New Understandings in Gravitational Theory and Cosmology

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ABSTRACT

This discussion paper sets out a simple, elegant theory of gravity that necessarily follows from revised perspectives on mass, light-speed and spacetime. It still has time changing with both movement and gravitational potential of massive objects, but distance (space) is not contracted or distorted. Nevertheless, the new theory appears able to reproduce all the predictions claimed by general relativity's warped spacetime. Moreover, it is backed by solid observational evidence and by removing the need for dark energy, dark matter and singularities inside black holes. It also overcomes the flatness and horizon problems, and the claimed 'Hubble tension'. Further challenges to the current consensus model of cosmology include the removal of the evidence for the universe to be expanding, to have arisen in a big bang, or to have undergone cosmic inflation. These remarkable claims are not made lightly or without evidence but take time and space to be acceptably explained. Observational and experimental tests are also put forward. The implications flow into much of theoretical physics. It appears that all the current claims for physics beyond the standard model of particle physics are removed. The aim is to encourage critical analysis of the arguments, evidence and observational tests.

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Introduction

General Relativity (GR) explains gravity as a distortion of the geometry of a fabric of spacetime. This fabric alters the perceived time and distance of a linked combination (spacetime) in which mass and the speed of light are invariant for the local observer. It was built on the success of Special Relativity (SR) which proposed that the behaviour of events in space and time was altered by high-speed motion relative to the observer, but light-speed was invariant.

The observations and arguments for a new picture are set out here together with their consequences. The most important change in understanding is that mass is solely the energy stored within matter, and that the amount stored decreases when the speed of light increases. The source of gravitational attraction is the release of this stored energy (mass), per unit matter, as kinetic energy of motion. The force of gravity comes from the fractional loss in mass proportional to the gradient in gravitational potential energy. The new understanding then provides an alternate cause for the Hubble redshift of distant galaxies. It will be shown that clumping of matter, and increasing inertia, as the universe evolves should steadily reduce light-speed and increase mass. Galaxy redshifts looking back in time come from a decrease in the energy levels of atoms with increasing light-speed as is seen in gravitational attraction. Supernovae observations then indicate no need for the universe to be expanding at all.

The replacement theory has a real background field that replaces the fabric of spacetime. GR's increased distortion of the geometry of spacetime in which unchanged objects are embedded is replaced by an undistorted space in which objects, and the speed of light, are altered by the background. Movement relative to this background, from all other mass, slows frequency (clock-rate) of massive objects and increases inertia, and can contract length, but does not contract distance. The speed of light and properties of objects, including mass, frequency and inertia, are altered by the magnitude and asymmetry of the components of a field from all other matter. This is why the new theory has been labelled Full Relativity (FR).

A background field is essential

The first step in accepting the revised picture is that some sort of invisible background is essential to convey action-at-a-distance. Such backgrounds are now typically referred to as fields. The best known are electric, magnetic and gravitational fields. Rubbing an insulator can free electric charges on its surface. These will raise the hair on your skin from a distance. Compasses in space can still align with the magnetic field of the Earth. Gravity can act over the vast distances and near perfect vacuum between galaxies. Interestingly, changes in all three fields are observed to propagate in a vacuum at the speed of light. Light being oscillations between electric and magnetic fields (photons) that come in lumps (quanta). The one speed suggests that all three fields are aspects of a single more-complex underlying field, that gives rise to the scalar and vector potentials of gravity and electromagnetism.

Originally a background field was invoked as an aether, the medium which allowed light to propagate through the vacuum of empty space. However, experiments to detect the motion of the Earth (in its orbit around the Sun) relative to this aether have always failed to see an effect. After developing SR, Einstein proposed that the introduction of a "luminiferous aether" was superfluous as far as defining a location relative to which electromagnetic processes take place [1]. However, after developing GR he argued that a medium (aether) to carry light and enable the existence of standards of space and time, and of spacetime intervals, was still essential. However, it could not have the "*characteristic of ponderable media*", i.e. matter that could "*be tracked through time*". "*The idea of motion may not be applied to it*" [2].

These statements embody aspects of the alternative that is being proposed. A background medium that carries radiation and enables gravitational attraction is still essential. This invisible medium is still needed to carry the oscillations and give rise to changes in strength of electric, magnetic and gravitational fields. It is also essential as the medium that enables matter (mass-carrying wave-particles) to exist and move. However, the movement of light does not follow the rules for massive (ponderable) matter. Light and the medium cannot be massive (behave like ponderable matter) and light-speed after emission cannot be judged relative to nearby massive objects. These requirements are met if the movement of light (the propagation of massless electromagnetic fields in the medium) is insensitive (almost) to the modest size and speed of movement of single massive objects (e.g. stars). Distance (space) and time intervals still exist, but they do not have to keep light-speed exactly constant.

The next step is to challenge the claims that the speed of light and the mass of stationary particles are invariants. These become untenable when the revised understanding of the nature of mass is accepted.

Mass is stored energy

When the bob of a pendulum is released it gains kinetic energy and loses potential energy. On the upward swing it loses all its kinetic energy and, if there are no frictional losses, comes to rest at the original height. Where has the kinetic energy, input to the bob in raising its mass through a vertical height against the force of gravity, gone? The usual answer is unedifying: "it goes into gravitational potential energy". A <u>potential</u> energy being one that depends on relative position or location. The potential energy of an arrow depends on how much the bow is bent. But what is bent by gravity? How and where is it stored?

Einstein's original answer in 1905 when he derived $E = mc^2$ (for a body emitting back-to-back identical photons) was that: "*The mass of a body is a measure of its energy content*" [3]. He later observed 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*" [4]. The necessary conclusion is that mass is the energy stored in a body at rest. The same, seemingly unchanged, matter cannot hold as much mass when the density of surrounding matter increases, e.g. when it gets closer to the Earth. It gets released as kinetic energy of motion. A change of state, with emission of particles or radiation, is not needed. It can be recovered, and gets stored in the object, from the work needed to move it further from other mass, i.e. to overcome gravitational attraction.

Every known particle has an antiparticle of opposite (or zero) charge. When such matched particles and antiparticles meet they annihilate leaving no mass. All the energy can be radiated away as massless photons, which carry momentum equivalent to E/c with total momentum conserved. Thus, it can be concluded that all mass is stored energy, in the form of energy/momentum trapped at or around a mean location.

The mass of a "particle" entirely reflects its stored energy and this energy arises from the trapping of momentum about a finite (not point-like) location of the components present in the background field. Each wave-particle state corresponds to a different repetitive oscillating pattern of components. Any mechanism which traps momentum about a stationary location gives rise to mass. This is consistent with the standard textbook statement that a hot brick (or container of hot gas) weighs a very small amount more than a cold brick (gas). It is not interactions with a surrounding field (from Higgs particles or a distorted spacetime) that gives rise to mass. The masses of all elementary particles reflect the effectiveness of the multiple components that trap momentum about a location. The mechanism involves handedness (chirality) and is altered by charge. The association with handedness is deduced from the observation that it is only the exchange bosons of the weak interaction that are massive and only the weak interaction is sensitive to handedness. Most of the mass in atoms is held in the protons and neutrons of the nucleus. The confined quarks (of the proton and neutron) do not hold much mass but the strong confinement of trapped energy/momentum mediated by the exchange of massless gluons equates to a large store of energy and hence mass.

The gravitational potential energy of matter is the energy stored in a given quantity of matter. The total potential energy at a given location always reflects the total mass (energy stored). The one-to-one correspondence is independent of the type of matter or its density. The gradient in stored energy with position causes the force. A larger background field from other matter decreases the amount of stored energy (mass) that can be trapped by matter. The same body of matter (that currently stores rest energy $m_0 = E/c^2$) stores less energy when the magnitude of the field from other matter, and the speed of light (c), increases.

Under GR, reducing the local mass density by moving the objects apart will reduce the distortion of spacetime. When all objects are completely separated, the density and the distortion go to zero and potential energy is maximised. Thus empty space, devoid of matter, must hold an enormous pool of energy that it gives up to objects as they move closer. Even before GR, Maxwell in 1864 was unable to accept such a field [5]. To paraphrase him: *If gravitation arises from the action of the surrounding medium then every part of this medium must possess an enormous intrinsic energy that is diminished by the presence of dense bodies. I am unable to understand in what way a medium can possess such properties.*

Einstein's original answer is to be preferred. Matter does not gain the energy from the medium. FR has the mass stored in the object rather than the field. A pendulum's oscillation between potential and kinetic energy shows that a change in state, accompanied by emission of particles or radiation, is not required. The simple explanation is that mass can be emitted as kinetic energy and absorbed as increased mass. However, this implies that the conversion factor between mass and energy varies with the location of the matter, dependent on the magnitude of the field. If $m_0 = E / c^2$ holds, then c must increase closer to other mass.

FR is not the first time a variable speed of light has been suggested, even Einstein did so [6]. The differences here include that it connects it quantitively with the change in mass/energy and change in time (clock-rate); that it has a faster light-speed with increasing mass density; and there is no distortion or expansion of space. It is an alternative to GR that is not based on a metric tensor or curved spacetime, yet reproduces predictions such as the advance in the perihelion of Mercury and is consistent with a revised understanding of Lorentz invariance.

FR has the speed of light increasing as the background field increases which reduces the mass (stored energy) of otherwise seemingly-unchanged matter. Thus atoms hold less energy when the speed of light is faster, e.g. closer to a massive object. No change in the momentum/energy ($p = E / c$) of already-emitted photons is required.

In contrast, GR has both mass per unit matter and the speed of light, measured at the location (and potential) of the matter, invariant (i.e. constant). It has photons redshifted at a higher gravitational potential, when further from a massive object. This gravitational redshift of light was a key prediction of GR. It claims that time runs faster at a higher gravitational potential. Thus, the wavelength of light would be redshifted in moving to a higher potential. If true, this implied that a photon would lose energy in escaping a gravitational field. Since it is massless it was assumed to have to be attracted in proportion to its momentum.

The gravitational redshift of light is a blueshift of atoms

GR's claimed gravitational redshift was first observed in a remarkable series of experiments by Pound and Rebka [7]. They examined gamma rays sent up or down between sensors in a tower. They found that photons emitted at a lower excited crystal were not resonantly absorbed at the matched upper detecting crystal unless they were given a Doppler boost in energy (by motion of the emitter). The experiment was repeated with the positions of source and receiver reversed. The photons were only resonantly absorbed when the increase or decrease in energy compensated for the supposed gravitational redshift of the photons with height. This appeared to confirm that photons lose energy with increased altitude and hence were redshifted. However, a blueshift of the atoms but none for the photons gives the same apparent result as GR's redshift of the photons with no change in the atoms.

FR has the total energy of atoms and all their transition energy levels increased at higher altitude. Photons, being massless, do not lose energy in escaping a gravitational field. They are not attracted in proportion to their momentum. Their energy and momentum, after emission, are unchanged. This is consistent with Newton's law of gravitational attraction which has the force proportional to mass. Photon wavelength is not "stretched" in moving to a higher potential and there is no need for the scale of distance (i.e. 'space') to expand. This faulty idea of a flexible distance scale first arose from SR's principle of relativity (Appendix A).

As set out in Appendix B, the equivalence principle of GR claims that physical laws for an observer in free-fall are equivalent to those in an inertial frame without gravity. Thus it claims that such an observer will not be able to detect any physical effects associated with gravity or acceleration [8]. This requirement led to the prediction that the wavelength of light would be redshifted by gravity, with a frequency shift of $\Delta\omega / \omega = -\Delta\Phi / c^2$. GR claims a distortion of space and time such that time runs faster and the wavelength of light expands at a higher gravitational potential. A photon will therefore appear to lose energy in escaping a gravitational field, e.g. when the same photon is observed further from the Earth. To explain this loss it has generally been concluded that the massless photon must be gravitationally attracted in proportion to its momentum, which is a reflection of the energy of motion it can carry to a new location. However, a few authors have claimed instead that the correct understanding, under GR, is that it is "the standards of time" that have changed so that the energy levels of the atoms will be perceived, and measured, to be blueshifted [9,10,11].

However, the straightforward explanation is that the clock-rates (frequencies) of massive objects, including atoms, change; as seen in the faster clocks of the GPS satellites. Unchanged photons moving from a lower to a higher potential will appear to be redshifted at the location where clock-rate (time) runs faster. The frequency of atomic clocks reflects the energy levels of their atomic transitions. FR has the total mass/energy, and those of all the energy-level transitions of the atoms increased, i.e. blueshifted, at a higher potential. Photon energy is unchanged after emission. Interestingly, in his 1907 paper introducing the equivalence principle [6,12], Einstein deduced that light emitted by the Sun, with its lower potential, but measured at the Earth, would be redshifted (because time is going slower for the Sun's atoms)! All his subsequent derivations of the redshift of light were consistent with a clock going more slowly if set up in the neighbourhood of ponderable masses [12]. Moreover, they were based on the difference in gravitational potential between locations and not on the difference in the gravitational force field. The supposed gravitational redshift of light with increasing gravitational potential is a misunderstanding. Gravitational potential (energy) simply reflects the increase in energy (blueshift) held by matter. The side-effect is a change in clock-rate (time of atomic clocks) and there is no need for, or evidence of, a change in space (distance).

A variable speed of light is allowed

The belief that the speed of light is a universal constant arose in SR, which holds in the absence of a gravitational field (i.e. no gradient in gravitational potential). It therefore applies within any region of constant mass density. This limited applicability means that a fixed speed of light only needs to apply within a region having a constant background field from all other matter. There is no obvious reason or requirement for light-speed to be the same across regions having different but constant magnitudes of background fields. A uniform background field that only slowly changes with time, is not ruled out by current experiments.

A variable speed of light is not new, but the understanding or appreciation that clocks, including atoms, tick faster because they have more energy seems to have been lost. The evidence is that the change in frequency is that expected from the change in energy. However, in GR it has been replaced by the idea that all of physics (including light-speed and mass) is the same if the local gradient in potential is negligible and that physical laws are independent of the total potential, when there is no difference in potential between object and observer. This is even claimed to apply in free-fall when both object and observer are continually moving into a region of reduced gravitational potential.

The new understanding has the propagation speed of massless radiation, once radiated, insensitive to the speed relative to its environment. Sensitivity to movement relative to the background from mass is a property of massive objects. The arms of a Michelson-Morley interferometer are at the same potential and so light-speed is the same in both arms. However, the speed of photons and gravity can vary with the magnitude of the background field. The requirements are that the field convey massless electromagnetic and gravitational fields at the maximum speed, and that massive particles have resistance (inertia) to changes in velocity but, once accelerated, travel at the new constant velocity. However, the energy stored in massive objects decreases when the magnitude of the field and the speed of light increase. This means that all clocks, whether stationary or freely-falling, tick more slowly.

The original observation on which SR was ostensibly based is that the observed speed of light is independent of the speed of the emitting source. However, it was subtly changed to the postulate that the observed speed of light was constant independent of the speed of observers provided they were co-moving with their clocks (see Appendix A).

The oscillation of electromagnetic waves is perpendicular to the direction of motion relative to their constant speed along the direction of motion and independent of the motion of the emitter or observer. FR proposes that, once emitted, the forward speed depends only on the magnitude of the background field due to surrounding matter. If there is no gradient in this field then there is no gravitational force. So the field is constant in the apparent "absence of gravity" (actually just the absence of a force from a gradient in potential). Unless there are changes, in the magnitude of the field that determines this speed, the underlying speed of massless radiation is constant. However, any measurement of speed requires or assumes that the observers' clocks tick at the same rate, and that the arrival time of signals at the observer takes into account relative movement of the observer during the signal propagation time. These differences were missed in the derivation of SR (Appendix A).

In proposing SR, Einstein noted that Maxwell's equations, which governed the induction of electric and magnetic fields by each other, depended only on the relative speed of the sources of the fields. He also noted that it did not seem possible to tell which of two objects was in motion without reference to other objects. Together with the unsuccessful attempts to discover any motion of the Earth relative to the medium that carried light (i.e. Michelson/Morley interferometer experiments), it appeared to suggest that both electrodynamics (the interaction of massless fields) and mechanics (the motion of massive bodies) followed the same rules. He proposed that they possessed no properties corresponding to the idea of absolute rest [1]. Thus the apparent behaviour of massless light was extended to massive objects (the sources). It led to the claim that it was impossible for an observer moving at a constant velocity to detect whether they or another object were stationary. The possibility that motion of massive objects might be relative to the motion of the weighted field from all other objects was eliminated.

If Einstein's postulate (impossibility of detecting absolute motion) were true, then the effects of motion of mass had to be the same for all observers moving at constant speed. A slowing of events (time) and increased difficulty of acceleration with high-speed motion had already been found for particles carrying mass (such as beta rays). This slowing of time and increased inertia now had to be the same for all such observers. Therefore, it was mistakenly concluded that the slowing of time always had to be matched by a contraction of distance (empty space) in order to keep gravitational propagation-speed invariant.

The idea that light-speed must be constant had arisen from observations. To good accuracy, light-speed appeared to be independent of the speed of the source. This is not what is observed for solid objects, for example, when a ball is thrown from a moving car. However, observations for light are different. Consider the light from the stars of binary star systems (including pulsars) that are light years distant. If movement reduced the light-speed towards us from the star moving away then it could be overtaken by light emitted later in the orbit when it was moving towards us. So the later location would be seen first. No such effect has been observed. That is: the orbit of the two stars agrees with expectations without adjusting light-speed for the speed of movement of the stars or Earth. Nevertheless, movement of each star and of the Earth is still seen in the Doppler shifting of the received emission spectra.

Further evidence of constant speed came from horizontally-mounted interferometers in which light beams were split and sent down separate paths before being recombined. Changes in relative light-speed between the two paths would induce a shift in the interference pattern. No shifts were observed which indicated that local light-speed was independent of the relative directions and speed of rotation of pairs of arms "carrying" the light paths. Thus, the field that carries light appeared uniform and isotropic over the size of horizontally rotating measurement equipment (interferometers).

However, the first set of observations have only been made for modest speeds of the stars and over small changes in time (years) and location (the diameter of the orbits) compared with the size and multi-billion-year age of our galaxy and the universe. A slow or modest change in light-speed with time or location can be easily accommodated. A 40% change in light-speed over 14 billion years amounts to a fractional change of only 1 in 10^{10} per year.

The second set of observations only applies to the one location and time within a region of fixed gravitational potential. Neither set establishes that light-speed is independent of changes in the magnitude of the background field over large distances or times or of gravitational potential. They only require: i) that the rate of change of light-speed is small over modest distances and times, and ii) that once emitted, the speed of massless light is insensitive to movement of the sources and receivers.

The assumption was made that constancy of light-speed, independent of movement of the source or receiver also meant that massive objects moving at constant speed were unaffected by movement relative to the background from massive objects. Yet, we know that clocks, including the decay rates of unstable elementary particles, are slowed by high-speed motion. Under SR, the questionable conclusion has been made that the cause of time dilation is motion relative to the observer, not motion relative to the background. However, the decay rates of stationary unstable particles have not been measured by clocks moving at high-speed relative to the background from all other mass. We also know that clock-rate is slower at lower gravitational potential. However, there is no evidence (for GR's claim) that the empty space between objects, rather than their lengths, is contracted to keep observed light-speed (and gravitational-speed) constant. There is also no evidence supporting the slowing of time being due to the difference between the potential of the observer and the events <u>rather</u> than due to the absolute values of gravitational potential at the events. The distinction becomes important when there are large changes in the total potential with time or location.

SR and GR claim not only that light-speed is constant at the location of the observer but that this is achieved by altering both the observed space (distance) and time. They have the timing and spacing of events (involving massive objects) altered in a way that keeps light-speed constant. Distances are contracted and time slowed dependent on relative motion, and (signed) potential difference, relative to every observer. The values of time and distance have become malleable dependent on the observer's motion and potential. Only their combination, as a constant interval of spacetime, with an invariant speed of light is claimed to be observed.

Einstein combined the constancy of light-speed with another postulate, which he called 'the principle of relativity'. This principle was based on the apparent inability of an observer travelling at constant velocity (in an enclosed space such as a windowless train carriage) to detect their motion when the outside could not be seen. It seemed that no experiment, within the enclosed space, could reveal that movement of the enclosure was occurring. The movement of objects (mechanics) and waves (electrodynamics) seemed to possess no properties corresponding to the idea of absolute rest; only <u>relative</u> motion between objects and observers appeared to have an importance. The principle <u>requires</u> physical laws for any object moving at constant velocity to be the same as for the object at rest. Thus, the postulate became that an observer in an inertial frame cannot determine an absolute speed or direction of travel in space, and may only speak of relative velocity.

SR assumes that there are no changes in any properties (for the on-board observer) if the hypothetical train is moving at close to light-speed relative to the background of stars and galaxies. However, we know that elementary particles are more difficult to accelerate and decay more slowly as their speed relative to the accelerator approaches the speed of light. FR's alternative is that time and inertia of massive objects, but not light, are altered by speed relative to a background. The speed of light is independent of movement of the source, but movement of the source relative to the background medium from all other mass causes the time of massive objects (i.e. moving clocks and observers) to slow. Massive objects are sensitive to movement relative to this background, but massless light is sensitive only to the magnitude of the background. Light-speed is then constant for the same constant background, independent of the speed of the source.

It is a remarkable leap of faith to assume that there are no changes in any properties if the train is moving at close to light-speed relative to the background of stars and galaxies. FR agrees that, for example, it is still possible to play table-tennis, but claims that the faster the train is travelling the slower the players' watches will be ticking and the harder it will be to move their arms. The apparent independence of motion is in the limit that the speed of movement relative to the current background, from the rest of the mass in the universe, is much less than the speed of light.

Gravitational attraction comes from a loss of mass

The postulate of relativity, under SR, is that all physical laws are the same for objects moving at constant speed. The apparent constancy of the speed of light independent of motion is claimed to be because relative motion changes space and time, but does it in a way that keeps light-speed, distance divided by time, constant (i.e. $c = x/t = x'/t'$). Thus, it proposes that all observers <u>measure</u> the same speed of light. The space and time of objects and events, perceived by an observer, is fixed if the observer is stationary relative to the events. However, under SR, the distance between events is contracted and their speed of occurrence is slowed in proportion to the relative speed between objects and observers, but c is unchanged.

GR has physical laws, including the speed of light, invariant at the location of events in the limit that the local gradient of any gravitational field is negligible. However, it claims that the speed of light measured by an observer will be altered in proportion to the difference between the gravitational potential of the observer and the events, independent of the total potential. SR and GR link contracted distance and time via a locally constant speed of light.

FR has an unchanged distance linked by the time it takes a variable speed of light to travel that distance. The distance (space) between objects is not altered by the observer's situation. Time varies inversely with a light-speed that determines the energy and frequency of massive particle states. The speed of light is proportional to the magnitude of the field (this magnitude will be in inverse proportion to the total potential at that location). It is independent of the potential at the observer provided the effect of the total potential on clock-rate (time) at the events, via altered mass, is taken into account.

The concept of gravitational potential arose from Newton's universal law of gravitation. This law has the gravitational force (F) between a small mass (m) and a large point mass (M) being proportional to $F = G_N Mm/r^2$, with distance (r) between them. G_N is Newton's gravitational constant which appears to have the same value for an apple falling to the ground on Earth, to that keeping the planets revolving around the Sun. The gravitational acceleration (force per unit mass) could be seen to be proportional to the gradient (with distance r) of what came to be called the gravitational potential ($\Phi = -G_N M / r$). The potential has units of energy and decreases (becomes more negative) as massive objects get closer.

All such objects made up of matter (massive wave-particle states) have a frequency of oscillation (Compton frequency) proportional to their mass. The observed difference in frequency of oscillation at higher altitudes (as seen, for example, in the clocks of the GPS satellites), after correcting for any speed of motion, is exactly in line with the increase in mass. Thus confirming that the work done to raise objects against a gravitational field (i.e. to a higher gravitational potential energy) is stored as increased mass. (All massless radiation also holds energy in proportion to its frequency, but it can only travel at the speed of light.)

The understanding that gravitational potential reflects changes in energy per unit mass provides a changed appreciation of Newton's "universal" law of gravitation. The new perspective has the work done against the force of gravity becoming a gain (ΔE) in the total stored energy per unit mass (i.e. $\Delta E / m$).

If mass increases as the surrounding field reduces then all massive particles, including atoms, contain more energy with increasing distance from a large source of mass. The gain in stored energy per unit of (assumed negligibly small) changes in mass, in separating a particle by distance dr against a gravitational force F , is:

Work done per unit mass = $\int_{r_1}^{r_2} (F/m)dr = \Delta E / m = \Delta mc^2 / m = -G_N M (1/r_2 - 1/r_1) = \Delta\Phi$

where $\Delta E = \Delta mc^2$ has been substituted, and $\Delta\Phi$ is the change in gravitational potential.

Hence, the fractional change ($\Delta E / E$) in rest energy ($E_0 = m_0 c^2$) of the small mass m is, to a good approximation:

$$\Delta m / m_0 = \Delta E / E_0 = \Delta\Phi / c^2 \qquad (1)$$

where $\Delta\Phi$ is the change in gravitational potential (energy per unit mass).

Equation 1 is a dimensionless energy-balance equation. The magnitude of the fractional change in mass, or energy, or inverse time (Compton frequency of oscillation), equals the change in gravitational potential per unit of mass, divided by c^2 .

Combining Einstein's rest mass equation with Newton's gravitational equation for the simplest case of a small mass at a distance from a large massive object, indicates that gravitational attraction arises from a fractional decrease in mass/energy. It does not arise from a distortion of spacetime. There is no need for such changes in energy to be quantized.

The gain in kinetic energy per unit of stored energy, relative to a value of zero at complete (infinite) separation, is $G_N M / Rc^2$, to the extent that G_N / c^2 is constant. The fractional change in energy is independent of the size of the small mass and of the nature of the matter, as observed. The first attribute can be expected in the limit that the contribution of the large nearby mass to the background is negligible relative to that from all other mass. However, the proportionality factor, contained in G_N / c^2 , will vary, if the inertial resistance of mass to acceleration also varies with the background field (or with the speed of movement relative to the background, as with $p = \gamma m v$). The independence from the nature of the matter implies that changes in c affect all forces that trap energy at a location in the same proportion. The fractional energy input (from lifting the mass) will always equal the fractional energy output (as the lost mass is converted to kinetic energy when it falls), but the observed acceleration per unit gravitational mass will vary with location if inertia changes.

The new reality and its implications for cosmology

SR has distance (the empty space between objects not in relative motion) and time linked to give a constant speed of light. A slower time is matched by a contracted distance when there is relative movement between object and observer, even if object and observer are swapped. However, Einstein's derivation of SR and its claimed Lorentz transformation are faulty (see Appendix A). The new perspective is that, for objects having mass, the speed relative to the background (not relative to the observer) slows time but distance is untouched.

GR has physical laws, including the speed of light, invariant at the location of events in the limit that the local gradient of the field is negligible (i.e. there is no gravitational force). However, it claims that the observed speed of light will be altered in proportion to the difference between the gravitational potential of the observer and the events, independent of the total potential. This variation of properties dependent on the relative potential of the observer should be rejected. Underlying properties should be independent of the potential at the observer provided the effects on light-speed and clock-rate (time), via altered mass, are taken into account. The new perspective is that variations in light-speed give rise to differences in stored energy, and that gravitational potential reflects the total stored energy.

The core ideas of SR and GR are that observed reality is dependent on the relative speed of movement and the difference in gravitational potential between observer and events. The observed results are dependent on how every observer is moving and where they are located. For example, the actual distances between, and timing of, interacting objects (events) varies with what the observer is doing. It is analogous to the same falling tree in a forest making less noise because it appears to fall more slowly for every observer at a lower gravitational potential or higher relative speed (independent of whether moving closer or further away).

The observed gravitationally induced changes in time (e.g. faster ticking of the clocks of the GPS satellites far from the Earth) come from the increase in their stored energy (higher gravitational potential). A gravitational time dilation for Earth-bound clocks relative to satellites is a direct and necessary consequence of the decrease in atomic energy levels, including those of atomic clocks, which reflects the decrease in potential (Equation 1). However, there is no reason to add in GR's flexible scale of distance. It was mistakenly introduced via the claim that the effects of gravity disappear for an object and observer in free-fall. This is the Einstein equivalence principle. Physics in a frame, freely-falling in a gravitational field, is equivalent to physics in an inertial frame without gravity. This unjustified claim forces a constant c. The self-consistent solution is to have c, mass and clock-rate vary with gravitational potential.

GR added a contraction of space to the dilation of time (deeper in a potential) in order to keep c constant. The alternative is to keep the scale of distance between objects not in relative motion (i.e. space) constant and simply have $c =$ distance/time.

The claimed evidence for an expanding space is based on the increasing (cosmological) redshift of galaxies with distance and the uniform glow of the long-wavelength cosmic microwave background (CMB) radiation. There is now an alternative. It can be explained as the same phenomenon as gravitational attraction; a loss of energy as the speed of light increases. The CMB and galaxy redshifts will arise if matter held less mass in the past when the speed of light was faster. Why this should be the case will be examined after considering the nature of matter and the background field. However, all that is required is that the speed of light decreases (and time speeds up) as the universe evolves so that the mass per unit matter (trapped energy) increases.

The cosmological redshift is then the same as the gravitational blueshift of atoms (giving an apparent redshift of photons) because matter must hold more energy (i.e. has increased gravitational potential) when light-speed decreases. Looking further back in time, the energy held per unit matter will have been smaller and light-speed faster (per unit of current time) earlier in the evolution of the Universe. Thus, increasing galaxy redshifts with distance will be observed. The prediction is that the fractional redshift (increase in wavelength) will be equal to the fractional increase in light-speed (relative to the current value) at the time of emission.

Originally, the observation of increasing galaxy redshifts or "Hubble expansion", was taken as evidence for a uniformly increasing Doppler shift going back in time. This implied that those galaxies further from the centre of an enormous concentration started off travelling faster (with speeds exceeding the current speed of light) and/or that all galaxies had been slowing (from these speeds) at a fixed rate over time. A force that could provide an initial acceleration (repulsion) that is insensitive to the non-linear increase in inertia as light-speed is approached is not known. The alternative, a fixed slowing rate, is also unexpected, as gravitational attraction reduces as $1/R^2$, with increasing mean distance (R) between galaxies.

However, GR appeared to come to the rescue by allowing an expansion of spacetime in which the metric changes. Under GR, the empty space between objects has been expanding since an initial "big bang" 13.8 billion years ago and the wavelength of every photon has been stretched according to the amount of expansion since it was emitted [13]. Moreover, to be consistent with the apparent lack of an observed local expansion it has been proposed that the space within objects as small as atoms or as large as galaxies does not expand. Only the space between gravitationally unbound regions is expanding. This remarkable flexibility is claimed possible because "space is not a thing", it is just a relationship [14]. Only the combination of space and time into a spacetime that keeps the speed of light invariant has a real existence. These are amazing claims because 'space' is the fixed distance between objects not in relative motion. The scale and geometry of this space and time has been made subjective, dependent on the observer's location (relative gravitational potential) and their speed of motion relative to the observed events. In addition, the expectation from an expansion is that it will lead to a non-uniform distribution of galaxies on a large scale. Yet it is observed to be remarkably uniform (homogeneous and isotropic) across the visible universe. This has been inverted by claiming the Cosmological Principle - that the universe must look the same (on large scales) whoever or wherever you are. In turn, this is based on i) using "proper time" – SR's flawed concept that the timing of events measured by a clock moving with the events and observer is universal (i.e. invariant) and ii) GR's flawed concept that the spacing of events is subjective based on the difference in potential between observer and events. The evidence for an expanding universe should be challenged.

Einstein's equations, arising under GR, have space expanding or contracting as a function of the density of matter and energy/momentum of the universe. This gives rise to a feedback mechanism whereby a change in energy/momentum density changes the gravitational attraction via distortion (curvature) of the spacetime metric which then alters the contributions of the different components. This unstable feedback means that an undistorted (flat) spacetime should only occur once in the lifetime of the universe. However, it is observed that spacetime is currently undistorted (Euclidean) but that there does not seem to be enough visible matter to account for gravitational attraction, or a source of energy that could explain a redshift from the expansion of space. Thus, the current consensus model of cosmology involves an additional invisible (dark) source of repulsive energy and more gravitational attraction than that expected from the visible matter. Consistency with the observed flatness requires about 68% (repulsive) dark energy to balance the gravitational contraction from visible baryons and five times their mass from an invisible dark matter.

Currently, there is no evidence for the nature of this unexpected new form of matter that only interacts gravitationally. It does not interact electromagnetically (i.e. is invisible) and has no place within the existing standard model of particle physics. Similarly, there is no explanation or evidence, other than expanding space, for a repulsive energy that can drive all of the matter of the universe apart at speeds faster than the, supposedly universal, speed of light.

Under FR, there is no need for an expansion to explain galaxy redshifts, and there is no need or reason for space to expand or contract, to match the change in time and keep light-speed fixed. The postulate of a new form of (dark) matter that only interacts gravitationally, with itself and ordinary matter, and so clumps but does not travel at the speed of light (like a neutrino) appears ad hoc. Under FR, gravitational attraction arises from a fractional change in mass. However, it will be necessary to show that FR can explain all the claimed evidence for a big bang and expanding universe plus the observed rotation curves of galaxies and amount of gravitational lensing that appear to require dark matter.

Spacetime as a background must be rejected. The scale of space (distance) should not be flexible and able to expand. The speed of light and mass are not locally invariant. Time varies with the energy (mass) held by matter, and its velocity relative to the background. Fractional changes in energy depend on the total background field. However, a better understanding of this background field that gives rise to wave-particles and their behaviour is needed. This will help in assessing the evidence for FR and how GR's evidence can be reproduced.

The nature of matter and the background field

A first clue about the nature of the background field is the that the $1/R^2$ dependence of gravitational force arises from the gradient of a potential energy that only varies as $1/R$, with distance R from massive objects. This should be seen as an enormous surprise. How can the effect or influence of potential energy only fall off as $1/R$ when the surface area around a source of stored energy (mass) increases as $4\pi R^2$? The influence of light, the force from the flux of energy-carrying photons hitting the same sized surface, decreases as $1/R^2$, because the total flow of energy is conserved. The $1/R$ behaviour of gravity is equivalent to the number of "gravitons", the supposed quantised provider of the attractive flux or flow of gravity, increasing (by R) with distance from their source! Conservation of energy demands that the flux giving rise to mass does not carry energy. Whatever determines the potential energy of matter, its trapped energy/momentum, cannot be a carrier of that energy.

However, we can be quite confident that the $1/R$ potential is the important property determined by the background field. If gravitational acceleration (the $1/R^2$ force per unit mass) was the property determined by the field (the energy source of gravitational attraction) then nearby sources should dominate. We feel the force of Earth's gravity more strongly than that of the Sun, but we and our planet rotate around the Sun.

The force depends on the gradient so we do not feel the strength of the total potential, only its fractional rate of change with distance from a source, i.e. the amount relative to the total potential. This dependence on potential, rather than forces, has also been claimed to be experimentally established for both electromagnetism and gravitation, via the Aharonov-Bohm effect. The potentials are the underlying quantities that determine behaviour [15,16].

Mach's principle, as seen in the constant orientation of gyroscopes and pendula relative to the "fixed" stars, means that distant sources actually dominate. This is also demanded by the very small changes of Equation 1 which reflect the tiny strength of gravity per unit of local mass. The very small fractional change in mass (and light-speed) implies that the total potential, i.e. total stored energy per unit mass, is enormous. $E = mc^2$ has a 1 kg object containing the energy of a 20 megaton (of TNT) hydrogen bomb. The fractional loss in mass in falling all the way to the Earth's surface from afar (say 10^5 km) is tiny, only 6 x 10^{-10}. The large denominator (the total potential) is the enormous pool of energy that must be given up by the medium (see earlier Maxwell quote) when objects move closer together. However, this energy is stored in objects as mass, not in the surrounding medium.

The loss of mass with a changing speed of light explains gravity, but does not immediately explain why gravitational attraction falls off only as the inverse of distance. It also does not explain why the speed and direction of any motion, including rotation, of massive objects remains constant when no forces are acting. Yet, acceleration, i.e. changes in linear and rotational velocity, are resisted. This resistance to change, inertia, is proportional to mass but sensitive to changes in direction even at constant speed, when the object's energy is unchanged. Inertia and the vector nature and conservation of momentum (p) require an additional dependence on the background beyond a simple scalar effect on the energy that can be stored. The resistance to changes in direction and speed (a conserved vector) necessarily implies both a finite rotation and a finite spatial extent of particles of matter.

A second clue as to the nature of the background comes from elementary particle physics. The mechanism for how elementary particles gain mass in the Standard Model of particle physics is called the Higgs mechanism. Mass appears to arise from a breaking of mirror symmetry, and only the weak interactions show a dependence on chirality (a left or right handedness), and matter and antimatter have opposite handedness. The mechanism is seen as involving a spontaneous breaking of an underlying global symmetry (broken gauge invariance) that includes a background-dependent scalar interaction. The discovery of the Higgs boson and the remarkably accurate predictions of the Standard Model imply that particle mass, and hence gravitational attraction, has arisen from a background dependence that is scalar (non-directional), related to handedness, and has grown over time (but not necessarily suddenly). It should not be a concern, for understanding mass, that very little of the mass inside a nucleon is carried by the valence quarks, because all energy/momentum trapped at a location gives rise to mass. The Higgs mechanism is the trapping of momentum (internal energy) by any and all matter from chiral components that have changed over time.

These clues suggest that the $1/R$ dependence arises from a handedness of the background that limits the decrease in flux/influence with distance. This implies a two-component chiral background in which the amount of energy/momentum trapped by oscillating/rotating components of massive wave-particles, is determined by the speed of light. The background cannot, and does not, carry energy. Instead, the energy-carrying states, that a two-component background allows have the amount determined by c (with $m = E/c^2$, and $p = E/c$ for massless radiation). The implication appears to be that if only one chiral component of the background increases then its impact on c is halved by being shared with the other component (giving the $1/R$ dependence). For massless states (photons, gluons and, it is proposed, neutrinos) the energy carried is insensitive to motion relative to the background mass, but total momentum is always conserved in their production.

All particles have a Compton frequency of oscillation, which is consistent with quantum mechanics and with particles being cyclic wave states. The revised gravitational perspective suggests that massive elementary particles are cyclic 'standing-wave' states in three spatial dimensions that trap momentum. Waves in one and two dimensions spread out, that is, diffuse. However, oscillating elementary particle states, have confined but finite locations in three dimensions. They are what should be seen as "wave-particles". Their wave-functions do not diffuse or dissipate. This implies that the pattern of superimposed (interfering) wave components of their four-vector momenta are oscillating but the total momentum is continuously conserved. It is proposed that a slower speed of light requires a larger force (i.e. rate of change of momentum) in order to maintain the same 'standing-wave' pattern.

A new postulate is that the inertial resistance of mass to changes in velocity, is related to the local asymmetry in the magnitude of the chiral components of the background. It is observed that the speed of motion of mass increases its inertia (by γ) but slows the decay-rate of unstable elementary particles (by $1/\gamma$). This seems strange because increased mass would be expected to increase decay rate. It is also observed that gravitational potential (mass as trapped energy) decreases when the speed of light increases. It is therefore proposed that inertia increases by $\gamma^2 = c^2/[(c+v)(c-v)]$ while mass decreases by $1/\gamma$, giving $p = \gamma mv$. The increase in inertia arises when there are pairs of opposing components in which one is increased (by $(c+v)/c$) by motion and the other decreased (by $(c-v)/c$). It seems that the existing asymmetry between the components of the background field are unchanged by motion but the magnitude of the opposing components within a particle change with velocity relative to a balanced background. This suggests that the asymmetry from being in a region of excess matter is small relative to the large background but much larger than the effect on asymmetry of the usually modest changes in speed of large massive objects.

Matter/antimatter pairs of states (at rest) each have positive energy but opposing internal momenta which add to zero but do not disappear (cancel) on annihilation. The pairs of states have opposite spin and charge and, in free-fall, accelerate at the same rate until the apparent backgrounds are balanced. This makes possible pairs of particle-antiparticle states, with matched mass and inertia, that can annihilate but leave total momentum unchanged. The proposal is that changes in the relative speeds of the chiral components require changes in both their amplitude and frequency. The mass is determined by the mean speed of propagation in the field, but the small difference in angular speed with direction of rotation relative to direction of motion (chirality) slows the mean oscillation frequency of massive particles. The new balance then remains for the new constant speed.

The Compton wavelengths of massive particles are those of a photon having the same energy (proportional to frequency) as the local inertial energy of the massive particle. Thus, all atoms, at matched locations (potential and speed), will have the same fractional change in stored energy and the same fractional change in frequency of photons emitted from all transitions. Photons emitted from atoms at a lower potential need a boost in energy to be absorbed by atoms containing more energy at a higher gravitational potential.

FR has the required background field replacing the pseudo-background fabric of spacetime. An increased distortion of the geometry of spacetime in which unchanged objects are embedded is replaced by an undistorted space in which objects, and the speed of light, are altered by the background. Movement relative to this background, from all other mass, slows time (i.e. oscillation frequency of massive wave-particles). The speed of light and properties of objects, including mass, frequency and inertia, are altered by the magnitude and asymmetry of the field. Gravitational attraction is the release of stored energy (mass), per unit matter, as kinetic energy of motion. It is seen as the gradient in gravitational potential energy, but comes from changes in the background field. These alter the energy stored in all matter, and its inertia. The redshift of galaxies with distance is the same phenomenon as gravitational attraction because stored energy reduces as the speed of light increases.

A complete proposal for the mechanism of energy storage requires further development, but must involve at least two opposing components with the amount of trapping being reduced as the propagation speed increases. This is consistent with the eigenstates seen in the energy levels of the transition spectra of all atoms. Quantum mechanics provides a picture of orbitals as standing-wave patterns (as per the Bohr model and Schrödinger picture), <u>not</u> wave packets. However, like the standing-wave patterns in an organ pipe they are continuous repetitive cyclic oscillations. If light-speed (the speed of propagation of the field components) increases, then the same pattern must contract. Transitions to a lower eigenstate involve an electron moving <u>closer</u> to the nucleus, and <u>releasing</u> energy. It is also consistent with the Rydberg constant relating spectral lines to wavenumber (and hence distance scale) where all energy levels scale in proportion to change in total energy. A faster speed of light necessarily means a tighter pattern and less energy stored. Thus, mass can be emitted as kinetic energy and absorbed as increased mass. The same, seemingly unchanged, matter cannot hold as much mass when the density of surrounding mass and light-speed increase. It gets released as kinetic energy of motion. It can be recovered and stored in the object, from the work needed to move it further from other mass.

The observational evidence for, and the enormous advantages of, the new perspective are now examined followed by an explanation of how and why the supposed repeated "proofs" of GR are reproduced or challenged. The implications for the Standard Model of particle physics and the understanding of quantum mechanics, and some further speculations towards a revised understanding of particles are set out in Appendix C. They suggest, for example, that neutrinos are not required to have mass in order to oscillate between the three types. Together, with the removal of dark matter and dark energy, it appears that all evidence for physics beyond the Standard Model is removed. The revised understanding also suggests that the concept of entanglement is based on a misunderstanding (Appendix C).

Evidence for the new perspective

The nature of the Hubble redshifts

Under GR, the universe must be expanding or contracting. Hence, the observed ever-increasing redshifts of distant galaxies was explained as resulting from an expansion of spacetime. The redshift was taken to be an indication of how much the wavelength of light had been stretched by the expansion of the universe since the light was emitted. Thus, given GR's constant speed of light, the redshift could be used to measure the rate of expansion.

Under FR, gravitational redshifts arise from a decreasing stored energy (mass per unit matter) when the speed of light increases looking further back in time. It offers a much more attractive explanation for the Hubble observations. An increasing redshift of galaxies with distance will arise from a steady decrease in the energy held per unit matter, when the speed of light was faster (in units of current time), i.e. earlier in the history of the universe.

FR has the $1/R$ dependence of gravitational potential arising from the effect on wave-particles of opposing chiral components (from matter and antimatter). Clumping of matter within regions leads to an increase in light-speed within clumps giving a drop in mass per unit matter. This decreases the contribution of the chiral component outside the clump in regions of both matter and antimatter. The net effect is a decrease in the mean of the balanced contributions and a decrease in c. The decrease in light-speed over time, drives a net increase in mass per unit matter (and limits the rate at which distant changes contribute). Within a clump there will be an increase in asymmetry and therefore inertia. Rotating galaxies will contract as the gradient in inertia increases until gravitational forces are balanced by centripetal forces with inertia increasing towards galaxy centres. This should give a steady reduction in light-speed and a matched opposite increase in the energy held per unit matter as the universe evolves. FR predicts a faster speed of light earlier in the history of the universe, whereas GR claims that the speed of light is constant. FR's redshift (increase in wavelength with drop in energy) will be proportional to light-speed at the time of emission.

An interesting side-effect of mass increasing over cosmological time means that even isolated white dwarf stars that have collapsed after burning all their fuel can explode. These explosions (Type 1a supernovae) occur when the electron degeneracy pressure in the star's core is insufficient to balance the star's own gravitational self-attraction. This happens when the white dwarf reaches a mass of about 1.4 solar masses. Crossing of this threshold (the Chandrasekhar limit) has generally been assumed to come from pulling mass off a companion star in a binary system. There had been uncertainty about whether it came from either accretion from a companion star or a merger between two white dwarfs. However, results from the Chandra X-ray Observatory showed that the X-ray radiation from galaxies was much fainter than expected if there was radiation by the accretion discs of the needed number of binary Type 1a supernova progenitors. This indicated that few white dwarfs possess accretion discs, implying that the merger of two white dwarfs is the main trigger for Type 1a supernovas [17]. On the other hand, if the mechanism is merger or collision of two white dwarfs then the amount by which the limit is crossed would be expected to vary significantly, yet Type 1a supernovae are remarkably similar. In addition, unlike other types of supernovae, they generally occur in all types of galaxies, including ellipticals. They show no preference for regions of current stellar formation [18]. Together, these observations would seem to be strong evidence in support of mass per unit matter increasing over time throughout the universe and thus enabling crossing of the threshold.

Standard candles

It has been found that relatively nearby Type 1a supernovae always explode with an almost constant energy. Only small corrections are needed for such differences as the amount of heavy elements they contain and the amount of intervening dust. The first affects the rate and which their light curves change with time. After these small corrections the very bright explosions can be used as standard candles. Their apparent brightness gives a measure of their distance at the time of emission. A doubling of distance halves the brightness.

Systematic searches for distant Type 1a supernovae were done by two groups. Both groups found that the redshift for a given brightness was increasingly less than expected for more distant supernovae. Under GR, this implied that the more recent speed of expansion had been faster than in the past. The light emitted earlier in the history of the universe had not been stretched as much as expected from the current rate of expansion. They concluded that the rate of expansion had begun increasing over relatively recent times. This observation led to the award of the 2011 Nobel prize in physics "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae".

An accelerating expansion of GR's spacetime then required the hypothesis of an invisible repulsive form of energy that increased as the volume of empty space increased. This explanation required that around 70% of the Universe was a previously unknown form of energy, called dark energy, that arose from the total volume of empty space. The unexpected repulsion then needed to be balanced by roughly 30% of gravitationally attractive matter. GR requires such a balance if spacetime is to be flat (Euclidean) i.e. the mean geometry away from massive objects has to have zero curvature, because this is what is currently observed.

This 30% of gravitationally attractive matter had already been a problem because the observed amount of gas, dust and stars seemed far smaller than needed to explain other observations. In particular, the rotation curves of large spiral galaxies tended towards a constant value. The speed of rotation about the galaxy centre of the most distant stars did not decrease with distance, as expected, from the centre. This seemed to imply that such galaxies must have an additional giant halo of unseen gravitationally attractive matter. A large additional amount of gravitational attraction was also required by the amount light from distant galaxies and quasars was bent by nearer intervening galaxies. This invisible matter, that neither emitted nor absorbed electromagnetic radiation, was labelled dark matter.

The supernovae results and other observations, interpreted under GR, implied that around 95% of the mass/energy of the Universe was previously unknown forms of matter and energy. Only the remaining 5% could be the regular matter that makes up galaxies, stars, and us. The dark energy was unexpected and has the very unusual property of a negative pressure. It opposes gravity more strongly as the volume of space expands, and the density of matter, galaxies per unit volume, decreases. The dark matter was also unexpected because there was no place for it within the standard model of particle physics.

Under FR, the interpretation of the supernovae standard candles is different. The speed of light at the time of emission will have been proportional to the ratio of wavelengths (inverse of photon energy) of the same transitions of the emitting atoms (λ_{then}) relative to those emitted now (λ_0). The predicted redshift is $\lambda_{then} / \lambda_0 = 1 + Z = c / c_0$, where $Z = (\lambda_{then} - \lambda_0) / \lambda_0$. $Z = 0$ is the current value (i.e. $c = c_0$) and $Z = 1$ is when the speed of light was twice as fast. Light will travel further by a factor proportional to the integral of $1 + Z$, the fractional increase in light speed (c / c_0) over the time since emission, i.e. by $Z(1 + Z / 2)$. Thus the distance data versus Z , determined from Type 1a supernova brightness, must be divided by $(1 + Z / 2)c_0$ to correct for the increase in distance light travels per unit time when plotted against time. A plot of brightness versus redshift then reflects the time, in current units, that light has taken to travel from the supernova at the given Z. The observed frequency spectra and time evolution of the supernova will reflect the reduced energy of each atomic transition and slower time at emission, by $1/(1+Z)$. If there is no relative movement, then there is no stretching of photon wavelength between source and receiver. Type 1a supernova arise from the gravitational collapse of white dwarf stars. They occur when the total energy (not energy per atom) exceeds the Chandrasekhar limit so the emitted energy should be constant.

The publicly available data from the Dark Energy Survey (DES) [19] is plotted in Figures 1 & 2. The raw distance data (blue squares) is shown in Fig. 1, together with the corrected data (green circles). The upward curve in the raw data, indicating distant supernovae were fainter than expected, had led to the claim that the rate of expansion of the universe was increasing.

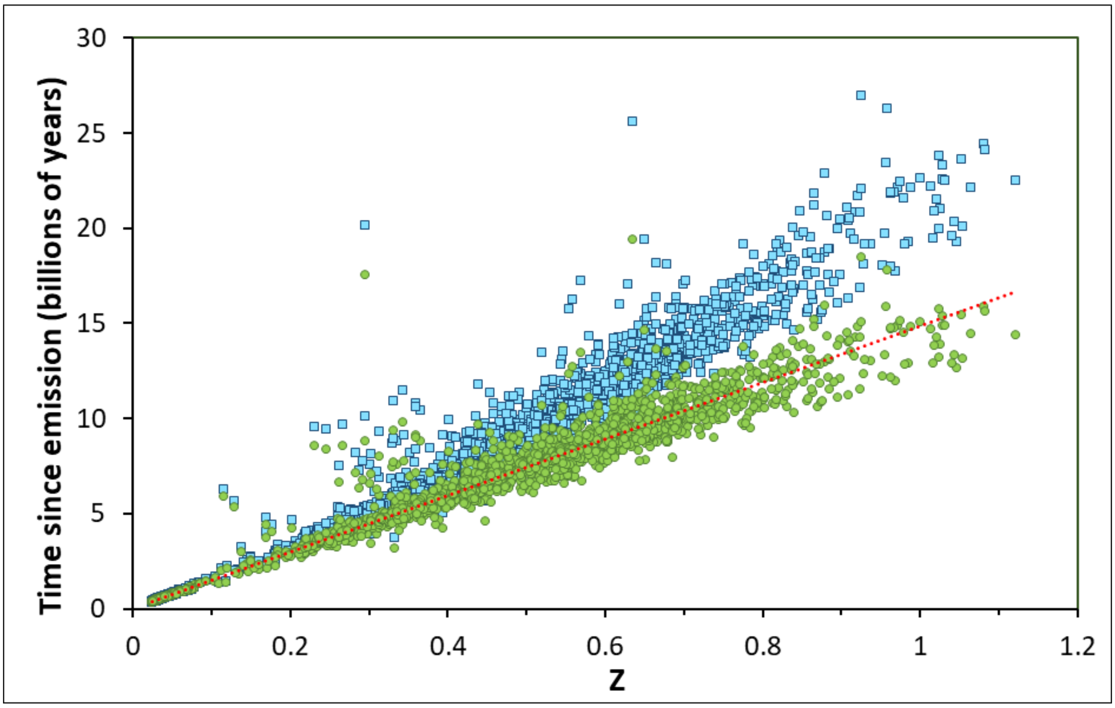

Fig. 1 Raw data (blue squares) and corrected data (green circles).

The corrected data, with error bars, for just the supernovae with a high probability (Prob. > 0.67) of being Type 1a are plotted in Figure 2, along with an additional set of reference nearby supernovae (yellow circles). The weighted least squares fit to the data takes into account the estimated distance errors. The displayed plus and minus errors are based on the quoted error of the distance moduli converted to increased and decreased distances then reduced by the factor $(1+Z/2)$ to convert to travel time.

Space is not expanding

The slope is constant and so the correction removes any accelerating expansion. The weighted fits with or without the additional low redshift supernovae (yellow) are the same (Time = $-0.0020+14.4728*Z$ and $-0.00002+14.4732*Z$). Both fits accurately pass through the origin. Thus, the observational evidence is that the cause of the Hubble redshift is the lower energy, per unit of matter, at the time of emission. There is no need or reason to posit any expansion. The data is consistent with a non-expanding distribution of galaxies that is uniform on a large scale. The accurately constant slope implies a fixed fractional rate of change of galaxy redshifts (a doubling every 14.473 billion years) of $H_0 = 67.56$ km s^{-1} Mpc^{-1}.

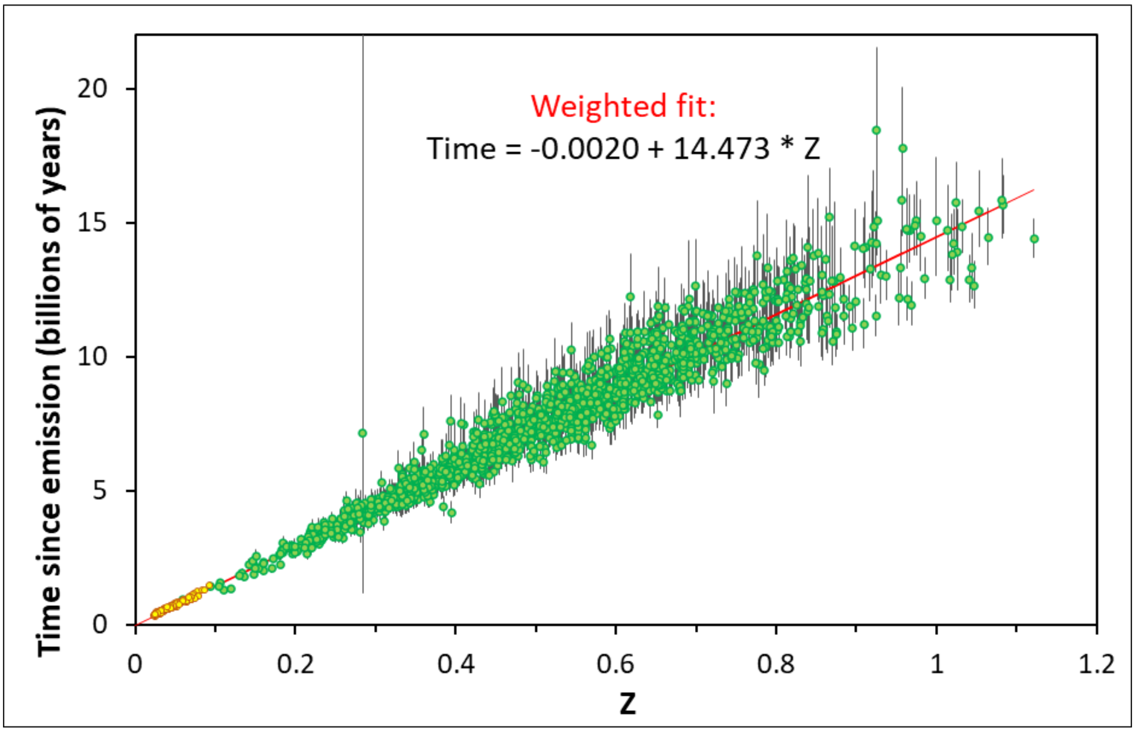

Fig. 2 Corrected data with error bars (and limited to prob. > 0.67 that Type 1a).

The universe appears to have separated into regions of gravitationally isolated matter and antimatter in which galaxies are clumping over time. The average mass/energy per unit matter has increased and light-speed steadily decreased. An initially hot, dense universe that cooled by expansion is not required and wavelengths have not been stretched by the empty space between galaxies expanding from an initial singularity.

Moreover, under a Doppler shift interpretation, the relative recession speed of distant galaxies at the Hubble time of $Z = 1$ equals the current speed of light, and increases at higher Z. This highlights the need, under GR, to accept the claim that “space is not a thing”. It is just a relationship in which the space between galaxies can expand without galaxies actually accelerating and therefore encountering inertial resistance.

Instead, the data is consistent with the energy held per unit matter having doubled over the last 14.47 billion years (of current time) while light-speed halved. The universe is not 13.8 billion years old in current years. However, time was going slower (expanded or dilated) in proportion to $1+Z$ at earlier epochs, as has been convincingly observed in the DES data [20].

The slowing of time was initially a claimed consequence of SR, not GR. The faster an object moves through space, the slower time passes for that object relative to a stationary observer. Therefore SR claimed that it was motion of the observer relative to the events that caused them to appear to unfold more slowly. However, this is a misunderstanding. Motion of massive objects relative to the free-fall background from all other mass causes time dilation. Under FR, time is slower by $1/(1+Z)$ because matter held less energy at the time of emission. The average speed of motion of galaxies is actually modest and the mean velocity negligible.

The supernovae result is consistent with the earlier Union 2.1 data (Figure 3)) [21], as previously reported [22]. It covered a wider range of Z values (out to 1.41) but with far fewer supernovae and somewhat increased errors. The slopes (Time in billions of years)/ Z are similar 14.473 and 14.535 .

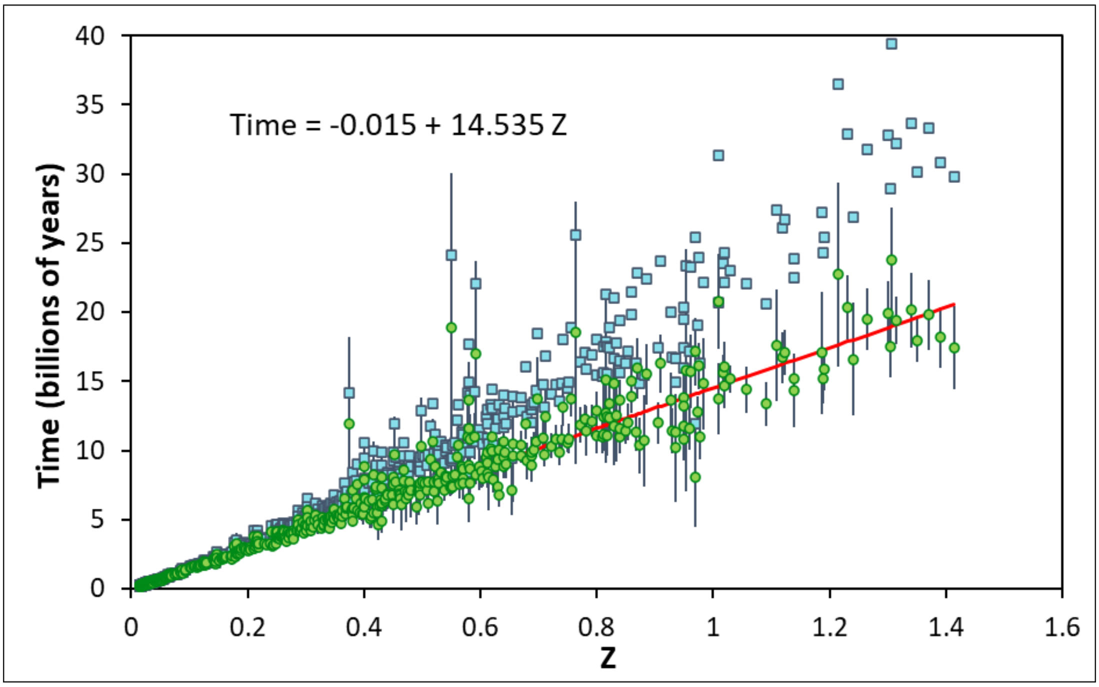

Fig. 3. Union 2.1 data, raw (blue squares), corrected (green circles), with least squares fit.

Note: An important caveat is that the corrections to apparent luminosity of the supernovae, and other standard candles, need to take into account changes in the universe over time. It has been standard practice to correct light curves of supernovae with a stretch factor that aims to return the spectra to the 'rest frames' of the filter bandwidths used. This is based on treating the light-curves as being Doppler shifted according to their recession speed. However, a redshift change in wavelength can also be attributed to a reduction in the energy of atoms at the time of emission, but no expansion. Thus, what has been the normal procedure will mimic the needed and observed ($1/(1+Z)$) contraction of time [20]. If applied to all wavelength intervals it will bring the light curves back to matched inherent shapes. Supernovae of similar colour, metallicity etc., will be matched provided any variations in bandwidth and sensitivity of the light filters, sensors, and intervening atmosphere are taken into account. No further correction for distance based on redshift, i.e. any expansion at all, appears to be needed.

The primary evidence for space expanding had been the Hubble (cosmological) redshift of galaxy and supernova light with increasing distance, plus the uniform glow of the CMB radiation. The realisation that gravitational redshifts arise from decreasing stored energy (mass per unit matter) when light-speed increases, however, gives a much more attractive explanation for the Hubble observations. The change in perspective allows the removal of the decrease in brightness of high-Z supernovae in terms of a recent increase in the rate of expansion of “space” that stretches the wavelength of light after emission. Instead, the redshift reflects the energy of the emitting atoms at the time that the light was emitted.

The cosmological redshift is then the same phenomenon as the gravitational blueshift of atoms (giving an apparent redshift of photons). Both occur because matter must hold more energy (i.e. has increased gravitational potential) when light-speed decreases. The energy held per unit matter was smaller and light-speed faster earlier in the evolution of the Universe. Thus, galaxy redshifts will be observed to increase looking back in time (increased distance travelled by the light). The fractional decrease in trapped energy (mass), gives a fractional increase in wavelength (redshift) proportional to the fractional increase in light-speed at the time of emission. If empty space cannot expand then the time taken for light to arrive will be the integral of distance divided by light-speed at each point along the light-path.

The Type 1a supernovae are standard candles because the brightness of the explosion is determined by the total energy (mass) needed to set off gravitational collapse. If the matter has less energy per particle then there must be more particles until the total energy threshold is crossed.

Thus, the brightness of these supernovae standard candles gives a correct measure of their distance at the time of emission. However, a determination of the rate of change in their distance with time requires the brightness distance to be reduced by the integral of the fractional decrease in light-speed during its transmission. The predicted constant fractional rate of increase in light-speed, in inverse proportion to the fractional decrease in clock-rate (time at the source relative to current time), is then observed. A doubling of wavelength and light-speed corresponds to a halving of clock-rate (doubling of time intervals and halving of energy per unit matter). This also removes the need for an accelerating expansion.

Other high-redshift probes

High redshift probes of interstellar atomic or molecular species that have transition energies in the sub-millimetre range have also been analysed under the assumption of cosmic expansion. These species can be excited by CMB photons if their wavelengths match. When the relative population of the different energy levels are in radiative equilibrium with the CMB radiation, the excitation temperature of the species equals that of the black-body radiation at that redshift. This has been used to determine the evolution of the CMB temperature as a function of redshift [23]. Under the assumption that the redshift arises from the expansion of space after emission the detection of these species has been used to determine the black-body temperature of the CMB in the distant Universe. These measurements confirm an expected linear $T_Z = (1+Z)T_0$ scaling up to $Z \sim 6$. However, if the universe is not expanding then equilibrium is reached when the wavelength (T_Z) of the absorption transition, at the time of absorption, matches the unchanged wavelength (T_0) of the peak in the black-body radiation. The wavelength of the black-body radiation reflects the energy at which neutral hydrogen could form and the CMB could escape. This value should not increase after release of the CMB radiation, or with a decrease in the time that the radiation has taken to reach us, or with a recent accelerating expansion of distance scale. It is only consistent with no expansion, and that out to much higher Z values than the supernovae data.

Hubble Tension resolved

Analysis of supernova distance versus redshift assuming the redshift arises from expansion is what led to the conclusion that there was an accelerating expansion. It has also led to the conclusion that the current rate of expansion is around $H_0 = 73.2 \pm 0.9$ km s^{-1} Mpc^{-1} [24]. However, an analysis of the Planck satellite data on the characteristics of anisotropies in the CMB, gives a value of $H_0 = 67.4 \pm 0.5$ km s^{-1} Mpc^{-1}. A discrepancy of 5 to 6 σ. This is known as the 'Hubble tension' and is part of a broad range of discrepancies in cosmological observations analysed according to GR and the ΛCDM model of an expanding universe [25].

Analysing the DES data without expansion but with a lower energy (longer wavelength at emission) matched by a faster light-speed gives a value of $H_0 = 67.56$ km s^{-1} Mpc^{-1}. A value which is in agreement with the Planck data and so removes the tension. However, why the current analyses give a higher value needs to be explained. This is addressed in Appendix D.

No big bang, no cosmic inflation, no horizon or flatness problems

The light-speed correction for supernovae and scaling of CMB absorption remove evidence for any expansion at all and, hence, for the need of a hot, dense state that expanded and cooled after an initial big bang. The lack of expansion and the earlier faster speed of light and lower mass overcome the need to explain the observed uniformity of the large-scale distribution of galaxies and of the CMB. All parts of the early universe arose from an initially uniform state which remained in equilibrium (via radiation) until regions of matter and antimatter grew large enough for the reduced light-speed to allow gravitational trapping and atomic binding (removing charged species into neutral atoms), and for clumping to increase inertia. Modelling of the energy/momentum, and hence Z value, at which this should occur is needed but it would seem plausible that it would mimic the existing calculations because energy levels and temperatures scale together, and the shape of all black-body radiation curves are identical. Combination into neutral atoms will free photons, greatly increasing the photon to baryon ratio. However, matter and antimatter annihilation will decrease as separated regions grow, increasing inertia and clumping while slowing light-speed.

The so-called 'horizon' problem arose in GR because the observed uniformity seemed to require that all parts of the early universe were in contact and in thermal equilibrium. This could have occurred prior to a big bang. However, galaxies in opposite directions are now so far apart, that for the current speed of light, they could not have interacted in GR's calculated lifetime of the universe (which uses the supposed rate of expansion seen in the redshift).

Therefore, it seemed necessary for GR to introduce an initial very rapid ‘cosmic inflation’. This proposal has it that the entire universe expanded by some 20 orders of magnitude (10^{20}) in the first 10^{-36} to 10^{-32} seconds after the big bang. This incomprehensibly rapid expansion, much greater than the speed of light, would, it is claimed, have locked in the initial uniformity and been responsible for most of the current separation. Cosmic inflation also sought to explain the ‘flatness’ problem. If the geometry of space had deviated ever so slightly from being undistorted (flat), then GR’s distortion (curvature) would have been rapidly amplified over time by gravity (and dark energy). Yet, it is currently observed to be flat (Euclidean), or very close to it.

Under FR, no expansion from a big bang, in which the early density of matter would have been such that it would have collapsed into a black hole, is necessary. Cosmic inflation is not needed to explain why the universe is so uniform on a large scale. It was uniform at the start but is becoming more clumped within regions of finite size (galaxy clusters). The idea that the entire contents of the universe expanded much faster than the speed of light should have always been seen to be untenable when we know that it would take infinite energy to accelerate one electron to the speed of light. It is not possible for the scale of the space between massive objects to expand without the objects resisting. The horizon and flatness problems are avoided. Space is not expanding and the speed of light was faster in the past. Going back in time ever larger volumes were in contact and in equilibrium via radiation. Under FR, the geometry of space has always been flat. There is no curvature or expansion of space.

An equal quantity of antimatter

The problem of why antimatter is missing is overcome. The Standard Model demands equal quantities of matter and antimatter, and similar amounts are also needed to explain the $1/R$ dependence of gravitational potential. However, the annihilation of matter with antimatter gives a very characteristic signal and there appears to be no evidence for matter and antimatter galaxies colliding. So it had been assumed that antimatter was not present.

The new perspective has the speed of light much faster and inertia and mass per unit matter much smaller early in the evolution of the universe. This would have led to rapid annihilation of any matter with antimatter for which the components of velocity towards each other were strong enough to overcome the small gravitational attraction. It is therefore proposed that the apparent dearth of antimatter is because most of the matter in opposite regions annihilated until they became separated into interlaced regions of gravitationally bound like-matter. The mass of the matter increased as the speed of light slowed and the clumping of like matter increased over time, as the Universe evolved. This led to the formation and contraction of clusters of like-matter galaxies as inertia increased. After an early burst of annihilation the increased inertia away from the boundaries maintained the separation of isolated regions of matter and antimatter.

Photons, with equal chiral components and no gravitational attraction, would be expected to cross freely between regions of matter and antimatter, and undergo the same bending (see later). It is not that antimatter is not present or invisible. It is just that, unless significant quantities annihilate, there is no signal to establish which are antimatter galaxies. Overall there are equal quantities but the presence of the antimatter regions is no longer revealed by annihilation.

An extended large cluster of like-matter galaxies would produce an alignment in the boundary of zero inertia between regions of opposite chirality. Smaller galaxies and gas clouds would move faster in these regions and so their motion would tend to align with the boundary. Hence, regions of opposite galaxies would change size, shape and induce collective motions in each other. It would be interesting to compare this observed cluster and galaxy motions.

No singularities in black holes

The presence of singularities inside black holes should be seen to establish that GR is either wrong or has been pushed beyond its limits of validity. It has gravitational attraction of massless photons arising from their momentum. As a result, all energy and momentum must distort spacetime. When the density of mass/energy is small there should be negligible distortion. Spacetime then becomes increasingly distorted as the mass density increases. The increasing distortion gives rise to additional gravitational acceleration with its associated kinetic energy and momentum, which then gives rise to more distortion. This is a positive feedback mechanism (similar to when a microphone is placed near a speaker). It is what gives rise to the putative singularities inside black holes. Part of the 2020 Nobel prize for physics was awarded for the discovery that black hole formation is a robust prediction of GR. They become inevitable once a critical density is passed.

FR has the mass per unit matter decreasing as local density increases. This is a negative feedback. The mass per unit matter decreases as mass density, and light-speed, increase. The gravity from the same quantity of matter decreases, preventing the infinity. Thus, FR removes the unphysical singularities at the centre of black holes.

The fact that a photon does not lose energy in escaping a gravitational field also means that black holes do not trap light behind an event horizon. This does not mean that extreme concentrations of matter, giving apparent black holes, do not exist. The wavelength of any electromagnetic radiation is shifted far to the red before, not after, emission. Any radiation emitted towards us from a central region outside and behind a large enough concentration of mass will spiral inwards because of bending and be absorbed. Surrounding massless radiation will be redshifted but will still be able to escape. The famous images (shadows) of black holes at the centre of our and another galaxy can still arise.

Under GR, nothing travelling at the speed of light can cross (outwardly) the claimed event horizon of a black hole. However, it is observed that gravitational attraction moves when the massive source moves and that changes in strength and direction propagate at the speed of light. Once GR's claimed horizon has formed then no changes in the location, strength, or movement of the mass inside the event horizon should be sensed or observed by an external observer or object. Just like light, gravity should be trapped. However, under FR, gravitational potential does not carry energy and its effects should not be trapped. These differences allow stars and black holes to rotate around each other. Up until now, this inherent problem has been ignored by assuming the distortion of spacetime not only remains but can also move.

An apparent dark energy is predicted

FR not only removes the presence of an accelerating expansion but also predicts that the faulty assumptions of GR will necessarily lead to the appearance of an apparent dark energy. The effect of local clumping of matter (i.e. increased density ρ) is to reduce the mass per unit matter. This means that the derivation of the differential, or Poisson, form ($\nabla^2\Phi = 4\pi G_N \rho$) of Newton's equation, on which GR is based, does not hold (see Appendix E). The derivation assumes Gauss's law for a conserved flux. However, the flux due to mass from a constant amount of matter is not conserved. The mass per unit matter within any region of matter reduces if movement within a local concentration of matter increases the density of that matter. The mistaken assumption of a constant flux forces GR's equation to predict that an increase in volume, of a fixed amount of matter, will lead to an apparent repulsive force. The same matter appears to gain kinetic energy (if mass is assumed constant).

Under GR's assumptions, an apparent dark energy must appear if the universe is expanding. The amount predicted will be that needed to produce a flat spacetime, because empty space (distance) cannot be distorted. Under GR, an expanding universe requires an apparent repulsive gravity (dark energy) whose magnitude depends on the increase in empty space (reduction in density). This is why GR's ΛCDM model (that incorporates Einstein's cosmological constant Λ and Cold Dark Matter) can appear to fit observations. The cosmological constant was introduced to achieve a flat, non-expanding universe.

Dark matter potentially solved

A decrease of oscillation frequency and therefore inertia with decreasing chiral asymmetry means that inertia will decrease away from the centre of an isolated galaxy (of just matter or just antimatter). However, asymmetry will be almost constant within our solar system (miniscule in size relative to the galaxy). Asymmetry and inertia will reduce with distance from the centre of an isolated galaxy giving rise to an apparent increase in the strength of gravity. This appears potentially able to explain the flat rotation curves of galaxies with a large spherical central mass. The inertia should decrease at a comparable rate to the gravitational force once outside the near field.

The relationship between inertial and gravitational mass will vary with position in a galaxy. The calculation of the mass of our galaxy assumes that the inertia at our location well away from the centre applies to the whole galaxy, and all other (similarly large) galaxies. The speed of stars rotating around the central black hole of our galaxy are assumed to have the inertia observed at the location of our solar system. Thus it is likely that the strength of gravity, and hence mass, is underestimated from the rotation speed of stars around the nearby centre and its black hole. Under FR the inertia will be much higher leading to a significant underestimate of the mass of the core of stars and the black hole of our galaxy. Far away from the dominant centre the inertia will decrease at nearly the same rate as the gravitational potential leading to an apparently constant gravitational force giving a constant rotation speed. Smaller and more uniformly dense galaxies will require an additional apparent gravitational mass that extends further towards their centres to explain most of their rotation curves. The changes in inertia and the underestimate of the mass of large galaxies should then explain both the flat rotation curves of spiral galaxies and gravitational lensing, without dark matter.

A comprehensive analysis of galaxy radial acceleration data has proposed that various observations, such as the baryonic Tully-Fisher, can be subsumed into a more general relationship [26]. If FR's proposal for inertia is correct, then it should be possible to predict the observed relationship, and explain the observations attributed to MOdified Newtonian Dynamics (MOND). This needs further investigation.

The revised understanding challenges 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 [27]. Under GR, it is claimed that the bulk of hadronic matter is at the location of the visible plasma while the gravitational bending indicates that the centres of gravitational attraction are at the centres of the galaxy clusters, which is where the (electromagnetically) non-interacting dark matter should be expected to reside. FR also has the centres of gravitation and gravitational lensing at the centres of galaxies and their clusters.

The suggestion that the plasma should indicate the location of the dominant source of mass appears to be based on tenuous evidence. Most or all galaxies in a cluster should pass through unless their cores get close, because they are well spaced and have high inertia. The inertia of the cores of the galaxies (any region with asymmetry significantly larger than that in our solar system) will also be much larger than expected using our value for G_N . Their momentum will be correspondingly greater for a given velocity. It is the diffuse gas clouds between galaxies that are more likely to suffer impacts, be heated and slowed.

General Relativity's predictions reproduced

The reason that general relativity is so widely accepted by physicists appears to arise from repeated claims of the form: "Einstein proved right again". Such statements should always be treated with caution as the scientific method holds that a theory can only be refuted by observations and never proven correct. It turns out that many of GR's predictions are remarkably easy to reproduce or their derivations appear to be questionable.

FR automatically reproduces many of the standard predictions when the background is similar to that currently observed locally. This is because GR's fractional change in time ($\Delta\Phi / c^2$) and distortion of distance, with difference in gravitational potential, have the same magnitude as FR's fractional changes in mass and time. GR's constant stored energy but distorted distance and time with potential can be reproduced by FR's change in stored energy with potential and altered apparent distance from a changed speed of light.

Advances in the perihelion or periastron

GR's first "prediction", an explanation of a known advance in the perihelion of the eccentric orbit of Mercury, had a contraction of space and no effect of the distortion in (proper) time. The new perspective is that the advance simply comes from the observed reduction in mass (seen as a lower potential) but conservation of momentum, so that speed (apparent time of object movement) increases.

GR has time slowing and distances contracting as potential reduces. The method assumes that mass and angular momentum are conserved and uses a contraction of space based on the Schwarzschild solution for geodesics in a spherically distorted metric [28]. The procedure produces an additional term in a modified equation of motion. The Newtonian-based Kepler radial equation of motion (acceleration per unit mass) is:

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

The equation corresponds to a closed orbit with no advance in the perihelion because the forces are per unit mass, central and decrease as $1/r^2$. GR adds an additional term and uses the second derivative against proper time (τ) [29]:

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

The additional term modifies the form of the conserved angular momentum for locations closer to the large central mass. This acts like a small additional force being directed away from the Sun which delays the perihelion. The change in derivative from time to proper time reflects GR's distortion (dilation) of time. However, 'the physical interpretation of τ does not enter the calculation' [29], and so does not alter the predicted orbital advance.

Under FR, the fractional decrease in mass per unit matter is $-G_N M/rc^2$ (relative to that at $r = \infty$) with distance from the Sun. Conservation of momentum gives rise to an increase in velocity per unit mass of $(G_N M/rc^2)dr$ from a small change in distance. It corresponds to faster movement of the object when closer to the Sun. This leads to an increase in distance travelled, before the point of closest approach. Thus the perihelion advances in the direction of orbital rotation, as observed. The change matches that from GR's additional factor in centripetal acceleration. The change in velocity is the integral of GR's acceleration, i.e. $\int (3G_N MJ^2/c^2r^4)dr = (-G_N M/rc^2)(J^2/r^3)$. This is the fractional change in velocity predicted by FR's change in mass. Thus, the predictions agree. GR has the advance in perihelion coming from a contraction of space and no effect of the distortion in (proper) time. FR has the advance coming from a reduction in stored energy (mass) at lower potential but conservation of momentum.

In a strong field the change in periastron, Schwarzschild precession, of a star near our galaxy's central black hole has been observed [30]. The change in orbital angle was fitted using the rate of change in distance scale of the Schwarzschild metric over just the region of the periastron of an extremely eccentric orbit. It is suggested that this is equivalent to ignoring GR's change in time and again the predictions will match.

Bending of light

Einstein's second prediction from GR was that light would be bent by a massive object such as the Sun. The amount of bending was claimed to be double that from just the loss of energy (seen in the supposed gravitational redshift of photons) from an assumed gravitational attraction of photons. Half the bending is attributed to a supposedly shorter wavelength of photons at lower potentials and half to a matched contraction of space. This contraction was initially introduced under SR to ensure that the local speed of light remained constant. If the local speed of light is invariant (constant) then spacetime should not induce any bending. The claim under GR amounts to an inverted distortion of length relative to time in the warping of spacetime, i.e. $g_{rr} = -1/g_{00}$ [31]. Einstein made a similar inversion of meaning in SR (see Appendix A). The claim is that, deeper in a gravitational potential, time is dilated (meaning the wavelength of light is shorter) while space is contracted (meaning less time is taken by light rays to travel a given distance). Photons are bent when there is a difference in potential between the observer and events. If light is bent because perceptions vary due to differences in potential relative to each observer, it is a nonsense, a rejection of an underlying reality.

Under FR, light does not gain or lose energy in a gravitational field, and distance is not distorted by matter. So neither can be a cause of bending. However, a gradient in light-speed, perpendicular to the direction of motion, should cause light to bend, and by twice the expected amount, because the oscillation involves both electric and magnetic fields. The bending will be towards the region of higher speed of the oscillating component fields closer to a massive object. It would appear akin to a helical path in which the length of the path and the distance between successive spirals both shorten closer to the massive object.

This direction is opposite to that familiar in the refraction of light. There it is bent towards the matter with the slower speed. The slowing in matter arises from electromagnetic interactions. The bending is towards the stronger interaction of the photon. The bending is away from increased time spent in locations of higher speed, perpendicular to the direction of motion. This follows Fermat's principle, known as the principle of least time, which is subsumed by the principle of least action. This principle minimizes the integral of a system's Lagrangian (kinetic energy minus potential energy) over time. However, light is massless, its energy in a vacuum is constant. In a massive medium it is temporarily slowed, relative to the stationary medium, and Fermat's principle applies. In a vacuum light-speed varies with the magnitude of the background field, but this field does not carry energy, and light is insensitive to speed relative to this background. Fluctuations in electric and magnetic fields induce changes in each other according only to their relative speed and amplitude. Their movement is relative to each other, not to a location that is stationary relative to the background from massive objects. The speed of oscillation of both components depends on the magnitude of the field.

Gravitational redshift

Einstein's third prediction was a gravitational redshift of photons escaping a gravitational field. The new perspective is that it is a blueshift of atoms with no change in photons. Photons emitted from a lower detector need to be given a Doppler boost in energy (by upward motion of the source) if they are to be resonantly absorbed by a matched detector higher in the field. GR's explanation in terms of a change in time with location is unacceptable because such a change should apply to both the atoms of the detector and the photons. The explanation, as a loss of energy of a massless photon, is also inconsistent with Newton's law of gravitation, because its force of attraction is proportional to mass.

Shapiro delay

A fourth prediction, by Shapiro, is a delay in the travel time of electromagnetic radiation (e.g. radio waves) from planets or spacecraft as they pass near or behind the Sun. A delay of the expected amount has been observed. However, an examination of all fits to the delay have used the expected logarithmic dependence of the change in signal arrival times expected from changes in path length. This logarithmic dependence arises from the integral of the $1/R$ dependence of gravitational potential. The fitting procedure is designed to remove all slow changes in elapsed time due to uncertainties in orbit and orbital velocity, or from changes in light-speed (which will be hidden if radar ranging is used to determine orbit). The lever arm on the amount of bending enables an accurate measure of the rate of change in deflection angle. This rate is very sensitive to the distance of closest approach and the fitting removes slow changes. So the delays predicted by current analyses will match provided the proposed mechanisms produce the same amount of bending. GR's prediction assumes that a slowing of time is matched by a contraction of distance (or an increase in perceived light-speed). FR argues for oscillations in which both the amplitude of each oscillation and distance between successive oscillations shorten closer to the massive object because of increased light-speed.

Big bang nucleosynthesis

The relative abundances of light elements has been put forward as strong evidence for a big bang. However, FR will mimic the behaviour of a drop in temperature (kinetic energy) from the supposed expansion-cooling of a big bang, by an increase in stored energy as c decreases. The annihilation of particles/antiparticles until matter and antimatter separate will ensure sufficient photons per baryon and enough photon energy for protons and neutrons to transform into each other easily. All energy levels and cross-sections will be in the same proportions to those input to the current model for nucleosynthesis so the same ratios of elemental abundances follow. For example, the proton to neutron ratio, determined by their relative masses and free neutron decay, will similarly give about 1 neutron to 7 protons and primordial abundance of about 25% helium-4 by mass. The energies of all particles will be much lower but the same chain of nuclear pathways should occur. The major observed elemental abundances are not restricted to there being a cooling of an initial big bang at a rate determined by expansion.

FR has the energy of all particles much lower but the same chain of nuclear pathways should occur. The observed elemental abundances are not restricted to there being a cooling of an initial big bang. However, the changed timescales, densities and energy levels in the direct production of lithium versus decay from beryllium may resolve the problem of the lower-than-expected abundance of lithium (^{7}Li) [32]. This is a possible test for FR versus GR.

Cosmic Microwave Background

The nearly uniform background radiation at microwave wavelengths, from all directions in space, was predicted before it was unknowingly observed. Under GR, it was predicted as the remnant glow from the big bang when the initial hot dense state cooled sufficiently for neutral hydrogen atoms to form. The photons in the plasma would then be released (freed from electromagnetic interactions with charged particles). The supposed expansion of space is then supposed to have redshifted these photons to microwave wavelengths. Under FR, the release will still have occurred but the microwave wavelengths reflect the much lower energy held by atoms at the time of emission and unchanged photon energy after emission. It is the energy of massive objects that changes. The empty spacetime between them cannot expand and thereby stretch light but not stretch atoms (i.e. other wave-particle states).

Baryon acoustic oscillations

Under GR, these are claimed fluctuations in the density of normal (baryonic) matter caused by acoustic density waves in the hot plasma (electrons and protons) of the early universe. Their length scale is given by the distance the acoustic waves could travel in the plasma before it cooled enough for neutral hydrogen atoms to form. The photons could then travel freely without being absorbed. This recombination happened at about 3000 ^{0}K, when the universe was around 379,000 years old, or at a redshift of Z = 1089. At this age, the size of acoustic bubbles were 450,000 light-years in radius (490 million light-years today divided by Z = 1089).

Under FR, the universe was not hot, nor was it expanding, and so was not extremely dense. This makes the idea of acoustic pressure waves seem unlikely. The kinetic energy of photons in the early universe (from annihilation) escaped when the photons were released and their wavelengths have not been subsequently stretched. The speed of light was, instead, about 1089 times faster (but time was correspondingly slower) when the energy density of the photons and inertia of baryons allowed stable atoms, mostly hydrogen, to persist. The principle (i.e. combination into atoms allowed radiation to escape) and the prediction of the size of "temperature" (energy) fluctuations in the CMB may be the same but the explanation is different. Variations in wavelength should arise from differences in the degree of clumping when a region began to let radiation escape. The transverse scale of regions with similar properties (at similar redshifts) would be expected to decrease as the speed of light decreases as the universe evolves and clumping increases.

It has been claimed that the magnitude and location of peaks in the spectrum of small fluctuations (of order 10^{-5}) in the apparent temperature of the CMB is a result of random (quantum) fluctuations in the early universe prior to the release of the CMB. It is further claimed that the peaks in the frequency spectrum can be modelled by GR. This needs investigation but must be treated with considerable scepticism.

The removal of the 'Hubble tension' and of an accelerating expansion showed that FR with no expansion is consistent with the spectrum of 'early-time' fluctuations in the CMB deduced under GR with a constant rate of expansion. Thus the fluctuations should, in principle, be able to reproduced under FR for the observed fixed Hubble constant without any expansion. However, the implications of the replacement mechanism of early-time lower energy and faster light-speed replacing a cooling from expansion needs detailed investigation. A realistic model for the growth of structure including size and distribution of galaxies needs to be developed. Confirmation that dark matter is not needed would provide strong support for FR.

Gravitational waves

Rotations of asymmetric distributions of mass will produce gravitational forces at a distance. GR claims that the effects are transmitted by energy-carrying gravitational waves that are "ripples in spacetime" (quadrupole stretching of space against time). These waves have been observed in terms of changes in the perpendicular path lengths of the interferometer arms of the LIGO detectors. The expected energy loss has been claimed to be separately confirmed in the rate of change in the orbit of rotating pairs of binary pulsars.

However, the four textbook arguments commonly taken to establish that gravitational waves (GWs) carry energy-momentum have been critically examined and found wanting [33]. Moreover, it was claimed that GR's equations of motion and Einstein's equation were able to produce orbital decays without there being any need for a loss of energy.

FR claims that gravitational "waves" are asymmetric rotations of massive objects that give rise to periodic changes in the magnitude of the background field. Consequently, they alter the speed of light. They are not distortions of spacetime and do not carry energy. The latter is because the $1/R$ dependence of gravitational potential energy requires that the influencing flux does not transport energy, otherwise conservation of energy is violated. The influence of the energy would have to increase with distance from the source of gravity. Instead, the "waves" alter light-speed and hence the energy that can be held by matter. However, the LIGO detectors will also detect travelling variations in light-speed (wave-like, if from periodic oscillations of the source masses). These variations alter travel time, and thus apparent path length of interferometer arms; and so will be detected by LIGO.

An examination of the calculation of the apparent energy loss of binary pulsars shows that the reference energy (for no radiation) is based on a non-relativistic circular orbital equation. This reference energy and the orbit do not change with time. However, the known and necessary effects of the finite speed of light, such as retarded apparent positions and Doppler shifting, are present in GR. The predicted rate of orbital change is also corrected for orbital eccentricity and the mass ratio of the pulsars. The size of these changes in similar mass binary systems with eccentric orbits will differ from those when there is a large central mass, but these are applied only to the GR prediction and not the circular reference orbit. The calculated loss of energy via gravitational radiation in binary pulsar systems uses a faulty reference.

FR's changes in mass (and inertia) with gravitational potential are not included in the calculation of orbital energy. However, these have been shown to give the same changes in orbit as GR' constant mass and a contraction of distance (Schwarzschild metric). This was shown in the prediction of perihelion advance based on FR's change in mass and conservation of momentum. Thus, it is the omissions in the calculation of orbital energy that leads to the apparent loss of energy while the predicted rate of orbital change can be expected to be the same. These claims need to be examined and extended to a critical review of the timing changes and their causes in the modelling of more recent pulsar data [34].

Merged black holes will also appear to have less mass in total than their progenitors. Under FR the amount arises from the reduction in stored energy as the speed of light increases. The negative feedback inherent in this behaviour versus the positive feedback in GR and its loss of mass coming from the radiation of energy-carrying gravitational waves may lead to different predictions.

Frame dragging

Predictions, such as frame dragging, appear to relate to the wave nature of particles and interactions, and to the finite propagation speed of light. These imply that the strength of interactions will be altered by relative speed of motion, as seen in the Doppler shifting of photons. Thus, the component of the mass of a rotating spherical object, moving towards a small nearby object will have a larger effect than the component moving away. This will lead to torques on objects of finite dimensions or with angular momentum vectors (gyroscopes) pointing in different directions to the axis of rotation of a massive sphere (e.g. the Earth). This amounts to frame dragging.

Summary

It appears that all the confirmed predictions of GR can be reproduced by FR. First, it can be the understanding of the cause that changes, as with a blueshift replacing a redshift. Secondly, GR's claimed changes in both distance ('space') and time can be chosen to mimic FR's changes in c and mass/energy. Thirdly, unreasonable assumptions and faulty mathematical steps have been hidden by a flexibility in interpretation of terms. These have included inversions in the meaning of coordinate magnitudes versus intervals, and confusion between real and apparent effects (see below and Appendices A & B). The result has been that some of GR's claims, such as the prediction of a doubling in the bending of light, are not tenable. The doubling occurs but it does not follow from GR. Other explanations of behaviour by GR also need to be challenged. The use of the derivative of a potential as the determining field under GR has removed the effects of the absolute magnitude of the underlying field, and allowed the belief to persist that effects are due to differences in potential relative to the observer.

This followed from the untenable conclusion of SR that, for massive objects it is speed relative to the observer rather than the background, that determines behaviour.

Faulty assumptions and deductions

A closer examination of the literature establishing SR and GR shows overly generous assumptions, faulty steps and misunderstandings. An examination of these aids in the appreciation of why the beliefs took hold and why the new understanding is to be preferred.

The first faulty assumption in SR was that the clocks of a moving system keep the same time as those of the stationary system, independent of the speed of any steady motion. This only holds in the limit of low speeds relative to the background field from matter/mass. It was followed by the failure to take into account the effect of movement of objects during the time taken for signal transmission. These and other mistakes then allowed a faulty interpretation of the meaning, and role, of the length and time coordinates in the Lorentz transformation. An inversion in the meaning of time intervals relative to distance intervals allowed the increase in apparent speed of light from slower clocks (time dilation) to be cancelled by an unneeded contraction in distance intervals to keep light-speed constant. However, the speed of light is necessarily constant within a region of constant mass density. No distortion of distance, labelled as 'space', is needed. A misunderstanding of the Lorentz transformation allowed the incorrect claim that spherical radiation of the emitted light rays, at speed c, is observed in both moving and stationary frames. This is simply not true unless distances are corrected for movement during the time of signal transmission (see Appendix A) and clock-rates are adjusted for movement relative to the background. However, it allowed acceptance of the proposition that perceived space and time was dependent on <u>relative movement between events and the observer</u>. Under SR, only their combination in a spacetime linked by a constant speed of light was fixed. FR claims, instead, that the reality is that clock-rate (of massive objects) is dependent on <u>movement relative to the background</u>. A spacetime, in which the scale of distance is contracted by movement relative to the observer, is an illusion.

Faulty assumptions have also occurred in GR. The key one was that it was assumed that because a freely-falling observer no longer felt a gravitational force then its effects were transformed away. This is untenable. It gave rise to the unjustifiable Einstein equivalence principle, which amounts to the claim that physical laws are independent of gravitational potential. A freely-falling observer is continually moving into a region of lower gravitational potential which increases the speed of light and reduces mass. The observer feels no gravity because the force on every atom in their body is exactly matched by the inertial resistance to acceleration. The observer's momentum relative to a nearby large mass continuously increases, as will be found soon enough, unless there is sufficient sideways velocity. The flawed concept and mathematics of spacetime was then absorbed into a fabric whose geometry and scale of distance was distortable. In addition to malleability with speed of movement relative to the observer, spacetime was now malleable in proportion to the relative gravitational potential of the observer.

The Lorentz interval ($s=\sqrt{x^2+y^2+z^2-c^2t^2}$) and c are claimed to be invariant for all inertial frames. That is, light is perceived to be spherically radiated by all observers moving at constant velocity. It is a critical underpinning of SR and GR. However, the conclusion that $c'=c$, is based on faulty mathematics.

It has: $x'^2+y'^2+z'^2-c^2t'^2=x^2+y^2+z^2-c^2t^2$

so that: $x'^2-c^2t'^2=x^2-c^2t^2$ for motion in the x - direction, since $y'^2+z'^2=y^2+z^2$.

However, this always holds because: $x'^2-c'^2t'^2=0=x^2-c^2t^2$, if $c=x/t,\ \ c'=x'/t'$

There is no requirement for a fixed speed of light ($c'=c$), if time taken is distance divided by light-speed. It is therefore unnecessary to demand distortions of the scale of distance ('space') in order to keep light-speed constant. The flawed mathematics also allows $c'=\pm c$, so the sign of any relative motion was able to be ignored.

Further details of where faults occurred, and their impact, can be found in Appendix A. They emphasise that the derivation of spacetime as a background in which space and time are malleable but in a way that keeps the speed of light constant is demonstrably flawed. The arguments, logic and mathematics that gave rise to SR and GR have numerous errors. There is no evidence that the scale of distance between objects not in relative motion, or at different potentials, is flexible; although changes in clock-rate occur. How can empty 'space' be malleable dependent on the speed of movement and different potential of each observer?

There is good evidence that the dimensions of individual (massive) nuclei are Lorentz contracted (flattened) in the direction of motion [35]. However, there is no reason that the empty space between objects should be affected.

Future tests and opportunities

There are clear differences in predictions, and explanations, that allow both logical assessment and experimental or observational tests that distinguish between the new and current perspectives. A yes/no difference between the theories of gravity is in the apparent versus real distortion of distance. In principle, this can be tested by examining direct timing signals (using on-board clocks) and returned (reflected) signals to Earth from and between spacecraft with increasing measured distance from the Sun.

Perhaps the most straightforward test is to establish whether it is movement relative to the observer or movement of the observer relative to the background that slows time. It should be possible to compare very low mass but accurate clocks moving linearly towards each other and to a central clock (or spaced pair of clocks) at a very high, but constant, velocity and compare all clock-rates after allowing for movement during the transmission time of signals. This needs to be done in space, i.e. at high vacuum, with lengthy initial acceleration followed by nearly constant velocity in a known and nearly constant gravitational potential.

The forthcoming much more extensive data from distant Type 1a supernovae ($Z\geq 1$), and other distance indicators, should be tested to see if a variable speed of light continues to remove any need for expansion. However, it is important that the standard candle data be analysed under the expectation that the wavelength of light has not been altered post emission (although light can be absorbed during its journey and be detected with different efficiencies as a function of wavelength).

The measurement of accurate redshifts for millions of distant galaxies in all directions, and uncontaminated by faulty spectral line assignments, is becoming available. This should enable errors on number counts to be removed. The analyses should very clearly establish whether our location has the same movement relative to the CMB as it does to the background from matter. It can therefore establish whether the currently perceived anomalous dipole in the number count of galactic sources (and hence movement relative to us) is an artefact of limited or biased samples.

It would be desirable if the location and amplitude of the minute fluctuations in the almost uniform CMB (after removal of the dipole) could be reproduced for FR without the need for dark matter and dark energy. This would provide strong support for FR. The implications for the nature and rate of growth of pre-galaxy structures such as the so-called little red dots should be investigated. It may be possible to show that large, dense clouds of hydrogen could collapse into a black hole without the initiation of fusion reactions and the much later catastrophic explosion when a dense core of heavy elements implodes after the fuel is burnt.

Data from the James Webb telescope may be able to provide evidence for the expected contraction in the size of galaxies over time. The mass of individual galaxies should correspondingly increase over time, although the visible matter will also be lost to black holes. The total number density of galaxies (including proto-galaxies) is likely to have decreased over time because of mergers and lack of expansion. It is potentially confounded by the contraction and increase in mass of galaxies making previously fainter ones visible.

A test for matter/antimatter asymmetry as the source of inertia is the dependence of inertia on position within galaxies. It seems that it should be visible in the expansion rate of matter in Type 1a supernovae explosions. This is distinct from the slope of the decay of the light curve with time, which depends on the half-lives of the radioactive species. However, the slope is expected to also have a dependence on the rate of change with density of opacity to radiation and therefore with speed of expansion. As far as is known there do not seem to be any candidate supernovae within sufficient proximity for angular resolution of the expansion so that any deductions about expansion rate of matter must rely on Doppler broadening of known species. The rate should reflect the inertia at the supernova location estimated from the galaxy rotation curve and luminosity distribution.

The impact of the changes in mass and the hypothesised dependence of inertia on asymmetry inertia needs further investigation. They will affect the development of galaxies over time, and the motion of galaxies within clusters. The modelling needs to include the effects of changes in local anisotropy on relative movement within and between clusters and the effect of the changing speed of propagation of gravity over time. The sensitivity of ionised matter to clumping or other forms of collective motion on structure as a function of varying mass and inertia also needs to be considered.

The changes in inertia due to variations in asymmetry because of local anisotropies in the number, locations and movement of matter and antimatter galaxies may allow the determination of which superclusters are made of matter or antimatter. Such anisotropies may also affect the rate of development of structure from the small amount already visible in the CMB. The impact of the greatly extended timescale for stellar and galaxy evolution including the growth and merger of black holes needs modelling. The changes in mass and inertia should be tested as the explanation for the observed radial acceleration relationship of vastly different galaxies, without the need for dark matter [26]. It is suggested that the generation and persistence of spiral arms may be determined by gradients in inertia across the disk of spiral galaxies due to extended large opposite matter galaxy clusters. These gradients may give rise to radial locations that preferentially move stars together or apart at resonant distances from the rotating central bar.

FR implies changed timescales, densities and energy levels for the direct production of lithium versus decay from beryllium from those occurring due to expansion cooling under big bang nucleosynthesis. A test of FR is if this can explain the lower-than-expected abundance of lithium (^{7}Li).

The mass inside black holes is predicted to be underestimated from the orbital speed of nearby stars. The estimate of the change in mass from a merger of black holes or of a neutron star and black hole should appear to be less than expected because of the negative feedback mechanism of a decrease in mass per unit matter when density increases. The mass of the pulsar at the centre of the Crab nebula appears to be less than expected from the total mass of the pulsar and nebula relative to that of the hypothesised parent star. This should be investigated to see if it can be explained by the changes in mass and inertia.

CMB dipole anomaly

The cosmic microwave background (CMB) radiation is remarkably uniform independent of direction in the sky. It corresponds to a black-body temperature of 2.72548 ± 0.00057 K. The largest temperature (i.e. energy) anisotropy in the CMB is a dipole at just over one thousandth of the uniform level. Under both GR and FR, the simplest interpretation of the dipole is the kinematic one. That is that the dipole is from Doppler shifting of the received radiation due to our motion of 370 km s^{-1} with respect to the rest frame of the CMB. This speed is 0.00123 that of light, so the received wavelength is blueshifted in the direction of our motion by this factor and redshifted against our motion relative to the expected uniform background. The CMB uniformity is presumed to reflect the very even distribution of radiating matter in the early universe at the time when light could first escape.

However, under FR, the "light" seen in the CMB is not redshifted into the microwave region by GR's expansion of the space carrying the light. The much lower frequency reflects the much lower energy at the time of emission when hydrogen atoms could first form (as mass per unit matter and inertia increased) and photon radiation could first escape. It does not require a hot big bang and no cooling from expansion is needed.

Our motion reflects both the rotation of our galaxy and its movement due to gravitational attraction. About half appears to be from the rotation and the rest might be expected to be predominantly towards the gravitational centre of our supercluster. Once well outside this region it is expected that the average distribution of galaxies should increasingly match that of the CMB. This has been tested in terms of the distribution of the count (numbers of sources), as a function of redshift, of distant galaxies emitting at radio frequencies or quasars at optical/infrared frequencies. In most cases the dipole, seen in the number count of the sources, points in the same direction as the CMB dipole but it has often appeared significantly larger. This is what is referred to as the CMB dipole anomaly.

Under FR, the redshift due to our motion relative to the CMB should have the same magnitude (per unit of received wavelength) independent of the epoch (time and redshift of the emitted light). Under GR, the ΛCDM model is based on an expanding universe that implicitly assumes the Cosmological Principle (CP) that the universe appears the same to all <u>co-moving</u> observers. The metric of spacetime then has the maximally symmetric Robertson Walker form. The CP is broadly equivalent to the expectation from FR that the dipole-free CMB background is the same as the sampled background if it covers a sufficient volume that the sources sampled are representative of the large-scale distribution at the time of emission.

The CMB dipole indicates a fractional change in energy of 0.00123 $\cos\theta$ (with angle of the direction of our motion relative to the mass distribution at the time the CMB was emitted). A number count includes the effect of changes in energy and in brightness from Doppler shifting and relativistic aberration. Such peculiar velocity alters the apparent number of sources as a function of a source's spectral characteristics and of the photometry's sensitivity. However, the uniformity of the number count can be affected by contamination of the sample and biases in sensitivity due to, for example, dust or other obscuration.

The effect of our movement, relative to the CMB background, on average redshifts is potentially much cleaner than that for number counts of quasars or radio sources, provided the accuracy of the redshift measurement is better than 0.1%. It has been noted that above a redshift cut-off of Z = 0.02, the expected effect of peculiar velocities on the redshift values of distant supernovae when the spectra of the host galaxy is available is negligible [36]. Under FR, there is no expansion and, if enough galaxy sources are sampled, their average peculiar velocity should be zero. Our movement relative to the background should have a constant fractional effect on the <u>measured</u> wavelengths of every distant source. The fractional change in wavelength should be independent of brightness and of Z, i.e. of the energy at the time of emission. Every fractional change can be counted. Nevertheless, it will be necessary to first perform an average over all directions as a function of Z to determine the isotropic background. The average redshift in each direction could be biased unless the same number of sources are included in every redshift interval range. The number of sources in each interval (range) of distance will change if the count is sensitive to brightness or galaxies merge or otherwise evolve, or because there is obscuration by our galaxy's stars and dust. However, if the same fraction of galaxies in each redshift interval are included for every direction interval, then a weighted mean can remove such biases.

A re-examination of all existing galaxy data for which accurate spectroscopic redshifts are available should be made. It does not matter whether the number count is isotropic, provided the count as a function of redshift is matched for every directional interval.

Discussion

The changes in understanding set out in this document go much further than just eliminating the need for unexpected, invisible, and dominant new forms of matter and energy. The alternate perspectives on gravity and mass overcome the need for a malleable geometry of a linked spacetime that keeps light-speed constant. The explanations for, and removal of, many inconsistencies besides the unexpected ad hoc hypotheses of dark matter and dark energy, provides strong support for the changed understanding.

A key underlying belief that is being challenged is a concept of an observer-dependent "relativity" that has been 'sold' as having been experimentally 'proven'. It has not. Instead, the revised understanding is that the properties and behaviour of matter and radiation is dependent on all other matter and radiation. A full relativity that removes the current relativity's subjective, observer-dependent, malleable reality for events. An underlying reality exists independent of who is watching and what they are doing. The apparent simultaneity of separated events can appear different if the observer is in motion, and clock-rate will depend on the magnitude of the background and the speed of motion of the clock relative to the background. However, if arrival times were able to be corrected for signal travel time and clock-rate, an underlying reality, a single fixed causal order, exists for all observers.

An underlying relativity exists, but there is no need for the speed of light to be constant, it depends on all other matter and antimatter. As a consequence, the stored energy (mass) per unit of matter is also variable. The resistance to movement and the frequency of oscillation of all matter and radiation, all wave-particle states, and the time taken for events to occur depends on the properties and influence of the surrounding medium that enables the existence and alters the motion of these states. On the other hand, the distance between objects and events is a measurement not a property. The equipment used and measurement units can change but not the separation of the objects unless they are put into relative motion.

It has been noted that: "*If the Einstein equivalence principle [EEP] is valid then gravitation must be a 'curved spacetime' phenomenon*" and that; "*the only theories of gravity that can fully embody EEP are … 'metric theories of gravity'* " [37]. The revised theory retains Euclidean geometry. It is not a metric theory that distorts the geometry of a linked distance (space) and time. Energy/momentum and time are changed but not distance. The EEP is flawed and so is a curved spacetime. Space, as currently observed, is and always has been flat (Euclidean).

There is no evidence that the scale of space (distance) can be contracted by motion of objects or observers. However, clock-rate (time) changes with the speed of massive objects, and stored energy (mass) changes with the speed of light, which can lead to changes in apparent distance. The new understanding explains the gravitational redshift of massless light as a blueshift of the energy levels of matter (e.g. atoms). The same phenomenon explains the redshift of galaxies when looking back in time. A revised analysis of standard candles (Type 1a supernovae) establishes that the universe is not expanding, let alone the empty space between galaxies expanding at an increasing rate. This removes the need for dark energy, cosmic inflation, the horizon and flatness problems and the 'Hubble tension'. An equal quantity of antimatter is allowed and needed and the proposed dependency of inertia on chiral asymmetry appears able to remove the evidence for dark matter. Further evidence for the revised understanding includes the removal of the singularities inside black holes while allowing them to gravitationally interact. It also allows the transport of mass to, and ejection from, the rotation poles of black holes. Under, GR there should be a one-way loss of mass from the accretion disk across the event horizon due to the dissipative mechanisms present in hot dense environments. Therefore, accretion disks should not persist.

The hypotheses on which both SR and GR are based are unreasonable and not supported by evidence. All their claimed predictions can be reproduced without the need for an invariant light-speed, or mass, or of intervals of spacetime in which space can expand or contract.

No replacement for Einstein's coupled set of differential equations is presented. The equations are manifestly faulty because the input assumptions are not correct. Their existence appears to have provided a false sense of confidence. It seems that when an equation such as $a \times b = b$ occurs (for real quantities) that most of us accept that $a = 1$ is established. We easily forget to allow for the single case of what if $b = 0$. This is not to say that putting arguments into words rather than symbols is better. The widespread acceptance of the claims that there are no effects on all physical laws when the observer is moving at constant speed or that gravity is transformed away in free-fall argues the opposite.

The core information for new gravitational equations is already present in Newton's law of universal gravitation except that it is not universal! It does not allow for the finite propagation speed of light, or for its variable speed which gives rise to variable mass, or for variable inertia and variable time. Each of these properties is dependent on the amount, distribution and movement of all other mass. Under the new understanding the entire universe is fully relative in the sense of being fully dependent on everything else, but the consequences need to be modelled, tested and further explored.

An attempt has been made to base the revised understanding of gravity and cosmology on a better understanding of the nature of particles and their interactions. This has helped but much of it is speculative and does need further development (see Appendix C). However, it seems to offer a path to a deeper understanding of the Standard Model.

Conclusion

The invariant interval of Special Relativity (SR), which had distance (space) contracted to match dilated time and keep light-speed constant, was incorporated into General Relativity (GR). This spacetime arose in SR because the assumption of a constant perceived light-speed across all inertial frames was inserted as fact. SR assumed, without evidence, that time (clock-rate) was the same for all objects moving at the same speed as their observers. Constant measured light-speed applies for observers moving at the same relative speed within a region of constant potential. However, the value will be different for observations using clocks moving at different speeds relative to the background, and for regions of different, even if constant, potential.

Under GR, objects of constant mass are claimed to distort the scale of distance (space), as well as time, as a function of the difference in gravitational potential. Under Full Relativity (FR), the clocks of observers at higher gravitational potential tick faster because light-speed is slower, but distances are not altered. It replaces both SR and GR. It has a background field from massive objects determining a variable speed of light. The mass held by objects is stored energy, and the amount stored reduces as the current local background due to massive objects and speed of light increase, but distances are unchanged. Gravitational attraction then arises from the fractional decrease in the energy held by matter when nearer other matter, rather than from GR's increase in the distortion of the fabric of spacetime but no change in light-speed or mass (when seen by a co-moving observer at the same potential).

The reduction in the energy levels of the same matter fully explains the slowing of frequency, and hence the slowing of time, deeper in a gravitational potential. It is consistent with the faster ticking of the clocks of the GPS satellite. The apparent redshift of massless photons in escaping a gravitational field is, instead, a real increase (a blueshift) in the energy levels of the more massive receiving atoms. The energy and momentum of the photons are unchanged, in agreement with Newton's law of gravitation.

An increase in the density of matter within a region of like-matter increases light-speed within the clump but decreases it elsewhere including in regions of antimatter. The mass per unit matter therefore decreases with clumping and matter to antimatter asymmetry increases within clumps increasing inertia in an evolving universe. This means that the stored energy per unit matter was lower looking back in time while the speed of light was faster by the inverse amount. Thus, the increasing galactic redshift with distance, i.e. going back in time, is the same phenomenon as the locally observed gravitational redshift of atoms with increasing speed of light. It corresponds to a reduced energy of the atoms at time of emission. The distance to standard candles at a given redshift (Z) must then allow for the increased light-speed at earlier times. The distance travelled since emission will be increased in proportion to the integral of the $1+Z$ change in time at emission, i.e. by $Z(1+Z/2)$. Frequencies will slow by $1/(1+Z)$ as will particle energies in terms of mass per unit matter.

Correcting for the change in energy with c gives an accurately constant slope of the Hubble diagram. It removes the apparent "accelerating expansion" and hence the need for dark energy. Moreover, the local reduction in mass per unit matter when the local density of matter changes means that Gauss's law, used in deriving the differential form of Newton's gravitational equation does not hold. This equation was the basis of Einstein's gravitational equation. The decrease in the flux from a constant amount of matter (holding less energy) when there is a decrease in local density necessarily leads to an apparent, but non-existent, and therefore invisible energy. It was needed to make the hypothesised spacetime of GR's expanding universe undistorted (flat). FR removes the remarkable coincidence, that it is currently flat when such flatness should be rapidly destroyed by gravity or dark energy. The geometry of spacetime is, and always has been, flat because the distance between objects cannot change without the objects being in relative motion.

There is no need for an expanding universe, because galaxy redshifts with distance are entirely explained by the decrease in energy levels with increasing speed of light looking back in time. Thus, there is no need for an initial big bang or the impossibly rapid initial cosmic expansion, and the flatness and horizon problems are avoided. Moreover, the so-called 'Hubble tension' is removed because it is an artefact of inserting a recent variable rate of expansion as the cause of cosmological redshifts, to try and mimic a non-expanding space in which redshifts arise from a linear increase in light-speed decrease in mass per unit matter.

The introduction of a pair of chiral background components allows effects of the background on mass (stored energy) to reduce more slowly (as $1/R$) with distance. This is why distant galaxies dominate and the background field is related to the gravitational potential, rather than to the acceleration field. The modest asymmetry in the contributions from matter and antimatter, that occurs within isolated galaxies, gives rise to resistance to acceleration (inertia). This, in turn, appears able to remove the need for dark matter by explaining galaxy rotation curves and gravitational lensing. It also explains the link between inertial and gravitational mass. Both depend on stored energy but local asymmetry determines inertia. The $1/R$ dependence also demands that gravitational 'waves' do not carry energy but are variations in gravitational potential that are detected because they alter light-speed.

It appears that all the confirmed predictions of GR can be reproduced by FR. It can be the understanding of the cause that changes, as with a blueshift replacing a redshift; or that GR's changes in distance ('space') and time mimic FR's changes in light-speed and mass/energy; or because SR's and GR's unreasonable assumptions and faulty steps have been hidden by an inversion of meanings or a flexibility in interpretation of terms and confusion between real and apparent effects.

The introduction of unusual, invisible, and previously unknown substances, such as dark matter and dark energy, after observations of unexpected behaviour, deserved to be treated with greater scepticism. The removal of the need for these and other ad hoc hypotheses, together with the avoidance of singularities inside black-holes and that gravity can cross their supposed uncrossable event horizons, is strong evidence for the validity of FR. In addition, unreasonable postulates, faulty assumptions, and logical errors in SR and GR have been demonstrated together with how they give rise to inconsistencies and apparent effects such as dark energy and expansion of empty space. Moreover, unlike GR, FR is consistent with Quantum Mechanics and with the Higgs mechanism as a source of mass. It appears able to remove all current evidence for new physics beyond the Standard Model of particle physics.

For further documents on Full Relativity (although with some of the arguments and understandings superseded by this document) please visit: www.fullyrelative.com

Appendix A. Faulty assumptions, hypotheses and other errors

The faulty derivation of the Lorentz transformation

Einstein's 1905 paper that led to SR was based on a thought experiment. He sought to relate the same events (locations in space and time) seen in a moving and stationary frame, by referring all values back to the stationary frame [1]. Each frame is a set of spatial (x, y, z) coordinates with a time (t) coordinate based on having a clock at every point, with all clocks, stationary relative to each other, within that frame, synchronised. This means that if all clocks in the frame could be examined at the one instant of time, or that their observed times were corrected for the time taken for the message to reach the observer, then they would show the same time. The moving frame (x', y', z', t') was allowed to have a different scale of distance and time, as a function of relative speed, from those in the stationary frame. Einstein used this approach to derive a transformation between the space and time coordinates of frames in relative motion. This Lorentz transformation (LT) had already been put forward by Lorentz, with corrections from Poincaré, to try and explain why movement of the Earth relative to the aether could not be detected.

The first problem is that, a priori, Einstein's method cannot yield the time of a clock in a moving frame. The clock-rate must be examined. It cannot be assumed. Relating the positions with time of the same events, back to the stationary observer, amounts to measuring the position of a moving object as a function of your time without any information on the rate at which the clocks on the moving object are ticking. SR claimed that all moving clocks, if stationary relative to their observer, would show the same time. This was based on Einstein's conjecture (the first postulate of SR) that the laws of physics (electrodynamics, optics, and mechanics) were independent of motion at constant speed. This assumption demands that light-speed and clock-rate are the same in all inertial frames, and was inserted in Einstein's claimed derivation of the LT. Subsequent derivations have mostly used this belief to obtain the LT which, for constant velocity (v) in the x-direction, is:

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

Maxwell's equations are invariant under an LT, but not Galilean transformations, and the LT and Lorentz invariance are at the centre of the concept of spacetime. This linkage of space and time via a locally invariant speed of light is also an assumption. The LT was formulated to try and explain experimental observations. Its correctness must be critically examined.

Einstein argued that "the principle of the constancy of the velocity of light" in the stationary system, in combination with the first postulate - the 'principle of relativity' - that the laws of physics are independent of motion at constant speed, meant that light also propagated with velocity c when measured in the moving system. The analysis therefore demanded that $c = x/t = x'/t'$ 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 involves two assumptions. First, it assumes that the clocks of the moving system keep the same time as those of the stationary system and, secondly, that the measurement of position and velocity has taken into account relative movement during the time taken for propagation of the light between source and receiver. The observational requirement is, and was, that the (underlying) speed of light is independent of the speed of the emitting object.

For a constant underlying speed of light, the distance travelled by light, per unit of observed time (ticks of a clock), increases if the observer's clocks are slowed. Keeping the observed speed of light constant for observers whose clocks are slowed requires distances to be reduced. Under FR, time dilation arises because the clocks of objects and observers (which both have mass) are slowed by motion relative to the background from all other massive objects. However, the speed of (massless) light is not affected. Consequently, its speed will measure faster, but is unchanged if the background is constant. The misunderstanding, that the perceived speed must be constant, explains why the 'space' of spacetime, the distance between objects not in relative motion, is reduced by the slowing of time with movement of the observer. The apparent distance travelled must be less for the same number of ticks.

Einstein's analysis examined the timing of light signals emitted (at τ_0), reflected (τ_1) and received back (τ_2) in a moving frame in terms of the time of a stationary frame after initial coincidence of the origins. He then claimed that $(\tau_0+\tau_2)/2=\tau_1$ (within the moving frame), and that by inserting the coordinates of the function τ and applying the principle of the constancy of the velocity of light in the stationary system he arrived at:

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

To my knowledge no-one has been able to follow the rest of the steps claimed to give rise to the LT. However, at least two authors have found the method to have ambiguities [38] and internally inconsistent [39].

The underlying problem is that the apparent timing is altered by the changing separation of the frames during the finite signal transmission time. Timing of events (emission and receipt of signals at matched locations) can be synchronised within frames, but must be corrected for movement during signal transmission if they are to be synchronised between frames. When moving apart, the average distance to their positions is slightly larger than the distance at the time the signal is reflected because the signal transmission time is larger for the longer path. This difference increases with the increasing separation of the moving and stationary frames. This means that $(\tau_0+\tau_2)/2\neq\tau_1$, the claimed equality does not hold.

The average round-trip distance to positions between frames is increased by the factor ($[c/(c+v)+c/(c-v)]/2=\gamma^2$). Einstein's claimed derivation of the LT, did not correctly allow for the changing transmission times. In addition, the function $\phi(v)$ to allow the scale of time and distance to differ between moving frames was in his initially derived transformation:

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

These equations are those of the LT except for the function $\phi(v)$. His analysis then examined a third frame (x'', y'', z'', t'') which, relative to the origin of system, was moving in the opposite direction (with velocity $-v$) and found that a "two-fold application" (v followed by $-v$) of the transformation gave:

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

The doubly-transformed position coordinates had no time dependence. He took this to mean the two-fold transformation gave a return to the original (stationary) frame and, therefore, to its clock-rate. Thus, Einstein concluded that $\phi(v) = \phi(-v) = 1$ for all coordinates, and supposedly arrived at the equations of the LT. However, the time-independence is not because of a return to the stationary frame. Instead, the two-fold application compares the coordinates (relative to the stationary frame) of two frames moving at the same speed in opposite directions away from the origin after initial coincidence (i.e. after all three frames overlapped at time zero). Their distances match with time (although going in opposite directions). This explains the lack of a time dependence, but the frames are not at rest relative to each other. The inverse transformation is not achieved by reversing the sign of the velocity. The two frames only overlap at time zero. Using $-v$ is only the inverse transformation if the unit of time (rate of ticking) is independent of absolute movement of the clock so that $1/\gamma = \gamma$, i.e. $\gamma = 1$. The faulty assumption removes the function $\phi(v)$ that should have allowed different scales of time and apparent distance between frames and the effects of different scales to be inverted between the two frames. The function must be inverted in returning to the initial frame. Moreover, the function that applies to time should be the same as that for distance, within each frame, if c is to remain constant independent of scale.

If time is found to be slowed in the moving frame, then time must be increased in returning. However, the alternative proposed by Einstein was that observed clock-rate was increasingly slowed by <u>speed of movement</u> of the clocks <u>relative to the observer</u> in both frames, independent of direction. The claim became that absolute motion could not be detected. He then used the slowing of time to argue that a rigid spherical body must be foreshortened in just the direction of motion. The result was a contraction of distance that kept the speed of light constant. Time and shape/size had become subjective dependent on the relative movement of the observer. A side-effect is that the time and spacing claimed to be seen by every observer for another relatively moving frame and events, is non-linear. If the frames are moving apart at $x = vt$, then the clock-rate is $t' = t/\gamma$. Thus, a third observer midway between two oppositely moving clocks is required to see a smaller total slowing than the observers at each clock, due to the non-linearity of γ. Thus, reality has become malleable. Time of the same events is slowed, and distances are contracted, dependent on their speed relative to the observer.

The conclusion is that Einstein's supposed derivation of the LT was faulty on multiple counts and its applicability and interpretation must be critically examined.

Interpreting the Lorentz transformation

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

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

Substituting $x = vt$ in the LT equation for x' gives $x' = \gamma(x - vt) = 0$. All this says is that the separation between matched locations when the frames overlap is zero. We could instead assume that $x' = \gamma(x - vt)$ applies at $t = t' = 0$ and for all times. This requires a change in the accepted interpretation, which does not seem to have been pointed out previously. The scales of the matched arrays of points in each frame, that remain matched for all time, are not the same in the two frames if time is proceeding at different rates in each frame. The locations are coincident, but not the scale of the x and x' axes. However, inserting $x = vt$ in the expression for t' leads to an inverted change in the scale of time relative to the change in distance scale. Matched locations, when the speed of light is the same in both frames, requires the change in distance scale to be the inverse of the change in the scale of time.

If actual time is running slower, then apparent lengths should increase. If $x = vt$ applies to a separation Δx then, for a positive velocity, the separation should be decreasing when $t < 0$ and increasing when $t > 0$. The sign of the $(v / c)(x / c)$ term changes at $t = 0$, when all matched locations coincide. The term is the needed correction for the change in arrival time of signals due to relative motion during signal transmission. For observers of objects emitting signals at constant intervals of time the apparent arrival time and apparent distance travelled will steadily decrease for movement towards, but steadily increase for movement away.

Einstein argued that the distance expression $x' = \gamma(x - vt)$ means that "a rigid body which, measured in a state of rest [$v = 0$], has the form of a sphere, has in a state of motion (viewed from the stationary system) the form of an ellipsoid of revolution" with $x' = \gamma x$ (i.e. the scale of the x-axis is increased by the factor γ). However, this is only an apparent effect for an object moving away, if the correction for movement during signal transmission is not made. If an object and observer are moving closer together then the apparent effects are inverted relative to a fixed underlying emission interval of time and known velocity.

If the time intervals in the other frame are increased (slowed) then distance intervals must decrease for a constant signal speed. Inserting $x = vt$ in $t' = \gamma(t - vx/c^2)$ gives $t' = t/\gamma$ and $x' = \gamma(x - vt) = 0$. It can only apply if $\gamma = 1$. The LT cannot explain observations if the effects are the same when observers and objects are swapped. If the scale factor for time changes by $1/\gamma$ going from frame A to B, then it must change by γ in going from frame B to A. It does not give an ellipsoid. A slowing of time that occurs independent of movement towards or away implies that the slowing is inherent to the movement and the changes in distance are apparent. Such a slowing of time for the object that is viewed implies that it is the movement of the object that causes the slowing. A slowing, and never a speeding up, of a time whose magnitude depends on only relative motion, implies that the effects of motion are real, and must be able to be sensed by the object.

Einstein's interpretation arrived at $x' = \gamma x$ and $\tau = t' = t/\gamma$. Next, he took $x = x'/\gamma$ as the length that objects of length x' (in the moving frame) will have in the stationary frame, so that the size (length) of moving objects appears shorter (FitzGerald contraction) in the stationary frame. On the other hand, he took the time (τ or t') of a clock in the moving system as "nothing else than the summary of the data of clocks at rest in the system" [1]. This is the time at rest in the moving system. However, this leaves out the inversion used in interpreting lengths, which should have $t = \gamma t'$ being the size of time that moving time has in the stationary frame. Instead, $t' = t/\gamma$ was taken to be the time of the moving clock (in terms of the elapsed time in the stationary frame) and, since $t' < t$, time was slowed (less time occurred for the moving clock).

If the elapsed time within a frame is the sum of time intervals (summary of data of clocks at rest in the moving system) the interpretation should be that time intervals are smaller. Minkowski [40] made this interpretation, that total time was $\int dt$. If $\tau = t/\gamma$ refers to time intervals (i.e. $d\tau = dt/\gamma$) then the intervals between ticks of a clock in the moving frame are smaller and time is proceeding faster (more ticks than in the stationary frame). If $x' = \gamma x$ is also taken to mean $dx' = \gamma dx$, then the distance intervals of the moving frame should be larger than those of the stationary frame. Larger distance intervals should mean that an object of the same length will appear shorter. Either way the inconsistency between the treatment of lengths and times means that lengths and times change in unison keeping the "measured" c constant. However, a mapping in which time is slower (intervals between ticks larger) in the moving frame means distances intervals travelled per unit time interval will be larger.

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

This interpretation is faulty; the changes in distance intervals (scale) in the other frame should be the same as the change in their time intervals (dilated intervals giving slower clock-rates). The inversion between time and distance allowed the faulty deduction that the changes would match. The apparent dependence only on relative motion arose from mistakenly assuming that v followed by $-v$ gave a return to the stationary frame. Instead it represented movement in opposite directions away from the stationary origin. Time is altered for moving massive clocks and observers but the distance travelled by the same light ray is unaltered. The measured distance will be the same once the measurements are corrected for changes in clock-rate and for apparent changes due to movement during signal transmission. There is no reason to believe that the empty space or distance between objects, not in relative motion, can be increasingly reduced as a function of the speed of the observer, and by the same amount independent of whether the observer is approaching or receding.

The spherical radiation of light is a misunderstanding

Einstein demonstrated that the LT left Maxwell's equations unchanged. He then claimed that the result: $x'^2 + y'^2 + z'^2 - c^2t'^2 = x^2 + y^2 + z^2 - c^2t^2$ confirmed that light was radiated spherically in both frames at speed c. However, the conclusion results from: i) failing to allow for the effect of delays in signal arrival time due to movement during signal transmission on measured distance, and ii) using an inverted meaning of distance relative to time intervals. (The LT can hold if the size of objects is contracted rather than the distance between them.)

Einstein sought to prove that any ray of light, measured in the moving system, has the velocity c, that it has in the stationary system. This would establish that: "the principle of the constancy of the velocity of light is compatible with the principle of relativity" [1]. The conclusion appeared to be confirmed because the LT converted $x^2 + y^2 + z^2 = c^2t^2$ into $x'^2 + y'^2 + z'^2 = c^2t'^2$. It was claimed that this meant that spherical radiation of light, at speed c, in the stationary frame is also observed in the moving frame (i.e. is seen by both moving and stationary observers). This is false. It does not correct the measurements for movement of objects during the transmission time of signals. It does not allow for: i) a slower clock in the moving frame meaning that the same light ray will appear to travel further; or ii) that the delays/advances in signal propagation times due to the relative movement of the frames become increasingly different for locations that were matched at $t = 0$. It is an artefact of having both x' and t' dependent on both x and t, so that cross-terms cancel, leaving x and t terms to be grouped.

Substituting in the LT: $x'^2 - c^2t'^2 = \gamma^2(x - vt)^2 - c^2\gamma^2(t - vx/c^2)^2$

$$= \gamma^2[x^2 - 2xvt + v^2t^2 - c^2t^2 + 2vxt - v^2x^2/c^2]$$

$$= \gamma^2[x^2(1 - v^2/c^2) - c^2t^2(1 - v^2/c^2)]$$

$$= x^2 - c^2t^2 \qquad \text{because } \gamma^2 = 1/(1 - v^2/c^2)$$

We arrive at $x^2 - c^2t^2 = x'^2 - c^2t'^2$ and it is assumed that $y^2 + z^2 = y'^2 + z'^2$, i.e. that the distortions of distance and time are only along the line of relative movement of the observer and events. Thus, it is claimed that light is always observed to radiate spherically independent of the speed and direction of the source emitting the light. This contradicts reality. If a burst of light is observed to reflect from a surrounding spherical surface moving at the speed of the emitter, the delays (effects of increased distance to the surface at the time of reflection) must be taken into account.

The spherical radiation of light occurs independent of movement relative to the observer and the radius of the sphere will be doubled if the clock-rate used is halved by movement relative to an approximately stationary background. The delays or advances in signal arrival time must first be applied to obtain the correct position of the source (at emission) after allowing for its movement during signal transmission. If the corrections are not applied, then the unobserved, but assumed, contraction of distance, plus the dilation of time give $x'^2 + y'^2 + z'^2 = c^2t'^2$.

The new perspective on the LT

The alternate perspective on the LT is that the term vx/c^2 in the time t' of the moving frame is essential to correct for the advance/delay in the arrival time of signals (moving at c) when there is relative movement of v/c in the time x/c that light takes to travel the $\Delta x = vt$ distance interval between matched points. Hence, the time in the moving frame becomes: $t' = \gamma(t - v^2t/c) = t/\gamma$, which is consistent with a real slowing of time (fewer ticks of an identical clock) in the moving frame. The apparent distance between matched points in the two frames, according to the slower time in the moving frame, will then be $x' = \gamma(x - vt) = 0$ for $x = vt$. It applies to points that were coincident at $t = t' = 0$. Thus, every point in the two frames, matched at $t = 0$, has $x' = \gamma x$ and $t' = t/\gamma$, and moves apart at vt. The distance scale is the inverse of the clock-rate so that underlying speeds are unchanged. If an underlying reality exists independent of the motion of the observer, as should be expected, then distance is not contracted. It is only an apparent effect of a slower clock-rate. The apparent invariant interval $x'^2 + y'^2 + z'^2 - c^2t'^2 = x^2 + y^2 + z^2 - c^2t^2$ arises from using x as both the interval between matched points in the expression for t', and as the fixed distance from the origin in the expression for x'. This is not allowed and forces a distortion of distance.

The LT only applies for $\Delta x = vt$, so that a simplified transformation is necessary:
i) $x' = \gamma(x - vt),\ y' = y,\ z' = z,\ t' = t/\gamma$, where x' is the apparent separation distance with time in the moving frame when the clocks of the moving frame are ticking more slowly; or
ii) $x' = x - vt,\ y' = y,\ z' = z,\ t' = t/\gamma$, where the underlying scale of distance is constant and the time of the stationary frame is used.

The new perspective is that the Galilean transformation ($x' = x - vt$) applies to distance. However, the LT fortuitously brought in the observation that the time of clocks moving relative to the background are slowed by the factor $1/\gamma$ (less time elapses). The speed of light is insensitive to such movement of clocks. Time (clock-rate) is, first, a measure of the invariant mass (stored energy) of massive objects and, second, a measure of the slowing of oscillations by $1/\gamma$ with motion relative to the background. It is not a property of empty space that can be influenced by motion relative to the observer.

Allowing $\Delta x = vt$ to apply to locations other than the origin leads to a distorted distance and time. This is the mistake behind the claimed visual distortion and rotation of objects, passing at close to the speed of light, known as the Terrell effect [41,42]. It is claimed that the differences in arrival times of signals reaching the observer from different parts of an object cancels SR's length contraction, making it invisible. In addition, a receding object will appear contracted, an approaching object will appear elongated, and a passing object will appear to be rotated. Under FR, the non-existent Lorentz contraction of space arises from the failure to correct for movement during signal transmission. Not correcting will result in an approaching object appearing contracted and a receding object appearing elongated (not vice-versa). The apparent rotation of a passing object, comes from the changing viewing direction to the non-rotating object as it passes the observer.

Einstein's faulty conclusion that the principle of relativity held, and only relative speed mattered, led to the perception that space, the scale of distance between objects, and the scale of time were both flexible (observer dependent). Only their combination in terms of a fixed light-speed had a real existence. However, the position coordinate intervals ('space') represent the fixed separations between the positions of the same events seen by observers in relatively moving coordinate frames. The scale of time for observers moving at different speeds, but seeing the same events, cannot change the underlying spacing. The actual distance between events cannot be altered by motion of the observer. A subjective 'space' instead of a fixed separation distance allowed the idea that space and time could contract in unison because the observer was moving.

Lorentz invariance

Minkowski built on the combined ideas of Lorentz and Einstein to propose invariant intervals of spacetime. The time of events in empty space and their spacing, the amount of empty space between events, was flexible. This enabled the idea of relative simultaneity. The order of events perceived by moving observers was subjective dependent on relative motion between the observer and events. This was encapsulated in the Minkowski spacetime diagram which included the LT in terms of changed angles and scales due to time dilation and length contraction. However, the revised perspective has an existing underlying simultaneity whose apparent ordering is altered by arrival time at the observer. The actual ordering exists but could only be known if there existed instantaneous signal transmission or the timing was corrected for the signal transmission time. There is no length contraction, and time dilation arises from high-speed movement relative to the background. This does not affect the speed of light, only its apparent speed when using the slower clock.

The apparent invariant intervals of spacetime arise because of the inversion of time relative to distance. If the intervals of time in the moving frame are larger, then $dt' = \gamma dt$. This gives rise to an expansion of distance scales, which amounts to a contraction of apparent distance intervals $dx' = \gamma dx$. The scales of the intervals appear to have matched changes giving $ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2 = dx'^2 + dy'^2 + dz'^2 - c^2dt'^2$ with a constant speed of light. This "covariant" formulation, applies locally at every point in the assumed, but non-existent, spacetime because it simply reflects "time x c = distance" and that the speed of light is independent of movement of the source and observer.

Time is something applicable to objects with mass. It is not applicable to light, except via the clocks with which we measure its speed. Light-speed is independent of its frequency of oscillation and constant if the background from mass (related to gravitational potential) is constant, which is the case within any region without a gradient, but it does not have to be the same speed in a region of different potential.

There is no need for a contraction of 'space'

Spacetime, a linkage of the space and time into a constant speed of light perceived by an observer when there is relative motion, is a core conclusion of SR. It applies to motion at constant velocity in the absence of a gravitational field. Under SR, time slows and space contracts with relative motion, keeping the speed of light constant.

The invariance of Maxwell's equations under the LT is because massless electric and magnetic fields travel at speed c and their interactions depend only on the relative speed of the sources and receivers. The effect of speed, seen in the difficulty in changing the momentum of charged and uncharged massive particles, comes from increased inertia. Under FR, this arises because massive particles, but not massless photons, are sensitive to movement relative to the nearly stationary background.

The alternative that has been eliminated, under SR, is that the behaviour of all massive objects, including clocks, is slowed by movement at high-speed relative to the background field from all mass in the universe. Observations of the slowed rate of decay of unstable elementary particles moving at high-speed relative to the observer have not yet distinguished between whether the slowing arises from (unaccelerated) movement relative to the observer or relative to a nearly stationary background in which the observer is in free-fall. However, the speed of massless light is independent of movement relative to the emitter, receiver, or the background field that conveys the photons.

The alternative perspective to spacetime in Special Relativity

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

The revised hypotheses also mean that the transformation from a moving (slowed) frame back to a frame that is stationary relative to the free-fall background is:

$dx' = dx,\ dy' = dy,\ dz' = dz,\ dt' = \gamma dt$, with an apparent $dx' = dx/\gamma$ contraction of distance.

Clocks (massive objects) are slowed by movement relative to the background but, since freely-falling objects accelerate until they are in equilibrium with the background, it would seem that effectively we are nearly stationary relative to the current background.

Lorentz contraction in the size of high-speed heavy nuclei (by $1/\gamma$) along the direction of motion appears to occur [35]. An expansion (by γ) perpendicular to the direction of motion may explain the observed slowing of time in the decay rates of unstable elementary particles.

The clocks in a moving frame tick more slowly causing light to appear, and be measured, to travel further per tick. However, the increased distance scale is only apparent. The fabric of a linked but malleable space and time, altered by the relative speed of the observer, does not exist. The invariant interval of flat Minkowski spacetime, within a region of constant c, holds because the speed of light is independent of movement of the emitter and receiver relative to the background field. For massive objects, time is slowed by movement relative to the background, so that a contraction of distance appears needed to reduce the apparent increase in distance travelled by light when using slower ticking clocks.

The deduction of the LT was faulty. It requires, rather than rules out, a background-dependent explanation of the observed kinematics and dynamics of massive objects. The underlying speed of light is independent of the velocity of the emitting object, and time is slowed by movement relative to the balanced background.

SR's dependence of observed distance and time on relative speed between observer and observed has space, the scale of distance between objects, and the scale of time, both flexible. Only their combination in terms of light-speed has a real existence. This idea is at the core of the disputed paradoxes of relativity. Students happily accept that relative motion between observer and object will lead to apparent effects, but many do not realise that the theory requires the effects to be real. The idea that space and time are malleable, or have a subjective nature, seems to be more readily accepted by those who see that the scale of coordinate frames can be arbitrary. It ties in with the use of the word 'space' (in Minkowski's influential explanation of SR as a fabric of spacetime in "Raum und Zeit" [40], which translates as "Room/Space and Time"). Einstein used spatial and temporal coordinate frames in his derivation of SR and allowed for possible changes in scale. He incorrectly inserted that the scale of the transformation between observers would be the same for both observers so that each saw a slowing of time. This was matched by a contraction of distance that kept light-speed constant. However, the position coordinates represent the fixed separations between the positions of the same events seen by observers in relatively moving coordinate frames. The initial choice of scale is arbitrary but the ratio of scales of a transformation from the second frame to the first will be the inverse of that from the first to the second. The ratio of scales for observers moving at different speeds, but seeing the same events cannot change the underlying spacing. The actual distance between events cannot be altered by motion of the observer. A subjective 'space' instead of a fixed 'separation distance' allowed the idea that space could contract because the observer was moving relative to the events.

FR, in replacing SR, has massive objects sensitive to their speed of movement relative to a background from all other mass. However, massless light is insensitive to such movement, although its speed is determined by the magnitude of the background. Thus, light does not perceive movement of the background field, rather than that "the idea of motion may not be applied to it [the aether]", as Einstein claimed [2]. A simplified transformation, and its inversion, applies for massive objects and there is no requirement for c to be constant.

Appendix B. The faulty Equivalence Principle of General Relativity

The apparent, but unneeded, contraction of distance and assumed constant light-speed were taken over into GR via SR's concept of a fabric of linked spacetime that kept c constant. This appeared to be required by the equivalence principle that all observations in free-fall are the same as those in an inertial frame without gravity. However, this principle is based on the assumption that gravity is transformed away under free-fall so that no experiment can detect a difference. This is untenable under the changed perspectives because the mass of the matter is continually reducing with depth in a gravitational potential. The gravitational force and acceleration have not disappeared. Instead, the force is no longer sensed because it is matched by an equal and opposite inertial force. This force steadily increases, with v / c, but always appears balanced because the rate of change of momentum is limited ($F = dp / dt$).

Under GR, the geometry of this spacetime fabric is distorted by mass and energy/momentum. However, the speed of light remains constant for the local observer not feeling a gravitational force. The first step towards GR was what is now called the Weak Equivalence Principle – that there is no difference between inertial and gravitational mass. This principle has been experimentally confirmed to high accuracy, but only in terms of gravitational and inertial mass having a fixed ratio independent of the type of matter <u>at the same location in space and time</u>. The next step was the Einstein Equivalence Principle. The principle claims firstly that physics in a frame, freely-falling in a gravitational field, is equivalent to physics in an inertial frame without gravity. It then claims that physics in a non-accelerating frame with gravity $\vec{g}$, is equivalent to physics in a frame without gravity, but accelerating with $\vec{a} = -\vec{g}$.

These should be seen as absurd claims. The freely-falling observer is continually increasing in speed and continually moving into a region of lower gravitational potential where matter holds less mass and time runs more slowly. Just because a moving observer does not sense the tiny differences at slow speeds does not mean they do not exist. Being stationary or moving at an arbitrary constant speed (i.e. in a non-accelerating frame) but staying within a region with a fixed gradient in gravitational potential ($\vec{g}$) can only have an instantaneous agreement (matching of forces) with that due to a fixed rate of acceleration ($-\vec{g}$) in the opposite direction. The value for agreement will change with speed and total potential.

The faulty claims led Einstein to replace SR's invariant interval of Euclidean (flat) space, i.e.: $ds^2 = c^2dt^2 - (dx^2 + dy^2 + dz^2)$ with: $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$, where $x^0 = ct,\ x^1 = x,\ x^2 = y,\ x^3 = z$. The metric $g_{\mu\nu}$, the geometry of the fabric, is a 4 x 4 matrix and there is a sum over the indices for repeated terms. The flat, undistorted metric of SR has only the diagonal terms of (-1,1,1,1) with the others zero. The cross-terms involving both distance and time allow for the finite propagation speed of gravity (at c). However, GR inverts the distortions of time (g_{00}) relative to those of distance ($g_{00} = -1 / g_{rr}$) to claim a doubling in the bending of light [31].

Einstein concluded that the metric was the relativistic equivalent of the gravitational potential (Φ) as expressed in the differential form of Newton's gravitational equation ($\nabla^2\Phi = 4\pi G_N \rho$).

His replacement equation then expresses how mass, energy, and momentum, distort space and time. This is a generalisation of the observation that the source of the acceleration field is (appears to be) the gradient in mass density (ρ). Once an initial distribution of matter, energy and movement is set out then Einstein's gravitational equation (actually a coupled set of equations) can be used to predict how it will evolve over time.

However, Einstein's original deduction that mass is a form of stored energy leads to FR's alternate set of hypotheses. The first is that the speed of massless particles (including photons) is insensitive to movement relative to the field from massive objects. The second is that massive objects are sensitive to movement relative to this background field. The sensitivity to motion reduces the oscillation frequency of opposing components of the wavefunction of particle states. However, inertia increases with speed relative to a balanced background from all other matter and antimatter (primarily distant galaxies) and its magnitude increases in proportion to the local asymmetry between matter and antimatter contributions. The third hypothesis is that the speed of light is not constant but depends on the magnitude of the background field, and that the mass (stored energy) of particle states reduces as c increases.

Together the new hypotheses allow an alternate understanding of gravity in which the scale of distance (i.e. the 'space' of a linked spacetime that keeps the speed of light constant) is not affected by the relative speed of the observer or by changes in the density of matter. Only time is altered, and not 'space'. The revised perspective has the distance travelled by light always c x time taken, consistent with constant distance. SR's change in the scale of distance (i.e. 'space') with movement of the observer is only apparent and not real. When time (clock-rate) is slowed, then the apparent distance travelled by the same light ray is increased. Light appears to travel further because the clocks of observers, moving at constant high-speed relative to the background field, tick more slowly. Similarly, in a varying background (where GR applies), an increased density of matter (lower gravitational potential) gives rise to a faster speed of light, and therefore an apparent contraction of distance.

The invariant interval and four-vector formulation of momentum/energy and distance/time can be retained by having the scale of distance fixed but a variable speed of light reflecting the time taken for light to travel a given fixed distance. Thus, the many successes of GR do not establish that the speed of light is a universal constant for the local observer.

Currently, the only evidence for a spacetime with matched changes of time and space that keep the speed of light constant is its claim to double the expected bending of light in a gravitational field. SR applies only in the absence of a gravitational field and so is not relevant. GR calculations double the amount of bending by requiring the spatial distortion of the metric to be the negative reciprocal of the distortion of time. The spatial and temporal curvatures are claimed to double the retardation of the light signal [43]. These distortions are elsewhere claimed to keep light-speed constant in terms of local physical quantities. However, no bending should occur if c is constant along the actual light path.

The inconsistency should be enough to totally discredit GR. It arises because the equivalence principle has removed the effects of total potential on observed behaviour. GR therefore has unappreciated extra degrees of freedom. Results can be tailored by the choice of boundary conditions. For example, under GR, an isotropic, uniform shell of matter of any density or radius will have no discernible effects upon the laws of physics as they are observed in the interior [44]. The spacetime inside the shell is unaffected because contributions from opposite directions cancel. That contradicts Mach's principle and the dependence of gravitation on the potential, not the gradient. Gradients from opposite directions will cancel because they act as vectors. Scalar potentials will add. The second cause of problems is the inversion of meaning of time interval versus distance intervals This allowed the claim of a real contraction of distance rather than an apparent one because time ran faster. Observations of the interactions of high-speed nuclei indicate that there is a real contraction of dimension (size) along the direction of motion but this should have negligible effect on the empty space (distance) between separate particles.

Appendix C. Further speculations on matter and fields

It is proposed that the mean propagation speed of balanced chiral components is the propagation speed of the medium. However, wave-particles can have components from multiple directions and of different magnitudes contributing. All wave-particles are repetitive patterns of multiple components about a mean, or cyclically varying, location. Massive wave-particles trap opposing momenta, while massless exchange “quanta” (photons, gluons, neutrinos) have supportive components. The latter patterns can only exist by travelling at the maximum (mean) speed of the medium. This speed is determined by the mean magnitude of the two-component chiral background. It is further proposed that the cyclic frequency, per unit energy, of all wave-particles, including massless quanta, varies with the asymmetry between matter and antimatter contributions to the background.

It appears probable that linear movement of like chirality, but oppositely directed, components relative to a balanced background will increase the rotation rate of one component and reduce the other to maintain the force balance. The relative speed of rotation of the pair of components, around the axis of the direction of motion, changes. The increasing difference in the resistance to rotation of the chiral pair, with speed along the direction of motion, produces a slowing of the mean frequency of oscillation and a reduced amplitude in order to keep the total internal angular momentum constant. The frequency of oscillation is reduced but the stored energy is unchanged. The result is that massive particles have a “memory” of their speed relative to the background and relative to their current pattern. Such particles will also come in pairs of opposite chirality (i.e. matter and antimatter). Both particles will trap the same angular momentum because the oppositely directed components, although of the same chirality, counter-rotate. Hence, particle/antiparticle pairs will have the same positive mass (i.e. stored energy) in the same background. This model would seem to give rise to an inertia that is dependent on both mass and chiral asymmetry of the background and is sensitive to changes in velocity relative to the background.

Massless photons are sensitive to the magnitude of the balanced background of opposing chiral components. The background determines their speed, but that speed is independent of the speed of the emitting source. However, the photon still retains the information (relative frequency of electric to magnetic field oscillation) internally, because observed Doppler shifting depends on relative motion between source and receiver. The explanation must lie in the self-propagating nature of electromagnetic waves. They are oscillations between electric and magnetic fields which both travel at the speed of light. Their propagation speed is independent of the energy carried but must have a finite extent and rotation perpendicular to the direction of motion. The rotation frequency is faster and extent smaller with increasing energy carried. Their emission and later absorption conserves linear and angular momentum.

A clue to the nature of the wave pattern is that a photon, except that it is moving at c, has properties that match that of a stationary co-rotating positron and electron, both of spin ½, of the same total energy. The components of their wave patterns should therefore be the same but differ in their phases (and possibly their relative location).

It is proposed that pairs 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. It is further proposed that the photon is the missing ninth gluon that is an equal mixture of the three colourless gluons ($r\overline{r}, g\overline{g}, b\overline{b}$) in which the components lie along the same axis. Previously, the ninth gluon has been assumed not to exist because it has no colour and leaves coloured quarks and gluons unchanged under the strong interaction. The photon does this, and so has no strong interactions, but interacts with the electric charge of particles by flipping aligned spin axes through π. Gluons can flip pairs of spins by $\pi / 2$.

The model of the photon is therefore an equal mixture of three gluon components that can be resolved into two fields (carrying spin =2 x ½) oscillating in the plane perpendicular to the direction of motion and a third component corresponding to a continuous displacement of the equilibrium point in the direction of motion.

Other particles, notably the three types of neutrinos, which are massless according to the Standard Model, must also have components such that their combined state can only maintain its existence by travelling at c. In addition, they must not trap angular momentum in a way that is resisted by asymmetry of the background. However, the existence of three types of neutrinos implies that there are three ways of achieving this by different patterns, i.e. numbers of components with different geometric and phase relations (that presumably sum to constant values along the direction of motion). They should then have different oscillation frequencies when carrying the same momentum. Oscillation between neutrino types would then <u>not</u> require that they have mass, as has been routinely assumed or claimed.

It seems that wave-particle states, carrying half units of spin, trap larger out-of-balance flows of energy (angular momentum) when components from other directions are slower at cancelling an oscillation in another direction, i.e. when the wave-propagation speed is slower.

It must be stressed that these proposals are speculative and need further development. However, they suggest a path towards a deeper understanding of the Standard Model that incorporates all four fundamental forces and that can predict all wave-particle masses and interaction strengths from first principles. The revised picture of wave-particles also throws a light on quantum mechanics. It indicates a solution to the problem of Schrödinger's cat and avoids the need for so-called "entanglement". An oscillating wave-function can have a fixed (time-averaged) angular momentum vector relative to one axis, but an oscillating value relative to an orthogonal axis. Wave-particle states have definite properties but are continuously oscillating. Testing of the spin along one axis can always give the same result (up or down), but a test along an orthogonal axis can give an up or down result with equal probability, and reset it about the new axis. The wave-particle then appears to be in a definite state (when repeatedly viewed from the same direction). However, it is not a mixture of all possible states, but the relative phases of the components, giving the orientation of the state, are not known before measurement and are reset by measurement. The number and magnitudes of the wave-particle's components is fixed but their relative phases determine the orientation of its cyclic oscillations in space.

The wave-function does not "collapse" on measurement. Properties exist independent of whether they are observed. The cat is not in an equal mixture of being alive and dead. The probability reflects the randomness of the phases of the detecting interaction relative to the phase of the wave-particle. Pairs of wave-particles with oppositely directed angular momenta (or polarisation) will maintain those directions after separation. There is no need for faster-than-light communication or non-locality.

There is also no need for a quantum gravity because the quantities of energy/momentum that can be exchanged are continuous. However, the quantities emitted and received depend on transitions between allowed 'standing-wave' states (cyclic patterns) of fixed energy levels for a given constant background, and on the relative speed of emitter and receiver. Only patterns of the interfering wave states that conserve total momentum can be absorbed or separate into new wave states. This appears a possible explanation for the interpretation of the wave-function as a probability distribution.

Heisenberg's uncertainty principle is a reflection of the wave nature of particle states. The concept of mass as trapped momentum held by cyclic patterns about a mean location means that mass is what has been labelled as zero-point energy. However, this labelling applies to wave-particle states and does not imply that the empty space between particles in a vacuum holds energy. The uncertainty principle does not mean a vacuum is constantly bubbling with quantum fluctuations and virtual particles all of which possess zero-point energy. The background field does not carry energy itself but enables massive wave-particle states that trap momentum and massless wave-particles that can convey energy to different locations. The quanta of energy/momentum of every pattern is determined by the number and orientation of its components plus the effect of transmission speed (i.e. light-speed). The linear momentum of moving massive wave-particles, seen as kinetic energy, is because the patterns rotate slowly with movement in proportion to the local asymmetry in chirality.

Since zero-point energy is mass it already gravitates so there is no additional energy of "space" that would, under GR, alter the rate of expansion of the universe as a function of the density of empty space. This overcomes "the worst prediction in physics" - the theoretical calculation of the vacuum energy density of empty space versus the observed value from cosmology. Zero-point energy also does not appear necessary to explain why helium remains a liquid regardless of temperature at standard atmospheric pressure. It remains a liquid because all electron states are filled and at their lowest energy. A lower energy cannot be reached by spatial rearrangement. The Casimir effect has been calculated in terms of the zero-point energy of a quantized field in the space between the surfaces. However, it can also be expressed in terms of virtual particles interacting between closely spaced surfaces. It is claimed that no known phenomenon, including the Casimir effect, demonstrates that zero-point energies are "real" [45].

The ”reality” of virtual particles needs further examination. They only have a fleeting existence, in line with the uncertainty principle and are not directly observed. However, their presence is in agreement with many quantum field theory calculations (e.g. of anomalous magnetic moments) using internal loops in Feynman diagrams. It is suggested that their success is likely to be because the underlying (wave-particle) patterns are time varying but continuously conserve momentum. Using such loops seems potentially equivalent to taking into account that, for example, virtual particle/antiparticle pairs may be seen as a different superposition of the same components of time-varying patterns. The components would have different speeds and relative phases but trap the same total momentum. Their presence would come into play because wave-particle interactions can occur with variable phases, directions and overlap. The same idea seems to imply that a photon could also be seen as a superposition of overlapping electron and positron wave-patterns that is equivalent to oscillating, mutually inducing, electric and magnetic fields.

These ideas are preliminary and need further discussion, development and critical evaluation.

Appendix D. Explaining why the Hubble tension arose

The 'Hubble tension' refers to the discrepancy in the expansion rate of the universe, as seen in the different values of the Hubble constant determined from observations of the early universe and of the late (i.e. recent) universe. Early universe constraints, primarily from the Planck satellite, which maps CMB anisotropies, give a value of $H_0 = 67.4 \pm 0.5$ km s^{-1} Mpc^{-1}.

Considerable effort has been put into combining the various late-time measurements. The most recent publicly available compilation, Pantheon+, contains 1550 spectroscopically confirmed Type 1a supernovae from 18 studies [46]. The Hubble Space Telescope was used to measure multiple Cepheids in nearby galaxies with one or more supernovas, plus other distance measurements, to more accurately establish the cosmic distance ladder [24]. This significant undertaking greatly reduced the errors in determining the value of the Hubble constant (H_0). The analysis yielded values around $H_0 = 73.2 \pm 0.9$ km s^{-1} Mpc^{-1}, for the current rate of expansion. This yields a discrepancy of 5 to 6 σ with the Planck value.

The analysis of the data has incorporated GR's assumption of an expanding spacetime, a redshift due solely to expansion, and the cosmological principle that the universe appears identical (on large scales) to all observers co-moving with the expansion. These models include a relatively recent (low Z) accelerating expansion. Under GR the matter and energy/momentum density will induce a Z-dependence of the expansion according to $H(z) = H_0\sqrt{(\Omega_m(1+Z)^3 + \Omega_\Lambda + \Omega_k(1+Z)^2)}$. This expectation has contributions from all matter (normal and dark) m, dark energy Λ, and curvature k. A constant slope of luminosity distance versus redshift indicates a constant rate of expansion with time (assuming light-speed is constant). An accelerating expansion implies the rate was smaller in the past. For a redshift that reflects recession speed, the time and distance needed to reach that speed (observed redshift) will have been greater.

The underlying issue is that GR assumes that redshifts of distant galaxies are due to an expanding universe. It allows the scale of distance (empty space) between galaxies to expand (including at speeds faster than light) without objects moving. The expanding space stretches light, but not particles, giving a redshift (increase in the wavelength) from an ongoing expansion (appearing as a Doppler speed of recession). FR, instead, has the redshift of distant galaxies reflecting the lower energy of massive particles at the time of emission, arising from a faster speed of light, with no change in the photon energy or wavelength after emission. There is no expansion of space. Distance (space) cannot, and does not, stretch to give an increase in the wavelength of light (after emission) but not of massive wave-particles.

The analysis of the DES supernovae data under FR gives an accurately constant slope of luminosity distance with time. This is seen in Figure 2 of the DES supernova fit (14.473 billion years per unit Z) which yields a constant value for the Hubble factor of 67.56 km s^{-1} Mpc^{-1} (with a small statistical error). The linear fit (including all supernovae out to $Z = 1.12$) accurately passes through the origin after the $c(1+Z/2)$ division that converts luminosity distance to time since emission. The adjustment is that expected from a faster light-speed but fixed absolute brightness of Type 1a supernovae (after minor corrections for metallicity, dust etc.). This is in very good agreement with the early-time Planck data. Under FR, the value of the Hubble factor simply reflects a rate of change of light-speed which matches the rate of change in energy (wavelength) at emission. No expansion is required, instead H is observed to be independent of Z, implying a fixed relationship between energy per unit matter and time via a changing speed of light, and no stretching of the scale of distance.

The FR analysis used the publicly available measured values of supernovae distance modulus in the DES and Union2.1 data. However, if the FR correction is applied to the publicly released distance moduli in the Pantheon+ data it yields a value of ~ 72.0 km s^{-1} Mpc^{-1} when the linear fit is constrained to pass through zero, and ~ 70.5 km s^{-1} Mpc^{-1} when an offset is allowed. This applies to both the $0 < Z < 0.025$ range and for $0.2 < Z < 0.8$. The implication of the FR analysis of the Pantheon+ data not yielding a value around 67.56 appears to be that the distance ladder may have been distorted by faulty linkages between the rungs of the ladder.

This author does not have a deep enough understanding of the SH0ES analysis of the Parthenon+ data to definitely assert how and where this might have occurred. However, the different underlying assumptions of FR and GR are inherent to the analysis of the data. The potential impact of such assumptions must therefore be carefully examined.

FR has the luminosity distance L_D being the distance (based on a doubling of distance reducing luminosity by a factor of four) to a source of the same luminosity. If the universe is not expanding, then the time taken for light to arrive from this distance, if the wavelengths of all transitions were (at emission) $1+Z$ times that of the same transitions currently observed, is $1/H_0 = (1+Z/2)c/L_D$. The factor H_0 will be constant if the scale of space (i.e. distance) is fixed, if the scale of time (atomic clock-rate) is proportional to stored energy, and if the rate of change of energy per unit matter is constant over time.

The SH0ES analysis sets out how the distance ladder is adjusted for the expected expansion rate. This rate is quantified as the intercept, a_B of the luminosity distance-redshift relation.

It claims that:
$$a_B = \log cz - 0.2m_B^0 \qquad (2)$$
is the low-redshift limit ($z \approx 0$) and that an arbitrary expansion history with $z > 0$ can be accommodated by using:

$$a_B = \log cz\{1+\frac{1}{2}[1-q_0]z - \frac{1}{6}[1-q_0-3q_0{}^2+j_0]z^2 + O(z^3)\} - 0.2m_B^0, \qquad (3)$$

measured from a set of Type 1a supernova, where q_0 is a deceleration parameter and j_0 is the jerk.

The determination of H_0 followed from:
$$\log H_0 = 0.2M_B^0 + a_B + 5, \qquad (4)$$

if $L_D = cz/H_0$, whereas $L_D = cz(1+z/2)/H_0$ is expected under FR.

The first comment on this analysis is that the expansion interpretation has the luminosity distance proportional to z, whereas FR has it independent. The linkage between the Cepheid and supernovae data occurs around an $m-M$ magnitude of 33, corresponding to $z < 0.01$. Thus the straight line fit to all the data below this value is entirely consistent with the distance scale being independent of redshift.

A set of supernovae in the host galaxies having multiple Cepheids were used to determine the fiducial luminosity M_B^0 and a set of supernovae in the Hubble flow ($0.023 < z < 0.15$) were used to determine a_B. The Hubble flow incorporates the assumption that for this range of redshift, the motion of galaxies away from each other is caused by the current rate of expansion of the universe. There is a known non-trivial covariance between the common sources of error on luminosity for supernovae in the two sets. Therefore, the determinations of a_B and M_B^0 were simultaneously optimized. Hence, the negligible error on the measured value of z will mean that the Hubble flow supernovae will have their luminosity distance values (for a given cz) fitted by an expression omitting a factor of $1+z/2$. The mean overestimate of the dependence of H on cz will be about 8%, assuming $z \approx 0$ reflects the current rate of expansion. This appears to have the potential to turn 67.56 into approx. 73.

The determination of H_0 for more distant supernovae appears to have been accommodated by using Equation 3 [24]. It is stated that the fitted value of $q_0 = -0.51$ is close to $q_0 = -0.55$, which is the expectation for a consensus ΛCDM model with $\Omega_M = 0.3$ and $\Omega_\Lambda = 0.7$ (approx. 4% baryons, 26% dark matter, 70% dark energy). The negative value of q_0 indicates an accelerating expansion rather than a deceleration. The polynomial fit adjusts the brightness distance according to the time (at constant c) taken to reach the observed value of redshift.

The values of the polynomial fit can be used to examine whether the 'Hubble tension' may be explained as an artefact of fitting the measurements under the assumptions that space is expanding and that the change in brightness is proportional to cZ. For this investigation, the jerk (j_0) was set to zero, and higher order terms ignored. The size of the correction factors to Z are shown in Figure 4 for three values of q_0, together with the FR adjustment needed if the universe is not expanding but the speed of light was faster in the past (blue).

The correction factor is large, approx. 1.6 at $Z = 1$, meaning, under GR, that all recent supernovae are fainter than expected. They are markedly fainter (x1.6 further away) than expected at $Z = 1$ and x2 further away at $Z = 2$. The polynomials shown give quite similar values to $1+Z/2$ over that range but are 50% steeper at $Z < 0.1$.

FR's explanation for the increasing brightness distance with redshift is that the speed of light was faster in the past. This means that the time for light from the supernova to reach us was a factor of $1/(1+Z/2)$ smaller. It can be seen that the difference between the effects of the supposed expansion history and a faster speed of light are within 10% for $0 < Z < 2.5$.

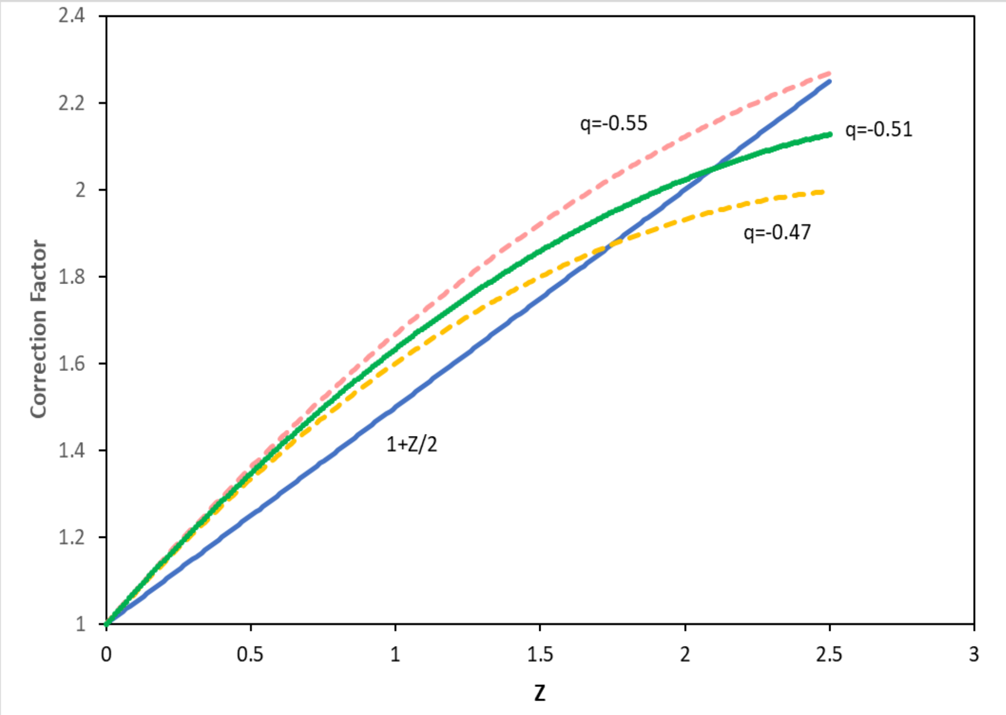

Fig. 4. Correction factors to supernovae as a function of observed redshift.

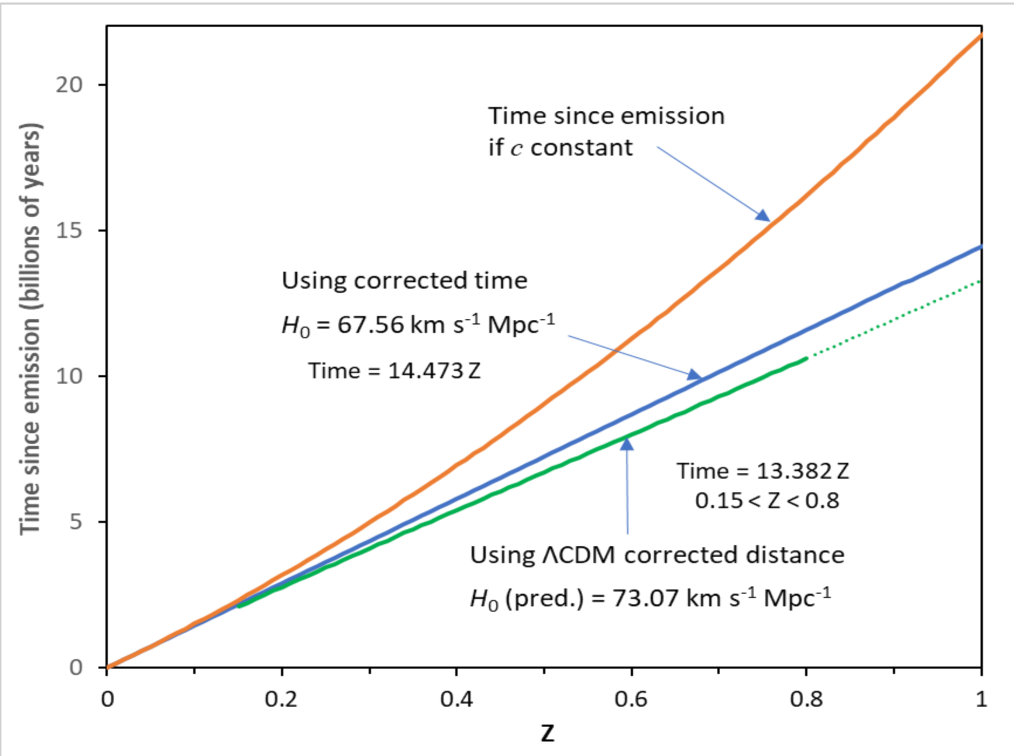

Fig. 5. Comparison of the effect of the Parthenon+ correction factors on raw DES data.

In Figure 5 the observed constant slope of the Hubble constant with time of 14.473 x 10^9 years per unit Z (blue line) seen in the corrected DES data, giving $H_0 = 67.56$ km s^{-1} Mpc^{-1}, is multiplied by $1+Z/2$ to give the expected luminosity distance as a function of Z, given the integrated increase in light-speed (orange line). The correction factor (using $q_0 = -0.51$ and

$j_0 = 0$) of the SH0ES analysis [24], is then applied to the orange line giving the solid green line for the supernovae in the range $0.15 < Z < 0.8$. A linear fit through the origin yields 13.382 x 10^9 years per unit Z, giving $H_0 = 73.07$ km s^{-1} Mpc^{-1}. This value is very close to that derived from the fit to the Pantheon+ data set of Type 1a supernovae at $0.15 < Z < 0.8$ which found $q_0 = -0.51 \pm 0.024$ and $H_0 = 73.30 \pm 1.04$ km s^{-1} Mpc^{-1}.

The change in the expected value of H_0 suggests that the 'Hubble tension' is an artefact of including an expansion history in the fitting of the standard-candle data across all Z. The disagreement appears to arise from using a model that has the redshift arising from expansion. This expansion has a variable rate. It is slowed by a non-existent dark matter in the past and accelerated in more recent times by a non-existent dark energy.

The proposed replacement, FR, has the redshift of emission spectra arising from energy reflecting clock-rate (time) of emission, proportional to $1/(1+Z)$. The observed evolution with time rather than distance then needs to take into account the effect of the integral of the increased speed of light between emission and reception. This replacement not only removes the Hubble tension but is also consistent with the understanding that gravitational attraction arises from an increase in light-speed causing a loss in energy held (mass) per unit matter.

Appendix E. Why dark energy must appear to occur

The revised perspective predicts that GR will require an apparent dark energy if the mass per unit matter is dependent on the surrounding mass density. Einstein's field equation of GR is a generalisation of the differential form of Newton's gravitational equation:

$$\vec{\nabla}.\vec{g} = -4\pi G_N \rho \qquad \text{(C1)}$$

The curvature of spacetime and the divergence of the acceleration ($\vec{g}$) are directly proportional to the stress-energy tensor, the generalisation of mass density (ρ) to energy/momentum density.

Newtonian gravity gives rise to a force field ($\vec{F} = m\vec{g}$) that maintains its value while a static distribution of mass is present. The derivation of the differential form (C1) follows from applying Gauss's law to the gravitational force law, as is done for electromagnetic fields [47]. 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 of his second law to give an equation of motion. This yields a vector gravitational acceleration field (force per unit mass $\vec{F}/m$) due to a point mass M of:

$$\vec{g}(\vec{r}) = -G_N M\hat{r}/r^2 \quad \text{where } \hat{r} \text{ is the unit radial vector.} \qquad \text{(C2)}$$

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

$$\oint_S \vec{g} \cdot d\vec{A} = -4\pi G_N M \qquad \text{(C3)}$$

The area integral on the left is the gravitational field flux through any closed surface S, and M on the right is the total mass enclosed inside S. If the flux is assumed to be constant, the divergence theorem, where the area integral is the volume integral of the divergence of a vector field, can be used on the left, and the mass on the right can be expressed as the integral of the mass density function ρ, giving:

$$\int \vec{\nabla}.\vec{g}dV = -4\pi G_N \int \rho dV \qquad \text{(C4)}$$

If this equality holds for any volume, the integrands on both sides must also be equal, giving the differential form (Equation C1). However, if mass per unit matter is not a constant, Gauss's law does not hold. Mass will increase with increasing volume because light-speed reduces when density decreases. This necessarily gives the appearance of an invisible dark energy that pushes objects apart more strongly as their density decreases. If the redshift of distant galaxies is taken to mean 'space' is expanding then there will be an apparent accelerating expansion whose source will appear to be the increase in empty space.

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