A new understanding of gravity and particles voids the need for dark matter, dark energy, and cosmic expansion

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ABSTRACT

The gravitational redshift is best explained by atoms deeper in a gravitational potential emitting redshifted light. All transition frequencies are reduced in proportion to the fractional decrease in every atom's stored energy (mass) when the field from surrounding mass increases. Gravitational attraction arises from this loss in mass, which implies that light-speed increases closer to massive bodies. The decrease in mass is released as kinetic energy without emission of particles or radiation. A slowing in clock-rate (time) is demanded by the reduction in energy. However, no contraction of 'space' (distance scale) is needed. The gravitational redshift of galaxies with increasing distance is the same phenomenon. It reflects the lower energy held by matter at earlier times when light-speed was faster. It does not arise from an expansion of the universe. Correcting supernovae distance data for the faster light-speed with increasing redshift accurately removes the evidence for an accelerating expansion. No expansion at all is required. Consequences include: no need for dark energy, or an initial big bang, or cosmic inflation, or dark matter, or singularities inside black holes. The Hubble tension, CMB dipole anomaly, and the horizon and flatness problems are explained and removed. However, the revised theory still reproduces the many apparent successes of General Relativity. The 1/R dependence of gravitational potential and the Higgs mechanism imply that massive particles are non-diffusing standing-wave patterns of mixed chiral components in which trapped momentum is continuously conserved. They oscillate in a background field of balanced but nearly equal contributions from matter and antimatter. Inertia per unit mass arises from rotations induced by their modest asymmetry within regions of like matter. Over time, separated excesses of matter and antimatter have contracted into gravitationally isolated regions of matter and antimatter galaxies. Their flat rotation curves and gravitational lensing do not require dark matter.

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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 spacetime was invariant.

The observations and arguments for a new picture are set out together with their consequences. The most important is that the energy stored by matter (its mass) decreases as the speed of light increases when the field from surrounding mass increases. This leads to an alternate cause for the Hubble redshift of distant galaxies. The clumping of matter as the universe has evolved has reduced light-speed and increased mass per unit matter. The phenomenon is the same as gravitational attraction. Multiple lines of observational evidence then show that there is no need for the universe to be expanding at all.

The replacement theory re-introduces a real background field from that replaces the pseudo-background fabric of spacetime. An increased distortion of the geometry of spacetime in which unchanged objects are embedded is replaced by an undistorted space in which objects, and the speed of light, are altered by the background. Movement relative to this background, from all other mass, slows time. The speed of light and properties of objects, including mass, frequency and inertia, are altered by the magnitude and asymmetry of the field. This is why the new theory has been labelled Full Relativity (FR). The source of gravitational attraction is the release of stored energy (mass), per unit matter, as kinetic energy of motion when there is a gradient in potential due to the background field from all matter.

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, which is a propagating oscillation between electric and magnetic fields that comes in lumps (quanta). When matter is present (not a vacuum), such as a solid, liquid or gas, the electric and magnetic fields of the matter can slow, scatter or absorb these electromagnetic waves.

Originally a light-carrying aether was invoked as 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. These included the experiments of Michelson–Morley (1887) that split light beams down perpendicular paths and looked for changes in the interference pattern when the light was re-combined. No movement could be detected. 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 proposed that a linkage of space and time into spacetime acted like a new aether [2].

It is widely believed that SR and GR established that an aether is not necessary because photons and distortions of spacetime can self-propagate through the vacuum of space. This belief is now part of the consensus picture, but should be rejected because fields are still needed to carry the oscillations or changes in strength. Space and time have no properties that can carry electromagnetic or gravitational fields. The need for a background medium that carries radiation and enables gravity is still essential. It is also essential as the medium that enables mass-carrying wave-particles to exist.

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 potential 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 momentum trapped at a mean location.

The gravitational potential energy of matter is the energy stored in a given quantity of matter. It is independent of the type of matter or its density. It only depends on the total mass. 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.

The mechanism of energy storage is proposed but requires further development. It is consistent with the eigen-states 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). 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 closer to the nucleus, and releasing energy. It is also consistent with the Rydberg constant relating spectral lines to wavenumber (and hence distance scale) where all energy levels scale with the matched change in 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.

[Note: The momentum of a massless particle is $p = E/c$, while $p = \gamma mv$ holds for a massive particle. This implies that, if momentum and energy are both conserved, then inertia must depend on the factor v/c and applies only to massive particles; with $p = h/\lambda$ being the e angular momentum carried by massless particles if h is constant. The Compton wavelength can then be expected to vary with the asymmetry at the location, i.e. the local inertia.]

FR has the speed of light increasing as the background field increases which reduces the mass (stored energy in the form of trapped momentum) of otherwise unchanged matter. Thus atoms hold less energy when the speed of light is faster closer to a massive object.

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, rather than atoms blueshifted. This gravitational redshift of light has been a key prediction of GR. The claim is that time runs faster at a higher gravitational potential. Thus, the wavelength of light moving to a higher potential will be redshifted. Under GR, this implies that all energy, including the energy carried in the momentum of photons, increases the distortion of spacetime.

The gravitational redshift of light is a blueshift of atoms

GR's predicted 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 a redshift of the photons with no change in the atoms.

FR has the total energy of atoms and all their transition energy levels increased. Photons, being massless, do not lose energy in escaping a gravitational field. They are not attracted in proportion to their momentum ($p = E / c$). 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.

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 will 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 wavelength expands at a higher gravitational potential. A photon will then 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 appear, or be 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, blueshifted, at a higher potential. Photon energy is unchanged after emission. Interestingly, in his 1907 paper introducing the equivalence principle [6,12], Einstein originally deduced that light emitted by the Sun but measured at the higher potential of the Earth would be redshifted (because time is going slower for the Sun's atoms)!

There is no need for space to expand

The only evidence for an expanding space is 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. The CMB and galaxy redshifts will arise if matter held less mass in the past when the speed of light was faster. What is required is a mechanism that, when the universe evolves and matter clumps, the increased mass (from trapped momentum) per unit matter is that expected from a decrease in the speed of light over time.

The cosmological redshift is then the same phenomenon as the blueshift of atoms (giving an apparent redshift of photons) with increased gravitational potential (as light-speed increases). The energy held per unit matter being smaller and light-speed faster earlier in the evolution of the Universe explains galaxy redshifts. The decrease in trapped momentum (mass) will be inversely proportional to the speed of light at the time the light was emitted.

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 galaxies further from the centre of an enormous concentration started off travelling faster (closer to and then exceeding the 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 of a fixed slowing rate is also unexpected, as gravitational attraction should reduce 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 expansion of matter 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 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. Under GR, this demands that the universe requires about 68% (repulsive) dark energy to balance the gravitational contraction, of space, from visible baryons plus five times their mass in invisible dark matter. This is to ensure that spacetime is currently undistorted (Euclidean). If there is no need for expansion, there is no need for space to expand or contract, to match the change in time and keep light-speed fixed.

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. However, there is no obvious reason that a region with a different, but constant, mass density should have the same speed of light.

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 even applies in free-fall when both 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 even stationary clocks 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 the co-moving observer. 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 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. 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. This was missed in the derivation of SR (Appendix A).

A steady light-speed independent of the observer's or object's speed is consistent with measurements of the light from binary star systems (including pulsars) that are many light years away, provided there is negligible relative change in background potential with time. If movement reduced the light-speed towards us when a star was moving away then it could be overtaken by light emitted later in the orbit when it was moving towards us. No such effect has been observed. However, the relative speed of movement of each star and of the Earth can be seen in the Doppler shifting of their emission spectra. The orbits of the two stars agrees with expectations without adjusting light-speed for the speed of movement of the star.

Consequences of variable mass with light-speed

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. However, it claims that the measured 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.

FR has the speed of light proportional to the magnitude of the field (seen in 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), 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 decreases (becomes more negative) as objects get closer.

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 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 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 <u>fractional</u> 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 (<u>energy per unit mass</u>).

Equation 1 is a dimensionless energy-balance equation. The magnitude of the fractional change in mass, or energy, or time, 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. 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 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 $p = \gamma mv$). 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.

Light-speed increases with the field strength but 'space' is unaltered.

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. A gravitational time dilation is a direct and necessary consequence of the changes in atomic energy levels, including those of atomic clocks, which reflect changes in potential (Equation 1). However, there is no reason to add in GR's flexible scale of distance. It was mistakenly introduced simply to force a constant c. The self-consistent solution is to have c, mass and clock-rate vary with gravitational potential.

SR applies within a constant background (hence within a region where c is constant). However, the new perspective is that, for objects having mass, the speed relative to the background (not the observer) slows time. Einstein's derivation of the Lorentz transformation did not allow for movement of objects during signal transmission (see Appendix A). This led to a faulty interpretation that distorts space in order to keep c constant.

GR added a contraction of space to the dilation of time (deeper in a potential) in order to also 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 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!

However, we can be quite confident that the $1/R$ potential is the important property of the field. If the gravitational acceleration (force per unit mass) was the underlying behaviour-determining property then nearby sources should dominate. We feel the force of Earth's gravity more strongly than that of the Sun, but the planets rotate around the Sun. Mach's principle, as seen in the constant orientation of gyroscopes and pendula relative to the "fixed" stars, means that distant sources actually dominate. It is also required by the small fractional changes of Equation 1 which reflect the tiny strength of gravity per unit of mass.

The very small fractional change in mass implies that the total potential and total stored energy per unit mass is enormous, with 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 nearby (say 10^5 km) space, is tiny, only 6 x 10^{-10}. The enormous pool of energy (see earlier), required if the kinetic energy of motion due to gravity came from the medium, is stored in objects as mass, not in the surrounding medium. The large change in potential comes from a very small change in the speed of light.

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. In addition, it has been claimed to be experimentally established via something called the Aharonov-Bohm effect, that the potentials of both electromagnetism and gravity, rather than the forces, are the underlying quantities that determine behaviour [15,16].

The loss of mass with a changing speed of light explains gravity, but does not immediately explain why the effect of the gravitational field 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 velocity and rotational direction, 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 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 necessarily implies both a finite amount of 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) and related to handedness.

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 rotating components of massive wave-particles, is determined by the speed of light. The background cannot carry energy but the energy-carrying states that a two-component background allows have the amount determined by c. For massless states (photons, gluons and, it is proposed, neutrinos) this energy has no resistance to motion relative to the background. However, 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 increases the inertia of mass (by γ) but slows the decay-rate of unstable elementary particles (by $1/\gamma$). Therefore, it is proposed that the energy of massive states is stored between opposing like-chirality, components. However, any asymmetry between the magnitudes of the chiral components of the background increases the mean internal resistance to rotation by γ but reduces the mean rotation speed by $1/\gamma$. This enables pairs of particle-antiparticle states, with matched mass and inertia, that can annihilate leaving only stored energy. 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. The new balance then remains for the new constant speed.

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.

The Compton wavelengths of massive particles are those of a photon having the same energy (proportional to frequency) as the 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. The size of any change will be proportional to the difference in potential between the locations, independent of the gradient in potential at either location. According to Newton's law a particle of zero mass should not feel a gravitational force. Therefore, the momentum of a photon should not change with location in a gravitational field. Thus, the revised perspective is that an unchanged photon emitted from an atom at a lower potential should need a boost in energy if it is to be absorbed by an identical atom at a higher gravitational potential.

Further speculations towards a revised understanding of particles are set out in Appendix B. They need further development but the ideas have implications for the Standard Model of particle physics and the understanding of quantum mechanics. They suggest, for example, that neutrinos are not required to have mass in order to oscillate between the three types and that the concept of entanglement is based on a misunderstanding.

Evidence for the new perspective

The realisation that local gravitational redshifts arise from decreasing stored energy (mass per unit matter) when the speed of light increases 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, if the speed of light was faster going back in time, i.e. earlier in the history of the universe.

FR has the $1/R$ dependence of gravitational potential arising from opposing chiral components (from matter and antimatter). Clumping of matter within regions leads to an increase in light-speed within clumps but 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 effect on c is twice as large as a change in just one chiral component. The net effect is a decrease in the mean of the balanced contributions. Thus, light-speed will decrease over time, forcing a net increase in mass per unit matter. Within a clump there will be an increase in asymmetry and inertia. Rotating galaxies should therefore contract 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.

Dark energy not required

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. These affect the rate and which their light curves change with time. They act as standard candles whose apparent brightness can give an accurate measure of their distance. This can be plotted against the redshift of the light of their host galaxy. Systematic searches for distant supernovae were done by two groups. Both groups found that the more distant supernovae were fainter than expected and 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. Gravity had been expected to slow the expansion, so 'dark energy' was hypothesised to drive this 'accelerating expansion' of the universe. Such dark energy was unexpected and had the very unusual property of a negative pressure that opposed gravity more strongly as the density of matter, galaxies per unit volume, decreased.

Under FR, the speed of light at the time of emission will have been proportional to the ratio of wavelengths (inverse of trapped momenta) of the same transitions of the emitting atoms (λ_{then}) relative to those emitted now (λ_0). The redshift is $\lambda_{then}/\lambda_0 = 1+Z = c/c_0$. $Z=0$ 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 $1+Z$ 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 $(1+Z/2)$ to correct for the apparent increase in distance scale going back in time. The plot 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 and slower time at emission, by $1/(1+Z)$, because there is no stretching of photon wavelength after emission.

The publicly available data from the Dark Energy Survey (DES) [17] 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, led to the claim that the rate of expansion of the universe was increasing. The corrected data, with error bars, for just the supernovae with a high probability (Prob. > 0.67) of being Type 1a are plotted in Fig. 2, along with the 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.

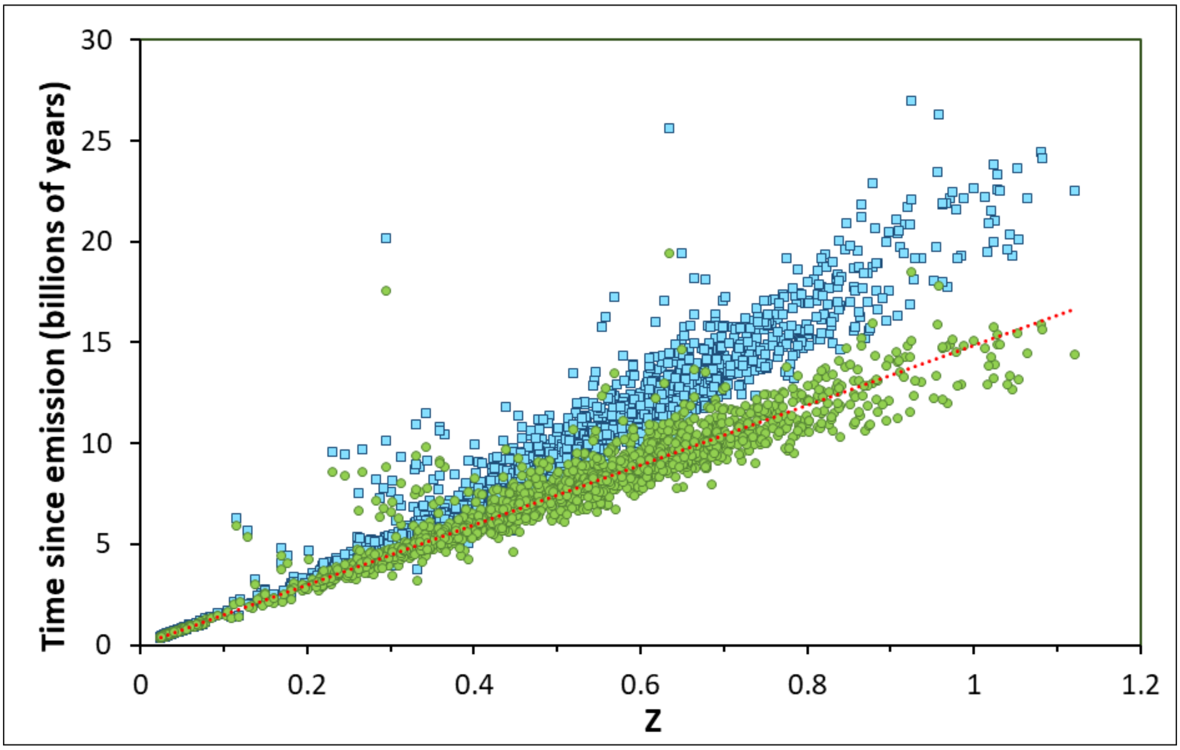

Fig. 1 Raw data (blue squares) and corrected data (green circles).

The correction removes any accelerating expansion. The weighted fits of the DES supernovae 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 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 yields a value for the Hubble constant of $H_0 = 67.56$ km s^{-1} Mpc^{-1}. 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.

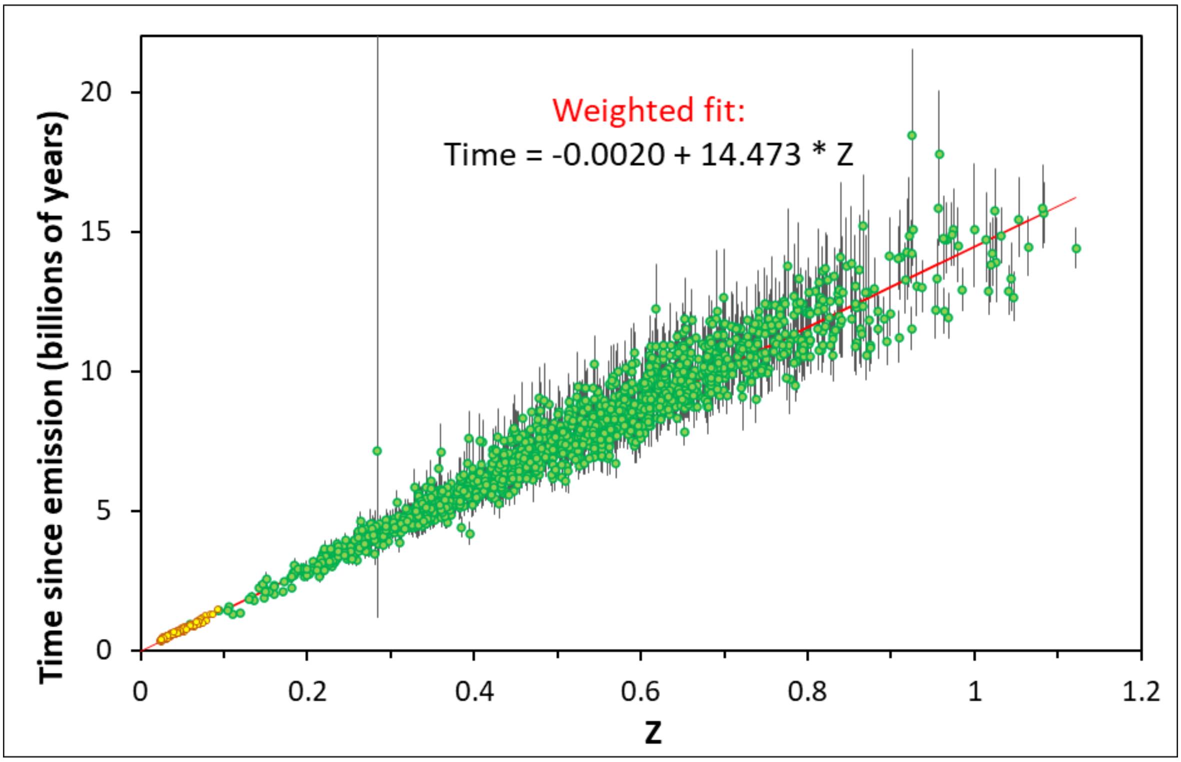

Fig. 2 Corrected data with error bars (and limited to prob. > 0.67 that Type 1a).

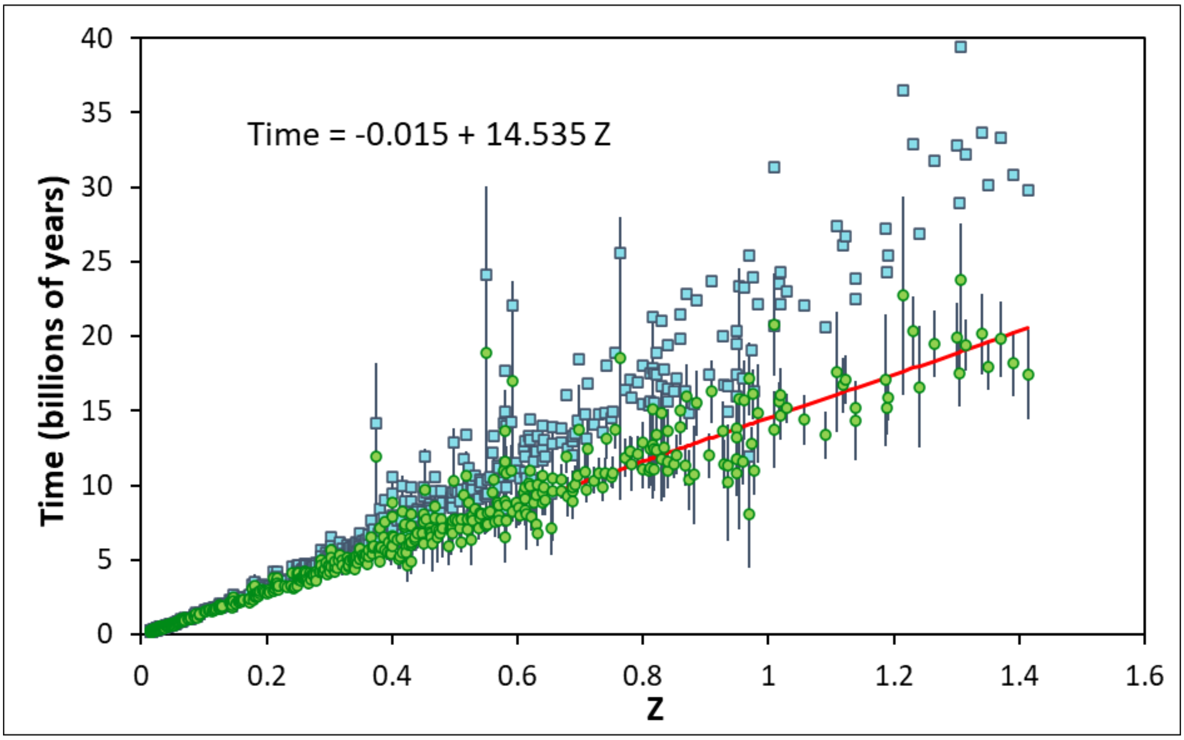

Fig. 3. Union 2.1 data, raw (blue squares), corrected (green circles), with least squares fit.

The data is consistent with the energy held per unit matter having doubled over the last 14.473 billion years (of current time) and light-speed having 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[18].

The supernovae result is consistent with the earlier Union 2.1 data (Fig. 3)) [19], as previously reported [20]. 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 .

[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 stretching of the same magnitude comes from a reduction in the energy of atoms at the time of emission, but no expansion. Thus, what has been the normal procedure will, in principle, mimic the needed and observed ($1/(1+Z)$) factor [18]. 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 correction for distance based on redshift, i.e. any expansion at all, should be made.]

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

The light-speed correction removes 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 overcomes 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, and for clumping to increase inertia. 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. 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 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, is claimed to 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.

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 '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.

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 seem to 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 galaxies as inertia increased, which maintained the separation of equal quantities of matter and antimatter. Therefore, the presence of the antimatter regions is no longer revealed by annihilation.

Photons, with equal chiral components, would be expected to cross freely between regions of matter and antimatter. It is not that antimatter is not present or invisible. The overall totals are matched. It is just that, unless significant quantities annihilate, there is no signal to establish which are antimatter galaxies.

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 positive feedback mechanism is what gives rise to putative singularities inside black holes. They become inevitable once a critical density is passed. Part of the 2020 Nobel prize for physics was awarded for the discovery that black hole formation is a robust prediction of GR.

FR has the mass per unit matter decreasing as local density increases. This is a negative feedback. 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 region outside and behind a large enough concentration of mass will spiral inwards because of bending and be absorbed. The famous images 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. Hence, just like light, gravity and changes in 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 <u>necessarily</u> lead to the appearance of an <u>apparent</u> 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 C). 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 a region of like matter reduces as movement relative to a local concentration of matter causes the density of local matter to increase. A necessary consequence of the mistaken assumption of a constant flux is that GR's equation predicts that an increase in volume, of a fixed amount of matter, will lead to an apparent repulsive force.

Under GR's assumptions, an apparent dark energy <u>must</u> 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 <u>apparent</u> 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

The decrease of frequency and 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, it will be almost constant within our solar system (miniscule in size relative to the galaxy). Asymmetry, and therefore 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 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.

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 [21]. 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 relationship between inertial and gravitational mass will vary with position in a galaxy. Thus it is likely that the mass of our galaxy based on the apparent or assumed strength of gravity closer to the centre of a galaxy and its black hole is underestimated. The speed of stars rotating around the central black hole of our galaxy are assumed to have the inertia characteristic of the location of our solar system. Under FR the inertia will be much higher leading to a significant underestimate of the mass of the black hole and of our galaxy. The changes in light-speed and inertia should then explain both the flat rotation curves of spiral galaxies and gravitational lensing, without dark matter.

The revised understanding voids the claim that the distribution of matter, and supposed dark matter, seen in the Bullet Cluster (1E 0657-56) of two colliding galaxy clusters, constitutes a "direct empirical proof" of the existence of dark matter [22]. 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. 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 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.

Hubble Tension resolved

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}. Late-time measurements, based primarily on the distance ladder using Cepheid variables and Type 1a supernovae data, analysed using ΛCDM, which inserts an expansion history, yield values around $H_0 = 73.2 \pm 0.9$ km s^{-1} Mpc^{-1}. A discrepancy of 5 to 6 σ .

The accurately constant slope (Fig. 2) of the supernova fit (14.473 billion years per unit Z) yields a value for the Hubble constant of $H_0 = 67.56$ km s^{-1} Mpc^{-1} (with a statistical error ≤ 0.01), as the apparent current and remarkably constant rate of expansion out to at least $Z = 1$. This is in very good agreement with the early-time data. Under FR, the value of the Hubble constant simply reflects a fixed rate of change of time for a given rate of change in frequency (energy at emission).

The late-time models incorporate GR's faulty assumption of a space whose scale changes as the universe expands. This includes a relatively recent (low Z) accelerating expansion that changes with matter and energy density (including dark energy) and curvature (k), e.g. by $H(z) = H_0\sqrt{(\Omega_m(1+Z)^3 + \Omega_\Lambda + \Omega_k(1+Z)^2)}$. The early-time data is consistent with the asymptotic slope of low Z supernovae which accurately passes through the origin after the $1+Z/2$ reduction in distance expected from a faster light-speed. The late-time model proposes or assumes that, at values of $Z \simeq 0.8$, there will have been a transition to a deceleration phase cancelling the recent accelerating phase needed to explain the unexpected faintness of supernovae. The recent period of accelerating expansion allows an increase in distance travelled per unit time the light was stretched. This increased stretching of light (larger H_0) is incorporated into the fitting procedure.

A published paper [23], on the measurement of the local (i.e. late time) value of the Hubble constant can be used to show that the supposed 'Hubble tension' is a simple artefact of fitting the measurements according to the faulty belief that space is expanding. The value of Z is adjusted by $\{1+\frac{1}{2}[1-q_0]Z - \frac{1}{6}[1-q_0-3q_0{}^2]Z^2\}$, where q_0 is referred to as a deceleration parameter, designed to take into account the expansion history. The fitted value of $q_0 = -0.51$ is close to $q_0 = -0.55$, which is stated to be 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 size of the correction factors to Z are given in Figure 4, for three values of q_0, together with the correction factor needed if the universe is not expanding but the speed of light was faster in the past. The correction factors are large but the difference between that expected from the expansion history and a faster speed of light barely exceeds 10% for $1 < Z < 2.5$. The polynomials used gives quite similar values to $1+Z/2$ over that range.

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) from the "uncalibrated" DES data, giving $H_0 = 67.56$ km s^{-1} Mpc^{-1}, is multiplied by $1+Z/2$ to give the expected observed distance before correction for the integrated increase in light-speed (orange line). The correction factor (using $q_0 = -0.51$) of the SH0ES analysis [23], 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}, which is very close to that derived from a fit to the "calibrated" 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}.

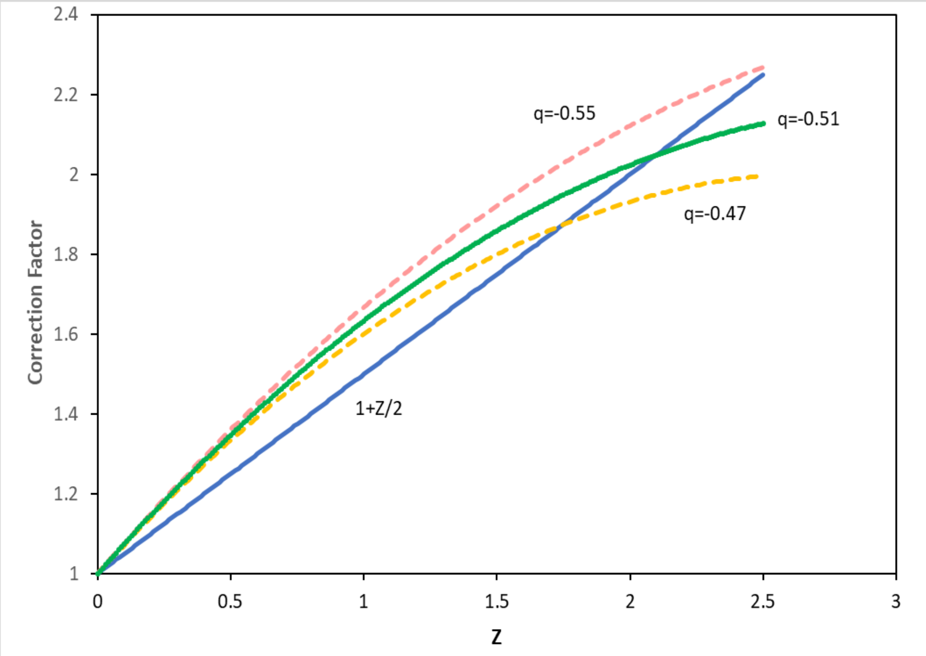

Fig. 4. Correction factors to supernovae as a function of observed redshift.

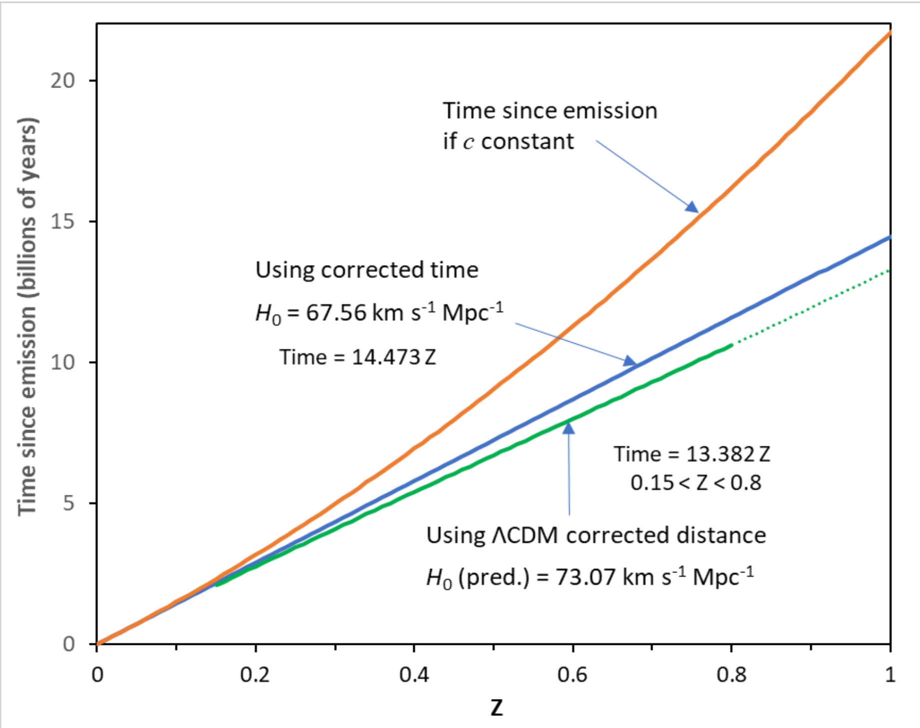

Fig. 5. Comparison of the effect of the correction factors on fit to DES data.

The Hubble tension is an artefact of including an expansion history in the fitting of the standard-candle data across all Z. The disagreement arises from "calibrating" the data according to a model that requires a faster rate of current expansion than is consistent with the rate expected if the universe is flat for all its history. The claimed independence of the low and high Z supernovae data is because the corrections are to the value of Z multiplied by the needed factor $1+0.5\times Z$ or an expansion history factor of $1+0.755\times Z-0.1216\times Z^2$. The differences are negligible for nearby supernovae $Z\leq 0.01$, leaving the fit unconstrained.

CMB dipole anomaly

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 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.

The radiation is remarkably uniform independent of direction and corresponds to a black-body temperature of 2.72548 ± 0.00057 K. The largest temperature (i.e. energy) anisotropy in this microwave background (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. 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 relative to the expected uniform mean wavelength and distribution of the radiating matter, in the early universe.

Our motion reflects both the rotation of our galaxy and its movement due to gravitational attraction predominantly towards the centre of our supercluster. Once outside this region we can expect the average distribution of galaxies to increasingly match that of the CMB. This has been tested in terms of the number count distribution as a function of redshift for distant galaxies emitting at radio frequencies and quasars at optical/infrared frequencies. In most cases the dipole in the number count of the sources points in the same direction as the CMB dipole but has often appeared significantly larger.

Under FR, the redshift due to our motion should have the same magnitude (per unit of received wavelength) independent of the epoch (time and redshift of the emitted light). The ΛCDM model is based on an expanding universe that implicitly assumes the Cosmological Principle (CP) that the universe appears the same to all co-moving 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.

The CMB dipole indicates a fractional change in energy of 0.00123 $\cos\theta$ (with angle relative to the direction of motion). A number count includes the effect of changes in energy and in brightness from Doppler shifting and relativistic aberration, which alter the apparent number of sources as a function of a sources 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 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 [24]. Under FR, there is no expansion and, if enough sources are sampled, their average velocity should be zero.

However, our movement relative to the background should have a constant fractional effect on the measured 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. Thus, an accurate measure of average redshift across a large number of galaxies (not weighted by brightness or redshift) should be consistent with the measured CMB dipole.

An all-sky catalogue of quasar-like objects with measured spectroscopic properties (Quaia) found by the Gaia survey has been made publicly available[25]. Surprisingly, an analysis of the quasar redshift data found that the redshift dipole appeared to point close to the galactic centre, at nearly right angles to the CMB pole and corresponded to a peculiar speed of ~ 1700 km s^{-1} [26]. However, a separate number count analysis using a Bayesian statistical approach had found that the Quaia data is influenced by selection effects with significant biases towards and away from, and in a region around l > +20^0 (i.e. above), the line to the galactic centre. After excising these regions (including |b|<30^0, and a wider region around the galactic centre i.e. l = 0^0, b = 0^0) significant evidence was found for a number count dipole consistent with the CMB dipole in terms of the expected amplitude and direction [27].

A revised redshift analysis has been made of the Quaia data (see Acknowledgements). This analysis looked at the average redshift of quasars as a function of galactic coordinates assuming no expansion as a function of redshift. It was found that after a |b|<20^0 galactic mask was applied:

- The Quaia $Z < 0.5$ redshift dipole agrees in direction with the CMB dipole within 10^0
- The agreement is robust to tests (randoms, regressions, shuffles, jackknife cuts)
- Its magnitude is ~ 0.002, in moderate agreement with expectations.

This supports the idea that the apparent CMB dipole "anomaly" in magnitude can be understood if the Universe is not expanding as in ΛCDM (or by an apparent independence of motion to a "co-moving" observer), and that both the CMB and the low-Z galaxy/quasar redshift fields reflect kinematic motion relative to a stationary background. However, the higher-than-expected magnitude of the redshift leaves room for our galaxy being a slower part of a flow within our galaxy super-cluster, relative to the CMB.

The Gaia sources cover the entire sky and have blue photometer (BP)/red photometer (RP) spectra, low-resolution spectra covering the wavelength range of 330–1050 nm. These spectra allow for redshift estimates of the sources, with 86% having a precision of $|\Delta Z/(1+Z)| < 0.01$ compared to their values in the Sloan Digital Sky Survey. This contamination was reduced to 6% in the final Quaia sample [25]. In hindsight, it is almost surprising that support for a non-expanding universe was found even though some 6% of the Quaia supernovae in the larger of the final samples were known to have discrepant redshifts values. The agreement only for low Z is probably because the discrepant values appear to have increased misidentification of spectral lines with increasing Z, as seen in Fig. 5b of [25].

A re-examination of existing galaxy data for which accurate spectroscopic redshifts are available, independent of whether they are quasars, should be made. It does not matter whether the number count is isotropic because the fractional Doppler shift in each source should be independent of brightness and Z.

General Relativity's predictions reproduced

FR automatically reproduces many of the standard predictions of GR 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 has advances in perihelion/periastron coming from a contraction of space (Schwarzschild metric) and no effect of the distortion in (proper) time. FR has the advance coming from a reduction in mass at lower potential but conservation of momentum, so that speed increases.

Einstein's first prediction from GR explained the already observed advance in the perihelion of Mercury. GR has time slowing and distances contracting as potential reduces. The method assumes that mass and angular momentum are conserved and uses 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 gives the fractional change in angular momentum predicted by FR. 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 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 introduced to ensure that the local speed of light remained constant. If the local speed of light is constant then spacetime should not induce any bending. The suggestion that it comes from a difference relative to the potential of an observer 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 causes 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 faster speed due to increased speed of the component fields with relative location during their oscillation.

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 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, and not relative to any location that is stationary relative to the background from massive objects.

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. The effect was first experimentally observed in the need for photons emitted from a lower detector to be given a Doppler boost in energy (by upward motion of the source) if they were 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, the calculated delay is determined by a fit to the expected logarithmic dependence of the change in signal arrival times due only to the amount bending changes the path length. This removes changes in apparent orbit from any changes in light-speed or distance and so the predictions will match. Any increase in the speed of light should lead to an apparent contraction of distance. It is not clear whether this is removed by the method for determining the delay. It should reduce the delay. However, since GR assumes a slowing of time is matched by a contraction of distance (or that a slowing of time gives an increase in perceived speed of light) the predictions can agree.

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 microwave wavelengths reflect the much lower energy held by atoms at the time of emission. Photons, with no mass have an unchanged 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).

Big bang nucleosynthesis

The relative abundances of light elements has been put forward as strong evidence for a big bang. This is because of the requirement that there were sufficient photons per baryon and enough heat energy for protons and neutrons to transform into each other easily. Their ratio, determined solely by their relative masses, is then about 1 neutron to 7 protons giving a primordial abundance of about 25% helium-4 by mass, as observed. FR, however, has the energy of protons and neutrons much lower and the kinetic energy (heat), and large photon to baryon ratio, can come from the annihilation of most matter and antimatter. This appears to be a plausible scenario subject to detailed modelling.

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 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 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 scale of regions with similar properties would have decreased as the speed of light decreased.

The removal of the Hubble tension and of an accelerating expansion showed that FR is consistent with the 'early-time' fluctuations in the CMB deduced under GR with a constant rate of expansion. Thus the fluctuations can be reproduced under FR for the observed fixed Hubble constant without any expansion. However, the replacement mechanism of early-time lower energy and faster light-speed replacing a cooling from expansion needs investigation.

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.

FR claims that gravitational "waves" are changes in the magnitude of the background field from massive objects that alter the speed of light. The $1/R$ dependence of gravitational potential requires that this influencing flux does not transport energy, otherwise the total energy must increase with distance from the source of gravity. These "waves" do not have to carry energy to be detected by current suggested mechanisms [31], and must not. They are not distortions of spacetime. Instead, they alter light-speed and 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; and so will be detected.

Binary pulsars should also not lose energy via gravitational radiation. An examination of the calculation of the apparent energy loss of binary pulsars shows that the reference energy (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.

FR's changes in mass (and inertia) with gravitational potential are not included in the calculation of orbital energy. However, GR has no change in mass but gave the same prediction of perihelion advance based on a contraction of distance (Schwarzschild metric) as FR gave from changes in mass and conservation of momentum. Thus, it seems probable that it is omissions in the calculation of orbital energy that leads to the apparent loss of energy while the predicted rate of orbital change is likely 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 [32].

Frame dragging and overview

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.

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 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 Appendix A). 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 that led to 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 to be cancelled by an unneeded contraction in distance 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 the one clock is used (or clock-rates are adjusted for movement relative to the background) and measurements are corrected for movement during the time of signal transmission (see Appendix A). However, it allowed acceptance of the proposition that perceived space and time was dependent on relative movement between events and the observer. Under SR, only their combination in a spacetime linked by a constant speed of light was fixed. FR claims that the reality is that clock-rate is dependent on movement relative to the background. Spacetime, in which the scale of distance is contracted, 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 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 the 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 invariant interval (below) claims c is invariant. It is a critical underpinning of SR and GR. However, the conclusion that $c' = c$, is based on faulty mathematics.

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

which amounts to: $x'^2 - c^2 t'^2 = x^2 - c^2 t^2$ because: $y'^2 + z'^2 = y^2 + z^2$

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

Hence, there is no requirement for a fixed speed of light ($c' = c$).

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 the observer?

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 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 and a nearly constant gravitational potential.

The forthcoming much more extensive data from distant Type 1a supernovae ($1 < Z < 2$), and other standard candles, 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).

An analysis of the fractional redshift, independent of redshift of the galactic source, should soon be possible. This will be measurements of accurate redshifts for millions of distant galaxies. 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 that there is no need for the universe to be expanding at all and wether the currently perceived anomalous dipole in the matter distribution of galactic sources using number count is an artefact of faulty assumptions in the analyses.

Data from the James Webb telescope may provide evidence for the expected contraction in the size of galaxies over time. The mass of individual galaxies should increase over time, although the visible matter may 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. However, contraction of galaxies may make 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 should be visible in the expansion rate of matter in supernovae explosions. This is distinct from the slope of the light curve with time. It would seem to require sufficient proximity for angular resolution of the expansion since the date of the explosion. The rate should reflect the inertia seen in the galaxy rotation curve at the supernova location.

The impact of the large changes in inertia and mass on the development of stars and galaxies with time, and on the motion of galaxies within clusters, needs investigation. The modelling needs to include the effects of changes in local anisotropy from 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. These may impact on the structure observed 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, plus the generation and persistence of spiral arms. 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 [21].

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. An attempt has been made to base the revised understanding of gravity and cosmology on a better understanding of the nature of particle interactions. Much of this is speculative but it does seem to offer a path to a deeper understanding of the Standard Model.

A key underlying belief that is being challenged is a concept of “relativity” that has been ‘sold’ as having been repeatedly experimentally ‘proven’. It has not. What has been presented is the understanding 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. Events are causally related. The apparent simultaneity of separated events can appear different if the observer is in motion, and clock-rate can 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, an underlying reality, a fixed causal order, exists.

Relativity also exists, but the new version requires that the speed of light is not 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 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'* " [33]. 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.

Conclusion

The invariant interval of Special Relativity (SR) in which there are matched changes in space and time that keep the speed of light constant was mistakenly incorporated into General Relativity (GR). This spacetime was unnecessary in SR because it applies within a region with no gravitational acceleration. Light-speed is constant within any such region but does not have to have the same value in regions of different, but constant, gravitational 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 and the 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 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 (in the limit of a small asymmetry). 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 galaxies at a given redshift (Z) will then be increased in proportion to the integral of the $1+Z$ change in time, i.e. by $Z(1+Z/2)$.

Correcting for this effect 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 (at the current, effectively constant, magnitude of the background) 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 change in the flux from a constant amount of matter with a change in density necessarily leads to an apparent, but non-existent, and therefore invisible energy. It was needed to make spacetime flat when GR's universe is expanding. The remarkable coincidence, that it is currently flat when such flatness should be rapidly destroyed by gravity or dark energy, is removed. The geometry of spacetime is 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 horizon problem is avoided. Moreover, the so-called 'Hubble tension' is removed while being explained as an artefact of inserting a variable expansion.

The introduction of a pair of chiral background components allows effects of the background 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 asymmetry determines inertia.

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 claimed changes in both distance ('space') and time mimic FR's changes in light-speed and mass/energy; or SR and GR's unreasonable assumptions and faulty steps that have been hidden by 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 can give rise to inconsistencies and apparent effects such as dark energy, dark matter, 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 also appears likely to remove all current evidence for new physics beyond the Standard Model of particle physics.

The changed perspectives also demand that gravitational 'waves' do not carry energy but are variations in gravitational potential that are detected because they alter light-speed.

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

Frames of reference and 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 moving clock without the clock signals being examined. 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 clock-rate is the same in all inertial frames, and was inserted in Einstein's claimed derivation of the LT. Subsequent derivations have mostly used this (faulty) belief - that all observers moving at constant velocity perceive the same results, including the same fixed speed of light – to obtain the LT.

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

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

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 must be examined carefully.

The doubtful claims behind light-speed invariance

The idea, that light-speed was constant, initially arose from observations and experiment where it was found that the speed of light was independent of the speed of the emitting source. More recent, stronger, evidence is seen in that the light reaching us from each star of a binary system takes the same time for the same distance. The time taken is independent of whether either star is approaching or receding. This differs from what we observe if we throw a ball from a moving car. The ball goes faster (relative to the ground) when it is thrown forward. This does not happen with light, otherwise the light emitted later in an orbit, when the star was approaching, might reach us before the light emitted earlier, when it was receding. No such effect is seen even when the light has taken many years to reach us. Einstein drew on the earlier information, and the result that the interferometer experiments of Michelson and Morley could not detect any effect of the movement of the Earth around the Sun on the speed of light, to postulate that the speed of light (in vacuo) was fixed.

He 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 relative motion between objects and observers appeared to have an importance. The principle requires 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. SR is only claimed to apply in the absence of a gravitational field, i.e. when there is no gradient in the background gravitational potential from surrounding matter. Hence, it provides no requirement for the speed of light to have the same value in a different constant background.

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 they will have to hit the ball. 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.

The postulate of relativity, under SR, is that all physical laws are the same for objects moving at constant speed. Thus, it was proposed that all observers would measure the same speed of light. The assumption became that relative motion changed space and time, but did it in a way that kept light-speed (distance divided by time) constant (i.e. $c = x / t = x' / t'$). The space and time of objects and events, perceived by an observer, is claimed to be fixed if the observer is stationary relative to the events. Otherwise, they are contracted and slowed in proportion to the relative speed of motion between objects and observers.

Einstein’s derivation of the Lorentz transformation

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 measured 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 went on to examine the timing of light signals emitted and received in a frame moving away relative to a stationary observer after initial coincidence. He claimed that the average time for the return trip to the object was the mean of the two time-intervals. This is not the case. The timing is altered by movement of the object during the signal transmission time. The average distance to their positions is slightly larger than the distance at the time the signal reaches the origin because the signal transmission time is larger for the longer path. This difference increases with the increasing separation of the moving and stationary frames.

Timing of events (emission and receipt of signals) can be synchronised within frames, but must be corrected for movement during signal transmission if they are to be synchronised between frames. The average round-trip distance to positions between frames is increased by the factor ($[c/(c+v)+c/(c-v)]/2 = 1/\gamma^2$). The above assumed equality, used by Einstein to derive the LT, missed including the change in timing due to finite travel time of light (between originally matched locations in each frame) into the transformation.

In his derivation he had included a function $\phi(v)$ to allow the scale of time and distance to differ between the two frames. It was present in his initially derived transformation:

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

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 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 and 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 that applies to time should be the same as that for distance, within each frame, if c is to remain constant independent of scale. The function must be inverted in returning to the initial frame.)

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. 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.

Interpreting the Lorentz transformation

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

The vx / c^2 term is a necessary correction to the arrival time (in the time units of the stationary observer) of signals received by the moving observer. These will be advanced or delayed by 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 can 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.

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). If time is running slower, then apparent distances should increase. However, if the expression $x = vt$ applies to a separation Δx then, for the origin, it should be decreasing when $t < 0$ and increasing when $t > 0$. The sign of the $(v / c)(x / c)$ term changes sign at $t = 0$, for the origin. It should be used as a correction for the change in arrival time of signals due to relative motion during transmission. Inserting $x = vt$, means that the time in the moving frame must be $t' = t / \gamma$ if the LT is to explain observations. If the scale factor for time changes by $1 / \gamma$ going from frame A to B, then it must change by γ in going from frame B to A. It does not give an ellipsoid. A slowing of time that occurs independent of movement towards or away implies that the slowing is inherent to the movement and the changes in distance are apparent. Such a slowing of time for the object that is viewed implies that it is the movement of the object that causes the slowing. A slowing, and never a speeding up, of a time whose magnitude depends on only relative motion, implies that the effects of motion are real, and must be able to be sensed by the object.

Einstein's interpretation arrived at $x' = \gamma x$ and $\tau = t' = t / \gamma$. Next, he took $x = x' / \gamma$ as the length that objects of length x' (in the moving frame) will have in the stationary frame, so that the size (length) of moving objects appears shorter (FitzGerald contraction) in the stationary frame. On the other hand, he took the time (τ or t') of a clock in the moving system as "nothing else than the summary of the data of clocks at rest in the system" [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 [34] 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: $x'^2 + y'^2 + z'^2 - c^2 t'^2 = x^2 + y^2 + z^2 - c^2 t^2$ 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) assigning incompatible meanings to x in the distance and time components of the transformation.

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 <u>observed</u> 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 <u>unobserved</u>, 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: $t' = \gamma(t - v^2 t / c) = t / \gamma$, 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 $x'^2 + y'^2 + z'^2 - c^2 t'^2 = x^2 + y^2 + z^2 - c^2 t^2$ 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, to 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 [35,36]. 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. 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 GR, 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).

Locations are unchanged, just apparent distances due to the slowing of clocks. 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 we are nearly stationary relative to the background, it does not show up, until high speeds. It can be observed in the decay rates of unstable elementary particles.

The clocks in the moving frame tick more slowly causing light to appear, and be measured, to travel further per tick. However, the increased distance scale (contraction of objects) 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 is 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" [34], 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, rather than that the idea of motion cannot be attributed to the background (as Einstein claimed [2]). A simplified transformation, and its inversion, applies and there is no requirement for c to be constant.

Spacetime is the mistaken core 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 observations in free fall are equivalent to 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 a steady increase, with v/c, in the inertial resistance to acceleration.

Under GR, the geometry of this fabric gets 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 them 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 or Strong 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 $\vec{a} = -\vec{g}$.

This ultimately 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).

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 the 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) but with its magnitude proportional 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. These distortions keep light-speed constant in terms of local physical quantities, yet ostensibly double the amount of bending because the spatial and temporal curvatures double the retardation of the light signal [36]. No bending should occur if c is constant along light's path.

Appendix B. Further speculations on the nature of matter

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).

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 not require that they have mass, as has been routinely claimed.

It must be stressed that these proposals are speculative and need further development. However, they may suggest a path towards a Standard Model that incorporates all four fundamental forces and that can predict all wave-particle masses and interaction strengths from first principles. The revised understanding 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 can appear to be in a definite state (when repeatedly viewed from the same direction). 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.

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 just a reflection of a key mechanism of trapping.

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.

Appendix C. An apparent dark energy is predicted

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 follows from applying Gauss's law to the gravitational force law, as is done for electromagnetic fields [37]. 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:

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

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 constant, decreasing with increasing volume, it will necessarily give 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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