving frame should have been faster. This contradicts the claimed time dilation.

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 change in distance and time intervals are matched. Both must be increased or both decreased. The propagation of light (if made visible) will not appear the same to observers in both frames unless an adjustment is made for the delays due to movement during the transmission time of the signals.

Consistency with the observations that gave rise to the LT, and its explanation of the null result for the Michelson-Morley experiments, require that smaller length intervals (contraction) be matched by larger time intervals (dilation). SR achieves an apparent LT by assuming c is constant (no background dependence) and by inverting the requirement for opposite changes in length and time intervals. Under SR, the increased delay (with separation) in returned signals by γ^2 is interpreted as a real decrease by $1/\gamma$ in clock-rate for the object and a reduction in distance travelled by $1/\gamma$.

2.5.3 The energy and momentum 4-vector

Having $E = pc$ allows an invariant energy-momentum interval but requires the same inversion. The momentum becomes γmv by incorrectly treating the real slowing of time as arising from a reduction in the size of time intervals. Instead, under FR, there is a real decrease in clock-rate and 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. However, just as FR has time altered but distance intervals unaltered, it has inertia altered but mass unaltered. Kinetic energy addition, as well as velocity, appears non-linear. SR does not establish a fabric of space-time and energy-momentum.

SR proposed that, since time in the moving frame was dilated by the factor γ, then momentum, and apparent mass, would also increase by the same factor (i.e. $p = \gamma mv$). 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 with an invariant (rest) mass of $m = E/c^2$ when the velocity was zero. However, time being slowed should mean velocity is reduced. If it is matched by distances being contracted (keeping the speed of light constant), then the velocity and momentum of constant mass should be unchanged. Thus, observations are inconsistent with the details of SR but consistent with an amended LT.

The observation that colliding beam experiments enable larger energy transfers than fixed target experiments does not confirm SR. The deduction of $p = \gamma mv$ and an invariant energy-momentum interval potentially suffers from the same error of interpretation as the invariant space-time interval. SR assumes that $p = \gamma m v$ means that energy and momentum increase by the factor γ and there is a non-linear addition of velocities relative to the observer. However, if γv is the apparent velocity then the addition of such velocities will appear non-linear. If the actual velocity is known then the relationship might also be explained by an increase in apparent energy due to an increase in the difficulty of acceleration (an increase in the ratio of inertial to gravitational mass by γ) with speed relative to the nearly stationary background of the observer.

2.5.4 Consistency with the Lorentz transformation

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 speed of light is the same for all observers. This requires that changes in length and time intervals match, which is the opposite to length 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 and the invariant interval of flat Minkowski space-time will appear to hold for any region in which the speed of light is constant. Moreover, the distinction between time intervals and time is unnecessary in the limit that the speed of light is constant. It only needs to be taken into account when the background changes.

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. Invariance under Lorentz transformations arises from a different pair of postulates. The 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 background of constant clout. However, this constancy only applies within an inertial frame, which, in turn, requires a constant background because the speed of light varies with background clout. Massive clocks must run slower 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 maintenance of the LT, and the requirement for a real time dilation with movement, allows all the apparent experimental confirmations of SR to be retained but rules out the postulates used.

2.5.5 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 relative to the local background.

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 the direction. 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 appear unchanged by relative motion but, under FR, the magnitudes, e.g. the speed of light and mass, depend on the clout of the 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.

2.5.6 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, but their magnitude will change if the background changes. The intervals are not invariant if the density of surrounding matter changes.

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. appearing independent of an absolute background. The increase in clock-rate with altitude appeared consistent with larger time intervals meaning time was proceeding faster. So, the same frequency appeared slowed, and the wavelength lengthened, in line with the observed red-shift of the photon with altitude. Under FR, the apparent red-shift of photons is a blue-shift of the energy of atoms and the energy of photons is unchanged after emission. The real increase in clock-rate with altitude corresponds to shorter time intervals between the ticks of a more energetic clock.

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 derived that the underlying clock-rate of clocks stationary in a frame, was independent of any relative (at constant velocity) movement of two frames. 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. However, the changed decay rate, seen either in a circular accelerator or in a straight line from the point of generation, is real in the moving frame. 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 a massive object moving relative to this background.

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 without a light signal being sent from the light-pulse clock. This will alter the apparent time intervals and the amount will differ according to whether the observer is moving to or from the clock.

The fabric of space-time, under GR, is even stranger than under SR. GR has it that matter distorts the geometry of space and time, but c is always the same for a local observer. (One in the same region of constant matter/energy density.) The magnitude of the effect on "time", from a change in energy density (via potential) is seen in the increase in the clock-rates of the GPS satellites by the factor γ. 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 readily observable. The distortions go to zero far away from other massive objects and increase when there is a gradient in the density of matter. 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 depth of the distortions and the total energy of the system head to infinity. This requires that the fabric holds 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.

2.5.7 The fabric of space-time is an illusion

Einstein expected the principle of relativity, "like every other general law of nature" [20], to apply to light. He, and many others, have then claimed that the speed of light in vacuo will be constant, independent of the speed of the observer, consistent with the theory of electrodynamics. The claim has become that all moving observers, independent of their speed, will observe the same speed of light. The addition of velocities is then non-linear, and their sum can never exceed the speed of light.

He concluded that our physical conceptions of space and time are altered, according to the LT, and only their combination in the speed of light is constant or invariant.

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 based on the belief, set out in Section 2.3 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. The observation of spherical radiation requires that the movement of the observer during the propagation time of the signals is 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).

Observations require that the time in the frame of the moving object must be slowed (expanded) because the decay rates and emission frequencies of such objects are slowed. If the measured value of c is to be the same 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. The incorrect contraction of both time and distance intervals will give an increase in the unseen (imagined) speed of light that cancels the effects of changed propagation times with increased separation and the slowing of time with motion relative to the background.

This provides a revised perspective on the nature 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 make them appear simultaneous 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 does not mean that the rate of passage of time is subjective. The LT can be used to convert observations of the location of a moving object by a stationary observer (using light signals) to the apparent, but not actual, position of the moving object. The contraction in distance and the time reduction are only apparent and not real.

The frequency of signals emitted by objects were not part of the thought experiment. Einstein actually assumed 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 be most easily explained by a real time dilation. FR claims a real increase in time intervals experienced by massive clocks moving at high-speed relative to the mean stationary 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 only becomes apparent 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. The dilation in time intervals by the factor γ means the elapsed time, observed after correction for the delay in transmission with increasing distance, is reduced by the factor $1/\gamma$. The addition of apparent velocities will appear non-linear but may not be true for actual velocities. Clock-rate of massive objects is a non-linear function of speed relative to the stationary background and the dependence of inertia on velocity needs re-examination.

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.

2.6 Summary

Einstein's derivation refers all measurements of distance and time back to the stationary observer. Such a procedure 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 altered by the movement of the object during the propagation time and this leads to an apparent increase in speed of movement both towards and away. The derivation interprets the apparent increase in distance travelled (contraction in distance intervals for the object) and apparent decrease in time intervals as real and applicable to the object. The conclusion is not possible without examining signals emitted by the moving object. The observed timing of emitted signals can only arise from a <u>real</u> increase in time intervals (a slowing of time) for the object with increased speed relative to a stationary background, giving an <u>apparent</u> reduction in distance intervals. The derivation of the LT in SR is faulty and does not establish either of the postulates used, i.e. that the measured speed of light is constant or that only relative motion matters.

The mixed interpretation of time intervals in the LT meant all the experimental tests of SR appeared to hold, and enabled SR to be widely accepted. However, the conclusions of SR are unjustified and internally inconsistent with observation. A dependence of time on movement relative to a stationary background is essential. There is no requirement from SR that the speed of light be constant between different but constant backgrounds. The deductions and postulates of SR are incorrect, particularly the invariant interval of space-time, but were taken over into GR.

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 <u>relationships</u> 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 and treats apparent effects as real. Only the slowing of time with speed relative to the background from other matter is real.

The changes in understanding make possible a background-dependent theory of gravitation in which the speed of light and mass both vary with the background. GR has the distortion of the fabric of space-time (in which objects are embedded) dependent on the difference in potential whereas the revised theory has the properties of objects dependent on the total background potential. The theories will give similar predictions for small changes in the current background. Hence, the current, local, experimentally confirmed predictions of GR can be reproduced. However, different predictions arise when or where the background is substantially different. This is the key to removing the need to postulate dark energy, dark matter, and cosmic inflation.

The observed behaviour can be explained if the speed of light (massless quanta), but not massive objects, depends only on the magnitude and not on movement relative the background due to all other massive objects. The real slowing of clock-rate for moving massive objects implies that the current observations are made from an approximately stationary background. It leads to the prediction that decay rates of particles, stationary relative to our 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, due to the clout from matter and antimatter, are altered.

Chapter 3

Background dependence versus General Relativity

The differences between GR and a background-dependent theory, such as FR, are explored. Under FR, gravity does not arise from a distortion of the geometry of space-time between massive objects but from changes in the energy that can be stored by particles, when the background changes. It is the objects and their properties that change and not the geometry of space and time between objects. Their combination as space-time is an illusion. It was faulty in SR and so cannot be taken over into GR. Nevertheless, GR has given some remarkably successful predictions, and so the similarities and differences between space-time and a background need to be examined. However, it is also explained how background-dependence should be expected and overcomes a number of problems with GR.

The proposed background (of FR) alters properties of objects with the rate of events (time) depending on its magnitude (the clout or the negative of the potential). Time intervals for light to travel the same distance depend on 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 exists as soon as the massive object is present. The propagation is instantaneous. GR is independent of the absolute level of any background and only dependent on relative changes, i.e. on relative gradients and motion. 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 some aspect of the background changes.

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 postulate that only relative motion is important. 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 background masses that determines the strength of gravity. Hence, a uniform field has no effect. This is familiar in electrodynamics which is independent of a uniform, isotropic background of electric and magnetic fields. The effects from the same electric or magnetic fields in opposite directions cancel because they are vector fields. Cancellation does not occur for scalar fields such as pressure. 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 dependence of mass on a uniform background can then be 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 background clout (or 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 clouts 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 ($\hbar$) 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 $\hbar$ can be questioned if it varies with a property of the background that does not affect energy and momentum. The measurement of $\hbar$ 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 particles at the same location. All this seems to imply that momentum and u-time will have a fixed relationship (via $\hbar$) 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, do not seem to be 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 $m = E/c^2$. Further comments on time can be found in Section 4.5.2.

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.

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 (whose second derivative 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 red-shift of the photon, proportional to [21]: $dt_1 = (1 + \frac{\phi_1 - \phi_2}{c^2})dt_2$, [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 blue-shift of atoms with increasing potential as a red-shift of photons hides the inversion in the interpretation of time intervals.

Minkowski [22] 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 [23]. 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 [24] are consistent with this revised perspective and the lack of any contraction in length intervals [25].

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. $E = mc^2$ [26].

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 mass density) 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 mass density 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 mass density of surrounding matter. 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 an object midway between identical masses feels no gravitation because matched distortions (either an expansion or a contraction) should not cancel. A distortion in space and/or time from one direction should be unable to cancel the distortion from an identical mass in the opposite direction unless time depends on the spatial direction to the source. GR achieves 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 $\vec{a} = -\vec{g}$ [27]. 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 by a uniform clout 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 well away from any 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 clout from surrounding, uniform background matter has no effect. The theory 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 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 the strong and weak interactions also have a form 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 observed, as Lorentz had found, that changes in a moving frame can be interpreted in terms of a dilation of time and a contraction in distance intervals, 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 γrather 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) because 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 $ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2$ [18]. 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 $\mathrm{distance}/c$. 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 $\mathrm{distance}/dt$ 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 also be formed based on $(E/c)^2 = p_x{}^2 + p_y{}^2 + p_z{}^2$, if energy minus the product pc also adds to zero.

Einstein [9] and Minkowski [18] 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. $\omega \propto 1/d\tau$ [22]. Hence, these time intervals are larger at higher gravitational potentials (lower mass densities) meaning the frequency of photons is lower (red-shifted). 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 red-shift 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 blue-shifted at higher gravitational potentials.

GR has time and space intervals distorted, so that a faster time is interpreted as an increase in time intervals and cdt, and a decrease in distance. 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. There should be no change in distance between stationary objects if the background energy density or speed of light changes. However, the size and apparent distance of a source of fixed brightness will be altered if the speed of light changes.

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 (no gravitational acceleration), which appears to be invariant under Lorentz transformations. SR has the apparent time and distance intervals dt and dx, altered in way consistent with only relative motion being important because of the finite and constant speed of light, which is independent of the speed of the observer. 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 analysis the SR predicted slowing effect had also included the deduction 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 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 [28]. 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 as older.

Background-dependent FR has clock-rate slowing for the twin (massive object) who is moving faster relative to the background clout from other massive objects. The speed of light, however, has only a scalar dependence on the background. Under FR, a higher 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 [29]. Another is that the concepts of time in quantum field theories and GR appear incompatible [30]. 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 Mass density 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 energy, can act as a source of gravity.

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

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

The curvature, and gradient of the acceleration, are directly proportional to the stress-energy tensor, the generalisation of mass density (ρ) to the density of energy and momentum.

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, to Newton's law (equation 1.1). The procedure will be repeated, following Cheng [31], to better understand the origin of the mass density function.

The gravitational acceleration field (force per unit mass $\vec{F}/m$) for a point mass M is:

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

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

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

The area integral on the LHS is the gravitational field flux through any closed surface S, and M on the RHS is the total mass enclosed inside S. 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:

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

<u>If this relation holds for any volume</u>, the integrals on both sides must also be equal. Hence:

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

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

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

The divergence of a vector field 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. Hence, equation (3.3) is based on the assumption that gravitational acceleration is the conserved flux of a vector field. The vector field arises from the gradient of a scalar field (the potential ϕ per unit mass). However, conservation of this flux carries the assumption that force per unit mass is constant independent of the environment over which the field extends (the volume). (Under GR, mass can give rise to a distortion of the surrounding space-time that accelerates objects but it leaves their mass unchanged.) Hence, the differential form of Newton's equation (1.2) assumes that mass is constant independent of the background mass density. The integral equation (3.3) does not hold if the background affects mass and hence alters the flux of the acceleration field.

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. Thus, if the gravitational force falls of as $1/r^2$ from a constant source of mass, as it does, then the LHS of equation 1.2 should be zero. The implication, if equation 1.2 holds, is that a mass density outside any matter produces a divergence in the gravitational field and therefore acts as a source of gravitation. 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. There is a basic inconsistency between a vector field that arises from mass (a form of energy) but reduces as $1/r^2$, because it means that the surrounding space acts as a source of energy even when no energy is enclosed. It is something from nothing.

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 gradient in potential.

It has been shown (Chapter 2) than 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 a faulty interpretation of the Lorentz transformation. The Einstein equivalence principle does 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.

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 wrongly 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 gravitation. 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 divided by c^2) 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. It is not a distorted space-time, but a reduction in the energy that can be stored, as background density and the speed of light increase, that gives rise to gravitational acceleration. 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 for 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 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 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 christened Full Relativity (FR). Clues to its further properties are available in the nature of energy, momentum, and inertia, for 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 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 per unit mass. The assumption of constant mass equates to independence from the absolute value of an isotropic background. Changes in the force are then due to nearby masses (local anisotropy). Under FR, changes in a large background clout can be hidden because the potential is 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 galaxies was the same as that of the Sun then the night sky should be as bright as day. This indicates that the brightness contribution of galaxies is much less than our Sun. It is an approximate argument as there is evidence that there is a larger amount of mass in neutral gas clouds than in stars and it also assumes that the light is not significantly blocked or redshifted.

If the speed of light was determined by the background density of matter then the flux contribution of a mass$M$ would be expected to fall off as M/r^2. In this case, 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 apparently uniform strength of gravity, within our solar system, requires the contribution to the background from outside our solar system to be much more important. This is not possible if the contributions 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 x 10^8: 4 x 10^5 : 1.

Newtonian gravity has the potential (energy that can be given per unit mass to a tiny test mass from a point source of mass M) falling off as $1/r$. 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 [32], the inherent nature of space, under Newton, was Euclidean and there existed an absolute space and time. Newton believed in a three-dimensional space that exists at every moment of time and that identically the same points of space persist through time. Space was homogeneous and isotropic and so the behaviour of objects was independent of position and direction of travel. This, his first law of motion, requires a metric, a geometric structure, of both space and time. Absolute space without relation to anything external remained always similar and immovable. Absolute time proceeded equably without relation to anything external. In Newtonian space and time, objects travel in straight lines at fixed speed unless acted on by a force.

SR has the observed scale of 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. GR takes the metric another 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, 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 wavelength/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 in which the potential 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 clout 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 is demanded because a flux of energy should 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 that a loss of stored energy can appear as energy of movement, implies 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 should be c^2 times the light-clock time interval. 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 moving 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 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 depends on its rate of change of momentum, which depends on relative velocity. Inertia should depend on the mass and its rate of change of movement relative to its current state but also 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. Moreover, the increase with speed 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 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 due to the local clout that arises from the position, magnitude, and movement of all 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 (once 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 relationship relative to their previous position and to the properties of the stationary background. For massive particles, the relationship depends on their velocity relative to that background plus 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 is proportional to (some combination of) the magnitudes of the background components and the frequency of oscillation 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 momentum, once emitted, is independent of the background. 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 arise from their interaction with this field [33], with the observed mass depending on the particle's "energy absorbing" ability, and on the strength of the Higgs field [34,35]. 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 theory 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 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 have 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 Standard Model of particle physics 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 seems to follow that chirality must be involved in the background-dependent interactions that give rise to mass and affect the energy of motion (momentum and inertia).

These considerations imply that the additional aspect of the background that gives rise to the vector dependence, apparent in inertia and momentum, is associated with the different handedness (chirality) of matter and antimatter. 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). This suggests that the background has contributions from both matter and antimatter, but the chirality does not lead to trapping of energy for any of the exchange bosons associated with interactions that are massless. 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. 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 and opposite spin relative to the direction of motion but identical mass. For these pairs of particles, the magnitude of chirality must be equal for all the interactions that give rise to the storage of energy.

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.

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 energy, its speed of movement relative to the background and on the rate of change of movement (i.e. have $F \propto d\vec{p}/dt$). The magnitude and frequency of the rotating components might reflect both the magnitude of the momentum carried in the components and any differences in the number and magnitudes of the chiral components of the background and the object. This could give a dependence of inertia on oscillation frequency as well as stored energy and the ratio of gravitational to inertial mass (m_g/m_i) might 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. However, the measured clock-rate also changes by $1/c^2$ in a gravitational field, so the ratio of inertial to gravitational mass appears constant. However, our measurements are probably within a region of similar asymmetry and the visible effects of an inertia that depends on the product of gravitational mass and asymmetry might be small (just as the fractional change in mass is small). The effect on time is hidden if the method of measuring time does not include inertia. Currently, time in terms of clock-rate, is that of clocks locked to a constant frequency of the photon from a particular atomic transition. The method appears to lock the number of wavelengths travelled by electromagnetic radiation in a given time to the wavelength of the atomic transition. If this is the case, then the clock-rate of massive objects would be independent of any oscillation whose frequency, per unit of energy, is the same for standing and travelling waves. Changes in the time of such clocks would only reflect changes in the amount of stored energy due to changes in the speed of light. Changes in inertia would appear as differences in the apparent strength of gravity in altering speeds of motion with changes in the ratio of inertial to gravitational mass. The change in distance travelled due to a variable speed of light would also be hidden if the size of the clock changes in the same proportion.

Time (clock-rate from photon frequency) is observed to increase with gravitational potential (ϕ), with the change consistent with the change in stored energy ($\Delta\phi/c^2$). Planck's constant (h), which relates frequency to energy, could still vary with asymmetry of the background, if this influences the rate of oscillation. 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 the mean 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 total momentum unchanged. This seems to imply that matter and antimatter are exact mirror images with the clout of their stored energy involving a balanced contribution from 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. A small ratio of inertial to gravitational mass may explain 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 might explain why the strength of gravity in the solar system appears to be consistent with constant inertia per unit of mass but an increasing strength, or decreasing inertia, with distance from the centre of the galaxy.

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 large, the fractional change in asymmetry due to δA will tend to zero. If the contributions to clout from each chirality are similar, then a gradient in just 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 always appear proportional to the local gradient in potential, but the proportionality factor will reduce as the background asymmetry increases, i.e. in moving towards the centre of a galaxy of only matter or only antimatter. For small changes in total clout, the change in inertia will appear proportional to the local gradient in one component (and with the supposed flux of the matter density of GR), with the dependence on total clout (and fractional asymmetry) hidden by equating the local values of inertial and gravitational mass.

This introduction of a rotation/oscillation that has a dependence of frequency, and of an inertia with a dependence 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 equilibrium state should not exert any force or torque that requires energy if there is no change in speed. The state 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 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-rotating contributions. If the magnitudes of the chiral components of the background were equal (i.e. arose from equal background contributions from matter and antimatter) then there would be no net rotation of the oscillations of all such stationary states. Such a balance might mean that no force would be needed for a new alignment and inertia would tend to zero.

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 $\rho_1\alpha = \rho_2/\alpha\rho_1$ and $\alpha = \sqrt{\rho_2/\rho_1}$. This is reminiscent of the speed of light being $c = 1/\sqrt{\mu_0\varepsilon_0}$. The proposal appears to be a promising step towards having a persistent field that, once established, does not involve a flux or flow. It needs to provide a $1/r$ dependence on distance from the source, which would be inconsistent with a flux or flow because a flow should decrease in strength in proportion to the increase in surface area of a sphere enclosing the source (i.e. a $1/r^2$ dependence).

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).

These are comments and speculations on how the two components of the background might combine to produce rotations and oscillations that determine the speed of light and inertia. A decision on how they combine needs further experimental and theoretical investigation.

4.3.4 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 direction of rotation of the components relative to the 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 to increased speed relative to a stationary background.

The size of the background affects mass and inertia via the speed of light. Gravitational forces arise when there are changes in the background with position. Inertial forces arise when the properties of an object need to change due to changes in its current velocity. The magnitude of this inertia depends on 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 (or density) 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 observed 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 momentum (mv) increase in accordance with γmv, with velocity v.

The sensitivity of momentum/inertia to speed seems to suggest that mass is increased by acceleration. However, it then should be able to be released by deceleration. In addition, particles moving at high speeds ($v/2$) from opposite directions relative to the stationary observer, provide more energy for the creation of new particles, than one particle moving at v hitting a stationary target. The energy available (under SR) reduces because of the larger increase in γ for the particle moving at v relative to the observer. 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 only apparent. There is an increase in inertia with speed relative to the approximately 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 appears to require 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, inertia is firstly dependent 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 massless chiral background interacting with oscillating wave/particles that contain chiral components. For massive particles, the degree of helicity is a measure of the alignment between spin and the direction of motion. The apparent alignment depends on the relative speed of motion. Under SR and GR the alignment of a massless particle cannot change because no observer can exceed the speed of light. Under FR, the alignment and therefore degree of helicity of a massive particle should be a measure of speed relative to the background. It is proposed that the alignment with the direction of motion and the frequency of internal rotations will depend on speed but that the stored energy is unchanged. The degree of 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 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 is also an effect on inertia, and on 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, but the degree of asymmetry could vary markedly with distance from the centre of an isolated galaxy. However, free-fall motion should lead to an apparently isotropic background. 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 next step is to fully formulate the nature of a background and of massless and massive particles that agrees with observations.

Under FR, gravity is due to a background whose magnitude alters the speed of propagation of both gravity and the quanta of electromagnetic radiation. An increase in the speed of light reduces the energy that can be stored by matter. Changes in the strength of both gravitational and electromagnetic fields propagate at this speed. This strongly indicates that electromagnetism and gravity are related aspects of the one background field. The stored energy of objects embedded in the field is determined by the magnitude of the background which arises from the presence of all other objects. The gravitational force per unit of stored energy is due to a gradient in a scalar magnitude of this background. An electrostatic force on a charged object arises from a gradient in a vector electric field from any charges embedded in the background. A magnetic force on a moving charged object arises from a field generated by an alignment of the spins of surrounding atoms or by the rotation of charges about an axis. FR has strong, electromagnetic, weak, and gravitational interactions all being part of the one fundamental set of interactions that generate forces that confine energy to the current location, i.e. give rise to mass. The one background needs to be able to embody all these aspects.

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, it is proposed that 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 a balanced combination. 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. The asymmetry of the contributions will decrease with distance from concentrations of either matter or antimatter in a uniform background.

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

An outline of a plausible underlying physical picture, embodied in the background-dependent theory of FR, is set out below. It may not be fully correct but is put forward as a further 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 freely travelling states (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 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 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 being determined by the speed of light as $1/c^2$. The speed of light depends on the clout, which is determined by both 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 both oscillate and 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 rotate. An increasing excess of either chiral component increases the frequency of a 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 the 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 the net rotation still provides 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 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 contributions. However, within regions of predominantly one chirality of matter, the speed of light may have a weaker dependence on changes to the dominant contribution. In addition, 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 which may be because the other background component has to increase by the inverse amount to maintain a balance.

A fractional increase in the magnitude of 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 stationary state of reduced energy is then less confined. Massive objects become larger so the length scale of space (the distance between stationary objects if it could be measured using 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 object (i.e. within the length of a continuous massive rod). 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 massive rods) was moved to the 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 $E = h\nu = pc$ 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 can be interpreted as the wavelength of light of a particular momentum or the amplitude of the trapped angular momentum of a massive (or massless) 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 sum of components times the factor $\sqrt{\rho_2/\rho_1}$ (see Section 4.3.3). The factor is very small for $\rho_1 \gg \rho_2$ and $1/2$ for $\rho_1 \simeq \rho_2$.

This possibility of a reduced effect of changes in the dominant component was introduced because it might be used to explain why the changes in the speed of light, required to explain gravity, appear to be so small. It seemed that the explanation of flat rotation curves required that a galaxy, near its centre, had a significant excess of like matter contributing to clout. The speed of light should then be expected to change significantly. However, the rotation curve has already flattened significantly not far from the central bulge of spiral galaxies, which implies that the asymmetry between contributions from matter and antimatter is already small. It is not clear whether there would be observable consequences, apart from rotation curves and the amount of bending, that would throw light on the way matter and antimatter contributions combine. Possibilities seem to be measurable changes in the value of Planck's constant or G_N with distance from the Sun.

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 interfering 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 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 by, massive objects. Local frequency and the inertia of a given stored energy decrease with decreasing asymmetry, with distance from a concentration of one chirality. Differences (between GR and FR) will appear when comparing regions with different total clout, or differences in asymmetry, where there are separate means of assessing clock-rate, distance or local frequency and 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 trapped momentum. 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 the background. If chiral components are equal then constant movement can be balanced by a matched pair of fluctuations. Inertia only occurs when changes in motion require a net force to alter the fluctuations.

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 be in 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 storage 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 dependence of clout on linear density 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 the field does not carry energy (in the direction of motion), 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 magnitudes of its energy and momentum are not altered by a gravitational field. Thus, the energy and momentum travel freely 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 has a pair of opposite components and can remain even in the absence of visible photons. It appears to be the same with gravity. 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 are both conserved. The background field can then be seen as a balanced two-component chirality that enables the existence of states that trap momentum and enables the transport of energy but 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 [37]. He proposed an alternative that depends solely on the GR 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 one part of the orbit could overtake light emitted earlier from another part. This is not observed. The postulate corresponding to 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 then appeared consistent with photons losing energy in a gravitational field whereas photon energy was unchanged. Instead, massive atoms stored more energy when the background decreased, time ran faster, and the speed of light was 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 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 ($p = \gamma m v$) 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 moving faster, then it should be expected to freely release this energy by slowing down. The inertia of the same amount of energy must be what changes.

In his 1905 paper [26], "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 [19], that the inertial mass and the energy of a physical system are equivalent (for all frames). Consequently, there is a widespread fallacy that the mass of a body increases when its velocity increases (following $p = (\gamma m)v$). Okun has pointed out [36], 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 [38].

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 as a function of 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 the small change due to speed within 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 an oscillating force 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 mass of the photon is zero 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 a cyclic force about a mean position. A change of this mean position, relative to 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 resists changes in direction, 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 they are also freely travelling states with a net chirality giving a rotation in 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 0 rather than spin 2 (and not oscillating and not carrying energy).

It appears that energy and momentum are both conserved for a photon (even if c varies), that $E = pc$, 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 ($p = \gamma m v$), 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 rate depends only on velocity 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 (mass) between the initial and final states.

However, the increase in momentum with velocity does not necessitate that gravitational mass increases with velocity because the inertia of the same amount of energy may increase. Moreover, if mass increased, 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 if inertia changes with speed relative to a stationary background. It is proposed that a stationary position in this background corresponds to a location where opposing components of massive particles are balanced without counter-rotation. 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, $p = \gamma mv$ 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, they 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 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 changed spacing between objects requires a force giving an acceleration. Space exist in terms of a constant separation and direction of objects if they initially move at the same velocity and neither accelerates. The backgrounds experienced by the two objects must be 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 time allows for the relative rate of events when the stored energy of the "same" massive object changes with 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. This energy clock-rate will vary with the energy of stationary atoms but will be independent of the inertia which resists changes in the speed of massive objects.

This 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. 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

Inertia and oscillation frequency of photons appears to reflect their 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 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, $G_N M(r) m_g / r^2 = m_g v^2 / r$ and $M(r) = (m_g/m_i) r v^2(r)/G_N'$.

The conventional explanation, of the constant speed independent of r, under 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. The effect is to decrease inertia, at large distances from a concentration of like matter, by the same amount as the change in that one component alters the speed of light. This removes the first reason for postulating dark matter.

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 greatly 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 is also removed because the bending of light is from changes in oscillation frequency. This 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. The putative amount of dark matter needed to account for gravitational lensing can then match that needed to explain the flat rotation curves.

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 [39]. The strong correlation implies that, if dark matter exists, its distribution is fully determined by the baryonic matter. However, the change in inertia, under FR, explains the relationship with visible matter without the need for dark matter. Further aspects of this explanation will be set out in Chapter 7.

4.5.4 The relationship between clout and the speed of light

Clout is proposed to arise from contributions from the energy stored in 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 $W = \int F dx$. 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 and to the change in wavelength.

4.6 Elaboration of the changed perspective and hypotheses

It is proposed that the following set of hypotheses has the potential to explain observations.

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 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 value between stationary objects, exists independent of the background.

6. A constant time scale exists in which energy and momentum are conserved, and in which speed of light 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. The $1/r$ dependence of clout appears to require 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 movement of massive objects.

The stored energy of the same amount of matter will increase in proportion to $1/c^2$ but 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 energy will vary as $1/c^2$ and as $1/c$ in terms of changes of momentum.

The decrease in stored energy with increasing speed of light is strongly suggestive of the trapping of momentum being dependent on the time taken for a fluctuation in a property of the medium to be cancelled by another fluctuation in the medium. This appears to be a direct consequence of the chiral nature of the background and the nature of the periodic oscillations that can be sustained. Ultimately, this must tie in with the Standard Model of particle physics.

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 of 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> red-shift, while FR has $\Delta\omega_a/\omega_a = \Delta\Phi/c^2$ for the <u>atom</u> blue-shift. The two theories give similar results for small changes to the current background energy density and speed of light. GR has the KE energy 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 the energy of massless particles unchanged and not contributing to gravitational attraction.

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, 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 red-shifted as potential increases to the surrounding massive objects being blue-shifted 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. There is also a matched decrease in the size of space (distance between objects) so the combined distortion gives twice the earlier predicted bending. The tensor formulation of GR using gradients means that space-time distortions are independent of a uniform background. The distortion of the invariant interval of Minkowski space-time incorporates the faulty inverted distance versus time interpretation of the LT.

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 needs 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 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, from a pseudo-background that alters the perceived time and space of events, to a real background that affects the properties of objects leads to many changes in understanding. These include that momentum is conserved but that the apparent energy depends on 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 no net trapped momentum in the direction of motion but still carry energy.

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, this 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. The unification of gravity with other forces via the shared back**g**round means that the quantum mechanical interactions of particles physics and the properties of gravity must be related. This is set out in Chapter 8. Implications and 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.

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 force per unit of gravitational mass m_g defines the gravitational acceleration as: $\vec{g} = \vec{F}/m_g$.

Under GR, the units of gravitational and inertial mass are equated. Under FR, the ratio m_i/m_g is approximately constant within our solar system to the extent that the fractional asymmetry between matter and antimatter backgrounds is constant. Changes in the value of the ratio m_i/m_g get 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.

Under FR, total energy and momentum are both conserved, with the energy lost as mass appearing 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:

$$\int (F/m_g)dx = \Delta KE/m_g = \Delta(m_g c^2)/m_g = -G_N\, M/r \qquad (5.1)$$

with distance r from a point source of mass M.

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

$$\Delta E/E = \Delta m/m = -G_N M/rc^2 \qquad (5.2)$$

The acceleration of an object arises from the gradient per metre in potential (energy per unit mass) at a surface surrounding a point source of mass M at distance d metres, i.e. $-G_N M/d$.

The clout from a point source of M kg is $G_N M/d$, relative to 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:

$$\Delta\rho/\rho_B = (M/d)/\rho_B \qquad (5.3)$$

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

$$(m + \Delta m)/m = \rho_B/(\rho_B + \Delta\rho) \text{ and } \Delta m/m \cong (-\Delta\rho)/\rho_B \qquad (5.4)$$

and: $$G_N M/rc^2 = M/r\rho_B \qquad (5.5)$$

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 $G_N = 6.67408 \times 10^{-11}$ m^3/kg.s^2

The value absorbs the ratio of inertial to gravitational mass into the proportionality factor between stored energy and the energy needed to overcome resistance to changes in movement. If m_i/m_g decreases, then G_N will appear to increase.

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) of the small test mass. The observed gradient appears to reflect the fractional change in mass of the object due to the effect of a fractional change in one of the two background contributions to the speed of light. This gradient can be equated with the gravitational acceleration field, or inertial force per unit mass, 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 mass density. However, under FR there is no fixed relation between clout and mass density. 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 becomes significant near the centre of a galaxy but the change in asymmetry within the region of our solar system is small. The effect of a small change in inertial to gravitational mass will be absorbed into a slightly changed value of G_N.

This dimensionless energy equation 5.2 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 constant 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 incorporates 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. The ratio of inertial to gravitational mass, implicit in the relationship between inertial clock-rate and time, is incorporated into the value of G_N/c^2.

If momentum is proportional to inertial mass times velocity relative to c, and the ratio of momentum to energy for massless photons is $1/c$, then the value of G_N in Newton's law includes a dependence of inertial clock-rate relative to u-time of m_i/m_g. Inertia and quantum oscillation frequency could then have a fixed relationship for massive and massless particles independent of u-time or c. The frequency of oscillations and inertia could still have the same dependence on fractional asymmetry, independent of movement relative to the background, even if momentum is no longer directly proportional to gravitational mass at high velocity.

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 energy ΔE). This energy appears as the kinetic energy of the object, which reflects its resistance to changes in velocity.

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 M is influenced by the 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.

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 allow the transmission of this energy to new locations. 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 [40], 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 and 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 opposes the decrease from any expansion. If there was a boundary to the universe then gravitational attraction should strongly oppose expansion. Therefore, it is not clear that ongoing expansion would occur. The redshift of distant galaxies indicates that clout is decreasing over time but it does not have to be a result of 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. However, the gain in KE from the reduction of stored energy can cause the masses to move apart again. Objects moving closer (i.e. clumping) gain KE and lose mass. However, if there is no dissipative mechanism, 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.

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 lead to contraction of orbits. 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 decreases with increased clumping.

Hence, the clumping of matter can reduce the background clout, even if there is no change in average density. 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 dense concentration of like matter, such as the centre of a galaxy, might then evolve into a region in which there is a significant local asymmetry between the components of the clout. The strength of gravity between objects rotating about each other (within a region of similar asymmetry) would appear to decrease but would most likely be attributed to a lower-than-expected mass of the components. The mass of the black-hole at the centre would 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 need to be resolved.

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 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 massive events) 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 an increasing density of 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 mass density, 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.

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, then the external distortion can no longer change and hence cannot move. Yet putative black holes are observed in revolving binary star, and binary black-hole, systems.

The observed propagation of gravity outside a black-hole is evidence against the strength of gravity being red-shifted, as claimed for light under GR. Under GR, the red-shift 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 the 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 corresponds 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, it seems very unlikely that matter and antimatter repel.

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) [41]. However, FR appears to 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 could 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 an approximately uniform sea of matter and antimatter. The apparently identical energy levels of anti-hydrogen and the dependence of the speed of light on clout also suggests that both matter and antimatter would lose energy in moving to a region of increased density from either source, so that antimatter would fall in the Earth's gravitational field.

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 [42]. 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 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 no energy would be released on annihilation.

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 has also been larger than expected. This has been used as the evidence for the gravitational attraction of unseen dark matter. Other predictions have included the apparent gravitational redshift of light and the (Shapiro) delay in light signals passing massive objects. The many successes of the 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 [43]. This follows an earlier conjecture by Schiff [44] 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 [45] and a Newtonian special relativistic analysis of redshift, light-bending and Shapiro delay [46]. 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) [47].

NRM has the gravitational force at distance r from a stationary, spherically-symmetric, source of mass M, proportional to $\vec{F} = d\vec{p}/dt = -\gamma G_N Mm\hat{r}/r^2$, 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 without a warped fabric of space-time.

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 consistent with Newton's law of gravitation. The energy balance equation of Newton's law is per unit of stored energy and each term is per unit mass so the change in mass has no effect on the force as a function of position (i.e. independent of time). However, the change in mass induces a change in velocity (in order to conserve momentum) with distance from the Sun. The velocity as the mass is reducing will therefore be faster than expected and so give rise to an advance in the perihelion.

The calculation of the amount predicted under FR can be compared with the GR prediction based on the supposed distortion of space-time. 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) [48]. 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:

$d^2r/dt^2 = -G_N M/r^2 + J^2/r^3$, 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:

$d^2r/d\tau^2 = -G_N M/r^2 + J^2/r^3 + 3G_N MJ^2/c^2r^4$, where τ is the proper time and does not contribute to orbital advance [49]. The additional term acts like a r^{-4} type of force with the factor of 3 arising from the differentiation of $1/r^3$.

The fractional change in velocity under FR is due to fractional change in clout of $G_N M/rc^2$ with distance from the Sun. The change exactly mimics the effect of the change in time 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.

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. This is only part of the delay; that attributed to the slowing of time (clock-rate) in a gravitational potential under GR. Under FR, the slowing of time (clock-rate) is irrelevant for massless photons, and instead their speed increases. However, there is a larger part to the delay when the light spends only a small amount of its path near the massive object. It 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 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. It changes only slowly and, for measurements within our solar system, will be absorbed into the calculated orbital parameters. It is therefore claimed (here) 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 a 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 frequency of rotation/oscillation, in the plane perpendicular to the direction of motion, will increase in proportion to the speed of light, and hence to clout. (The oscillation/rotation will double the amount of bending relative to that from a linear change in speed along a single axis). 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 frequency that is constant per unit energy. Any change in background that alters frequency perpendicular to the direction of motion will cause bending. This could arise from changes in the total background or from changes in the local asymmetry in the contributions to clout from matter and antimatter. Changes in the speed of photon oscillation in the plane perpendicular to its direction of motion is the source of bending.

The direction of a photon will be bent by a gradient in light speed in the direction of increased light speed and by an amount that matches the distortion in both space and time that gave rise to the doubling of the predicted bending under GR. The doubling is because the bending arises from changes in a circular oscillation. It is analogous to a helical path viewed in cross-section along the direction of motion, which appears like a zig-zag with two changes in direction per cycle. The amount of bending should also depend on asymmetry if it affects the local ratio of inertial to gravitational mass (and the difficulty of changing photon direction). The gradient in asymmetry will be proportional to the gradient in clout within a region in which the change in total asymmetry is small.

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 such as our Sun. Under FR, the amount of bending is determined by the gradient in both clout and asymmetry which affect oscillations perpendicular to the direction of motion. If the background chiral component from antimatter was constant over the region of interest, then the fractional asymmetry would change in proportion to the gradient in potential. However, the proportionality factor will increase as the asymmetry reduces. If a galaxy is an isolated excess of matter in an approximately uniform background of matter and antimatter, then the amount of bending will be larger than expected (from GR or if there was no dependence on asymmetry) at locations further from the centre of the galaxy.

Hence, GR and the effect of asymmetry under 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 observed gravitational acceleration if inertia is assumed constant.

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 [50].

5.6 Summary

FR changes the understanding of many phenomena but appear 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 revised understanding is already present in an altered form of Newton's gravitational equation as embodied in equation 5.2.

$$\frac{F}{mc^2} = \frac{\partial E/\partial r}{E} = \frac{\partial m/\partial r}{m} = -\frac{G_N^{'}}{c^2}\left(\frac{m_i}{m_g}\right)\frac{\partial}{\partial r}\left(\sum\nolimits_n \frac{M_n}{r_n}\right) \qquad (5.6)$$

where the value of $G_N = G_N^{'}\left(\frac{m_i}{m_g}\right)$ reflects the local value of the background clout and asymmetry.

The gravitational force $F = \partial E/\partial r$ depends on the gradient of the total clout. Equation 5.6 is a time-independent energy balance equation. It does not directly incorporate the finite propagation time of gravitational effects. However, 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 and the required consistency if the same background determines all forces. This awaits a clearer model for how the magnitude and asymmetry of the background give rise to particle states, including their mass, inertia, and spin. 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. 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 a gravitational acceleration which depends on the gradient of a gravitational potential that appears independent of a uniform background but is not.

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. Potential new predictions and improved explanations of existing phenomena also require investigation.

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 explain 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 [51]. 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'" [52]. 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 background of 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 red-shift experiments. However, great care needs to be taken in the interpretation of apparent changes in clock-rate, frequency and wavelength at different locations. The measuring system must be moved between locations with different backgrounds, or electromagnetic signals, whose speed can depend on location, must be used. 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 red-shift 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 blue-shifted.

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 similar proportion to the current, locally observed, values. Hence, the predictions are the same in our region of the solar system, now (i.e. over a time period during which the current background is unchanged). 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 only show up when comparing behaviour in regions or times with significant differences in clout due to changes in the speed of light and to inertia with asymmetry.

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

The first place where such differences occur 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. The observed red-shift 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 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, for the universe to be expanding.

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 reflect an increase in speed of separation with distance. However, the wavelength will not be stretched by increased separation of the source and receiver, because the photon is sensitive only to the magnitude of the background. Under FR, the space between objects does not 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 increase with distance, but a significant rate of slowing implies a large gravitational attraction and such an attraction should now be much larger.

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 or inverse pressure in that it pushes galaxies apart 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 space-time, 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.

Under FR, the measured change in wavelength is primarily 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 $(c_0/c)^2$ because the stored energy of the matter that makes up the clocks will have increased in this proportion. The trapped momentum of the energy levels of atoms when the photons were emitted will have been lower in proportion to c/c_0, and the energy levels will have been lower in proportion to $(c/c_0)^2$. So the ratio of the wavelengths at emission to now 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 energy 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 time-scales of individual light-curves are stretched to fit the norm and the brightness is scaled according to the stretch, then most light-curves match [53,54]. 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.

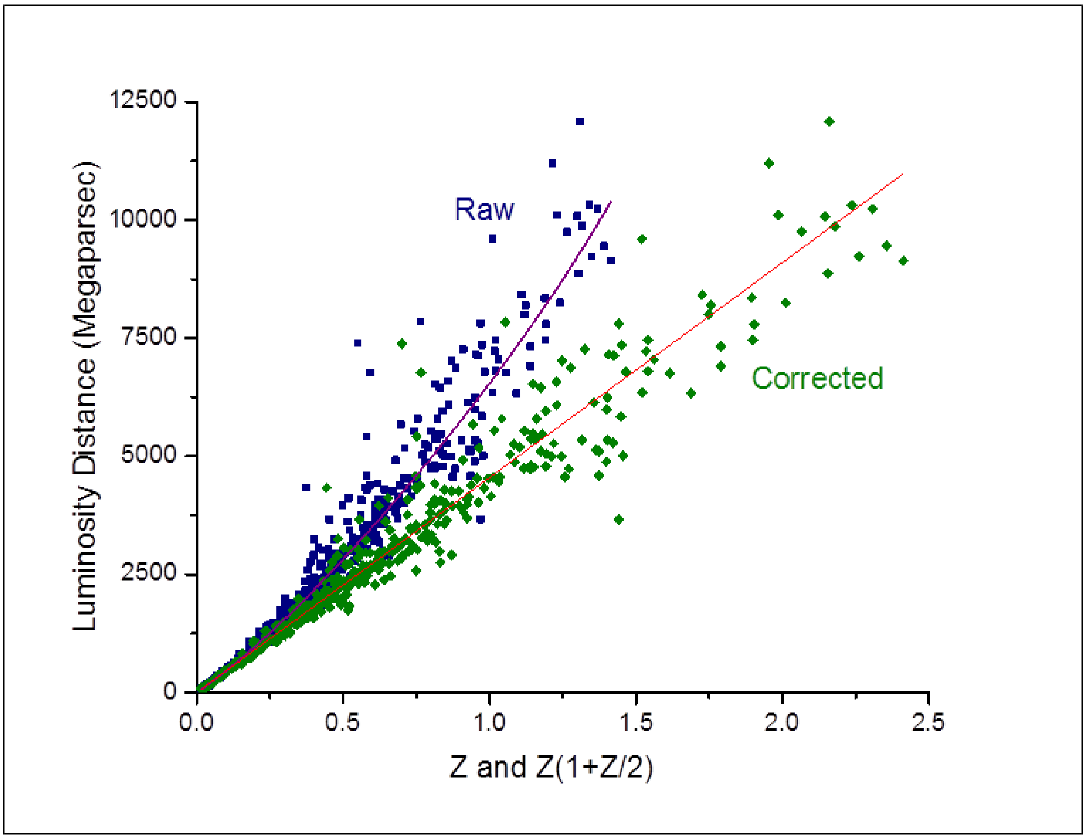

Fig. 1. Type 1a supernovae luminosity distance versus raw (Z) and adjusted ($Z(1 + Z/2)$) redshift.

The Union 2.1 data [55] 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 approximately constant. The observed red-shift can be explained by a fractional decrease in wavelength for the same transitions of the emitting atoms that is inversely 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.

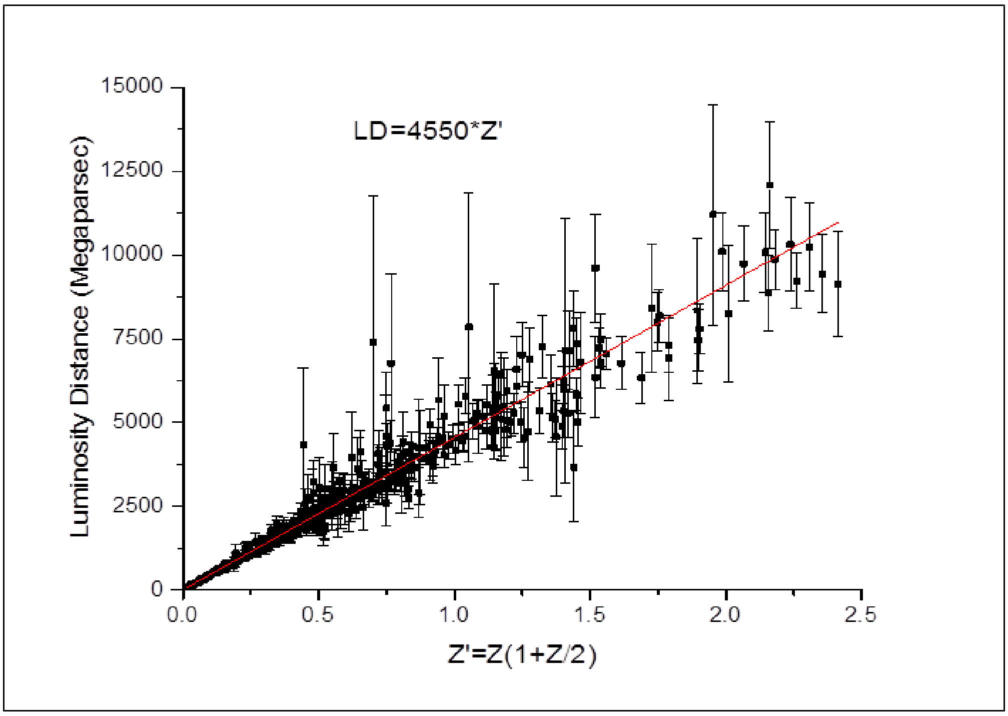

Fig. 2. Luminosity distance for type 1a supernovae with error bars (all data).

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).

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} [56]. The similarity in value 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.

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

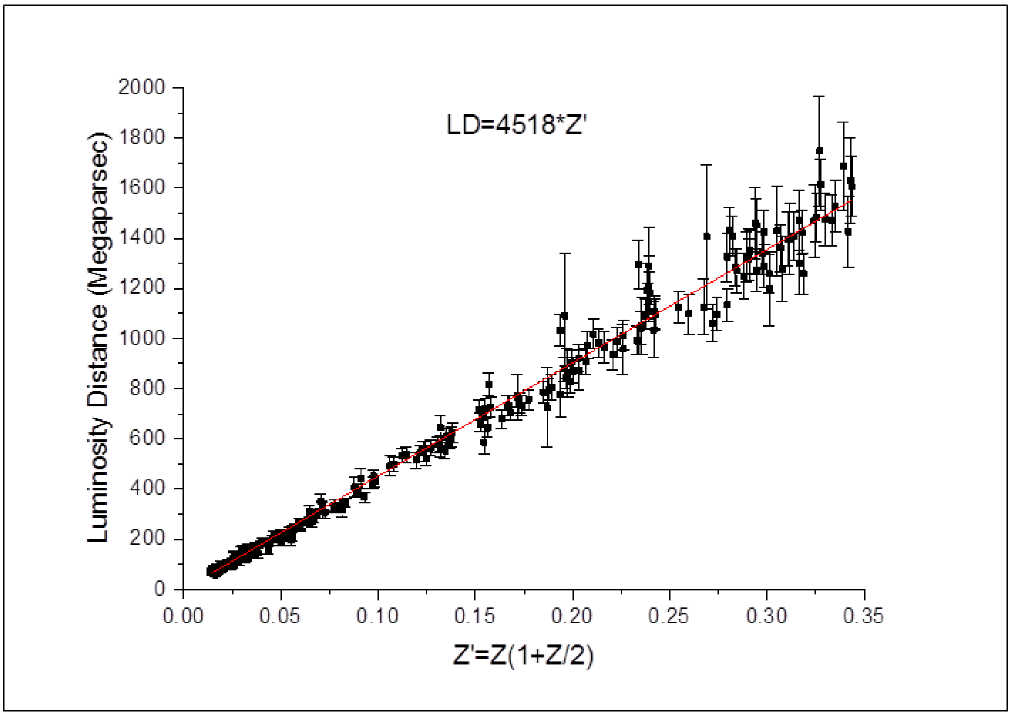

Fig. 3. Luminosity distance for type 1a supernovae with error bars ($Z < 0.3$).

A better way of looking at the data is to plot the time since the light was emitted against the Z-shift.

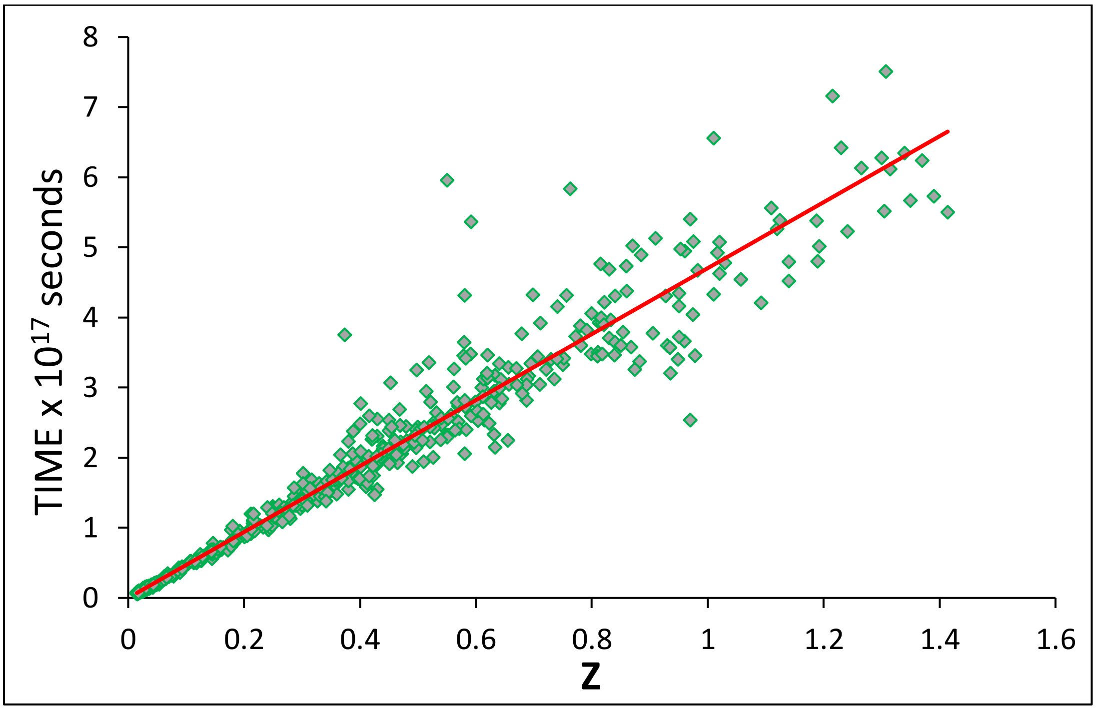

Fig. 4. Time in seconds since light was emitted for type 1a supernovae.

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 time that light speed has halved and so is currently changing at a rate of 2.13 x 10^{-18} second per second.

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.

The potential sources of the change in clout need to be better understood. The energy per particle must increase if the average background per particle reduces, but the asymmetry of the background will increase if the size of the galaxy decreases. 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. Rotational velocity will decrease with contraction if inertia increases and angular momentum is conserved. Clumping of matter can lead to an increase in clout from nearby matter but a decrease in the total amount of stored energy because the amount stored per unit of matter will reduce. 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 [57]. 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" [57]. The revised theory reveals that co-moving coordinates amount to the faulty assumption 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 with density yields an accurately constant rate of expansion, thereby eliminating the need to hypothesise Dark Energy. The concept of an energy that pushes massive objects apart more strongly as it gets thinner, should always have been seen to be suspect.

6.2 Prediction of the value of the gravitational constant

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 must be consistent with the changes in stored energy with changes in background (gravitational potential) seen in our solar system. The supernovae data can therefore yield a prediction for the value of Newton's gravitational constant G_N (for a given ratio of inertial to gravitational mass) and a prediction for the current rate of increase in time (inertial clock-rate).

Under FR, the energy levels of the atoms emitting the photons decrease as the surrounding density of matter 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, the acceleration, or force per unit mass, experienced by all massive objects. A gradient means that the background density is changing, which alters the stored energy (the potential) of massive objects.

As set out in Sections 5.1 and 5.6, Newton's universal law of gravitation reflects changes in energy of a massive object with distance from a concentration of stored energy. Under FR, this leads to equations 5.5 and 5.6:

$$\frac{\partial E/\partial r}{E} = \frac{\partial m/\partial r}{m} = -\frac{G_N'}{c^2}\left(\frac{m_i}{m_g}\right)\frac{\partial}{\partial r}\left(\sum_n \frac{M_n}{r_n}\right) \qquad \text{where} \quad G_N = G'_N\left(\frac{m_i}{m_g}\right)$$

$$\text{and} \qquad \frac{G_N'}{c^2}\left(\frac{m_i}{m_g}\right) \simeq \frac{1}{\rho_B}$$

giving: $\rho_B = c^2/G_N$ = 1.3467 x 10^{27} times the clout from 1 kg at 1 m,

based on G_N = 6.67408 × 10^{-11} $m^3/kg.s^2$.

The change of redshift with time is a measure of the change in stored energy with change in clout. It therefore gives a measure of the fractional change in mass corresponding to a given fractional change in background clout, and so of the strength of gravity. However, the movement of objects under gravity relates kinetic energy and momentum (dependent on inertial mass) to stored energy (gravitational mass).

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, $\mathrm{Z} = 1$ will correspond to a change in clout equal to the current clout. From the fit, the change in distance per constant unit 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 wavelength has doubled in 4.68 x 10^{17} seconds (of u-time). The speed of light for a clout of 1.3467 x 10^{27} kg/m is 2.998 x 10^8 m/s.

6.3 Prediction of change in clock-rate and Pioneer anomaly

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 of matter decreases. Clock-rate will increase with decreasing clout. Under FR, the fractional rate of change of clout and speed of light with current time is the distance that light travels in a second divided by the slope of the supernova data, i.e. 2.137 x 10^{-18} second 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 the signal 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 an amount $\Delta f/f$ of 2.14 x 10^{-18} s^{-1}, if clout is decreasing over time but the local value of asymmetry and hence h, is not changing. If the value of asymmetry is also increasing then the frequency of a signal of constant energy should increase by more than this fraction.

A signal, of locally constant frequency, was sent out from Earth then back from the Pioneer space-craft 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 space-craft. 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 steady as a function of journey time and should be at least that predicted from the rate of change of clout deduced from the supernovae data. The signals returned from the Pioneer spacecraft have been 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} [58]. This is 33% higher than that calculated from the supernovae data and therefore suggests that the local asymmetry is increasing at about one-third of the rate that the mean background clout is increasing. Interestingly this is close to the ratio of the contributions of dark matter versus dark energy to the total mass/energy required by GR to account for the supernovae and gravitational observations.

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 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 [59], 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 [60]. 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 [61]. The observed decrease in time of the generated heat energy enabled a fit to a reducing acceleration but the errors on the calculated anisotropies of the major sources were large (100%).

It is not disputed that preferential heat radiation would slow the spacecraft. Based on the return time of signals the position of the spacecraft was definitely altered consistent with such a slowing. 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 (red-shift) 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 examined. The signal is essentially a reflected signal and completely independent of the time of any clocks on the spacecraft.

FR requires a drift to lower frequency which is in plausible agreement with the observed drift. The observation is not sensitive to a small deceleration, which would lead to differences in the expected location. 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 confirmation that clock-rate is increasing is consistent with underlying time running slower and the speed of light being faster earlier in the history of the universe. However, the rate of movement of massive objects can vary with location (as seen in the light curves of supernovae) depending on local asymmetry. If there is an expansion then it is also much slower than implied by the GR interpretation of galaxy redshifts. These would appear to remove the need to hypothesise cosmic inflation (see Chapter 7)

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% [62]. 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 $\rho_c = 3{H_0}^2/8\pi G_N$ [63]. However, under FR the universe is necessarily flat, and the current background density (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 calculation of the background under FR from the value of G_N should be consistent with the total clout from all galaxies, and with the value of asymmetry at the solar system's location in our galaxy as it relates to the value of Planck's constant. In turn, these should be in agreement with the Pioneer anomaly and the supernovae data. The actual relationships need a clearer understanding of the ratio of inertial to gravitational mass due to the nature of elementary particles and how clout depends on the combination of the chiral components of the background.

6.5 Summary

FR can explain the supernovae data without the need for dark energy. It predicts most of the observed drift to lower frequency dubbed the Pioneer anomaly which, contrary to accepted understanding, cannot be explained by selective heat radiation. It also provides a potential explanation for why the drift is under-predicted.

FR provides a potential explanation for the discrepancy between the Planck data and the cosmic ladder-based data.

Further development of the theory should enable a prediction of the value of the gravitational constant based on galaxy observations and the value of Planck's constant.

Chapter 7

Further astrophysical predictions and consequences

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. This appears to remove the need for "cosmic inflation" which was hypothesised to explain why the observed Universe could be so uniform and isotropic if distant regions had not previously been in thermal equilibrium. The suggestion that the Universe expanded by 20 orders of magnitude in the first 10^{-35} seconds after the Big Bang should have always been seen to have been 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).

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. This discrepancy is thought to betray the presence of a halo of dark matter. 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 [64], while others maintain that there is a crisis [65]. 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 [66].

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 [67]. 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 [65,67,68].

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 densities. There are chiral components sensitive to matter and to antimatter density. The asymmetry of the background 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 [39]. 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 observed 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 energy density from matter (A) and antimatter ($\bar{A}$), the matter asymmetry will be $((A + \delta A - \bar{A})/(A + \bar{A} + \delta A))$ where δA is an increase in density of matter. An inertia that depended on the asymmetry of chiral components would then be proportional to $\delta A/2A$ when $A = \bar{A}$, far away from an isolated galaxy in a uniform background. The proportionality would decrease as the asymmetry increased and tend to a constant value deep in a region in which $A \gg \bar{A}$. This would appear consistent with the observed rotation curves if $c \propto (A + \bar{A})$, because the force due to the increase in mass, with decreasing speed of light, proportional to $1/c^2$, would be accelerating an object whose inertial mass was decreasing in proportion to c. The reduction in inertia accounts for the flat rotation curves.

Thus, 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 when the fractional asymmetry in chiral densities drops below that of our region of our galaxy (and hence of the local value of the ratio of inertial to gravitational mass). A diffuse galaxy will appear to need little dark matter within the diffuse region [69], because there will not be a large variation in asymmetry.

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 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. The revised theory implies that there is a similar amount of antimatter in the Universe, consistent with the observed symmetry of physical laws, but appears capable of removing (see Section 5.4) the expectation that the distinctive annihilation signal from a merger of matter and antimatter galaxies would still be common.

The theory indicates that clusters of galaxies of like matter will 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.

Clusters of galaxies, and large-scale separation of regions of matter and antimatter, would lead to a variation in the asymmetry of the background with direction. This would mean that inertia would vary along the gradient in background asymmetry. This would lead to a periodic variation in rotation velocity, 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, would explain why spiral arms 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 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 [41]. 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) has some 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 (putative 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 [70]. 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 existed) 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 amplitude of the rotation curve reflects the value of the inertia due to fractional asymmetry times the gradient in the gravitational potential. The fractional asymmetry depends on the excess of one component (clout) whose gradient falls off as $1/r^2$ while the Newtonian gravitational force also falls off as $1/r^2$. Therefore, each of the terms should give rise to a factor of $1/M^2$ in the needed central mass for the rotation curves to match. From which it follows that $L \propto W^4$.

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

The Sachs-Wolfe effect [71], 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 the energy of already emitted photons, but the relative values of clout in regions of initially different density and with 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 red-shift from large-scale differences in mean background clout.

It should be noted that variations in the temperature of the CMB predominantly reflect variations in red-shift due to differences in clout due to 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 [72]. 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 the separation of matter and antimatter, need deeper investigation. The predictions from baryon acoustic oscillations [73], 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.

Chapter 8

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.

The strong, weak, and electromagnetic interactions have been unified in terms of gauge interactions (QCD, Electroweak and QED) in which masses are predictable and linked via a finite self-consistent set of underlying parameters. This is known as the Standard Model of particle physics. The quanta of the interactions (photons and presumably gluons and the gauge bosons of the weak interaction) and massive particles have an oscillation whose de Broglie wavelength is dependent on the energy carried. This would appear to be strong evidence that gravitational mass corresponds to the stored energy from the strong and weak interactions as well as electromagnetic interactions. It also implies that the massive gluons of the weak interaction 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 Standard Model parameters to be predicted based on the values of the two-component chiral background.

Under FR the propagation of the gravitational field does not appear to carry energy or angular momentum and so should not be quantized. However, 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 will vary with the local asymmetry. A quantum theory of gravity is not needed. It is not space and time that need to be quantized, but 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 $E = \hbar\omega$ 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 the 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 [74]. 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 is a result of averaging over all relative phases in proportion to their overlap. An individual outcome is causal and definite, but it is impossible to predict with definiteness 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).

8.1 Beginnings of a model for the photon and graviton

A collection of seemingly relevant information is put forward with a view to establishing a model of the photon and graviton.

A photon is understood to be a self-propagating oscillation of electric and magnetic fields and the wave equation that appears in 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 model 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 relative rate of rotation appears to be altered by their 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 such that the product of the two ranges is $\Delta x \Delta k \geq 1/2$, 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 normally 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 proposed mechanism for establishing a persistent background related to the density of matter and antimatter is that the torques from the larger 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) correspond to the three orthogonal directions of space. It is further proposed that the photon is the missing ninth gluon that is an equal mixture of three gluons ($\mathrm{r\bar{r}}$, $\mathrm{g\bar{g}}$, $\mathrm{b\bar{b}}$). 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 of three orthogonal components with two pairs (carrying spin =2 x ½) rotating in the plane perpendicular to the direction of motion and the third corresponding to a continuous displacement of the equilibrium point in the direction of motion. The difference in spin between the photon and graviton (1 and 0 or undefined) 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 is aligned with the direction of motion, and ii) the pairs of rotating components have matched chirality, so that movement relative to the background affects the pairs equally. These attributes mean that it travels at constant speed independent of movement relative to the source of the background yet resists changes in direction.

8.2 Planck's constant should vary

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 $p = \hbar/\lambda$ 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 $E = h\nu$) 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 may 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.

8.3 Prediction of asymmetry from Planck's constant

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. However, 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 be observed to increase by the change in gravitational potential (because changes in density affect c and apparent time) and decrease with the fractional decrease in asymmetry.

The value of Planck's constant can be measured in terms of the frequency for a given energy, but the current accuracy of measurement may not be sufficient to detect changes in our solar system. The rate of change of asymmetry in moving away from the Sun or Earth would seem to be small given that the rotation curve within our solar system follows Newton's law. It seems that the current value of h is determined by the speed of light, asymmetry and the ratio m_g/m_i, so further analysis and experimental results should explain and predict its value.

The apparent value of the gravitational constant with distance from a centre of a large concentration of mass, as determined by the frequency of torsional oscillation of pairs of masses, should be affected by changes in inertia but the sensitivity may not be sufficient to measure asymmetry.

8.4 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 be measured to have 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 better 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 average contributions can be fixed). Nor does it mean that the same answer will be obtained under a different interrogation.

Chapter 9

Implications 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 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, that arise from a mixing 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.

9.1 Higgs mass prediction

The force carrying particles that give rise to mass must include not only the Higgs boson (H_0), but the vector mesons $(\mathrm{W}^{\pm}, \mathrm{Z}_0)$ and also the photon and gluons. The mass (gravitational interaction) 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. Under this scenario, 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 (which is its own antiparticle) and so the Z_0/γ form a pair. The Higgs is one of the three other boson pairs in which chirality and rotation trap energy and give rise to mass. The three required massive bosons are not the W^+, W^- and Z_0 (as previously understood) but the boson pairs $W^+/\mathrm{W}^-, \mathrm{Z}_0/\gamma, \mathrm{H}_0/\bar{\mathrm{H}}_0$. The W^+/W^- and $\mathrm{H}_0/\bar{\mathrm{H}}_0$ are particle/antiparticle pairs. The Higgs boson mass should then be: $(m_{\mathrm{W+}} + m_{\mathrm{W-}} + m_{\mathrm{Z}})/2 = 125.979 \pm 0.024$ GeV/c^2 [75], compared with the measured 125.09 ± 0.24 GeV/c^2 [76] and the latest value from the CMS collaboration of 125.35 ± 0.15 GeV/c^2 [77]. The factor of 2 arises because of the Higgs and 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 $H_0 \rightarrow \gamma\gamma$ channel is 125.78 ± 0.26 GeV/c^2, while for the four lepton final states $H_0 \rightarrow Z_0 Z_0 \rightarrow 4l$ 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 [78]. It is suggested 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.

9.2 Neutrinos may be massless

FR supports the Standard Model with three flavour families and massless neutrinos. They are massless because the net angular momentum and mean chirality are purely in the plane perpendicular to the direction of motion. However, the number of components differ for the three families. Although massless, the neutrinos can oscillate between families because the flavour families have different frequencies for a given energy (i.e. different values of $\hbar$). Thus, the belief that oscillations between neutrino states necessarily implies 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.

9.3 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 missing one or two components that are continually 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.

9.4 Variation in physical constants

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 red-shift 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.

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.

The number of changes to the current understanding, which might be better characterised as an interlocking belief system, are 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 frequency of photons from atomic transitions. The frequency 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 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. The asymmetry in the component of clout affects 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.

10.1 Summary of the changes in the theory 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 mass density. 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 blue-shifted. The binding energy of atoms increase, and their size reduces, as the background energy density and the speed of light decrease. Hence, FR has particles gaining stored energy (mass), when lifted 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 blue-shift (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.

A 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 causing light to bend and inertia to increase. 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, rather than the gradient in a single mass density, while the conversion factor between energy and frequency depends on the asymmetry. The energy levels of atoms increase when an object moves into a region of lower density 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 m and c constant, independent of the background density and mistakenly interprets smaller time intervals as a slower clock-rate.

The latter 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, but the number of events in a region in which the time interval taken for an event is shorter, means that relatively more events occur. Time runs faster when time intervals are shorter. The inverted interpretation, of Special Relativity, allows the Lorentz Invariance of massless electromagnetic interactions to appear to be applicable to massive states, whereas the size of massive objects increases as their energy decreases. 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 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 blue-shift 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) 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 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 [79]. Crease has recently discussed the different perspectives [80]. 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'. 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 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 Confirmation 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, Special and General Relativity have been shown to lead to inconsistencies, including the misinterpretation of space and time intervals, the existence of singularities, and between the altered postulates 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 explains most but not all of the observed anomaly in the returned signals of the Pioneer spacecraft. However, there should be an additional change in frequency due to changes in asymmetry with time. The expected amount would appear to be sensitive to the asymmetry at our current location in the galaxy which should be the determinant of Planck's constant. Therefore, it may be predictable. However, the current explanation of the Pioneer anomaly as due to a deceleration of the spacecraft is untenable as the resultant shift in frequency is independent of the clock-rate at the spacecraft.

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 possibly for the Pioneer anomaly, neutrino oscillations and Higgs mass. The removal of the need for ad hoc, implausible, hypotheses of dark energy, dark matter and cosmic inflation, and the unexpected predictions and explanations, should be taken as strong evidence for the validity of the core proposals of the replacement theory. However, further observational evidence is highly desirable.

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 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, it would be exciting if the new understanding could enable 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 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 reasons for questioning General Relativity 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 from later investors. The scheme breaks down with the finite limits on investors and funds. Arguably, the principle is conservation of energy or "you can't get something for nothing"!

The nature of the Universe is 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 book 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 two theories.

The new perspectives open up new opportunities and hopefully the expenditure on the search for dark matter, quantum gravity and even quantum computing might be channelled into new research.

Firstly, further development of FR is needed. 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 rejected or shown to be consistent with quantum chromodynamics. The successful prediction of all lepton and baryon masses, and what appeared to be 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.

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 demonstrated.

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 the structure of spiral galaxies. 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 to be studied.

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; that the reasons for the values of fundamental "constants" become understood and in most cases calculable; and even that quantum entanglement does not constitute the "spooky action at a distance" which Einstein hated.

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