Lighting a path out of gravitational darkness – a variable mass and light speed

Peter R. Lamb

Deakin University, Geelong, Australia   Email: lamb.peter@bigpond.com

A path out of gravitational darkness.

The path to a gravitational theory that reproduces the predictions of General Relativity (GR) but removes the need for ad hoc hypotheses such as dark matter and dark energy is outlined. It demands a real background that alters the speed of light which changes mass.

A The flat fabric of space-time is an illusion.

Special Relativity (SR) concluded that space and time are relational or malleable dependent on the speed of the observer and only their combination in terms of the speed of light is constant. SR was based on the postulates of the "principle of relativity" and a constant speed of light. It had been observed that the speed of light is independent of the speed of the emitting object. However, in SR the Lorentz transformation (LT) was derived (instead) from the claim that light takes the same time to reach the observer independent of relative speed. The resultant invariant space-time interval (a flat fabric) requires the assumption, made by Einstein and Minkowski, that shorter time intervals mean less time. This contradicts the original proposal by Lorentz that experimental results can be explained by a dilation of time intervals and a contraction of length intervals.

The result is that the LT applies to apparent effects due to the movement of objects during the finite time of light transmission AND to actual distances and times provided time runs slower for massive objects (including clocks and observers). The apparent effects seem to show that space and time are not fixed but are linked into a flat "fabric" that keeps *c* constant. This is an illusion.

The alternative explanation has the speed of light *c* constant within a constant background, but it does not need to have the same value in a different background. However, the clock-rate (and decay rate of massive particles) is dependent on speed relative to the background from other massive objects. Massless light is only sensitive to the magnitude of the background. The "principle of relativity" – that the laws of physics are independent of motion at constant speed – does not hold. The resistance to acceleration (inertia) changes with speed relative to the background. Our speed relative to this background from "the fixed stars" is negligible relative to the speed of light.

B Under GR, gravity is a distorted fabric of space-time.

Einstein deduced that gravity was a distortion of space-time rather than a real force. Special Relativity was given that name because it applied to the special case of relative motion at a constant velocity. Einstein realised that it needed to be generalised to include accelerated motion. In GR, the geometry of space-time is distorted by matter (via its energy and momentum): it tells matter how to move and matter tells space-time how to curve. Under GR, gravity is not a force. It is just the curvature of space-time. The more massive an object the more space-time is curved, which appears as a larger gravitational acceleration.

The path to GR is complex. The first step was what is now called the weak equivalence principle – that there is no difference between inertial and gravitational mass. The next step was Einstein's realisation that an observer in free-fall felt no gravitation. Gravity appears to be transformed away by acceleration and the laws of physics are (appear to be) the same as in an inertial frame. The laws of physics in a frame, freely falling in a gravitational field, appear equivalent to physics in an inertial frame without gravity. It is then claimed 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 is called the strong equivalence principle.

This ultimately led Einstein to replace the invariant interval of an undistorted (flat) space of SR with a distorted geometry of space-time (the metric). The curvature depends on the second derivative of the metric which is the relativistic equivalent of the gravitational potential (Φ) seen in Newton's gravitational equation.

However, Einstein's equation assumes that the effects of a gravitational field depend only on the gradient of the gravitational potential and not on the total potential. This means that it assumes, in the absence of a gradient, that mass is constant.

C The fabric of space-time can be replaced by a real background.

So, what is meant by a background? The simple answer is a field that permeates all of space and alters the properties of objects and signals embedded in that space. The concept of a field was introduced, as a medium to carry effects between locations, to explain action at a distance. It was therefore expected and understandable that there would be a finite speed of propagation. However, Einstein, in SR, concluded that it was unnecessary to postulate a medium (the aether). Instead, relative motion at constant velocity altered the perceived space and time of events, but *c* was constant.

The fabric of space-time acts like a pseudo-background. Firstly, it changes the time and space that applies to objects moving relative to the observer, even though the time and space of the same object, perceived by an observer not moving relative to the object, is unchanged. Secondly, it can be distorted by concentrations of mass so that the geometry of space is no longer Euclidean. The effects of changes in movement (i.e. acceleration) are claimed to be equivalent to such distortions. However, the time and space of an observer freely falling in the gravitational field, so not feeling any force, is undistorted. Under GR, time and space are also malleable, with their combination in terms of the speed of light being sensitive to an acceleration field, such as that indicated by a gravitational force.

The alternative scenario is that the force of gravity per unit mass and a constant acceleration are only instantaneously equivalent at a location. Free-fall takes the object into a different background. The effect of gravity varies with the total (scalar) potential rather than the (vector) gradient in the potential.

The big difference between scalar and vector fields is that vector fields from opposite directions cancel, whereas scalar fields add. The contributions of a homogeneous, isotropic distribution of sources of a vector field, about a location, cancel each other. This is known as gauge invariance. For a scalar gravitational potential, all contributions to the total field decrease in proportion to $1/r$. The contribution of every small mass δM has to be summed according to its distance d, i.e. according to $\sum \delta M/d$. If there is a large uniform background, then the gradient of this field will appear to depend only on nearby sources. Because of the $1/r$ dependence a major part of the background will come from distant sources and the strength of gravity will appear very weak.

GR's gauge-invariant pseudo-background of a distorted geometry of space-time can be replaced by a background that affects mass via the speed of light. It replaces space-time with a real background that affects clock-rate, the stored energy, inertia and frequency of objects.

The revised theory is consistent with the source of mass in the Standard Model of particle physics. The Higgs mechanism involves a "spontaneous breaking of gauge invariance". This is inconsistent with gauge-invariant GR. If mass corresponds to trapped momentum, then any force that confines energy and momentum to a location should give rise to mass. Hence, all forces (strong, electromagnetic and weak) should give rise to mass. The Higgs boson is just one member of the set of massive bosons of the weak interaction that have manifest chirality, and their interactions with particles that have opposite chirality (matter and antimatter) can exhibit this chirality. This leads to a prediction of a relationship between weak boson masses.

D The key clue to the new theory.

A photon does not lose energy in escaping a gravitational field!

According to Newton's law of gravitation objects are attracted to each other in proportion to their mass. The initial expectation was therefore that a photon would not be attracted to a massive object. However, GR has mass/energy distorting the space-time in which all objects, including photons, exist. This led to Einstein's prediction of a gravitational redshift with increased gravitational potential.

The gravitational redshift was finally observed in, and after, 1959 in a series of experiments by Pound and Rebka in which photons were not resonantly absorbed by a matched detector, higher in a tower, unless they were given a boost in energy. The opposite applied when the positions of emitter and detector were reversed.

Hence, a photon appeared to lose energy in escaping a gravitational field. Since it has no mass, it was argued that it is attracted in proportion to its kinetic energy. It thus became a pillar of GR that all objects are attracted, and space-time distorted, in proportion to energy. Under GR, there is an enormous pool of energy when massive objects are widely separated and space is hardly distorted. In moving closer, objects draw energy from this pool and this energy gives rise to more distortion. The result is that even gravitational energy gives rise to more gravitational energy. The non-linearity leads to an exponential growth of energy in a very strong gravitational field and the singularities inside black holes.

However, several authors have pointed out that the energy of the photon is unchanged and instead, under GR, the standards of time are changed so that the energy levels of the atoms appear blueshifted. The GR explanation is that a changing gravitational potential, an acceleration field, corresponds to a changed distortion of the metric of space-time. The change in time, a faster clock-rate with distance from a massive object, is a confirmed observational effect seen in the needed adjustments to the satellite clocks of the global positioning system.

A subtly different explanation for the blueshift and change in time is that they arise from a real increase in the energy levels of atoms with gravitational potential. After deriving $m = E/c^2$, Einstein concluded 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".*

Hence, all mass should just be seen as stored energy; energy of motion held at a location, i.e. trapped momentum. The mass (stored energy) of objects increases due to the work done in lifting them. The increased energy levels mean that frequencies and time are faster. The energy is released as the free kinetic energy of motion when a massive object falls.

The beautiful change in perspective is that gravitational attraction arises from a loss of mass. It is simply conservation of energy.

Photon momentum, and the kinetic energy it can deliver, is energy moving freely at the maximum speed allowed by the medium (i.e. at the speed of light). It is not trapped and does not require a net force and does not contribute to the gravitational field.

If only stored energy corresponds to mass, then photons will not gain or lose energy in a gravitational field. The change in perspective from a redshift of photons to a blue-shift of atoms means that photon energy is unchanged. The gravitational redshift of light is because the energy (and clock-rate) of the emitting atoms is lower when nearer to other matter, i.e. deeper in a gravitational potential.

Two immediate advantages are the removal of singularities because the mass per unit matter decreases as matter density increases and there is no need for an enormous pool of energy in empty space devoid of massive objects and distortion.

E Variable mass means a variable speed of light and clock-rate.

However, $m = E/c^2$ means that the stored energy (m) of the same amount of matter (current energy E) decreases as the speed of light increases nearer to a massive object.

Surprisingly, a variable speed of light appears consistent with all existing measurements and expectations. For example, measurements of the Shapiro delay only test for the change in timing due to the increased path length from bending. The size of atoms and the length of rods also decrease in proportion to the change in speed of light.

Gravity does not arise from a distortion of the geometry of space-time between massive objects but from changes in the energy that can be stored by particles when the background changes. It is the objects and their properties that change and not the geometry of space and time between objects. The proposed background alters properties of objects with the rate of events (time) depending on its magnitude (the clout or the negative of the potential). Time intervals for light to travel the same distance depend on the magnitude of the background. Time (clock-rate) is not altered by the presence of a gradient (i.e. of a gravitational field), only by being in a new, different background or by movement relative to the stationary background. Clock-rate depends on the energy of the clock, which increases as the background potential decreases. Space (the distance between unconnected stationary objects) is not distorted.

Newton's equation reflects fractional changes in energy.

The kinetic energy (KE) gained by falling objects comes from a loss in their stored energy. Energy is conserved but a massive object cannot store as much energy when the speed of light increases as the background increases. The gain in stored energy per unit mass (m) in raising an object distance dx against F is:

$\int (F/m)dx = \Delta KE/m = \Delta(mc^2)/m = -G_N M/r$ with distance r from a point source of mass M.

The equation has inertial and gravitational mass equated (i.e. $m_i/m_g = 1$).

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

$\Delta E/E = \Delta m/m = -G_N M/rc^2$ with the value of G_N increasing if m_i/m_g decreases.

If the clout (ρ_B) from a uniform background of sources is much larger than the clout from M kg at d metres, then the local fractional change in total clout is:

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

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

$(m + \Delta m)/m = \rho_B/(\rho_B + \Delta\rho)$ and $\Delta m/m \cong (-\Delta\rho)/\rho_B$

and: $G_N M/rc^2 = M/r\rho_B$

giving a local background clout of $\rho_B = c^2/G_N =$ 1.3467 x 10^{27} times that from 1 kg at 1 m.

F Full Relativity.

A simple scalar background can explain the energy conservation of gravitational attraction. A more complex background is needed to explain the vector nature of momentum. A two-component chiral background is required by the Higgs mechanism as well as being needed to explain momentum, inertia and to avoid the need for dark matter. The two-component background is presumed to have contributions from matter and antimatter and gives rise to a "clout" that falls of as $1/r$. The clout, which is proportional to minus the total background potential, determines the speed of light and hence mass. In contrast, GR assumes that gradients in potential from opposite directions cancel. This means that, under GR, mass is independent of a uniform background. The revised theory has gravity, and all energy and momentum, fully dependent on the background which is why it has been christened Full Relativity (FR).

GR has wrongly assumed that gravitational acceleration is a vector field with a conserved flux. Such a conserved flux assumes that mass is constant. Newton's and Einstein's field equations then require that empty space free of matter can act as a source of gravitation. This should be seen as unacceptable along with problems of GR including singularities, "quantum foam", block time, decay rates being subjective dependent on movement of the observer, and other inconsistencies. All these problems can be overcome by a background-dependent theory.

Clock-rate increases but light-time intervals decrease with increasing *c*. This, and the change from redshift to blueshift, mimics the misinterpretation, in SR, that smaller time intervals mean less time. The effects of small changes in total clout on *c* and mass in FR match the changes in the distortion of space-time with the gradient in potential of GR, provided m_i/m_g is constant. The equivalence of the changes in time and momentum of the two theories mean that effects such as the precession of the perihelion of Mercury are automatically reproduced. Differences between FR and GR show up when comparing behaviour in regions or times with significant differences in background clout or asymmetry. It is postulated that inertia is dependent on the asymmetry of the chiral components of the background.

No need for dark energy, dark matter, cosmic inflation or even a Big Bang.

The apparent accelerating expansion seen in supernova data is removed by the integrated increase in distance per unit time from an earlier, faster speed of light (Figure 1). Moreover, the change in clout can arise from the clumping of matter without any need for expansion. There is then no need for dark energy, cosmic inflation or an expanding universe.

It appears that the change in background asymmetry with distance from the centre of an isolated galaxy can also remove the need for dark matter seen in the flat rotation curves and amount of gravitational lensing. This asymmetry of the background alters inertia and the rate of bending of light.

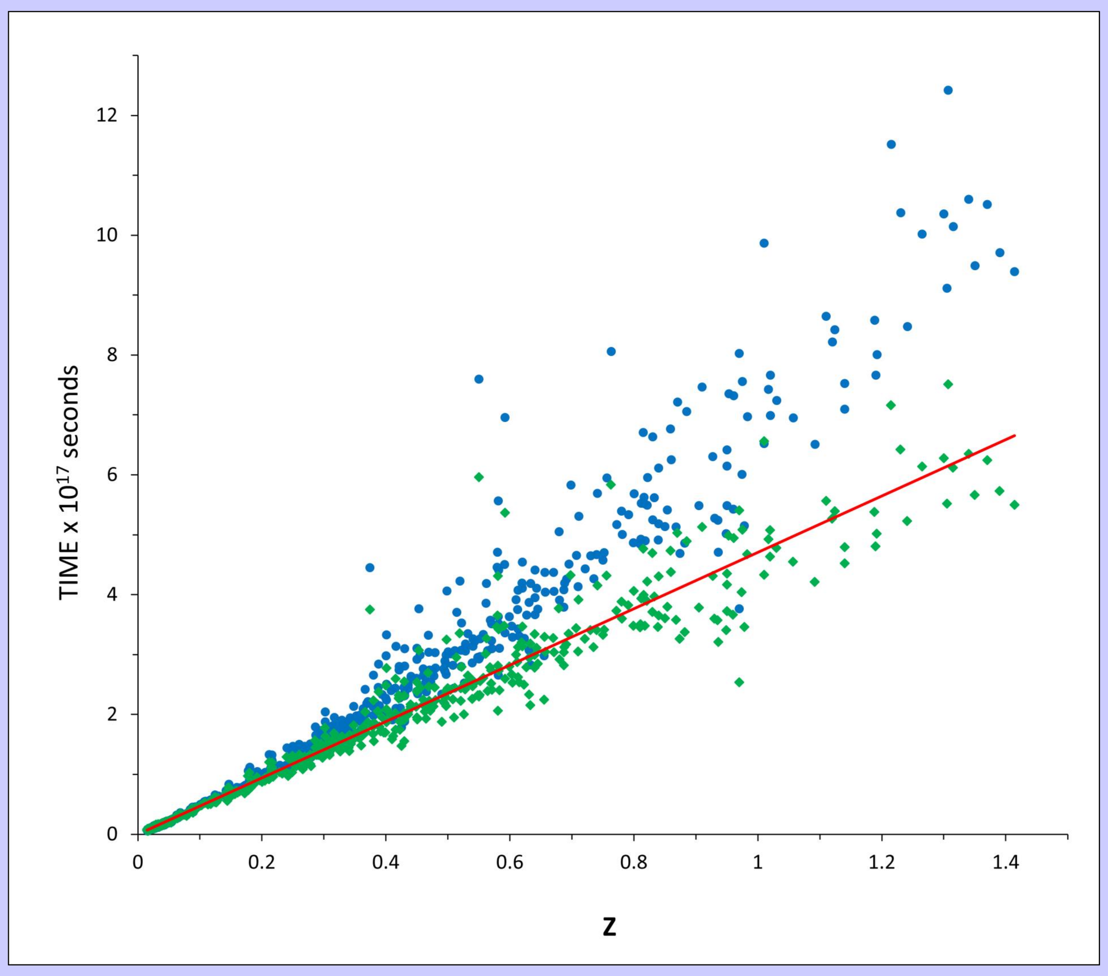

Fig. 1. Time since light emitted before (blue) and after (green) correction for a changing speed of light.

The Union 2.1 data for type 1a supernovae [Suzuki N. et al., 2012. *Astrophys. J.* 746, 85] gives the luminosity distance versus redshift $Z = \Delta\lambda/\lambda$. This is plotted as the elapsed time since the light was emitted based on the current speed of light and then after dividing by Z(1+Z/2) which allows for the integrated change in the speed of light. The supposed "accelerating expansion" is completely removed.

The new path to understanding gravity, Full Relativity, has been set out more fully in a publication:

"Making Sense of Gravity"

which can be downloaded free from www.fullyrelative.com or by contacting the author.

FR is a work in progress and would benefit from critical analysis, further development, plus modelling and comparison with observations. In particular, the implications for the evolution of the large-scale structure of galaxies and galaxy clusters needs modelling and testing.

FR provides an explanation of the bulk of the Pioneer anomaly and the Tully-Fisher relationship and a changed perspective on black holes.

The implications for many aspects of cosmology, for particle physics and even for quantum mechanics need to be taken further.