A changed understanding of gravity

Peter R. Lamb

Email: peter.r.lamb@bigpond.com

Abstract

A simple but profound change to the understanding of gravity is that gravitational potential arises from changes in the energy stored in objects as mass. This replaces gravity as a distortion of the surrounding fabric of spacetime while mass remains constant. The stored energy is released as kinetic energy when objects move closer to each other. Mass reduces when the magnitude of the background and the speed of light increase. Massless photons do not lose energy in escaping a gravitational field. Instead, the energy stored in atoms increases. The apparent redshift of photons is a blueshift of atoms and massive clocks run faster. The revised understanding avoids the singularities at the centre of black holes. Changes in gravity, which propagate at the speed of light, can now cross the supposed event horizon, allowing black holes to rotate around each other. The increased speed of light, going back in time, means that the standard supernovae candles are more distant than assumed from their wavelength shift. This entirely removes the need for an accelerating expansion and yields the current rate at which time is slowing. The amount is in excellent agreement with the observed Pioneer anomaly. Moreover, it is demonstrated that the apparent, but now unneeded, dark energy is a necessary consequence of the assumption that mass is independent of the surrounding density of matter. It is also shown that the current explanation of the Pioneer frequency drift is untenable. The revised theory, labelled Full Relativity, overcomes the need for other ad hoc hypotheses, including dark matter and cosmic inflation, while yielding the standard predictions of General Relativity. It links inertia to the asymmetry of contributions to the background field from the chiral components due to matter and antimatter. The asymmetry determines the rotation frequency of the trapped angular momentum seen in the Compton wavelength of quantum mechanics. The dependence of inertia on asymmetry then explains the observed galaxy rotation curves and gravitational lensing without the need for dark matter. Various tests which will distinguish between the two forms of Relativity are put forward. Finally, gravity can now be linked with the other three forces in a way that is consistent with the Standard Model of particle physics.

Introduction

The current understanding of gravity is based on Einstein's theory of General Relativity (GR). GR was based on the earlier theory of Special Relativity (SR) in which high-speed motion at constant velocity changed the linked space and time of the observer's "spacetime" in a way that kept the speed of light constant. Only the relative speed of object and observer mattered. Einstein noted that a person in free-fall no longer felt the force of gravity, so that in an accelerating frame gravity could be transformed away. Ultimately, this led to GR in which gravity is not a real force but a distortion of spacetime by gradients in the surrounding density of energy and momentum from matter. GR gave rise to predicted effects from the distortion of spacetime. The first was that it would cause the axis of an eccentric planetary orbit to rotate. This explained the observed, but previously unexplained, advance in the perihelion of Mercury. The second was that light passing close to a massive object would be bent, and by twice the amount of an earlier prediction, because both space and time were distorted. The third was that there would be a redshift of light escaping a gravitational field. Subsequently, many other predictions including black holes and gravitational waves have been observed. However, an ongoing concern has been that the "fictitious" force of gravity cannot be linked with the other three known forces (strong, weak and electromagnetic) which have been linked in terms of the remarkably successful Standard Model of particle physics.

The current understanding of the cosmos is that it consists of an enormous number of approximately evenly distributed galaxies. There is a steady increase in the mean redshift of their light with distance which 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.

Under GR, light moves at a known, constant velocity, so 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 apparent 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 isotropic and uniform.

In the late 1990s, the luminosity distance of type 1a supernovae (standard candles) was observed to be greater than that deduced from the redshift of their host galaxies. Under GR, this discrepancy required an accelerating expansion of the universe which led to the ad hoc postulate of an unknown energy to drive it. The observed rate of increase in expansion requires that around 70% of the universe is made of this invisible, unexplained 'dark energy'. Moreover, its relative importance increases as the universe expands and the density of matter decreases.

A second ad hoc hypothesis arose from studies of the speed of movement of the stars within spiral galaxies like our own. It was 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 that the enclosed mass increased with distance, because the galaxy was immersed in a diffuse cloud of 'dark matter' that gave additional gravitational attraction. However, this matter must not interact with electromagnetic radiation because it neither emits nor absorbs light and so is invisible.

Further evidence for 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 be calculated using GR and it was found that large diffuse clouds of additional invisible mass were again needed. This and additional lines of evidence are consistent with the ratio of dark matter to ordinary matter being about 5:1.

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

Cosmic inflation has it that space expanded extremely rapidly within the first tiny 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 required is about 20 orders of magnitude in the first 10^{-35} seconds after the Big Bang, implying the entire contents of the universe moved apart much faster than the speed of light. Under GR, this expansion is possible because "*space itself is expanding*" and carrying the galaxies with it.

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

A revised theory of gravity, Full Relativity (FR) replaces the explanation of gravity as a distortion of the spacetime in which objects with constant mass are embedded with one in which the mass of objects reduces when the background arising from other massive objects increases. GR has the distortion of spacetime dependent on the gradient in potential from local concentrations of momentum/energy. Equal constant gradients from opposite directions cancel. Therefore, the magnitude of the gradient is independent of a constant, isotropic, uniform background. FR claims that when the magnitude of a uniform background from matter changes (but there is still no gradient and so no field of gravitational acceleration) both the mass stored by matter and the speed of light will change. This builds on Einstein's famous equation $E = mc^2$ and his conclusion that: "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" [1]. The presence of other matter increases the speed of light (c) and hence reduces the stored energy. All mass should just be seen as stored energy, with the conversion factor, for an amount of matter that currently holds energy E, being $1/c^2$. FR proposes that the energy stored by the same amount of matter will decrease when the background field and speed of light increase.

Gravity arises from a loss of mass

If mass is stored energy and a massive object gains kinetic energy (KE) as it falls in a gravitational field, and so moves deeper in a gravitational potential, then conservation of energy implies that the KE has come from a loss in stored energy. Previously, it has been assumed that mass remains constant but gravitational attraction is proportional to mass so any change will only be seen in terms of an effect on momentum which is also proportional to mass. The change must be small but the conversion factor between mass and energy is enormous. The first place at which an effect might be seen is in the eccentric orbit of a planet in a large gravitational potential. The second is in an increased mass of objects higher in a gravitational potential.

The revised perspective is possible because the gravitational effect of distant galaxies is much more important than previously assumed. GR assumes that mass is constant and the acceleration field associated with the force of gravity causes a distortion of spacetime. The acceleration, from the gradient in potential, decreases inversely as distance squared. FR has the slope dependent on the total background, but it is so large that it appears constant. The contribution of each mass (M) to the background only declines inversely with distance, not distance squared. The force appears to arise from a gradient proportional to M / r^2 and the contribution of the enormous uniform, background is not noticed. However, the magnitude of the gradient and force depend on the background.

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

The work done to separate massive objects is stored in the objects as mass. Therefore, the first step in a changed understanding is to interpret the apparent gravitational redshift of massless photons as an increase (blueshift) in stored energy (mass) of massive atoms detecting photons of unchanged energy. This increase in mass, of the same amount of matter, implies that light-speed varies. The constancy of the locally measured speed of light is built into SR and GR so this requirement, and its consistency with observations, must also be re-examined.

Massless photons do not lose energy in escaping a gravitational field

According to Newton's law of gravitation, objects are attracted to each other in proportion to their mass. The initial expectation was therefore that a massless photon would not be attracted to a massive object. However, GR has matter distorting the spacetime in which all objects, including photons, exist. This led to Einstein's prediction of a gravitational redshift of light with increased gravitational potential. The GR explanation is that the gradient in gravitational potential, the acceleration field, produces a distortion of the geometry (the metric) of spacetime. The change in time, a faster clock-rate with distance from a massive object, is a confirmed observational effect seen in the needed adjustments to the satellite clocks of the global positioning system.

Under GR, the apparent loss in energy of a photon (redshift) in escaping gravitational attraction gave rise to the belief that the massless photon was attracted because of its kinetic energy. Hence, all energy must give rise to gravitational attraction. Gravity, as a distortion of spacetime, has objects gaining kinetic energy as they move into a region of increased density of matter/energy. Since all energy contributes to the distortion it is further increased. This feedback with increasing mass density means that, at sufficient density, nothing can resist the gravitational attraction and the matter collapses into a point of infinite density with a surrounding region from which no light, or radiation travelling at the speed of light, can escape. Such black holes have been observed but their necessary singularities imply that under such extreme conditions the theory (GR) has to be modified.

The gravitational redshift was first observed in a series of experiments by Pound and Rebka in which photons were not resonantly absorbed by a matched detector, higher in a tower, unless they were given a boost in energy [2]. The opposite applied when the positions of emitter and detector were reversed. Hence, a photon appeared to lose energy in escaping a gravitational field. However, several authors [3,4] have pointed out that the energy of the photon is unchanged and instead, under GR, the "standards" of time and frequency are changed so that the energy levels of the atoms <u>appear</u> blue-shifted. 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.

The subtly different explanation for the apparent redshift of massless photons, under FR, is that it is a real blueshift in the energy held in massive atoms, rather than a change in the "standards" of time. The upward shift in the energy levels of atoms with increasing gravitational potential gives higher frequencies and a faster clock-rate. The mass (stored energy) of all particles of matter increases from the work done in lifting them and the increased energy levels mean that frequencies and time for the atoms are faster. The Newtonian gravitational potential corresponds to the stored energy released as the free kinetic energy of motion when a massive object falls. A decrease in potential is a reduction in mass. Two immediate advantages are the removal of singularities because the mass per unit matter decreases as matter density increases and that there is no need for an enormous pool of energy in empty space. Under GR, objects of constant mass gain energy as they move closer together. Hence, a space that is devoid of massive objects and free of distortion must contain an enormous pool of energy. The revised perspective is that the enormous pool resides in the mass of objects, with the first atomic bombs converting just 1 g of mass to energy.

Under FR, 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 inside 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.

Under GR, the redshift of a wave travelling at c becomes infinite at the event horizon. Thus a gravitational wave could not cross as soon as an event horizon formed. So it should not be possible for black holes to rotate around each other. The claimed enormous density of the early universe would have also meant that all 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.

Under FR, the photon momentum, and the kinetic energy it can deliver, is energy moving freely at the maximum speed allowed by the medium (i.e. at the speed of light). It is a free oscillation of travelling components that are always matched but 180° out-of-phase. If only trapped energy corresponds to mass, then photons will not gain or lose energy in a gravitational field. The change in perspective from a redshift of photons to a blueshift of atoms means that photon energy is unchanged. The apparent gravitational redshift of light is because the energy (and clock-rate) of the emitting or receiving atoms is lower when nearer to other matter, i.e. deeper in a gravitational potential. The revised theory is called Full Relativity because the mass and movement of matter is dependent on the mass and movement of all other matter. It proposes that all mass, from strong, electromagnetic, weak, and gravitational interactions, is a result of constraining energy/momentum to a location.

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

A variable speed of light is allowed

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 spacetime. However, although the speed of light is constant within an inertial frame, it does not have to be the same value in different inertial frames with different constant backgrounds. SR was developed for objects moving at constant velocity. It applies within regions in which there is no acceleration. A fixed relationship between gravitational mass and stored energy should hold within a region of constant mass density. However, movement into a region with different mass density is non-inertial; it involves an acceleration. Therefore, it is not required that the mass of the same matter or the speed of light be the same in backgrounds of different mass density. The equation $m = E / c^2$ arose in SR from the interconversion of energy and momentum for observers moving at constant relative velocity. In the derivation the speed of light was fixed for the conversion but it does not need to always have the same fixed value. However, the apparently invariant spacetime interval of SR was taken over into the distorted spacetime of GR with a locally constant speed of light. The need for constant c and a linked spacetime must be reassessed.

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

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

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

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

The observational evidence for the speed of light being constant, for example from studies of the Hubble expansion and gravitational lensing are based on the assumptions of GR. 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.

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 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. However, the term “clout” will be used to represent the magnitude of the background which determines the speed of light and to distinguish it from minus the potential of the stored energy that has previously been assumed to be independent of a constant background. 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 clout provided by the background field.

No need for dark energy

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

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

An increasing redshift with distance could also arise from an increase in recession speed. This can give rise to a Doppler shift proportional to the speed of separation. However, the wavelength is not stretched by the increased separation of the source and receiver. This unusual property of empty space and the wavelength of signals expanding as the Universe expands is a claimed characteristic of GR. Under FR, the space between stationary unconnected objects cannot expand and the relative velocity of objects, in a homogeneous background, does not increase unless a force producing acceleration is present. If the speed of separation was higher in the past, then those galaxies would now be increasingly distant which would reduce the apparent rate of increase in redshift and imply enormous forces to produce and then slow recession speeds approaching the speed of light.

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. Yet, there is no persuasive theoretical explanation for the existence or magnitude of dark energy [6]. Moreover, this dark energy has the very unusual property of a negative pressure that opposes gravity more strongly as the density of the matter, the number of galaxies per unit volume, decreases!

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

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

For nearby type 1a supernovae, the total amount of energy released (area under the light curve) appears to be approximately constant, although brighter supernovae increase and decrease in brightness slightly more slowly than fainter ones. When the timescales of individual light-curves are stretched to fit the norm and the brightness is scaled according to the stretch, then most light-curves match. This can be seen as a way of determining the total energy independent of any difference in local inertia.

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

The Union 2.1 data [7] for type 1a supernovae in terms of the distance calculated from the luminosity versus the redshift, $Z=\Delta\lambda/\lambda$, is given in Figure 1. The distance is first plotted against Z, then against $Z(1+Z/2)$ which allows for the integrated change in speed of light. A linear fit (red line) shows a nearly constant slope and so removes the lower-than-expected brightness that necessitated the hypothesis of an accelerating expansion and the need for dark energy. A constant slope indicates that, once the distance is corrected for a speed of light proportional to the increased clout going back in time, the rate of change of clout with u-time is constant. The observed redshift can be explained by a fractional increase in wavelength for the same transitions of the emitting atoms that is proportional to the fractional increase in background clout, and a speed of light that is directly proportional to clout.

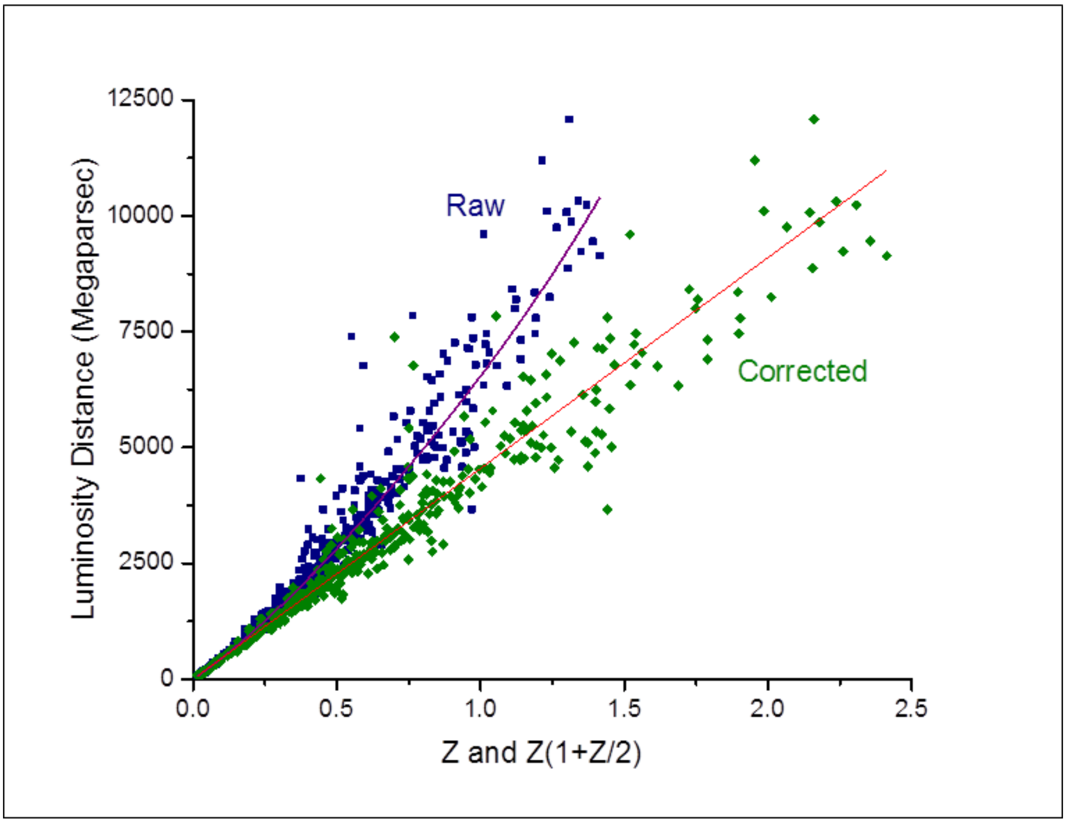

Fig. 1. Type 1a supernovae luminosity distance versus raw (Z) and adjusted ($Z(1+Z/2)$) redshift.

The plot indicates that the behaviour is approximately the same for all regions at a given epoch when averaged over the directions to the supernovae. The scatter appears to be about that expected from the quoted measurement errors, with roughly two-thirds of the points lying within their error bars for the straight-line fit (see Figures 2 & 3) except possibly at low Z.

The luminosity distance to a supernova that exploded at a redshift of one will reflect the distance the light actually had to travel even though the speed of light has decreased during the journey. The actual distance is 4550 x 1.5 Megaparsec (for $Z = 1$ at the time of emission) from a linear least-squares fit (weighted by the quoted error on each point) to Figure 2. For just the data out to Z <0.3 (Figure 3) the actual distance is 4518 x 1.5 Megaparsec (for $Z = 1$ at the time of emission).

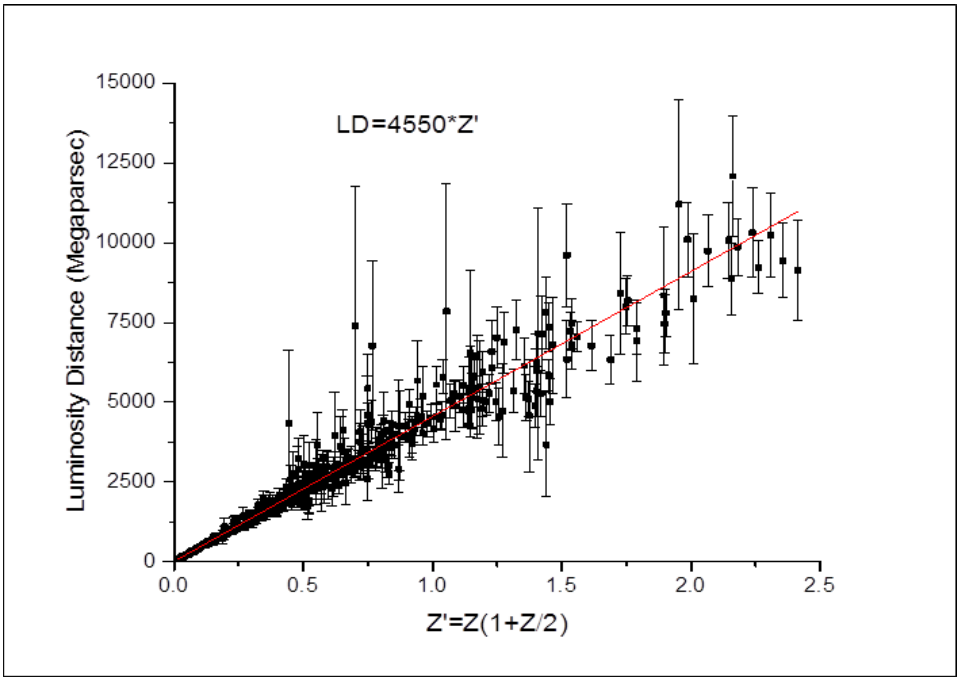

Fig. 2. Luminosity distance for type 1a supernovae with error bars (all data).

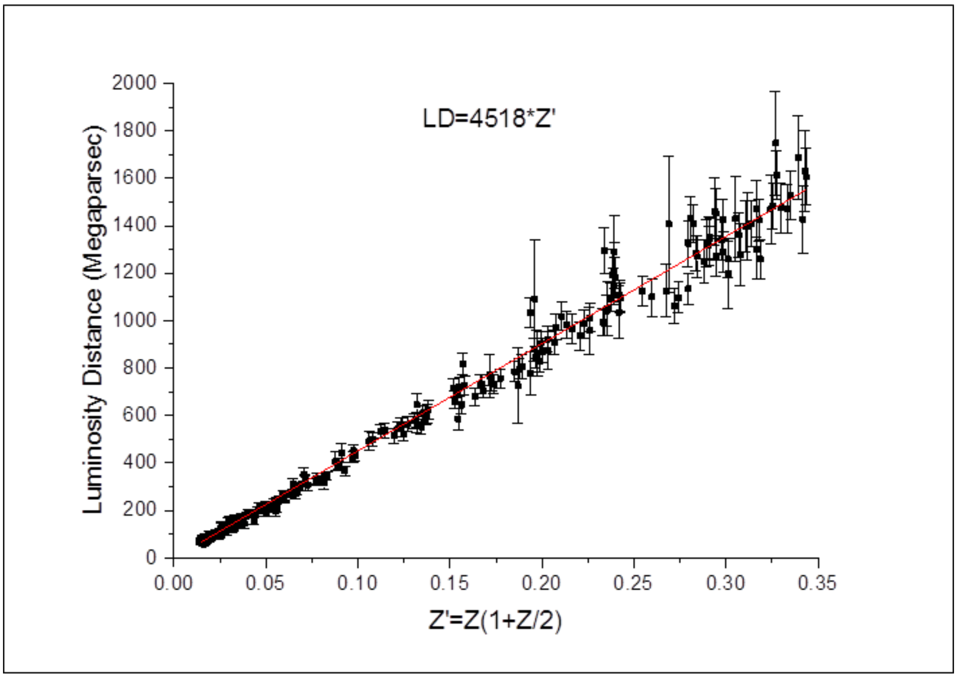

Fig. 3. Luminosity distance for type 1a supernovae with error bars (Z < 0.3).

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} [8]. The is because the current recession velocity ($v = H_0 D = cZ$) is given by the asymptotic slope of distance (D) vs. Z-shift at low Z.

A better way of looking at the data is to plot the u-time since the light was emitted against the Z -shift (Figure 4). The time taken is the luminosity distance divided by $c(1+Z/2)$ to correct for the changing speed of light. The straight-line fit indicates the underlying connection between the speed of light and the energy of atoms. The u-time taken for light to reach from $Z=1$ is 4.68 x 10^{17} seconds. Clock-rate has doubled in the u-time that light took to reach from $Z=1$ and so is currently changing at a fractional rate of 2.137 x 10^{-18} per second (if local inertia is constant).

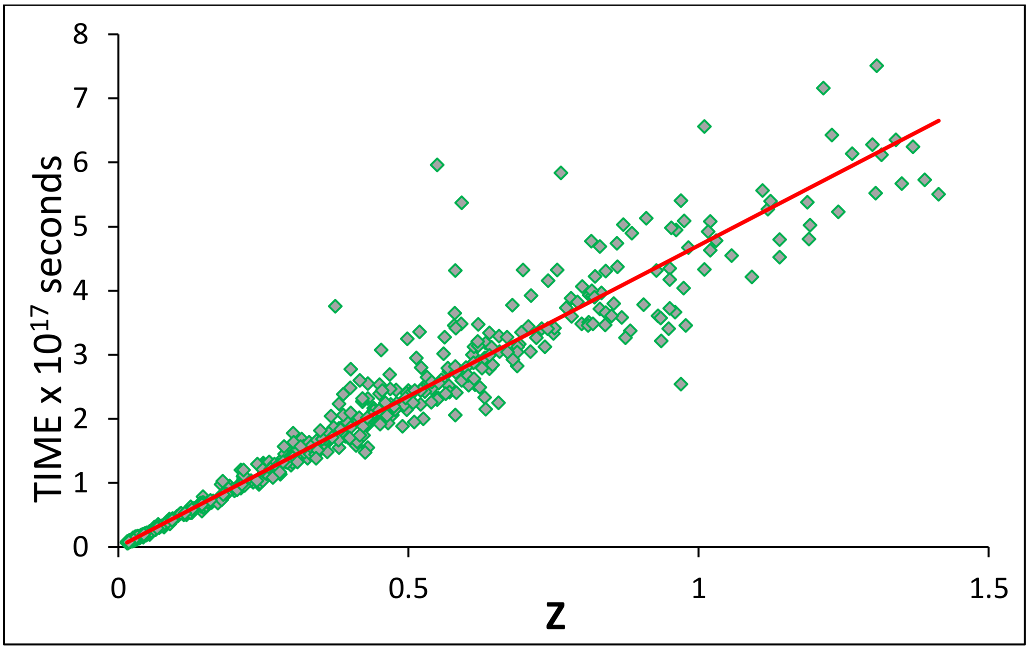

Fig. 4. Time in seconds since light was emitted for type 1a supernovae.

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

A decrease in density from an expansion in the spacing of galaxies would lead to a decrease in clout. However, supernovae could be expected to have zero average velocity relative to the background at the time of emission and our observation position appears approximately stationary relative to the current background. Therefore, an expansion should not lead to an additional redshift of the photons due to relative velocity. The redshift should solely reflect the change in the energy of the emitting atoms. The average spacing between galaxies could be increasing but it does not seem to be required.

Correcting the Type 1a supernovae distance data for the change in light speed yields an accurately constant apparent rate of expansion, thereby eliminating the need to hypothesise an invisible dark energy to drive an accelerating expansion. This also overcomes the problem, under GR, of why dark energy is becoming dominant now and will drive the universe away from its currently observed flatness. The concept of an energy whose influence grows as the space between objects increases, should always have been seen to be suspect.

Assuming constant mass causes dark energy to appear

Einstein's field equation (of GR) is a relativistic generalization of the differential form of Newton's gravitational equation:

$$\vec{\nabla}.\vec{g} = -4\pi G_N \rho \qquad (1)$$

The curvature of spacetime, and gradient (divergence) of the acceleration, are directly proportional to the stress-energy tensor, the generalization of mass density (ρ) to the density of energy and momentum. The hidden assumption in deriving this differential form (equation 1) is that mass is independent of surrounding mass density.

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

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

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

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

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

Newtonian gravity gives rise to a force field $(\vec{F} = m\vec{g})$ that maintains its existence while mass is present. This appears analogous to electrostatics where an electric field $(\vec{E})$ due to a static distribution of charge gives rise to a force $(\vec{F} = q\vec{E})$ on another charge (q). The derivation of the differential form (equation 1) follows from applying Gauss's law to the force law, as done for electromagnetic fields [5].

The first step of the derivation is to equate the gravitational mass of Newton's universal law of gravitation with the inertial mass of his equation of motion. This yields a vector gravitational acceleration field (force per unit mass $\vec{F}/m$) due to a point mass M of:

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

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

$$\oint_S \vec{g} \cdot d\vec{A} = -4\pi G_N M \qquad (3)$$

The area integral on the LHS is the gravitational field flux through any closed surface S, and M on the RHS is the total mass enclosed inside S. However, a constant flux through the enclosing surface assumes that the flux from the mass of an arbitrary matter distribution is constant, independent of the distribution of the matter. This requires the mass of each component to be independent of the location of other components (as applies to charge). Under FR, this assumption is faulty.

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

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

If this equality holds for any volume, the integrands on both sides must also be equal and equation 1 follows. However, equation 1 does not hold if the density of surrounding mass alters the mass held by a constant amount of matter. It will also need modification if the background affects the ratio of inertial to gravitational mass.

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

If the magnitude of a radial vector field about a point source reduces as $1/r^2$, then the divergence of a field that does not include a source is zero because the surface area around a source increases as $4\pi r^2$. Thus, if the gravitational acceleration falls of as $1/r^2$, as is observed, from a constant source of mass, then the RHS of equation 1 should be zero. The implication of the non-zero value is that the reduction in mass density, from including an increased volume of empty space surrounding the constant source, reduces the magnitude of the sink. Thus empty space outside any matter reduces the negative divergence in the gravitational field and therefore acts as a source of gravitational repulsion. The concept of mass density is extended to a volume adjacent to, but outside, any source of mass. This region of empty space alters the energy of objects and its size, the amount altered, depends primarily on nearby sources, because the $1/r^2$ dependence means these dominate.

A vector field that arises from mass (a form of energy) and provides energy to matter at a distance, without losing energy, is inconsistent. It means that the surrounding space acts as a source of energy even when no mass is enclosed. It is something from nothing. GR is based on an equation that does not apply if mass, stored energy, is dependent on the background. It also necessarily leads to an apparent increase in repulsion as the density of the same amount of matter decreases, even though the total mass and mean distance are unaltered. This gives the appearance of an invisible dark energy.

Spacetime is an illusion but time dilation remains

The concept of relativity with a spacetime that could be altered by motion arose in SR. Relative motion at constant speed is claimed to change the space and time perceived by an observer but in a way that keeps the speed of light constant. The linked spacetime was then taken over into GR.

Lorentz had shown that the null result of the Michelson-Morley experiments could be explained by a dilation of time and a contraction of the length of moving objects. This could be put in the form of the Lorentz transformation (LT) between the space and time of events in a moving frame (x',y',z',t') in terms of the coordinates (x,y,z,t) of the stationary frame.

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

$x' = \gamma(x - vt)$, $y' = y$, $z' = z$, $t' = \gamma(t - vx/c^2)$ where $\gamma = 1/\sqrt{1 - v^2/c^2}$

Einstein appeared to deduce this transformation from the postulates that physical laws were independent of motion at constant speed and that the speed of light was constant [9]. The derivation of the LT helped SR and its postulates to be accepted. The theory implied a linked spacetime in which space and time were distorted by relative motion, but the speed of light remained constant.

Einstein's original derivation referred the position and time of events in a moving frame back to a stationary frame. The method was designed to overcome the problem of changes in the apparent simultaneity of events when signals propagate at a finite speed. It allows a mapping of the coordinates of the same objects or events when seen by a stationary and moving observer. The method sought to express the coordinates of the moving frame in terms of the coordinates of the observer's frame using clocks synchronised within each frame. The derivation concluded that time for the moving object or frame was slowed (dilated) relative to the stationary frame. However, a mapping (the method used) cannot yield information about the time experienced in the moving frame. It must be measured, otherwise a hidden assumption has been inserted.

The timing of returned signals 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. It is these apparent changes that have been interpreted as real in SR.

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

The altered postulate (the constancy of the measured speed of light) requires that a change in distance intervals must be matched by a change in time intervals. The measured ratio (i.e. speed = distance/time) is then constant. This was the claimed interpretation of the LT in SR. However, the interpretation had a dilation of time arising from an increase in time intervals while a contraction in length arose from an increase in distance intervals. In his original derivation [9], Einstein arrived at $dt = \gamma dt_0$ and $dl = dl_0 / \gamma$, where dt_0 and dl_0 are duration and length intervals in the rest frame, but then inverted their interpretation so that $c = dl / dt$.

Under the Lorentz-Poincaré theory, the LT had been explained in terms of a dilation of time and a FitzGerald-Lorentz contraction in length of rods. Time in the moving frame is dilated meaning a slower clock-rate, which corresponds to longer intervals between ticks. A contraction in the length of rods means that length intervals are smaller. However, larger time intervals matching smaller length intervals is inconsistent with the altered postulate of SR, that the speed of light always measures the same (in the transformed coordinates). This requires $c = dx / dt = dx_0 / dt_0$, so that dt increases when dx increases and vice-versa. The altered postulate requires increased time intervals (dt), i.e. longer between ticks, to be matched by increased length intervals (dx), i.e. longer rods. The opposite to length contraction. Consistency with observation and the LT (after substituting $x = vt$) requires that slower (less) time, which corresponds to larger time intervals (between ticks), goes with greater distance per unit time, which corresponds to smaller distance intervals (between length marks).

Observed behaviour can only arise from an increase in time intervals (a slowing of time) for massive objects with increased speed relative to the background arising from all other matter, giving an apparent reduction in distance intervals. This is the source of the illusory link between space and time. FR claims that the interpretations of both redshift (to blueshift) and time versus distance need to be inverted. The result is a cancellation that enables FR to reproduce the predictions of SR.

Einstein argued that "the principle of the constancy of the velocity of light" in the stationary system, in combination with his first postulate - the "principle of relativity" - that the laws of physics are independent of motion at constant speed, meant that light also propagated with velocity c when measured in the moving system. The analysis therefore demanded that $c = x / t = x' / t'$ for light in both frames. However, the original second postulate was that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body. The subtle change amounts to the assumption that: if the time of a moving system proceeds at a slower rate than in the stationary frame, then distances must be reduced in the same proportion, so that the measured speed of light, using the time and distance of the moving frame, will be unchanged. The constancy of the measured speed was built into the derivation.

Einstein's derivation included a parameter $\phi(v)$ that allowed for a velocity dependent factor between the original and transformed coordinates of the LT. Its value was determined from a two-fold application of the transformation (using $-v$ followed by $+v$ for out and back). This procedure gave: $t'' = \phi(v)\phi(-v)t,\ x'' = \phi(v)\phi(-v)x,\ y'' = \phi(v)\phi(-v)y,\ z'' = \phi(v)\phi(-v)z$.

It was argued that the time-independence of the position coordinates (x'', y'', z'') meant the resultant frame was stationary relative to the original frame. Therefore, $\phi(v)\phi(-v) = 1$. Given that lengths perpendicular to the direction of motion must be the same for $+v$ and $-v$, it then followed that $\phi(v) = \phi(-v) = 1$. However, the time-independence is a consequence of comparing two frames moving at the same speed in opposite directions after coincidence at $t = 0$. The movement was to the left and right, at the same speed, away from the origin. This voids the conclusion that clocks moving with the object $(v = 0)$ in the moving frame will tick at the same rate as stationary clocks. If $t' = \phi(v)t$, then $t'' = t' / \phi(v)$, i.e. $\phi(-v) = 1/\phi(v)$, which leaves $\phi(v)$ unconstrained.

After purportedly deriving the LT, Einstein noted that a light beam emitted at time $t' = t = 0$ 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 the LT gave $x'^2 + y'^2 + z'^2 = c^2t'^2$. 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".

Subsequent derivations of the LT, by Einstein [10] and others, have used a variation of the spherical wave argument. 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 velocity 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 $x' \propto (x - vt)$, the LT follows. However, the claim that spherical radiation emitted from a stationary frame is "seen" as spherical from a moving frame is false unless the arrival time of the light is corrected for the movement of the observer during the different transmission times from locations on the sphere. The false claim of spherical radiation is based on using unseen, distorted scales of both space and time.

There is an increase in the travel time of return signals by $\gamma^2 = 1/(1 - v^2/c^2)$, 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 inverted interpretation of time and distance, applies to the apparent, but not actual, speed and distance of the moving object. It splits the time delays seen in returned signals (due to movement during signal transmission) equally between a contracted distance and reduced delays (of γ rather than γ^2). This means that the delayed time and apparent distance are both shortened by $1/\gamma$. 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 is constant because the changes in distance and time intervals are matched.

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

The original and subsequent derivations of the LT in SR do not establish the hypothesis that the speed of light has the same value for all observers (moving or stationary). Instead the assumption that the measured speed of light is constant despite movement of the observer forces a distortion of unobserved space and time that give an apparent spherical radiation of light at unchanged speed.

Special Relativity and spacetime replaced

The alternate postulates, to those of SR, are: 1) that the speed of light depends on the magnitude of a background (field) but not on the movement of the source or observer, and 2) massive observers and their clocks are sensitive to motion relative to this background from all massive objects. Once emitted, electromagnetic radiation travels at a speed that relates only to the properties of the medium but the rotation or oscillation speed of its component fields relative to those of the emitter and receiver determine the energy that can be transferred. On the other hand, the oscillation frequency, and hence time, of massive particles and clocks, slows (decreases by the factor $1/\gamma = \sqrt{1-v^2/c^2}$) with increasing speed relative to a background that is in a stationary equilibrium.

The new postulates appear to be able to accommodate observations. These include that the speed of light is independent of the speed of the emitting object; that clocks further from a concentration of matter tick faster; and that unstable particles decay more slowly if moving at high-speed relative to observers who are approximately stationary relative to the average background.

Under FR, the conversion between the position and time coordinates of the same events in a stationary frame and those applicable to a moving observer are:

$x' = x - vt$, $y' = y$, $z' = z$, $t' = t/\gamma$ where $\gamma = 1/\sqrt{1-v^2/c^2}$

The position with time is that based on the time and velocity in the stationary frame and instantaneous signals. The corrected x' position with time (i.e. for the same number of ticks) using the (slower) clock-rate (t') in the moving frame is $x'_c = \gamma(x - vt)$, for locations which had a separation distance of $x' = x$ at $t' = t = 0$. The distance scale will appear contracted because the distance covered by the same relative motion per unit of slowed time will increase according to $x'_c = \gamma x'$.

This transformation is consistent with a LT with $t' = \gamma(t - v\Delta x/c^2)$, where the distance (Δx) between matched locations for all points in the two frames is $\Delta x = vt = x - x'$. Time in the moving frame is then $t' = \gamma t(1 - v^2/c^2) = t/\gamma$. Using x rather than Δx , in the expression for t' , is only valid for the origin, otherwise it introduces a distortion of distance and time that enables $x'^2 + y'^2 + z'^2 = c^2 t'^2$.

The arrival time of signals received by the moving observer due to the fractional relative movement (v/c) during the transmission time (x/c) is altered by vx/c^2 . This timing correction factor is that for the separation of the observers with time after coincidence at $t = 0$. Hence, a signal transmission distance of $\Delta x = x$ only applies to the location $x' = 0$. Using it for $x' \neq 0$ yields imagined (unobserved), distorted, distance and time coordinates for the frame moving towards (or away from) the stationary observer. Under these distorted coordinates, the distance and time for light to propagate both expand (or both contract) resulting in $x'^2 = c^2 t'^2$, if $x = ct$, because $x'/t' = x/t = c$.

The interpretation of the LT in SR is that relative motion causes the perceived space and time to have matched changes, keeping the speed of light constant. The apparent changes seen in the other object depend only on relative, not absolute, motion. This leads to the mistaken claims that observers with either object see a slower time and contracted length for the other object that apply to its time (as seen in decay rates), yet the clock-rate is the same (not slowed) for clocks stationary relative to each observer. Time and space appear malleable, but all observers measure the same speed of light.

However, the experimental results can be explained by a speed of light that is independent of the speed of the emitting object in a space that is undistorted and a real slowing of time $(t' = t / \gamma)$ with movement relative to a stationary background. Increases in apparent distance arise from increased time intervals (slower clock-rate) for massive clocks moving relative to the balanced background. The underlying speed of (massless) light will be independent of the velocity of the source, but the speed will appear faster if measured using a constant distance and a moving clock.

This explanation is consistent with the real changes in time seen in the changed decay rates of unstable elementary particles. However, it requires that high-speed motion of massive objects, whether towards or away from our position relative to the background of stars and galaxies, causes a slowing of time (of massive objects). Space and time are not linked into an invariant interval via a constant speed of light, and the changes in time are opposite to those in apparent distance.

The invariant spacetime interval of SR was taken over into GR when gravitational acceleration was present. However, under FR, the energy of a clock decreases, deeper in a gravitational field. Its rate of ticking (clock-rate) will decrease by c_0 / c when the speed of light increases by c / c_0. This increase in distance travelled by light and a dilated time in terms of clock-rate enables the appearance of a linked fabric of spacetime and energy-momentum. The inverted interpretation of time relative to distance, implicit in keeping c constant, 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). The shortest path should be expected to take the minimum time.

Time can be altered by movement relative to the background and time and the speed of light will be altered by the amount of surrounding matter but the distance between objects is not malleable or dependent on the observer's speed. Space and time are not linked into a fabric whose components are distorted by relative motion and space is not distorted by matter. The speed of light is not a universal constant, in the absence of a gravitational field, and the "principle of relativity" only holds approximately at low speeds. This principle amounts to the claim that (when velocities are constant) behaviour depends only on relative velocity and is 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 then equivalent. It is a part of the broader hypothesis that, in the absence of a gravitational field, the laws of physics are independent of the place and time at which events occur. However, this is a belief based on observations by massive observers approximately stationary, and in almost free-fall, relative to the total background from all mass.

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

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

The fabric of spacetime, under GR, is even stranger than under SR. GR has it that matter distorts the geometry of spacetime, but c is always the same for the local observer (i.e. at the measurement location, and independent of the background matter/energy density). The effect on "time" is claimed to arise from the difference in energy density (via potential) between observers as seen in the real increase in the clock-rates of the GPS satellites. The supposed decrease in distance intervals is not seen, but is claimed to be present because of the amount of bending of light. Moreover, if time intervals are larger, then distance intervals should be larger if the speed of light is to remain constant.

Einstein expected the principle of relativity, "like every other general law of nature" [11], to apply to light. He, and many others, have then claimed that the speed of light in vacuo is constant, independent of the speed of the observer, consistent with the theory of electrodynamics. The claim has become that (in the absence of gravitational acceleration) all moving observers, independent of their speed, will observe the same speed of light. This is not correct unless there is adjustment for movement during signal propagation. It amounts to the claim that the properties of space and time are altered for the observed object when the observer is in relative motion. Apparent effects become real.

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

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

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

The deduction of an apparent invariant energy-momentum interval arises from $E = pc$. It suffers from similar errors of interpretation as the apparent invariant spacetime interval that simply arises from $x = ct$. SR assumes that $p = \gamma mv$ means that energy and momentum increase by the factor γ

because c is constant. However, it is the apparent velocity γv (due to the time delay from the finite speed of signals) that appears non-linear. If the actual velocity is known, then the increase in apparent energy is seen to be due to an increase in the difficulty of acceleration (the ratio of inertial to gravitational mass increases by γ) with speed relative to the background.

The nature and properties of the background

The new background-dependent perspective of FR replaces the GR fabric of spacetime that is alterable by relative motion and by gradients in energy/momentum. Under FR, gravitational attraction can be explained by a reduction in the amount of energy that can be stored in objects when the speed of light increases. This occurs when the "density" (or rather the clout) of surrounding matter increases. It gives rise to an acceleration of the object in which the energy lost from mass appears as energy of motion. The speed and direction of the induced motion remains constant if the force is removed. However, changes to the velocity of motion, i.e. acceleration of the object, are resisted.

The resistance to change, inertia, is sensitive to changes in direction even at constant speed, when the amount of energy is unchanged. This means that a more complex dependence on the background is needed than a simple scalar effect on the energy that can be stored. This more complex reality is part of FR. Clues to the needed further properties are available in the nature of clout and the energy, momentum, and inertia, of massive and massless particles. Any proposed background must also be compatible with the origin of mass according to particle physics, i.e. the Higgs mechanism.

Clues from the nature of momentum

If the distribution of matter was entirely uniform, then a scalar interaction that depended only on the magnitude of the background should not impede changes in motion. If the background was constant and completely uniform, then linear and angular motion (translation and rotation) would leave the appearance of the background unchanged. This is consistent with objects maintaining constant velocity in the absence of a force. However, if the apparent background is unchanged, then it is hard to see how it could give rise to inertia, i.e. impede changes in linear motion or rotation at all velocities. Force is needed to impart a change in velocity but, after the change, the velocity and momentum remain constant (when there is no further input of energy). This cannot arise from interaction with a direction-independent (scalar) background unless the background appears still, relative to every object as soon as a new velocity is achieved. A scalar background that is stationary relative to every <u>moving</u> object, but resists changes in velocity, does not seem possible. Momentum requires an additional contribution to inertial behaviour which depends not only on stored energy but also on the rate of change of movement relative to the current speed 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 object must carry properties that enable energy to be stored and that allow sensitivity to changes in movement relative to the current movement. If there is a resistance to a change in speed or direction of motion, but no resistance to constant velocity, then the object must carry 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 current alignment. If the rotation is only in the plane perpendicular to the direction of motion, then the object can travel at constant speed but still resist changes in direction.

Energy is required to alter the oscillation/rotation, but the revised pattern then moves at the new constant velocity without further input. 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 ($\frac{1}{2}mv^2$) of interactions between massive particles depends on velocity squared because the momentum that can be exchanged also depends on the rate of change of momentum, which depends on relative velocity. Inertia should depend on the energy carried and its rate of change of movement relative to both its current state and to the background. By analogy with gravity, the state should lose mass if movement increased the sensed background. However, inertia and apparent mass increase, rather than decrease, with speed and the increase is non-linear. These observations imply that mass, and hence inertia, depend on the speed of light, and that inertia but not mass increases with speed relative to the stationary background.

The speed of massless particles is observed to be independent of the velocity of the source. Hence, this speed depends on the magnitude of the background components but not on their direction or movement. However, high-speed movement of massive objects is observed to increase resistance to acceleration and to slow time (as seen in decay rates and clock-rate). Thus, the motion of stored energy (massive objects) depends on velocity relative to the background that arises from the position, magnitude, and movement of other massive objects. However, massive objects moving at high speed do not slow unless an external force is imposed. Only the resistance to changes in speed and direction increases (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 the background, give rise to inertia.

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 a photon's oscillation (after it has been emitted) is not altered by changes in the magnitude of the background (although the frequency or wavelength may be altered). The energy equivalence of this momentum will be proportional to the speed of the photons (i.e. of light).

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

The Higgs mechanism implies a chiral background

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 [12], with the observed mass depending on the particle’s “energy absorbing” ability, and on the strength of the Higgs field [13,14]. If this is the source of mass then we must be living in a world where the basic scalar interaction between elementary particles and their surroundings, that gives rise to their mass, is not gauge invariant. The initial gauge invariance has been broken. Hence, the Higgs boson implies that mass, and hence gravitational attraction, arises from a background dependence. The gauge invariance of the source of gravity has been broken, which is inconsistent with GR which is a tensor theory and gauge invariant.

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

This is a strange argument because it is the attraction between positive and negative charges of QED that generates a force which confines charged particles to a location and the force needed is dependent on the trapped mass (via momentum or KE). Similarly, QCD confines coloured quarks inside nucleons. The force per unit mass of the trapped particle may be independent of a uniform background of charge or colour, but the trapping gives rise to additional mass. The mass of a body is not a constant; it varies with changes in its energy [1]. 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 appearance of most mass being associated with gauge invariant (QCD and QED) interactions can also arise from the sum of all (gluon and photon) interactions having zero net chiral dependence and so appearing gauge invariant.

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

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

FR proposes 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 pairs of equal chiral components and the sum of their interactions will not show a chiral asymmetry.

Chiral asymmetry determines inertia

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

It is proposed 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 their mean value via the speed of light. The change in fractional asymmetry will be $(A+\delta A-\bar{A})/(A+\delta A+\bar{A})$, where δA is a small change in one component (A) and $\bar{A}$ is the component of opposite chirality.

This introduction of a rotation/oscillation whose frequency, and hence resistance to change in angular momentum (giving inertia), depends on the asymmetry of chiral components, allows an explanation of the bending of light, when the empty space between objects cannot be bent, and of inertia without time being distorted. Thus replacing GR's distortion of the geometry of spacetime by mass/energy.

If particle mass is determined by the speed of light, according to $m = E/c^2$, then movement at constant speed in a region of constant background clout should leave the mass, for a given speed of light, constant. However, it is observed that 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 indicates that movement reduces the mean oscillation frequency of the wavefunction. If this arose from the object "seeing" a larger background, then it should lose gravitational mass (as occurs under FR in moving into a region of higher background density) and, thus, have reduced inertia. However, resistance to acceleration, and therefore momentum, increases as γmv, with velocity v.

Thus, FR has 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 there should be 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 $\gamma^2 = 1/(1-v^2/c^2)$.

Inertia then depends on the amount of angular momentum, its velocity relative to the background and on its rate of change (i.e. $F \propto d\vec{p} / dt$). The magnitude and frequency of the oscillation reflect the magnitude of the momentum carried and any differences in the number and magnitudes of the chiral components of the background and the object. Inertia will depend on oscillation frequency as well as stored energy and the ratio of gravitational to inertial mass (m_g / m_i) will not be constant.

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

If inertia does not alter stored energy, then the frequency per unit of energy will depend on the asymmetry at the place of measurement and be independent of the asymmetry at the source. The visible effect of asymmetry on behaviour will then depend on whether differences in stored energy or inertia are being examined. The clock-rate of massive objects based on frequency will depend on inertia (because it depends on frequency) and on the speed of light (because it affects energy).

Time (clock-rate from photon frequency) is observed to increase with gravitational potential (Φ) per unit mass, consistent with the change in potential energy ($\Delta\Phi / c^2$). Planck's constant (h), which relates frequency to energy, will vary with asymmetry of the background if this influences the rate of oscillation but not the photon energy. Such an oscillation frequency, per unit of momentum, would be 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.

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

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" Doppler shift 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.

An equal amount of antimatter appears likely

The observational evidence is that regions of matter and antimatter are separated on scales at least as large as galaxy clusters [15]. If not, a characteristic signal from the annihilation of matter with antimatter should be seen. However, 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. Particles moving towards a region of zero asymmetry would cross the boundary and annihilate. This would remove components with outward momentum. It seems plausible that this would eventually leave behind equal quantities of gravitationally confined, but interlaced regions, of only matter or only antimatter. 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 appears to have the potential to avoid the complete annihilation of baryons and antibaryons expected from the Big-Bang model if particle and antiparticles are exactly symmetric. Galaxies of each matter type might now be locked into clusters of similar matter via gravitational attraction. The lack of interaction then means that the presence of the antimatter regions will not be revealed by annihilation.

The nature of clout

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 implies that changes in the field do not carry energy. Otherwise, the amount of energy gained by a new region must always be matched by the energy lost by the old region, independent of the speed of the object and despite the finite speed of gravity. It also requires that the underlying background can reach a new equilibrium, that persists at the new level, immediately upon the arrival of the propagating increase or decrease in the field. If the field had only one (unbalanced) component, then the change should propagate away altogether.

If the effects of gravitational fields behave like light, then the flux contribution of a mass M would be expected to fall off as M / r^2. Gravitational acceleration has this dependence. If this is the field that determines behaviour, then local matter should have a large effect on the total background and therefore on mass via the speed of light. Based on their mass and distance, the relative contributions to the background (at the surface of the Earth) from the Earth, Sun and our own galaxy would be expected to be in the ratio of 6×10^8: 4×10^5 : 1. However, any effects of Earth on c are tiny.

Newtonian gravity 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. The emission of light involves a flux of radiated energy. When the source stops emitting energy, it goes dark. However, the maintenance of a gravitational field does not lead to a loss in energy. This implies that there is no absorption or dissipation of energy in maintaining the background, suggesting that a gravitational field does not carry energy, instead it affects the amount of momentum that can be trapped by rotating or oscillating states and the speed of propagation of those oscillations.

The conclusion is that the observed dependence of the background potential (clout) on M / 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.

The persistent field of FR implies that there must be two components to the background that enable an equilibrium to be established so that it does not flow away. If there is a boundary that limits the flow away from a source then the volume fills up until the amount coming in stops, as with air in a tyre. The amount is then constant independent of distance. It appears to be essential to have a boundary for a static situation to develop. If there is no boundary any effect from a source would be expected to flow away until there is nothing left of the source. However, a rigid boundary removes any dependence on distance, a flexible boundary based on a balance is needed.

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

If the background chiral components are ρ_1 and ρ_2, and their contributions are to balance then the effect on the components must be complementary. The larger chiral component (ρ_1) could reduce in frequency and/or amplitude by the factor α while the smaller component could increase by $1/\alpha$. This would mean $\rho_1\alpha = \rho_2 / \alpha$ and $\alpha = \sqrt{\rho_2 / \rho_1}$, which is reminiscent of light-speed being $c = 1/\sqrt{\mu_0\varepsilon_0}$. Since chirality is associated with opposing directions of rotation it seems plausible to have a conceptual model based on balanced torques, or angular momenta, whereby the larger component can only induce an increase that is proportional to the square root of the excess in stored energy above the mean. This is because a balance requires an equal and opposite change in the opposing chiral component. The proposal appears to be a promising step towards having a persistent field with a $1/r$ dependence, rather than $1/4\pi r^2$, with distance from the source.

The observation of gravitational "waves" that travel at the speed of light does not confirm that they are travelling distortions of spacetime, or that they carry energy. Changes in the level (clout) of gravity of the proposed background will change the energy that objects can store and would be expected to also travel at a speed 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 the <u>total</u> energy and momentum of objects is conserved. The background field arises from a balanced two-component chirality that enables the existence of states that trap momentum and can transport energy but the field does not itself carry energy. Propagating changes in the background will still be observable and will appear like the gravitational waves of GR.

GR has a persisting gravitational field in the form of a constant distortion of spacetime from sources of stored energy, that can impart energy to objects without the source losing energy (mass). It also has propagating distortions (gravitational waves) that carry energy away from the source (which loses mass) and that energy can be imparted to a detector. This appears contradictory.

If FR is to be consistent with the apparent loss of energy of rotating pairs of pulsars (attributed to the loss of energy via gravitational waves under GR), then the apparent loss in orbital energy must be due to the decrease in the energy stored in the stars as they move closer and, possibly, also to 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 [16]. He proposed an alternative that depends solely on the general-relativistic equations of motion and the Einstein equations. Therefore, it should also be possible to show that FR is able to reproduce the apparent loss of energy, but this needs to be demonstrated.

The New Picture - Full Relativity

Full Relativity proposes a two-component massless chiral background interacting with oscillating wave/particles that contain chiral components. Gravity is due to this 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 and changes in the strength of gravitational and electromagnetic fields, plus gluons and neutrinos, propagate at this speed. This strongly indicates that gravity and the other forces are related aspects of the one background field. The stored energy of objects embedded in this background field is determined by its magnitude which arises from the energy and movement of all other objects. The gravitational force per unit of stored energy is due to the gradient in the magnitude. FR has strong, electromagnetic, weak, and gravitational interactions all being part of the one fundamental set of interactions that generate forces and enable stationary states that confine energy to the current location, i.e. give rise to mass.

Under FR, there are components of angular momentum with different chirality. The opposite sensitivity of these components to the chirality of the background can alter their rotation frequency with speed relative to the background. The sum of the effects on a pair of opposite rotations leads to a reduction in mean frequency of $1/\gamma$ with speed relative to the balanced background. However, if the total angular momentum vector is aligned with the direction of motion, then frequency is unaltered. If not, then inertia is altered but the stored energy is unchanged. Inertia will depend on the asymmetry of the background via rotation frequency for a given stored energy. Momentum will depend on the relative velocity of stored energy, and on its inertia, which will vary with velocity relative to the background and with background asymmetry. The asymmetry should generally be small because the contributions from both matter and antimatter from distant galaxies is large and approximately isotropic due to the large-scale homogeneity of galaxy distribution. However, the degree of asymmetry will vary markedly with position within, and distance from the centre of, an isolated galaxy. Bending of light will occur due to gradients in asymmetry, and hence frequency, perpendicular to the direction of motion.

This picture provides an explanation for the properties of momentum and the effects of high-speed motion. The energy exchanged depends on the relative velocity of interacting quantities of trapped momentum having constant stored energy. There are opposite effects on inertia and oscillation frequency, proportional to γ and $1/\gamma$, with speed relative to a stationary background.

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

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

Massive particles are oscillating standing-wave states containing balanced opposing components with anti-particles having the opposite chirality. These components can counter-rotate and thereby confine a net force (trapped angular momentum) and net stored energy to a mean location. The amount varies inversely with the speed of light, which suggests that the amount trapped depends on how quickly a change can be cancelled. If the background contributions from matter and antimatter were the same, then states would have a stationary pattern without a net rotation. An increasing excess of either chiral component increases the frequency of the net rotation, for a given amount of stored energy. Speed relative to the background alters the balance of counter-rotating components in the direction of motion (and so alters the helicity) but does not alter the stored energy. A change in speed or direction requires a force but there is no force opposing movement at constant speed in the direction of the angular momentum vector. The relative oscillation frequency and momentum transfer of two particles will depend on their speed relative to the background and their speed relative to each other.

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

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

Changes in understanding

The differences between FR and GR are more than just a change from a pseudo-background that alters the perceived time and space of events to a real background that affects the properties of objects. Many other aspects of the accepted understanding are called into question.

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

Einstein's 1905 derivation of $E = mc^2$ [17], was 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 [10], that the inertial mass and the energy of a physical system are equivalent (for all frames). Consequently, there is a widespread acceptance of the fallacy that the mass of a body increases when its velocity increases (following $p = (\gamma m)v$). This should not be possible with a background-independent theory (SR and GR) unless apparent effects become real. If an object stores more energy when accelerated, then it should freely release this energy by slowing. The inertia of the same amount of energy is what changes. Okun has pointed out [18], 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 [19].

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 matched chirality components (spin 1) which carries energy of movement to a new location. The movement energy that can be transferred to a massive particle depends on the relative velocity of the source and receiver of that photon, as per the classical Doppler shift. This shift in frequency with relative velocity implies that, although photon speed is independent of the speed of the emitting and receiving object, the speed of oscillation between the electric and magnetic fields of a photon and charged particle is sensitive to their relative motion. This enables the difference between the relative velocities of source and receiver to be conveyed by the photon. The energy of a photon is carried in rotations perpendicular to the direction of motion. The relativistic Doppler shift arises because the inertia of a massive particle's trapped momentum depends on its velocity relative to the background. The apparent mass of the photon is zero because there is no resistance to motion at the speed of light because there is no trapped momentum in the direction of motion. It is not because there is no energy of movement being carried to a new location.

The reduction in time and decay rate of particles moving at high-speed relative to the background is a real effect from rotation frequency of massive objects being sensitive to motion relative to a balanced background. It is not due to relative speed between observer and object and is not the same if object and observer are swapped unless they have the same speed relative to the background.

The new physical picture changes the understanding of space and time and the way in which they are linked. The relationship between time and space is now more fluid but, individually, time and space have clearer meanings in terms of the rate of events and the distance between objects. Clock-rate indicates the relative rate of events involving the movement and interactions of the same massive objects in different environments. Distances are not distorted and the speed of light can vary. However, observers can relate measurements at different locations, with different backgrounds, in terms of relative rate and separation (time and distance). The Einstein equivalence principle does not hold. The magnitudes involved in the laws of physics depend on the background.

The underlying time (u-time) is distance divided by the speed of light. Time can also be seen in terms of the clock-rate of events, e.g. the ticks of a massive clock. This clock-rate allows for changes in the stored energy of the "same" massive object with changes in the background according to $m = E / c^2$. If identical sets of events, centred on two locations at a fixed separation, remain synchronous, then time, in terms of clock-rate, is the same. Such an "energy" clock-rate will vary with the energy of stationary atoms but will need to take inertia into account if the clock's mechanism is based on the speed of movement of massive objects. Energy clock-rates will only be comparable if inertial mass maintains the same relationship to gravitational mass. The magnitude of inertia varies with speed relative to the background and with asymmetry of the background. An inertial clock-rate based on movement of massive objects does not have to be the same as an energy clock-rate based on the frequency of a given atomic transition.

Predictions and consequences of Full Relativity

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

A revised understanding of Newton's law of gravitation

Newton's law $F = G_N M m_g / r^2$ gives the gravitational force on a mass m_g due to a point mass (M) at distance *r*. The force per unit of inertial mass m_i gives a gravitational acceleration of $\vec{g} = \vec{F} / m_i$. Under GR, the units of gravitational and inertial mass are equated. Under FR, the ratio m_i / m_g depends on asymmetry but this is small and nearly constant within our solar system.

The asymmetry should be constant to the extent that the contributions from the solar system are modest relative to the contribution from our galaxy. If the core of our galaxy has 150 billion solar masses at a mean distance of 8 kpsec, then the contribution of the Sun at the Earth's orbit is about ten times that of the Earth at the Earth's surface but only about one hundredth that of just the core of the galaxy. Changes in asymmetry that alter inertia, and hence kinetic energy, still give rise to a gradient in the ratio m_i / m_g within the solar system but the gradient is reduced by the larger galaxy asymmetry. If m_i and m_g are equated then the effect of asymmetry will be absorbed into the value of G_N with $G_N' = (m_i / m_g) G_N$, where $m_i = m_g$ for the current local background.

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 of gravitational mass in raising an object distance dx against F is:

$$\int (F / m_g) dx = \int G_N M / r^2 dr = -G_N M / r + constant \qquad (5)$$

with distance r from a point source of mass M,

and $$\Delta KE / m_i = \Delta(m_g c^2) / m_g = -G_N M / r + constant \qquad (6)$$

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

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

$$\Delta E / E = \Delta m / m = -G_N M / rc^2 + constant \qquad (7)$$

The acceleration of an object arises from the gradient per metre, of the fractional change in its energy with distance (d metres), from a point source of mass M, i.e. $-G_N M / dc^2$. Such a dimensionless energy equation should apply to all regions in which energy is conserved. The clout from a point source of M kg at d metres, is M / d times the clout of 1 kg at 1 metre, for the current local value of the background that determines G_N and c.

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

$$\Delta\rho / \rho_B = (M / d) / \rho_B \qquad (8)$$

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:

$$(m + \Delta m) / m = \rho_B / (\rho_B + \Delta\rho) \text{ and } \Delta m / m \cong (-\Delta\rho) / \rho_B \qquad (9)$$

and: $$G_N M / rc^2 = M / r\rho_B \qquad (10)$$

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

The value of KE absorbs the ratio of inertial to gravitational mass (of the same amount of matter) into the proportionality factor between stored energy and the inertial energy needed to overcome resistance to changes in movement. If m_i / m_g decreases, then G_N will appear to increase. Its apparent value will vary between regions of the same clout, but different asymmetry, if the units of stored energy relative to movement energy are assumed constant.

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

Newton's equation appears to hold fairly accurately within our solar system because the large background values of stored energy and the speed of light are hardly changing within the periods of time and the differences in location being examined. However, under FR, there will be a fractional change of energy stored as mass giving a change in kinetic energy of $G_N M / rc^2$. This change in mass of $G_N M / r$ will, because of conservation of momentum, alter the speed. This mimics the correction factor of GR due to distortion of time that causes the advance in the perihelion of Mercury.

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 much larger background in the same manner. GR therefore appears consistent with Newton's law of gravitation being due to differences (gradient) in potential, i.e. appearing independent of an absolute background.

Equation 5 is a time-independent energy balance equation where c^2 / G_N is the constant large local value of the background clout and $\left(M / r\right) / (c^2 / G_N)$ is the fractional change in clout. The units of time appear in the equation via the speed of light but the units of c^2 / G_N are kg/m which no longer includes time. Just as in Newtonian gravity, the finite propagation time of gravitational effects is not incorporated. The clout of gravity appears to be a scalar property that carries influence, but not energy, between locations. The size and distance of all contributing masses will alter the clout and hence the energy that can be stored locally. They will also alter the rate of change of stored energy, or trapped momentum, with position after taking into account the arrival time of contributions.

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

Dark matter is not needed

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

The rotation speed of stars in the disk portions of spiral galaxies is observed to be in poor agreement with that expected from Newtonian gravitation and the observed mass distribution, based on assumptions for the luminance to mass ratio of matter in the cores of galaxies. The rotation curves do not decrease as the inverse square root of distance but are nearly constant outside of the central bulge. Under GR, this discrepancy is thought to betray the presence of a halo of dark matter. This extensive halo of invisible matter provides additional gravitational attraction. Diffuse dark matter haloes have also been put forward to explain the observed gravitational lensing of distant galaxies and galaxy clusters, and the evidence for dark matter is considered by some to be compelling [20], while others maintain that there is a crisis [21]. 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.

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

For a galaxy surrounded by an approximately uniform sea of clout from matter (A) and antimatter ($\bar{A}$), the matter asymmetry will be $(A+\delta A-\bar{A})/(A+\delta A+\bar{A})$ where δA is an increase in clout from matter. An inertia that depended on the asymmetry would be proportional to $\delta A/2A$ when $A=\bar{A}$, far away from an isolated galaxy in a uniform background. The M/r dependence of clout should mean that the enormous number of background galaxies, that are relatively large compared with their spacing, would dominate over any one galaxy. This appears consistent with the observed rotation curves if $c \propto (A+\bar{A})$, because the force, due to the ($1/c^2$) increase in mass with decreasing speed of light, would be accelerating objects whose inertial mass was decreasing in proportion to c. The effect is to decrease inertia, at large distances from a point source of like matter, by a similar amount to that by which the gravitational attraction from that same matter reduces. The gravitational force depends on the gradient in total clout while the inertial force also depends on the asymmetry between the matter and antimatter contributions. The latter depends on the excess of the sum, from all directions, of just one component. Within an extended uniform distribution of stars in a galaxy the asymmetry from the surrounding galaxy can dominate and be nearly constant near its centre, while the gradient from a nearby single star or planet can be large. The background asymmetry and inertia will reduce, leading to an apparent change in G_N, with decreasing isotropy of the source of asymmetry. This removes the first reason for postulating dark matter.

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

Evidence against the need for dark matter comes from a study of the rotation rate at different distances from the centre of spiral and irregular galaxies. It was found that the radial acceleration is strongly correlated with the amount of visible matter attracting it – but the relationship does not match that predicted by Newtonian dynamics [22]. The strong correlation implies that, if dark matter exists, its distribution is fully determined by the baryonic matter. The change in inertia, under FR, provides a simple explanation of the relationship with visible matter without the need for dark matter.

Implications for the development and expansion of the universe

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 will be negligible. However, clumping increases asymmetry which will increase inertia within the clump, which will slow the movement of massive objects and orbits will contract. 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 arises from stored energy and the amount per unit matter decreases with increased local clumping. If the distant background reduces then objects should move closer together by just the amount needed to maintain the same standing wave patterns and conserve energy under an altered speed of light.

Hence, the clumping of matter can reduce the background clout, even if there is no change in total matter. Thus, clout should decrease as the universe evolves, leading to an increasing redshift going back in time, without expansion being required. The increase in inertia with asymmetry implies that a galaxy of like matter will tend to evolve into a disk with a core where the asymmetry is so large that changes in inertia with changes in clout become small. The strength of gravity between objects rotating about each other (within a region of large asymmetry) would appear smaller but this would most likely be attributed to a lower-than-expected mass of the components. The mass and amount of matter of the black hole at the centre could then be greatly underestimated.

If the background clout is decreasing over time, then the energy and frequency of massive objects will be increasing. 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 leads 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. This 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 observed redshift will be due only to the change in energy with the change in the speed of light. Moreover, the clumping of matter and antimatter should be expected to change at the same rate keeping asymmetry small.

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 will take longer (u-time) to propagate because the mean speed of light, away from the clump, reduces as clumping increases. 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 of galaxies does not require an expanding universe, which means that a Big Bang was not necessary. Moreover, time (in terms of the clock-rate applying to the same objects) is getting faster.

Advance in perihelion of Mercury

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

The amount predicted under FR can be compared with that of GR based on the supposed distortion of spacetime. The latter assumes that mass and angular momentum are conserved and introduces an additional energy term of $G_N M / rc^2$ into the energy balance equation (per unit mass) [23]. 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 [24].

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

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. FR claims that the same amount of bending (as GR) arises because two components change, the amplitude of oscillation of both the electric and magnetic fields.

GR claims that the time delay is caused by spacetime dilation, which increases the time it takes light to travel a given distance from the perspective of an outside observer. The delay is attributed to the slowing of time (clock-rate) and contraction of distance deeper in a gravitational potential. This follows the strange, inverted behaviour claimed in SR. Under FR, the slowing of time (clock-rate) is irrelevant for massless photons, and instead their speed increases. FR and GR have opposite contributions from the changing speed of light. However, under both GR and FR, the observed delay arises from the increased path length, relative to the straight-line path, due to bending. This part of the delay has a logarithmic dependence on the ratio of the path length to the distance of closest approach. The logarithmic dependence has been used to fit the experimental data and therefore determine the delay. The extra delay (GR) or advance (FR) due, respectively, to the effect of the gravitational potential on time and the speed of light, is integrated over the length of the path through the altered potential. The difference in speed varies only slowly and steadily around the path across the orbit between source and receiver. For measurements within our solar system, the extra change will be absorbed into the calculated orbital parameters. FR claims that the measured delay, which is in good agreement with GR, is only that due to the changed path length. This is supported by the fact that it is twice that expected from Newtonian gravity which has half the amount of bending and no spacetime dilation. 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.

Under FR, the speed of light can change but photon momentum and energy are conserved. Thus bending does not arise from changes in energy of the photon. Instead, the fractional change in direction (bending) must arise from a fractional change in amplitude that is independent of energy. Any change in background that alters amplitude (independent of frequency) perpendicular to the direction of motion will cause bending. Gradients in asymmetry will change frequency in proportion to the fractional change in asymmetry. Thus, under FR, gradients in the amplitude of photon oscillation in the plane perpendicular to its direction of motion determine the amount of bending.

The photon will be bent by a gradient in amplitude of both the electric and magnetic oscillations in the direction of decreased amplitude (increased frequency from increased asymmetry). The amount will match that from the distortion in both space and time that gave rise to the doubling of the predicted bending under GR. The change in frequency of a photon perpendicular to the direction of motion should be the same as that which applies to massive objects. Within our solar system the local value of $G_N M / rc^2$ reflects the fractional change in energy when inertial and gravitational energy are equated. This inertia is primarily determined by the asymmetry of our location within our galaxy. Using the local value of G_N elsewhere will lead to disagreement with the observed bending.

If the background chiral component from antimatter is constant over the region of interest, then the fractional asymmetry is proportional to the gradient in the matter component of the clout. The asymmetry will change if a galaxy is an isolated excess of matter in an approximately uniform background of matter and antimatter. The amount of bending relative to that expected will vary in proportion to the disagreement with the value of G_N (for our solar system) that incorporates a fixed ratio of inertial to gravitational mass. Hence, GR and FR will give the same predicted amounts of bending in our local region of the galaxy. FR will give different predictions elsewhere, but these will agree with the rotation curves of galaxies, because oscillation frequency and inertia have the same dependence on asymmetry. The putative amount of dark matter needed to account for gravitational lensing will match that needed to account for the velocity of matter (e.g. galaxy rotation curves).

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 [25]. It is claimed that the bulk of hadronic matter is at the location of the visible plasma while the gravitational bending indicates that centres of gravitational attraction are at the centres of the galaxy clusters, which is where the (electromagnetically) non-interacting dark matter should be expected to reside. The suggestion that the plasma should indicate the location of the dominant source of mass appears to be based on tenuous evidence.

The local value of asymmetry

The position of the solar system in a spiral arm of our galaxy suggests that our location is one of finite but not large asymmetry as the flat rotation curve of similar galaxies begins to appear in the outer spiral arms. If background clout reduces, then the orbits of the stars of the galaxy will shrink as they take in energy in order to try and maintain the same standing waves of their matter. This will increase the proportion of the like matter component of the total clout and so increase the asymmetry and inertia. Hence, the absolute rate of change of time should also depend on the rate of change of asymmetry and position in a galaxy in terms of the rotation curve.

FR has no need for dark matter so the needed amount should be explained by the degree of asymmetry at our location in the universe. The apparent amount of dark matter should be consistent with our location within an isolated galaxy of known shape. It can be calculated if the sources of mass and their amounts and distances are known. Based on accepted masses, distances and constant inertia, the value of the clout from Earth at its surface is 9.4×10^{17} kg/m, the value from the Sun at its surface is 2.85×10^{21} kg/m, reducing to 1.34×10^{19} kg/m at the Earth. The mass of our galaxy has been determined to be 1.5×10^{12} solar masses but the calculations are based on the rotation curve assuming constant inertia and include the supposed dark matter of GR with it being estimated at 90% of the total. The mass of the core of our galaxy has been estimated to be between 100 and 400 billion solar masses. If its mass is 150 billion (1.5×10^{11}) solar masses at a mean distance of 8 kpsec, then the clout from the core of our galaxy at our solar system is about 1.22×10^{21} kg/m but the total clout could be ten times higher if the total surrounding mass is ten times the core at a similar average distance. This latter amount would dominate that from the Sun and the Earth at the Earth's surface by factors of roughly 10^3 and 10^4. However, it is small relative to the background clout (1.3×10^{27} kg/m) which is 10^5 to 10^6 times the estimated clout from the matter of our galaxy. Our galaxy should dominate the local asymmetry but it is still tiny.

The variation in asymmetry with distance from the core will approach a $1/r$ dependence as the distance to the core makes it appear point-like. This will significantly influence the rotation curve while the asymmetry at our position will be determined by both the core and bulk of the galaxy and be nearly independent of the contribution from the Sun. However, the calculation of the contributions to the clout needs to include the change in inertia (currently assumed constant) with location.

The value of asymmetry should be approximately constant for the planetary orbits within our solar system because the contribution to asymmetry from the Sun at the orbit of Mercury is significantly less than the likely background value from our galaxy. The correct prediction of the bending of light by the Sun would also suggest that the total asymmetry is hardly altered close to the Sun.

The increase in clock-rate with time explains the Pioneer anomaly

The fractional increase in energy of atoms with u-time should reflect the decrease in speed of light with decreasing background clout since the light was emitted. Hence, $Z = 1$ will correspond to a change in clout equal to the current clout. From the fit, the elapsed time for this change in constant units of u-time, i.e. after allowing for the speed of light being faster in the past, is 1.404×10^{26} m or 4550 Megaparsecs divided by the current speed of light. Hence, the clout has doubled in 4.68×10^{17} seconds (of u-time).

The constant slope of the supernovae data as a function of u-time yields the rate of increase in clout. The momentum trapped in massive objects is inversely proportional to the speed of light. Hence, clock-rate increases (time intervals reduce) if the background clout decreases. Under FR, the fractional rate of change of clout and of the current speed of light with current time is the distance light travels in a second divided by the slope of the supernova data, i.e. 2.137×10^{-18} per second. This increase means that a signal of supposedly fixed frequency, using an atomic clock, will actually be increasing in frequency over time. If a signal of nominally constant frequency is sent to a distant spacecraft and back it will appear to drift lower in frequency, because local time (energy clock-rate) will have increased during the time taken for the signal to make the round trip. The observed frequency should uniformly decrease by $\Delta f / f = 2.137 \times 10^{-18}$ per second, if the frequency per unit energy is constant. However, changes in asymmetry may also need to be taken into account.

The change in frequency with time for returned signals will reflect any change in emitted energy, during the time of signal transmission, of the reference transition used in the stable clock. It will also reflect any change with time in the frequency per unit energy of the clock. The photons of the returned signal will still have the unchanged energy of their emission. However, changes in frequency from changes in both energy and asymmetry will be visible if a delayed signal is compared with a newly emitted signal. If the background was larger at the time of emission, then the speed of light will have been faster and the emission energy and frequency smaller. If the asymmetry at emission was smaller than at reception then there will be an additional decrease in frequency.

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

A signal, of locally constant frequency, was sent out from Earth then back from the Pioneer spacecraft at a frequency locked to a fixed large fraction of the received signal. Such a procedure is equivalent to a reflection and is independent of clock-rate at the spacecraft. By the time of return, the frequency of the signal from the time of emission will be lower than the new reference frequency. Therefore, the returned frequency will appear to drift lower with increasing elapsed time of the journey. The rate of drift should be constant and the amount should be proportional to the return journey time of the signal. The signals returned from the Pioneer spacecraft were observed to show a steady downwards drift in frequency of approximately 6 x 10^{-9} Hz/s or 1.51 Hz in 2.11 GHz in 8 years or 2.84 x 10^{-18} s^{-1} [26]. This is in remarkable agreement with the predicted drift in frequency.

Under GR, a gravitational (acceleration) field leads to a time dilation, so that clocks on Earth run slower than the clocks of the GPS satellites which are in a weaker gravitational field. The Pioneer drift has therefore been attributed to an anomalous deceleration towards the sun of approximately 8 x 10^{-10} m/s^2. A more recent analysis has suggested that the anomalous deceleration decreased with time [27], 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 [28]. 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 [29]. The observed decrease in time of the generated heat energy enabled a fit to the navigational data (position with time). The fit was consistent with the slowing from thermal radiation and it was concluded that once the thermal recoil force was properly accounted for, no anomalous acceleration remained. However, it was not explained why the earlier paper [26], using a least-squares fit over the whole orbit, showed the <u>steady</u> drift in frequency (corresponding to an anomalous deceleration of 8.65 ± 0.03 × 10^{-10} m/s^2 under GR), which is inconsistent with the claimed decreasing thermal deceleration with time.

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

No need for cosmic inflation

The converse of clock-rate increasing with time is that clock-rate was progressively slower and the speed of light faster, earlier in the history of the universe. Moreover, the increasing redshift of galaxies with distance does not require an expansion. This removes the need for “cosmic inflation” which was hypothesised to explain why the observed universe could be so uniform and isotropic if distant regions had not previously been in thermal equilibrium. The suggestion that the universe expanded by 20 orders of magnitude in the first 10^{-35} seconds after the Big Bang should have always been seen as untenable, when the existing laws of physics say that infinite energy is needed to get even the smallest amount of matter moving at the speed of light. The incredibly rapid expansion would have to have been much greater than the speed of light, violating SR and GR. 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 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 spacetime being a distortable fabric (metric), a relationship and “not a thing”.

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 [30]. The relationship $L \propto W^4$ applies over several orders of magnitude. Since the intrinsic luminosity is inherently independent of dark matter, but dark matter (if it exists) should have an effect on the rotational velocity, the relationship is actually evidence that dark matter does not exist. The relationship appears to be explicable by FR.

The approximately flat rotation curves require the force of gravitational attraction to be matched by the centripetal acceleration force. Hence, $G_N Mm / r^2 = mv^2 / r$ and $M = (m_i / m_g) rv^2(r) / G_N$, where $m_i / m_g = 1$. The decrease in inertia as $1/r$ means $v^2 = G_N' M$ so that the square of the asymptotic velocity (amplitude of the rotation curve) reflects the mass of the galaxy. The inertia for the same distance from a single source of asymmetry will also be proportional to the mass of the source and the clock-rate of energy emission should increase as inertia decreases. Hence, the luminosity of an extended spiral galaxy should depend (roughly) on the number of stars (if they are on average the same) and their rate of emission and hence on mass squared. From which it follows that $L \propto W^4$.

The consequences of FR for many other astronomical observations, such as the distribution and evolution of galaxies, for nucleosynthesis, and for the separation of matter and antimatter, need deeper investigation. It would also be desirable to show that FR reproduces the apparent loss of energy of binary pulsars attributed to gravitational radiation under GR.

Experimental tests of FR versus GR

FR asserts that the there is a real background from the mass stored by all other objects and that mass and the speed of light vary with changes in this background. GR asserts that mass is constant but that the observed speed of light and clock-rate decrease when examined from a higher gravitational potential. FR also asserts that frequency and inertia should depend on the asymmetry of the background. Differences (between GR and FR) will appear when comparing regions with different total clout, or differences in asymmetry, where there are means of assessing relative clock-rate, or local frequency, or energy. A number of experimental tests, or possible observations, are put forward to distinguish between the theories.

Test of light-speed variation

If gravitational mass is stored energy and gravitational attraction arises from a reduction in mass, then $m = E / c^2$ implies that the speed of light increases with increasing clout. The stored energy (m) of the same amount of matter (current energy E) decreases with a conversion factor of $1/c^2$. Hence, FR requires a faster speed of light closer to a massive object. This conflicts with the distorted spacetime of GR with a locally constant speed of light. The distorted spacetime gives rise to a decrease in the speed of light when viewed from a location at a higher gravitational potential. The opposite change in the speed of light allows experimental tests of GR versus FR by examining the propagation time of signals along paths of different or varying mass density/clout.

The GR predicted slowing of time (clock-rate) lower in a gravitational potential is a confirmed effect seen in the faster clock-rate of the GPS satellites. In the language of gravity being a curved spacetime, the light trajectory in the curved spacetime will be different to that in a flat spacetime [31]. The dilation of time and contraction of space causes light to take a longer path giving an increase (Shapiro delay) in the time it takes light to travel a given distance from the perspective of an outside observer. Under FR, the slowing of time (clock-rate) is irrelevant for massless photons, and instead the speed of light increases closer to a massive object.

The effects of many alternatives to GR, that are still metric theories (unlike FR), have been formalised in terms of their effects on a finite set of parameters [32]. The relevant parameter for path length is γ (which is unrelated to the use of the same symbol in SR). The parameter measures the amount of curvature of space (only) relative to that predicted by GR $(\gamma = 1)$. The contribution of time to curvature, known from the dilation of time with gravitational potential, is set to 1. The accuracy of the predictions of different metric theories has been examined in terms of the value of $\frac{1}{2}(1+\gamma)$. Observations are consistent with the GR value of 1, for both the deflection of light and the Shapiro delay, to within 0.01 percent [33]. However, it needs to be recognised that the value of the Shapiro delay, as currently determined, is solely a measure of the amount of bending. The delay from the increased path length in spacetime is predicted to have a logarithmic dependence on the ratio of the path length to the distance of closest approach. All observations appear to have used this logarithmic dependence to remove effects from uncertainties in orbital movements and from distortions due to the solar corona.

Under both FR and GR, the path is determined by the bending and the predicted amount of bending is the same and in excellent agreement with observations. For FR, the amount of bending is determined by changes in oscillation frequency of both the electric and magnetic fields which gives twice the Newtonian bending.

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

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

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

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

Test of time dilation with speed relative to the background

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

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

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

The change of time with time

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

The effect of asymmetry on inertia and bending

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

The value of asymmetry should be approximately constant for the planetary orbits within our solar system because the clout from the Sun at the orbit of Mercury is 3.43 x 10^{19} kg/m which is about 1/35th that of the estimated background value of 1.2 x 10^{21} kg/m from just the core of our galaxy. However, this estimate does not allow for the increasing inertia towards the centre of our galaxy and the consequent underestimate of its mass, or for the contribution from stars in all directions. The apparent need for five times the amount of dark matter to ordinary matter when inertia is assumed constant suggests that the background from the galaxy is at least 6 x 10^{21} kg/m. This would mean that the orbital periods of Mercury and other inner planets would be marginally slower, relative to the other planets, than that predicted by Kepler's third law. A more stringent test would be in the bending of light by the Sun as the clout at its surface (assuming constant inertia) is 2.86 x 10^{21} kg/m. This is likely to be a significant fraction of the background from the galaxy and so may be enough to increase the amount of bending close to the Sun by an observable amount.

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

Modelling of galaxy distribution and evolution

Clusters of galaxies, and large-scale separation of regions of matter and antimatter, could lead to modest variations in the asymmetry of the background with direction. This would mean that inertia would vary along the gradient in background asymmetry. It would lead to a periodic variation in rotation velocity with direction, for the same distance from the galaxy centre. A unidirectional gradient could then be expected to give rise to a pair of spiral arms. The gradient might also explain why spiral arms are not rapidly wiped out 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.

It needs to be shown that a satisfactory picture of the observed large-scale structure and distribution of galaxies, including the apparent voids, can be modelled using FR. Ideally, modelling or improved theoretical arguments are needed to confirm that separated regions of surviving matter and antimatter should have been formed early in the universe and now be permanently separated and so not give rise to an annihilation signal. Modelling might also enable a clearer picture of the synthesis of light elements and their expected abundances and with the observed photon to baryon ratio.

Implications for particle physics

If gravity arises from the energy stored by all forces, then it is likely that all the properties and interactions of objects arise from different aspects of the one background. The observation that the speed of propagation of light, the speed of the quanta of electromagnetic interactions, is the same as the speed of propagation of gravity should be seen as strong evidence of the underlying unity of electromagnetic and gravitational fields and forces. The massless gluons of strong interactions are also understood to travel at the speed of light, but not the massive weak bosons.

Under FR the propagation of the gravitational field does not appear to carry energy or angular momentum and so should not be quantized. A quantum theory of gravity is not needed. Space and time do not need to be quantized. Instead, quantization amounts to having allowed stationary states in the wave behaviour of objects embedded in a background that allows oscillations.

The revised understanding emphasises that all particles (massive states as well as photons) are oscillating states, as put forward by Born [34]. 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 definitively because the relative phases of the wavefunctions cannot be established without altering their phase relationship.

The strong, weak, and electromagnetic interactions have been unified in terms of gauge interactions (QCD, Electroweak and QED) of a finite set of elementary particles in which masses are predictable and linked via a finite self-consistent set of parameters. This is known as the Standard Model (SM) of particle physics. The renormalizable quantum field theory, covering all interactions except gravity, can be written down in terms of a Lagrangian that has terms for each of the strong, electromagnetic and weak interactions. High energy experiments, so far, have been remarkably consistent with the SM. However, it has many arbitrary features and all attempts at understanding these features have failed abysmally [35]. In 1994 Veltman pointed out that the many unknowns included the origin of the particular symmetries of the SM, SU(3) x SU(2) x U(1), why there are three generations of particles, and any explanation of the values of the underlying set of coupling constants and masses. Moreover, in his words: “In the background, as always lurks non-renormalizable gravitation with its black and other holes”. Thus, the SM should be seen as a valid method for calculations and predictions but in need of an underlying physical explanation of how and why it works.

Many suggestions of physics beyond the SM have been put forward. These include dark matter and dark energy, the lack of antimatter when the laws of physics appear symmetric and that neutrinos have mass (because they oscillate between flavours). FR removes the infinities of black holes and the need for the blackness of dark matter and energy, and suggests that an equal amount of antimatter is actually present. It will be argued that neutrinos are also massless. FR also removes the problem of the GR claim that gravity is not a force but a property of spacetime. Such a force is incompatible with QM and the SM behaviour of the other forces.

The quanta of the interactions (photons and presumably gluons and the gauge bosons of the weak interaction) and massive particles have an oscillation whose Compton wavelength is dependent on the energy carried. FR proposes that the chiral asymmetry of the background determines the rotation frequency of the trapped angular momentum seen in this Compton wavelength of quantum mechanics. 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).

These observations would appear to be strong evidence that gravitational mass also includes the stored energy (trapped momentum) from the strong, weak and electromagnetic interactions. It also implies that the massive bosons of the weak interaction, plus quarks and multiple quark states (hadrons), store energy because of the chirality of the background. Hence, a model of the nature of the exchange bosons (graviton, photon, gluons, $W^{\pm}, Z_0, H$) and massive (or massless) fundamental fermions (neutrinos, leptons and quarks) in terms of chiral components is needed. The correct model should then allow the values of the SM parameters to be predicted based on the values of the two-component chiral background. It should also explain the modest mass of the Higgs (H_0) when its self-interaction might be expected to make it enormous.

In quantum field theory the wave behaviour means that two numbers are needed for each point in space, a magnitude and a phase. A simple gauge invariance arises for vector fields that have a magnitude and phase at each location and time. It means that the choice of the zero position of the phase is of no importance for interactions, only the relative phase matters. Gauge invariance gives, or results from, conservation of a physical property. QED is associated with conservation of electric charge. Local gauge invariance requires the agent that is carrying the information from one electron to another be a massless vector boson [36].

The development of the SM was based on the realisation that gauge invariant theories involving spin_1 bosons (Yang-Mills theories) were renormalizable. For the strong interaction there were 3 x 3 massless gauge bosons (the gluons) while the electro-weak interactions had the one massless boson (the photon) and three massive bosons ($W^{\pm}, Z_0$). These acquired their mass via the Higgs mechanism – a spontaneous breaking of an underlying gauge invariance, as occurs with the spontaneous alignment of spins in a ferromagnet cooled below its critical temperature. The Higgs mechanism applies to massive bosons and the understanding (under GR) has been that the mass terms preclude chiral gauge invariance for massive fermions (because a massive particle moves at less than the speed of light and its apparent direction of rotation will change when it is overtaken). The gluons of the strong interaction are massless but a (Yukawa-type) coupling between fermions and the Higgs field is introduced to handle and explain the non-zero mass of the fermions.

Under FR, there is an underlying gauge invariance of the particles but it is not fully manifest in regions in which there are differences in the contributions from chiral components (matter and antimatter) to the underlying field. The symmetry is broken, with a decreasing speed of light providing increased time before differences cancel (allowing trapped momentum), and the asymmetry of the background within regions providing rotations which introduce inertia. The postulated Higgs field is just a manifestation of part of one underlying field containing different chiral components.

Under the SM, it is the interactions of the fields of elementary particles (both fermions and bosons) with just the background Higgs field that gives rise to their mass and to the strength and symmetries of their interactions. Under FR, all interactions that involve the one background field can potentially lead to mass and broken symmetries when chiral components interact in a background from unequal chiral contributions. This underlying understanding of the nature of the field(s) and particles can, hopefully, enable the observed masses, couplings and symmetries to be reproduced.

FR supports the SM with its three flavour families and <u>massless</u> neutrinos. They are massless because the <u>net</u> angular momentum is purely in the plane perpendicular to the direction of motion. However, it is proposed that the number of components differs for the three families. Although massless, the neutrinos can oscillate between flavour families because they have different frequencies for a given energy (i.e. different values of h). The belief that oscillations between neutrino states necessitates that at least two states are massive must be questioned. If right-handed neutrinos or left-handed anti-neutrinos existed, then a photon should be able to decay into pairs of neutrinos.

The proposed mechanism for establishing a persistent background field related to the density of matter and antimatter is that the torques from the larger component of the field decreases and that from the weaker field increases until the contributions balance. Even if the contributions to the background are identical, oscillations of a torque about a mean position in space should be able to occur. If the contributions are slightly unequal then the behaviour of the component rotations would also be slightly different. The direction of rotation as a function of the direction of movement (i.e. chirality) would be opposite. Opposing components of the same chirality could trap a net force about the equilibrium point. Parallel components of opposite chirality would seem to be able to give rise to a travelling pattern that moves at a fixed speed but has a rotation proportional to asymmetry perpendicular to the direction of motion.

The photon is massless, not because it does not carry energy in the form of angular momentum, but because: i) its angular momentum vector is aligned with the direction of motion, and ii) the pairs or triplets of rotating components have matched chirality, so that movement relative to the background has the same effect on each chirality. These attributes mean that it travels at constant speed independent of movement relative to the source of the background yet resists changes in direction. It also is gravitationally attracted (bent) perpendicular to its direction of motion.

Some more speculative suggestions follow. It is proposed that a pair of chiral components corresponds to a gluon of the strong interaction and that the 3 colours of gluons (**r**ed, **g**reen, **b**lue) are associated with the three orthogonal directions of space. The photon is then the missing ninth gluon that is an equal mixture of pairs of the three orthogonal colourless gluons ($r\overline{r}$, $g\overline{g}$, $b\overline{b}$). Previously, the ninth gluon has been assumed not to exist because it has no colour and leaves coloured quarks and gluons unchanged under the strong interaction. The photon does this but interacts with the electric charge of quarks and merely flips the spin of charged particles. The bosons of the weak interaction would be doublets or triplets of mixed chirality components that trap momentum and so have mass.

The force carrying particles that give rise to mass must include not only the Higgs boson (H_0), but the vector mesons ($\mathrm{W}^{\pm}$, Z_0) and also the photon and gluons. The mass of particles is determined by the extent to which all the known forces (strong, electromagnetic, weak) act to store energy in a limited location. Any force that acts to localise a particle (a standing wave) stores more energy the greater the confinement of the particle. It is proposed that the sum of the chirality contributions in strong interactions balance and so the average interaction does not exhibit a handedness although the mass of quarks can still arise from chirality.

It is further proposed that the three required massive bosons are not the $\mathrm{W}^{+}, \mathrm{W}^{-}$ and Z_0 (as previously understood) but the boson pairs $\mathrm{W}^{+} / \mathrm{W}^{-}$, Z_0 / γ and $\mathrm{H}_0 / \overline{\mathrm{H}}_0$. Thus, the Higgs is one of three boson pairs in which chirality and rotation trap energy (except for the photon) which gives rise to their mass. This enables a prediction for the Higgs mass in terms of other bosons. It suggests that the Higgs mass should be: $(m_{\mathrm{W+}} + m_{\mathrm{W-}} + m_{\mathrm{Z}})/2$ = 125.979 ± 0.024 GeV/c^2 [37], compared with the measured 125.09 ± 0.24 GeV/c^2 [38] and the latest value from the CMS collaboration of 125.35 ± 0.15 GeV/c^2 [39]. The division by 2 arises because there is a Higgs and an anti-Higgs boson. Hence, FR gives a borderline prediction, as it is higher than the measured value for the Higgs mass by 4 to 5 σ. However, the CMS result for the $\mathrm{H}_0 \rightarrow \gamma\gamma$ channel is 125.78 ± 0.26 GeV/c^2, while for the four lepton final states

$H_0 \to Z_0 Z_0 \to 4l$ the values for the 4e, 2e2μ and 4μ channels have elsewhere been given separately as approximately 124.4, 126.0 and 125.0 GeV/c^2, respectively [40]. One possibility seems to be that the 4e and 4μ channels may have some contamination, for example, from a mis-identified e or μ and a missing neutrino which shifts the apparent Higgs mass lower. Contamination in the 2e2μ channel would need two missing neutrinos. Moreover, the H_0 mass is considerably less than twice the Z_0 mass, so one or both of them is virtual or off-shell and the broad mass of the Z_0 means the selection is poorly constrained against missing energy. Another possible explanation might be that electromagnetic (charged) self-interactions have raised the W^+ / W^- mass by $\alpha \simeq 1/137$.

It is proposed that the quarks of the three flavour families may be equivalent to temporary states of pairs or triplets of the charged lepton states of that family but missing one or two gluons that are continually being exchanged. Only two-thirds or one-third of the possible photon reactions are then possible making the quarks appear to have the corresponding fractional charges. The quark states cannot exist without the continual exchange of gluons which leads to confinement and asymptotic freedom because a change in momentum requires a torque that acts at a distance.

Conclusion

The proposition that gravity arises from a loss in mass stored by matter when the background from other matter and light-speed both increase is strongly supported by the advantages it gives. The decrease in gravitational potential is equal to the loss per unit matter in energy stored as mass. Gravity does not arise from a distortion of a fabric of spacetime linked by a constant speed of light. The source of the kinetic energy of gravitational acceleration is the stored energy of the object. The objects and their properties change rather than the geometry of empty spacetime between objects. The mass of matter decreases with increasing background from all sources of stored energy, with the contribution of each source having a $1/r$ dependence on distance. The background is therefore dominated by distant galactic contributions with the effect of nearby sources appearing like a small gradient on a large, only slowly changing, background. The variable mass removes the singularities inside black holes of GR, and there is no need for an enormous pool of energy in empty space or for the hypothesis of cosmic inflation. The increase in the speed of light going back in time removes the need for an accelerating expansion and, hence, for dark energy. Moreover, holding mass constant in GR necessarily leads to empty space giving rise to gravitational attraction and the appearance of a dark energy. Instead, the supernovae observations yield the rate at which time is slowing. The energy per unit of matter is increasing as matter clumps closer together over time. This explains the redshift of distant galaxies without the need for an expanding universe at all, let alone one in which space itself can expand. The hypothesis that inertia arises from asymmetry in a two-component chiral background enables an explanation for flat galaxy rotation curves and the amount of gravitational bending of light without the need for dark matter. The rate at which time is slowing, deduced from the supernovae data and the change in inertia, accurately predicts the Pioneer anomaly. FR is able to reproduce all the standard predictions of GR while suggesting explanations for observations such as the Tully-Fisher relation. Nevertheless, a number of experiments and observations that would distinguish between GR and FR are put forward.

Full Relativity has many further consequences which are still being developed. There are also many implications for particle physics and the unification of forces. It appears that FR removes most or all of the many suggestions for physics beyond the Standard Model. These and further aspects of FR are more fully set out in a draft book ‘Making Sense of Gravity’ which can be downloaded from the web at **www.fullyrelative.com** . The work is ongoing and the reader is invited to further develop the theory, its implications and possible experimental tests.

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