A Classical Unified theory of Gravity

replacing Einstein's General Relativity

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Abstract

The force of gravity and the physical effects of gravitational potential can all be explained in terms of the basic electric properties of the elementary charged particles with electric fields that coexist in space. If they exert a small influence on each other which reduces their ability to contain energy, then the energy released when a mass falls under the action of gravity actually comes from the energy stored in the electric fields of the elementary charged particles explaining the force we call gravity.

From this we develop a full theory of gravity showing that the physical effects of gravitational potential modify physical properties by factors of $e^{n\frac{\Phi}{c^2}}$ deriving the integer n for the common physical properties. The weak field approximation takes the first two terms of the expansion and coincides closely with Einstein's GR We derive the results for the bending of light and the advance of the perihelion of Mercury. We do not predict singularities and black holes, but derive the effect on massive neutron stars noting that a neutron star of 883 solar masses would be reduced to the size of golf ball in terms of Euclidean space.

The mathematics used in this theory is all within the grasp of undergraduates who study mathematics as part of a science or engineering degree.

Introduction

A theory of gravity has to explain:

- The force of gravity
  - Why the force is proportional to the mass of the source of gravity
  - Why the force is proportional to the mass of the object being attracted
  - Why it obeys an inverse square law
- The slowing of clocks by gravitational potential
- The delay in the transit times of radio signals passing close to the sun
- The bending of the path of light passing close to a star or black hole
- Gravitational redshift
- The missing 43 arc seconds per century in the advance of the perihelion of Mercury

It must start with the fact that matter is composed of elementary charged particles.

Many attempts have been made to unify the force of gravity with the electric properties of matter. The discovery of the neutron in 1932 put an end to such speculation, and it was not until the development of quark theory in 1964 that theories based on electric interactions once more became tenable. By that time, thinking had moved on and forces were thought to be exerted by the exchange of virtual particles.

The theory we shall advance here is based on the assertion that the electric fields of all the individual elementary charged particles coexist in space. When a mass falls under the action of gravity, it accelerates gaining kinetic energy. We say that the increase in kinetic energy results form a decrease in gravitational potential energy, but what is gravitational potential energy?

We assert that the energy released when a mass falls under the action of gravity comes from the energy stored in the electric fields of its elementary charged particles. The total energy in a mass m is $E = m c^2$ consisting of electric energy and kinetic energy. Three-quarters of the electric energy is stored in the electric fields of the elementary charged particles and a quarter exists as potential energy due to the separation of positive and negative charges. The kinetic energy is stored in the magnetic fields generated by the motion of its elementary charged particles.

We assert that in each other's presence, the coexisting electric fields exert an influence on each other reducing their ability to store energy. The primary effect is on the two properties which we call the permittivity and permeability of space. The change in the value of these properties influences many things including the separation of atoms in matter, the energy levels within atoms, inertial mass and the rate of time dependent processes.

As matter is added to a planet or star, each additional elementary charged particle results in a reduction in the energy contained in the electric fields of all the other particles subtracting a further portion of energy. This is not a subtraction process as in 1, 0.9, 0.8, 0.7, 0.6, … but a multiplicative process such as 1, 0.9, 0.81, 0.729, 0.6561, … The exponential function e^{-x} describes this form of repeated multiplicative action when a very large number of multiplications take place. It is defined as:

$$e^{-x} = \lim_{n \to \infty} \left(1 - \frac{x}{n}\right)^n$$

The gravitational potential Φ at a point is defined as the work which must be done to slowly remove a unit mass from that point to an infinite distance. It is a negative quantity. We shall show that the influence of gravitational potential is described by the function $e^{\frac{\Phi}{c^2}}$.

In the weak gravitational fields of our solar system $\frac{\Phi}{c^2}$ is very small and we can use the approximation $e^{\frac{\Phi}{c^2}} = \left(1 - \frac{|\Phi|}{c^2}\right)$ mostly resulting in the same equations as those of Einstein's theory.

The predictions of this theory differ from Einstein's in that we assert that the contraction in the length of rulers does not depend on their orientation. Neither does this theory predict the existence of event horizons where $2\left|\Phi\right| = c^2$. However sufficiently massive neutron stars are greatly reduced in size relative to Euclidean space and the extreme magnitude of gravitational potential makes them appear very much like black holes.

Einstein's general theory of relativity is based on the assumption that there is a physical entity called space-time which is curved by the presence of mass to produce the effects of gravity.

Our theory is a physical explanation of the force of gravity and the effects of gravitational potential on matter and electromagnetic fields. Gravitational potential exists as a physical property of the electric fields of the elementary charged particles.

While there is a considerable overlap in the resulting equations, the two theories are both physically and philosophically very different. In particular, our understanding of time is very different. We assert that time exists in nature only in the infinitesimal element dt, with the whole universe existing in the moment of now. Time to us is a way of classifying our memories of previous states of the universe. The finite speed of light means that we see the world as it was, seeing objects at different distances as they were at different times in the past! We take this into account in our theories of relativity, but Einstein's world view reverses the causality of nature. His reality is space time and he derives his physics from its nature. Our reality is the physical world and from an understanding of its physical processes, we derive the effects on measurements of space and time.

The General Theory of Relativity states that in the presence of a massive body, space time is curved. This may be a beautiful piece of mathematics, but as physics, it is nonsense. Matter and electromagnetic fields are affected by the gravitational field. That includes the body itself which if sufficiently dense and massive, will take on the appearance of a black hole. The space around such an object remains Euclidean and time remains Newtonian. The gravitational field affects material objects causing rulers to contract by a factor $e^{\frac{\Phi}{c^2}}$ and clocks to slow by the same factor because the time between ticks increases by a factor $e^{-\frac{\Phi}{c^2}}$. These physical effects apply equally to light which, because speed is distance divided by time, is slowed by a factor $e^{2\frac{\Phi}{c^2}}$. These are physical effects described relative to Euclidean space and Newtonian time.

Although we assert that there is no such physical entity as space-time, nature does enact some of the the geometrical properties attributed to the R3 component of space-time. This is because physical length is a property of electric potential fields. These are physical entities and they are physically affected by gravitational potential. When we observe that the ruler has contracted, it is because the physical presence of all the coexisting electric fields has contracted. Nature acts within that reality.

We will use the term "Euclidean" to describe the geometry of space which mathematicians refer to as R3. Space is infinite. We can imagine it spanned by a Cartesian co-ordinate system of unit $10^{30}\,m$ at which scale our universe is lost somewhere in the middle of a grid cube. As we zoom in, we have to keep dividing our base vectors into 10 smaller units and grid cubes into a 1000 smaller cubes. After doing this 20 times, we end up with a grid cube which most of our solar system would fill. Another 10 times and we have a Euclidean metre. It has the same definition in terms of the wavelength of light, but with one extra stipulation. The light must be emitted from a atom way out in space far beyond our universe where its gravitational potential has no influence. We can likewise define a Newtonian second from the frequency. As creatures of this universe, we and everything in it are subject to the effects of gravitational potential. Our metre rulers are shorter than a Euclidean metre and the seconds which are ticked off on our atomic clocks are longer than the Newtonian second. Unfortunately, we can at best guess by how much because we do not know the mass of the universe, or of our galactic core.

Einstein's general theory of relativity does not admit to the existence of Euclidean geometry and Newtonian time scale. Its exponents will go so far as to say that time and space do not exist outside of our universe. We assert that this a nonsense. That the effects of gravitational potential on rulers and clocks can be described against the background of Euclidean space and Newtonian time, even if they are only mathematical concepts which would need a God who can hold the universe in the palm of his hand as if it were no bigger than a acorn, to draw the grid lines and enumerate the passing of time; they are never the less meaningful concepts.

What is mass

We do not actually know what mass is!

Newton described three properties of matter which he attributed to mass; the property of inertia; the ability to create the attractive force of gravity and the ability to be attracted by gravity. Einstein gave mass another property, that of being equivalent to energy. Most scientists seem to think of mass and charge as two ingredients of elementary particles and in this sense, their concept of mass is in the same class as the classification of the four basic elements of earth, water air and fire. The deeper one delves into modern physics, the more mysterious this "element" becomes.

We are of the opinion that nature has one basic element: energy which has two stable forms; electric flux which terminates in charge and magnetic flux which always forms continuous loops. That the whole basis for the structure of matter is that moving electric flux (*D*) generates magnetic intensity (*H*) and moving magnetic flux (*B*) generates electric intensity (*E*) with the result that all actions of nature involve the transfer of energy between electric and magnetic fields. Electrons (and quarks) possess the property we call inertial mass because the motion of their electric field (through the background of all the other electric fields of elementary charged particles) generates a magnetic field which contains their kinetic energy. Mathematical analysis of this process shows that inertial mass is proportional to the energy content of the electron's electric field. Inertial mass is therefore a property of the electric nature of matter.

Newton's original conclusion was that inertial mass, active gravitational mass and passive gravitational mass are the same thing. In fact, they are proportional to one another and are made equal by the way in which we define our units. When it was discovered that beta radiation consisted of electrons moving at near light speed, experiments to measure charge and mass showed that inertial mass was an over simplistic concept. Lorentz showed that the laws of Electricity and Magnetism predicted a feedback effect in which the motion of the electron's magnetic field generated an electric *E* field which affected the electron's electric *D* field causing a contraction in length and increase in inertial mass. Together with Poincaré and others, the theory of SR was developed with the addition of *transverse mass* and *longitudinal mass* to the list. In latter years, these terms were dropped and replaced by the term *relativistic mass*.

We wish to add another name to the list: *physical mass*.

It must be emphasised that all of these different properties relate to the nature of the electron (and quarks) as an entity consisting of an electric field and the terminal charge on its inner surface. They are all related to its energy content. They arise from the different ways in which we measure mass.

- m_p Physical mass is measured with a beam balance against a standard mass
- m_i Inertial mass is measured from force and acceleration
- m_l Longitudinal mass is measured from electric force on a charge and its linear acceleration
- m_t Transverse mass is measured from the magnetic force on a moving charge and the resulting centripetal acceleration
- m_r Relativistic mass: replaces m_l and m_t being equal to m_t
- m_{pg} Passive gravitational mass is inferred from acceleration under gravity
- m_{ag} Active gravitational mass is assumed defining a gravitational constant which is then measured by the attraction between spheres of know physical mass.
- m_e Einstein Mass as in $E = m c^2$

We shall show that: $m_e = m_{pg} = m_{ag} = m_r e^{\frac{\Phi}{c^2}}$ $m_r = \gamma m_p$ $m_i = \gamma m_p e^{-3\frac{\Phi}{c^2}}$

The two gravitational masses are equal. There are two separate factors; the effect of gravitational potential and the effect of velocity. The relativistic increase in mass contributes to the gravitational mass, but the gravitational mass is reduced by gravitational potential. Newton's inertial mass is modified by velocity and gravitational potential, the latter resulting in a factor of $e^{-3\frac{\Phi}{c^2}}$.

The principle effect of gravitational potential

The previous section has summarised the results we will deduce below.

We have defined gravitational potential Φ as the work which must be done against the force of gravity per unit mass to slowly remove an object to an infinite distance. This is always expressed as a negative quantity. When a mass m falls slowly from a height with a gravitational potential Φ to a height with potential $\Phi + \delta\Phi$, we mean that Φ increases in magnitude; both Φ and $\delta\Phi$ being negative.

As we proceed to analyse the situation, it will become apparent that simple concepts and definitions do not necessarily still apply. If, as we assert, the energy $m|\delta\Phi|$ released comes from a reduction in the energy content $E = m c^2$ of the mass, how are we to understand the change in $m c^2$. We have been taught that the speed of light is a universal constant, but the transit times of radio signals passing close to the sun are observed to be delayed. The local measurement of the speed of light always gives the same answer because we are measuring distance and time with rulers and clocks which are effected in exactly the same way as the light. If we use the universal speed of light, then we must assume that the mass has decreased, say by δm. This is a loss in mass and δm is negative. We can write:

$$c^2 \, \delta m = m \, \delta\Phi$$

In the limit $\delta\Phi \to 0$ this becomes a differential equation which we can solve:

$$\frac{dm}{m} = \frac{d\Phi}{c^2}$$

$$ln(m) = \frac{\Phi}{c^2} + K$$

The boundary condition is that $m = m_0$ when $\Phi = 0$ giving $K = ln(m_0)$, then:

$$m = m_0 \, e^{\frac{\Phi}{c^2}} \qquad \text{which we can write as} \qquad m_\Phi = m_0 \, e^{\frac{\Phi}{c^2}}$$

We now find ourselves in a similar position to those physicists who first discovered that the mass of high speed electrons behaved in a strange way. They replaced the single word mass with three terms r*est mass*, *longitudinal mass* and *transverse mass*. After some years, they redefined mass in such a way that they only had *rest mass* and *relativistic mass*. The problem arose because of the different methods used for measuring mass: comparison with a standard mass, deflection of a charged particle in an electric field and deflection in a magnetic field.

The relationship $E = m c^2$ still holds, so the associated energies are:

$$E_0 = m_0 \, c^2 \qquad E_\phi = E_0 \, e^{\frac{\Phi}{c^2}}$$

In our laboratory where the gravitational potential is Φ, we can interpret these equations without ambiguity. The speed of light c is the universal locally measured speed of light which always has the same numerical value (in a particular system of units). The mass m_0 is that which we measure with a beam balance against standard masses. The energy E_0 is the energy the mass would possess in the absence of a gravitational field and is the value we calculate using Einstein's relationship. The actual energy which remains is E_Φ, but we have no way of measuring this because our unit of energy has also reduced in size. Just as we cannot measure the contraction in length of an object because the ruler has also contracted, we cannot measure the loss of energy from within the laboratory.

We know that there is a reduction in the energy content because single atoms emit photons of light with an energy equal to the difference in energy levels of electron orbital states. This gravitational redshift gives us a window to look at the variation of energy within atoms with change in gravitational potential and these observations verify the validity of that equation $E_\phi = E_0 \, e^{\frac{\Phi}{c^2}}$. The Mössbauer effect is so sensitive that we can use it to see the difference in energy levels over distances as small as the height of a building.

For the reader who understands Einstein's general theory of relativity, the previous paragraph may seem confused. This is because GR does not explicitly recognise that the energy content of photons is unaffected by motion in free fall through a gravitational field. An elementary charged particle in free fall experiences an energy transfer from potential energy stored in its electric field to kinetic energy stored in the magnetic field generated by its motion. This is expressed in classical mechanics as Loss of PE = Gain in KE. But the photon is all kinetic energy because its electric fields are generated by the motion of its magnetic fields and do not exist in their own right as do the electric fields of elementary charged particles. Plank's constant is unaffected by gravitational potential, so the photon with its preserved energy has a constant frequency. When we think we are measuring its frequency, we are in fact using its frequency to measure the local clock rate at various places along its path. The photon is not red shifted as it climbs through a gravitational field: rather, the atom which emitted it had a reduced energy content due to its position within the gravitation field. Gravitational redshift is not caused by motion through a gravitational field, but is the result of the effect of gravitational potential on the energy levels of the atoms which emit the light.

The effect on rulers, clocks and the speed of light

Let us now reflect on the energy of elementary charged particles. It is composed of three parts; the energy in their electrical fields, the potential energy due to the separation of positive and negative charges and their kinetic energy stored in the magnetic fields generated by their motion. The equations for the energy content all have the same dimensions [M] $[L]^2[T]^{-2}$ even though their composition is different:

$$E_{el} = \frac{q^2}{8\pi\,\varepsilon_0\,a} \qquad E_{pe} = \frac{q_1\,q_2}{8\pi\,\varepsilon_0\,r} \qquad E_{ke} = \frac{\mu_0\,q^2\,v^2}{12\pi\,a}$$

If these energies vary as $e^{\frac{\Phi}{c^2}}$ then this is a complex set of relationships involving length, velocity, charge, permittivity and permeability. Each of these quantities must be expressed in terms of its dimensions (e.g. $v = [L]\,[T]^{-1}$) and the variation attributed to the effect of gravitational potential on each dimension. The theory of dimensional analysis tells us that each must be affected by a single factor. To obtain a solution, these must all be powers of a single factor. This means that the dimensions [M]: mass, [L]: length, [T]: time and [Q]: charge must map onto themselves as:

$$[M] \leftrightarrow \left(e^{\frac{\Phi}{c^2}}\right)^m [M] \qquad [L] \leftrightarrow \left(e^{\frac{\Phi}{c^2}}\right)^l [L] \qquad [T] \leftrightarrow \left(e^{\frac{\Phi}{c^2}}\right)^t [T] \qquad [Q] \leftrightarrow \left(e^{\frac{\Phi}{c^2}}\right)^q [Q]$$

where *m*, *l*, *t* and *q* are to be determined.

The symbol ↔ has been used to indicate that these factors are involved in a set of relationships between the quantity, the unit and the number of units in the quantity. If we consider a rod, it has an original length in the absence of a gravitational field. Gravitational potential causes it to contract, so its length becomes less, but the unit of length defined in terms of the wavelength of light also contracts, so that the locally made measurement of the rod's length remains unaltered. Likewise, the speed of light slows and the unit of speed decreases so that the locally measured value of the speed of light remains equal to the universal constant.

All we need to do is to find four physical properties for which we know the effect of gravitational potential and form four equations using dimensional analysis, then solve for *m*, *l*, *t* and *q*. We have derived the effect on Energy, we know from experiment the effect on clocks and radio signals and we make the assumption that charge is invariant.

$$\text{Clocks } [T] \leftrightarrow [T]\left(1 - \frac{|\Phi|}{c^2}\right)^{-1} \qquad \text{Speed of light } [L]\,[T]^{-1} \leftrightarrow [L]\,[T]^{-1}\left(1 - \frac{|\Phi|}{c^2}\right)^{2}$$

$$\text{Charge } [Q] \leftrightarrow [Q] \qquad \text{Energy } [M]\,[L]^2\,[T]^{-2} \leftrightarrow [M]\,[L]^2\,[T]^{-2}\left(1 - \frac{|\Phi|}{c^2}\right)^{1}$$

In the weak gravitational fields of the solar system, clocks run slow because the length of the unit of time is increased by a factor $\left(1 - \frac{|\Phi|}{c^2}\right)^{-1}$ and the speed of light is decreased by a factor of $\left(1 - \frac{|\Phi|}{c^2}\right)^2$. In a weak gravity field, the function $e^{\frac{\Phi}{c^2}}$ need only be expanded to its first two terms so that $e^{\frac{\Phi}{c^2}} = \left(1 - \frac{|\Phi|}{c^2}\right)$. This allows us to equate the GR expressions for weak gravitational fields into powers of $e^{\frac{\Phi}{c^2}}$, e.g. $\left(1 - 3\frac{|\Phi|}{c^2}\right)^{-2} = e^{-6\frac{\Phi}{c^2}}$, allowing us to form four equations in m, l, t and q and solve them for l and m.

$$(i) \quad t = -1 \qquad (ii) \quad l - t = 2 \qquad (iii) \quad q = 0 \qquad (iv) \quad m + 2l - 2t = 1$$

two are answers and the other two solve easily to give

$$l = 1 \qquad m = -3 \qquad OH!$$

This is our first indication that all is not as simple it looks. Dimensional Analysis predates relativity and comes from an innocent age when mass was mass. In most instances the dimension [M] refers to inertial mass. We have discovered that in the non relativistic situation, the inertial mass $m_i = m_p\, e^{-3\frac{\Phi}{c^2}}$. The analysis below will show us that gravitational potential affects both electric and magnetic fields in the same way. When an object is in free fall in a gravitational field, loss in potential energy = gain in kinetic energy so there is a simple transfer of energy from the electric fields to the magnetic fields. There is every reason to assume that the kinetic energy contributes to the gravitational mass and that we should write $m_i = \gamma\, m_p\, e^{-3\frac{\Phi}{c^2}}$ to take into account the effect of relativistic velocities.

An object in free fall has a constant energy content. Its total energy $E = m\,c^2$is unaltered. Only when we arrest its fall and make the kinetic energy do work against the arresting force does the $E = m\,c^2$ energy become less.

We can see the effect of gravitational potential on the permittivity and permeability of space whose dimensions are $[M]^{-1}$ $[L]^{-3}$ $[T]^2$ $[Q]^2$ and $[M]^1$ $[L]$ $[Q]^{-2}$ respectively:

$$-m - 3l + 2t + 2q = -2 \Rightarrow \varepsilon_0 \rightarrow e^{-2\frac{\Phi}{c^2}}\,\varepsilon_0$$

$$m + l - 2q = -2 \Rightarrow \mu_0 \rightarrow e^{-2\frac{\Phi}{c^2}}\,\mu_0$$

$$c = \frac{1}{\sqrt{\varepsilon_0\,\mu_0}} \Rightarrow c \rightarrow e^{2\frac{\Phi}{c^2}}$$

Which, if we remember that **Φ** is negative, means that permittivity and permeability are increased by a factor $e^{-2\frac{\Phi}{c^2}}$ with the result that the speed of light calculated from the transit time between planets is slower by a factor of $e^{2\frac{\Phi}{c^2}}$ than the local measurement of the speed of light.

Dicke and Puthoff separately argued that gravitational potential has a physical effect on the permittivity and permeability of space and that this affects the velocity of light, the physical dimensions of matter and the rate of time dependant processes. The author is inclined to go one step further and say that the permittivity and permeability of space relate to the ability of electric and magnetic fields to store energy and that they change because of the loss of energy. Which ever is correct, the net effect is that the equations of physics remain valid and control the physical dimensions of material objects and the rate of time dependent processes.

The power of $e^{\frac{\Phi}{c^2}}$ to be used in understanding the effect of gravitational potential on physical quantities, as calculated by dimensional analysis is given in the table below. Remember **Φ** is negative so these factors are less than 1 unless they include a minus sign. The smallest multiplying constant is on the left of the table.

To describe the effect of gravitational potential on an object multiply by the factor shown.

The methods of dimensional analysis are not entirely reliable because of the different properties which are all called mass. For instance, density is [M] $[L]^{-3}$ but mass in this context is usually measured with a beam balance, so density is physical mass per unit volume. The [M] of dimensional analysis is inertial mass so the calculated factor for density of $e^{-6\frac{\Phi}{c^2}}$ needs interpreting with care.

$e^{3\frac{\Phi}{c^2}}$	$e^{2\frac{\Phi}{c^2}}$	$e^{\frac{\Phi}{c^2}}$	1	$e^{-\frac{\Phi}{c^2}}$	$e^{-2\frac{\Phi}{c^2}}$	$e^{-3\frac{\Phi}{c^2}}$	$e^{-6\frac{\Phi}{c^2}}$
Acceleration	Ang. acc.	Elec. potential	Charge	Time	Energy density	Inertial Mass	Density $_{im}$
Mag. mom.	Speed	Current	Force	Capacitance	Permittivity	Density$_{pm}$	
	Area	Energy	E	Inductance	Permeability		
		Length	H	MI	D		
		Ang. vel.	Ang. mom.		B		
		Torque	h		stress		
		Einstein mass	Φ (mag. flux)				
		Gravitational mass	Ψ (el. flux)				
			Physical mass				

Magnetic moment for a current loop is Area x current. The current is reduced by a factor of $e^{\frac{\Phi}{c^2}}$ because less electrons pass due to the slowing of time dependant processes and the area is obviously reduced by a factor of $e^{2\frac{\Phi}{c^2}}$. If a current loop has magnetic moment M in the absence of gravitational potential, it will be reduced to $e^{3\frac{\Phi}{c^2}} M$.

Inertial mass is force / acceleration. Force is unaltered and acceleration is increased by a factor $e^{-3\frac{\Phi}{c^2}}$. We can interpret this result in the following way. If we could watch from outside a region of high gravitational potential as a mass falls into it, we would see that its acceleration did not increase as we might expect form our calculation of the force of gravity. We would attribute this to an increase in inertial mass. While we cannot perform this observation, what we can do is send a mass through a region of high gravitational potential on a hyperbolic orbit and measure how much longer it takes than the calculated time. Then check this against an integration over its path of the effects on velocity and acceleration. More simply, we might consider a simple oscillator and how an increase in inertial mass by this factor results in the observed increase in the period of oscillation.

Density defined as inertial mass per unit volume does indeed increase by a factor of $e^{-6\frac{\Phi}{c^2}}$ due to the effects on inertial mass and volume. However, density is more usually used in the context of physical mass per unit volume in which case the correct factor is $e^{-3\frac{\Phi}{c^2}}$.

Of the things which are unaffected, charge, electric flux and magnetic flux are fundamental quantised elements of nature. Plank's constant $h = 2e\Phi_0$ is unaffected because its components are unaffected. Force is not a fundamental property of nature. Forces result from the exchange of energy in the process of doing work; work = force x distance. Because energy and distance are both reduced, the force remains unaltered.

Photons and gravity

We distinguish photons from radio waves by the geometry of their electric and magnetic fields. Photons have localised fields and since an elementary charged particle consists of nothing but electric and magnetic fields, photons and particles are quite similar. They differ in the geometry of their electric fields with the consequence that the magnetic fields generated by their motion have different effects. For a particle, the effect causes a Lorentz contraction of the fields and leaves the energy content of the electric field unaltered. The kinetic energy is carried in the magnetic field generated by its motion. In a photon, the electric and magnetic fields are perpendicular and have equal effects on each other, so the distinction between kinetic energy and self energy disappears. A photon is all kinetic energy and instead of it being $\frac{1}{2}m v^2$ as in a particle, it is $m c^2$ counting the $\frac{1}{2}m c^2$ in the electric fields and the $\frac{1}{2}m c^2$ in the magnetic fields. (plural because it has several phases each with its own fields).

When a particle is in free fall, it gains kinetic energy and looses an equal amount of (electric) self energy. When it hits the ground, the kinetic energy is released while the particle with its self energy remains. When a photon is in free fall, there is no distinction between self energy and kinetic energy. It is in this sense quite unaffected by gravity. The only effect is that of gravitational potential on the permittivity and permeability of its fields increasing their ability to store energy with the result that they can travel at a slower speed while still generating the necessary feedback effects between electric and magnetic fields.

The energy content of photons is unaffected by gravity. A photon emitted from the sun appears red shifted because it had less energy when it was emitted than it would have had if the atom which emitted it was on earth. Gravitational red shift is therefore a window into the effect of gravitational potential on energy.

When a photon has a horizontal component to its velocity, the side nearest to the source of gravity will be travelling more slowly than the side further away. This will cause the photon's direction to alter in exactly the same way that light is affected when it passes through a medium which varies in refractive index.

The law of gravity

We have not yet derived the inverse square law. A theory of gravity not only has to explain why there is a force of gravity, but also derive its force law. Let us consider Newton's conclusions. The first was that the force law must be an inverse square law. The second was that the three forms of mass, inertial mass, passive gravitational mass and active gravitational mass must all be equal. (Though it would be more correct to say that passive and active gravitational mass must be equal and that the constant of gravitation G is defined to have the value which makes them equal to the inertial mass.

If we consider weak gravitational fields, then gravity simply inherits its force law from the properties of the electric fields of charged particles. This is because the physical entity which pervades space is the electric flux of elementary charged particles. The flux is continuous and its density (flux per unit area) therefore obeys an inverse square law. This would be an adequate explanation if the force of gravity were proportional to some electric property such as the sum of the magnitudes of the charges on the elementary charged particles $\sum_i |q_i|$ of the matter of the source, but the force is proportional to it mass. This leads us consider the nature of space and the electric field.

Many theories have regarded space as some form of substance. The assertion that space has the properties of permittivity and permeability lives on from Maxwell's understanding of the luminiferous medium as substance. Even Einstein with his insistence that the concept of an aether is superfluous ends up in his general relativity with a very substance like description of space time. The problem with regarding space as a substance is that it results in the view of electric and magnetic fields as being singular in nature. If the electric flux is given by $\vec{D} = \varepsilon_0 \vec{E}$ where $\vec{E} = \sum_i \frac{q_i \hat{r}_i}{r_i^2}$ we have no explanation of the magnetic action of moving charges. Our fundamental assertion is that space as such has no substance, but is pervaded by the substances of the electric fields of all the individual elementary charged particles.

In the author's early attempts to develop a theory of gravity, he thought of space as a compressible substance acted upon by the internal stress $\vec{D}_i \cdot \vec{E}_i$ of the electric fields pervading it. This internal stress is radial, but if space is fluid rather than solid, it converts to a pressure which has no direction. The problem with this concept is that gravitational potential does not squeeze space reducing its volume, but rather, it would seem to pack more volume into space. We see this concept (of GR) expressed in Cosmology's inflation theory. As the universe expands reducing gravitational potential, so space itself is said to expand. The author rejected such a notion as physically impossible.

We can grasp the concept of something being squeezed. Whatever it is that is being squeezed, it is related to the properties of permittivity and permeability. The way in which these two properties are defined depends of the system of units. Much physics is written in older systems of units where they are numbers. Only in SI units do they take on the guise of genuine physical properties. It seems reasonable to suppose that there is a property of space which is responsible for permittivity and permeability and that is this property which we might think of as being squeezed, but such thinking needs to be further refined.

If we consider the effect of gravitational potential on an elementary charged particle, there is a readjustment of the structure of its electric field in which its total energy content is reduced and the structure of field and inner surface of the charge shrink. Since the radius of the charge has decreased, we might expect the energy content to increase by a factor of $e^{-\frac{\Phi}{c^2}}$ since $E_{el} = \frac{q^2}{8\pi \varepsilon_0 a}$, but this is not the case because the permittivity ε_0 increases by a factor of $e^{-2\frac{\Phi}{c^2}}$. It is a matter of historical accident that we have defined permittivity in the way we have. In the context of this discussion, the reciprocal property $\frac{1}{\varepsilon_0}$ would seem to be more fundamental. It would seem to be the property $\frac{1}{\varepsilon_0}$ which is squeezed by gravitational potential.

The energy content of the electric field of an elementary charged particle should then be written $E_{el} = \left(\frac{1}{\varepsilon_0}\right)\frac{q^2}{8\pi a}$. Energy is drawn from both the $\frac{3}{4}m\,c^2$ stored in the electric fields of the elementary charged particles and the $\frac{1}{4}m\,c^2$ which exists as potential energy due to the separation of positive and negative charges. Gravitational potential affects both equally. The direct action of gravitational potential is to reduce the value of $\frac{1}{\varepsilon_0}$ by a factor of $e^{2\frac{\Phi}{c^2}}$, but as a consequence of this the structure of the elementary charged particle reduces in size by a factor of $e^{\frac{\Phi}{c^2}}$ to attempt to compensate. The net result that the energy content is reduced by a factor of $e^{\frac{\Phi}{c^2}}$. The electric potential $\phi = \frac{E_{el}}{2q}$ at the surface of the charge is also reduced by a factor of $e^{\frac{\Phi}{c^2}}$. The reduction in ϕ applies to the whole field and in particular to the potential energy charges have by virtue of their relative position to each other.

If we now consider the action of just two elementary charged particles on each other, it is evident that the gravitational action is reciprocal. They each have this effect on the other causing a reduction in energy content. The structure of each acts as a whole tying together the different properties of each of their electric fields. The effects on ϕ and a and $\frac{1}{\varepsilon_0}$ all relate to the effect on the energy content E_{el} and this process integrates these effects over the total $E = m\,c^2$ energy content. Gravitational action is therefore dependent on energy content rather than charge. This continues to apply as nature assembles a large number of elementary charged particles into a massive body which forms the source of a gravitational field.

The result is that the force of gravity is proportional to mass and obeys an inverse square law.

Strong gravitational fields

We will regard a strong gravitational field as one in which $e^{\frac{\Phi}{c^2}}$ is significantly less than 1. The length of rulers is significantly reduced. If we could use rulers to measure the circumference and radius of an orbit, we would find that the radius was greater than it should be: $r > \frac{C}{2\pi}$. We might venture out in space to a very large orbit where the effect of gravitational potential is negligible, measure its circumference and calculate its radius. If we now measure back from this to a smaller orbit and subtract, we will get yet another value for the radius. This raises the question as to how we should calculate the gravitational potential. The results we have so far obtained regarding the effects of gravitational potential have been independent of the fact that potential is a function of radius. We did not consider moving a mass through a height, but rather from one potential to another.

To gain a better understanding of the effects of gravitational potential, let us consider a system in which a planet is in a highly eccentric orbit and has a moon and that the relative size of the orbits is such that the gravitational potential $\boldsymbol{\Phi}_s$ of its sun may be considered uniform over the planet moon system. We can look at the planet moon system as moving into regions of different background gravitational potential. This is no different from the way our own solar system is moving through the background gravitational potential field $\boldsymbol{\Phi}_g$ of our galaxy. Potential is additive. That means that the effect of gravitational potential is multiplicative:

$$e^{\frac{\Phi_s + \Phi_g}{c^2}} = e^{\frac{\Phi_s}{c^2}} e^{\frac{\Phi_g}{c^2}}$$

Now the radius of the moon's orbit has been calculated locally by equating the force of gravity with centripetal force.

$$\frac{G\,M\,m}{r^2} = F = m\,\omega^2\,r$$

If we now take into account the gravitational potential of the sun, each of the local measurements in the equation must be multiplied by an appropriate power of $e^{\frac{\Phi_s}{c^2}}$. The right hand side is easy to analyse.

$$RHS \qquad e^{-3\frac{\Phi_s}{c^2}}\,m_i \times \left(e^{\frac{\Phi_s}{c^2}}\,\omega\right)^2 \times e^{\frac{\Phi_s}{c^2}}\,r = m_i\,\omega^2\,r$$

The left hand side needs interpretation. If we look at the dimensional analysis results, G would appear to be affected as $e^{8\frac{\Phi_s}{c^2}}$ which is so ridiculous that we have not included it in the table. This is because dimensional analysis treats all mass as inertial mass. If we define G as a universal constant, then the gravitational masses must be affected. Since the LHS is of the form, $G\,\frac{Mm}{r^2}$ the effect on gravitational mass must be the same as the effect on rulers giving the correct analysis:

$$LHS \qquad \frac{1G \times e^{\frac{\Phi_s}{c^2}}\,M_{ag} \times e^{\frac{\Phi_s}{c^2}}\,m_{pg}}{\left(e^{\frac{\Phi_s}{c^2}}\,r\right)^2} = \frac{G\,M\,m}{r^2}$$

So we see that the masses on the left hand side are in fact gravitational masses which are affected in quite a different way by the sun's gravitational potential. Because gravitational potential is additive and its effects are multiplicative, it follows that what is true for the planet moon system is true for the sun planet system.

The orbital radius of the planet moon system is multiplied by a factor $e^{\frac{\Phi_s}{c^2}}$. The orbit shrinks as the planet moon system enters regions where the magnitude of the sun's gravitational potential $\boldsymbol{\Phi}_s$ is greater. It is interesting to note that the planet's gravitational potential $\boldsymbol{\Phi}_p$ in the region of the moon's orbit is invariant:

$$\frac{1G \times e^{\frac{\Phi_s}{c^2}}\,M_{ag}}{e^{\frac{\Phi_s}{c^2}}\,r} = \frac{G\,M}{r}$$

We can now apply this to the planet's orbit remembering that $\boldsymbol{\Phi}_s$ is a function of the distance from the sun.

- The sun's gravitational mass M_{ag} is affected by its own gravitational potential field and is smaller by a factor of $e^{\frac{\bar{\Phi}_s}{c^2}}$. (Note: we use an average value $\bar{\boldsymbol{\Phi}}_s$ for $\boldsymbol{\Phi}_s$ because it varies throughout the body of the sun.)
- The planet's passive gravitational mass m_{pg} is smaller by the factor $e^{\frac{\Phi_s}{c^2}}$.

- The planet's orbit is smaller by the same factor.
- The gravitational equipotential spherical surfaces about the sun are reduced in radius by the same factor.

When we are describing the effects of a gravitational potential field, we say that rulers shrink, so that if we measure the circumference of an orbit with a ruler, the answer will be too big. This simplistic statement does not take into account the fact that an orbit is controlled by physical laws; it is not just a geometrical object. This raises the thorny question which arises in all theories of relativity "What exactly is being mapped onto what?" As the planet moves into regions of different gravitational potential, the moon's orbit contracts and expands. We have to map the orbit onto itself for various values of $\mathbf{\Phi}_s$. We cannot map the geometrical circle in Euclidean space onto itself. The planet's orbit is smaller because of the effect of the sun's gravitational potential, but the measured circumference of the orbit has the correct value for use in the formulae:

$$F = \frac{G\,M\,m}{r^2} \qquad \mathbf{\Phi} = -\frac{G\,M}{r}$$

The local measurements and calculations give numerical values of physical mass M, m and orbit circumference $2\pi\,r$ which are all too big by a factor of $e^{-\frac{\Phi_s}{c^2}}$ and these factors cancel to give the correct answer for the force and potential.

$$\mathbf{\Phi} = -\frac{G\,M_p}{r_c}$$

The correct force and potential may also be calculated from the Euclidean radius and the reduced gravitational mass.

$$\mathbf{\Phi} = -\frac{G\,M_g}{r}$$

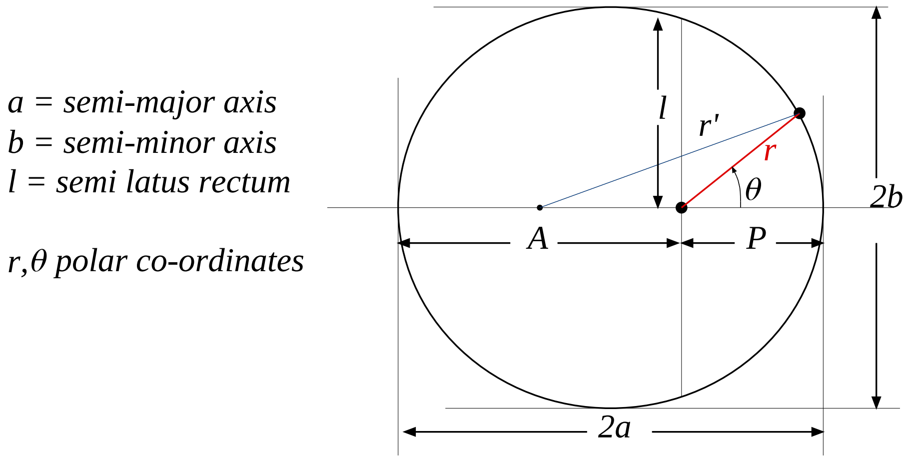
Advance of the perihelion of Mercury

In Newton's analysis, the planet knows only its mass, velocity and the force acting on it in the infinitesimal element of time. This causes its velocity to change over time. Unknown to the planet, Newton's mathematics then shows that the planet traces out an ellipse. It must be emphasised that nature knows nothing of the ellipse, only of the local action in the moment of now.

The mathematics of the ellipse is not easy. Some of its properties are beautiful, others are bastards. For instance, its area is $\pi\,a\,b$ (where a and b are the maximum and minimum radii from its centre) but there is no simple expression for the length of its arc. There are a number of ways of drawing a true ellipse, (but draughtsmen often use a quick method with compasses which does not produce a true ellipse). An ellipse has two foci which are the points where you put the pins to draw an ellipse with a loop of string and pencil. The elliptical orbit of a planet has the sun at one of its foci. The nearest distance P to the sun is at the perigee and the longest A at the apogee. The distance when the radius is perpendicular to the major axis is called the semi latus rectum l. We can write an equation in polar co-ordinates for the ellipse:

$$r = \frac{l}{1 + e\,cos\theta}$$

where e is the eccentricity.



$$A = \frac{l}{1-e} \qquad P = \frac{l}{1+e} \qquad a = \frac{A+P}{2} \qquad b = a\sqrt{1-e^2} \qquad r + r' = A + P$$

We have discovered that gravitational potential affects the local situation. The action of force on mass and velocity takes place in the local situation. The planet knows only its rate of change of direction. The only local indicator of direction is the equipotential surface of gravitational potential. We are familiar with this concept on earth where we call it the "water level". The equations of motion take place against the "water level". The local rate of change in direction is described by an angular velocity which we shall call $\frac{d\psi}{dt}$. Locally we have clocks and can integrate $\frac{d\psi}{dt}$ over a period of time until we get $\psi = 2\pi$. At this point, the angle between the planet's velocity and the "water level" has returned to its original value and we can say that, from its point of view, the planet has completed an orbit.

It is not possible to describe an elliptical as a nice function of time in the way that we can describe the parabola as $x = a\,t^2,\ y = 2\,a\,t$ or the circle as $x = r\cos(\omega\,t),\ y = r\sin(\omega\,t)$. So Newton's analysis of planetary motion has to derive properties of the orbit and match these to the geometry of the ellipse. This makes the task of authors trying to derive the advance of the perihelion from general relativity very difficult for their readers will not have the mathematical background to understand the basic method of deriving the equation of the ellipse from the differential equation of motion. Fortunately, this problem does not arise in the theory we present here.

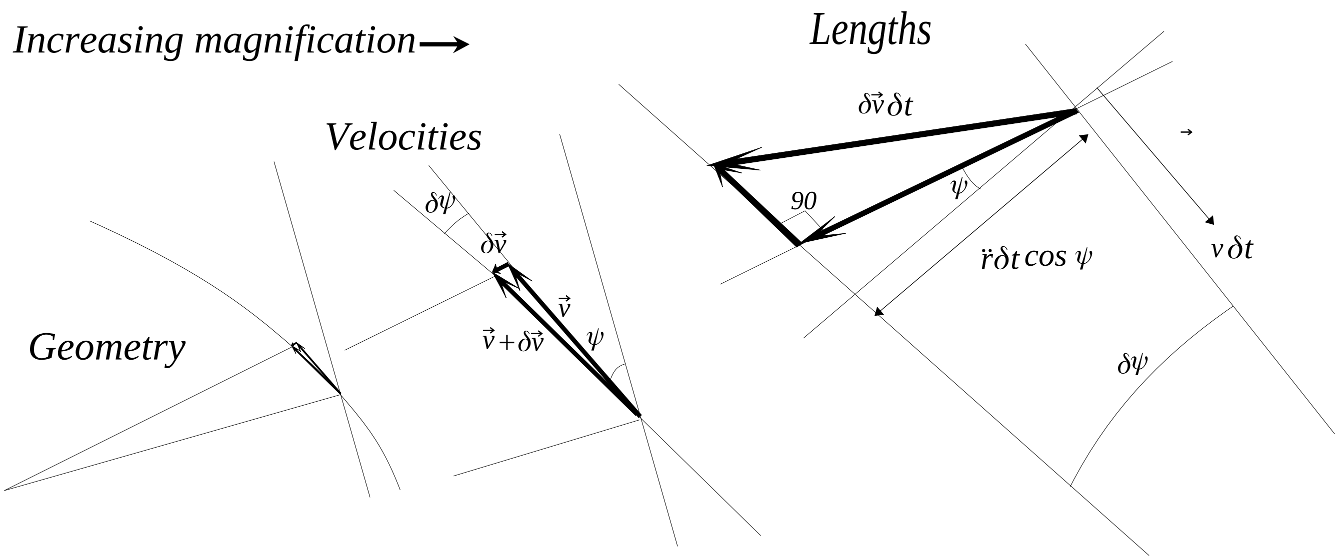
Let us return to our fundamental assertion that there is no such physical entity as space time. It is merely a mathematical artefact describing the numbers we get when we use rulers and clocks to set up co-ordinate systems. The co-ordinate system which we use to describe a planet's orbit are therefore those of Euclidean space and Newtonian time which use units of magnitude as defined in the absence of gravitational potential. The only relevant local effect is that on mass. As we have seen above, inertial mass is increased by a factor $e^{-3\frac{\Phi}{c^2}}$.

The increase in inertial mass has the effect of reducing the radial acceleration. We need to understand the relationship between the radial acceleration $\ddot{r}$ and the rate of rotation $\dot{\psi}$ of the direction. The observed orbit is a supposition of two motions, an elliptical orbit and a very slow rotation. In a perfect elliptical orbit, the direction of the planets path is only perpendicular to the radius from the sun at apogee and perigee. It is most convenient to measure the angle ψ between the direction of the path and the instantaneous line of the normal to the radius, since this lies in the equipotential surface. The affect of the acceleration $\ddot{r}$ is to vary ψ and we can identify an angular velocity $\dot{\psi}$. But as the planet progresses around its orbit, the instantaneous line of the normal to the radius has to be repeatedly redraw. Its direction also has an angular velocity $\dot{\theta}$ and the variation of ψ with time is given by:

$$\psi = \int_0^t \dot{\psi}\,dt - \int_0^t \dot{\theta}\,dt$$

The fact that we do not know the actual functions $\psi(t)$ and $\theta(t)$ does not matter. The advance of the perihelion occurs because gravitational potential effects $\dot{\psi}$ and the time for $\int_0^{T_\psi} \dot{\psi}\, dt = 2\pi$ is greater than the time for $\int_0^{T_\theta} \dot{\theta}\, dt = 2\pi$. Thus, starting at the perigee, when $\psi = 0$; at the next perigee, $\theta > 2\pi$ and the perigee has advanced.

The diagram shows the basic geometry at three magnifications. We have superimposed a vector triangle on each, the first two are velocity vectors and the third "journey" vectors.



In time δt, the planet moves $(\vec{v} + \delta\vec{v})\delta$t. The velocity $\delta\vec{v}$ has components parallel and perpendicular to $\vec{r}$. Only the component parallel to $\vec{r}$ affects the change in direction because the other component vanishes in the limit $\delta t \rightarrow 0$. The diagram is difficult to draw. In the process of exaggerating angles which tend to zero, the two components no longer actually look perpendicular, The right hand magnification shows the component $\ddot{r}\, \delta t$ of $\delta\vec{v}$ at an angle ψ to the perpendicular to the path, so the critical length is $\ddot{r}\, cos\theta\, \delta t$ and the increment in angle is:

$$\delta\psi = \frac{\ddot{r}\, cos\theta\, \delta t}{v} = \frac{\ddot{r}\, r\, \dot{\theta}}{v^2}\, \delta t$$

$$\dot{\psi} = \frac{\ddot{r}\, r\, \dot{\theta}}{v^2}$$

A planet's orbit is observed from afar noting the changes in its position against the background stars as seen by an observer. The parameters r, v, $\dot{\theta}$ and $\ddot{r}$ are calculated from these observations. Those related to position are the absolute measurements made from afar. The only local action is that of the accelerating force in Newton's law $\vec{F} = m\,\vec{a}$. We know that the inertial mass is increased by a factor $e^{-3\frac{\Phi}{c^2}}$ which would reduce the acceleration by a factor of $e^{3\frac{\Phi}{c^2}}$, therefore:

$$\text{When } T \text{ satisfies } \int_0^T d\psi = 2\,\pi \text{ , then } \int_0^T d\theta = 2\,\pi\, e^{-3\frac{\Phi}{c^2}} \qquad \Rightarrow\ T_\psi > T_\theta$$

The orbital period T is greater from perigee to perigee than position to position. This gives an advance of the perihelion by $2\,\pi\, e^{-3\frac{\Phi}{c^2}}$ radians per orbit which is 43 seconds of arc per century.

Since the gravitational potential varies over an elliptical orbit, we take a weighted average value of the gravitational potential. We have only used the eccentricity of the orbit to allow us to identify the perigee. The first order effect of gravitational potential is therefore independent of the eccentricity of the orbit. There is a second order effect caused by the fact that the angular momentum $m\, r^2 \dot{\theta}$ is a constant. Variations in gravitational potential over the orbit cause small changes in both $\dot{\psi}$ and $\dot{\theta}$. Although these average out over the orbit, the planet spends more time close to the sun because of the effect of gravitational potential on its inertial mass. This will affect the way we calculate the average radius to use in calculating the average gravitational potential. We have not attempted this analysis, but borrow the empirical result first calculated by Gerber and quoted in GR derivations:

$$\frac{24\,\pi^3\,a^2}{T^2\,c^2\,(1\,-\,e^2)}\text{ radians per orbit}$$

which is more simply expressed in terms of the semi-minor axis as $\frac{24\,\pi^3\,b^2}{T^2\,c^2}$. This gives us the length of the semi-minor axis as the appropriate weighted average for r in calculating the gravitational potential $\Phi\;=\;\frac{GM}{r}$ for substitution into $e^{-3\frac{\Phi}{c^2}}$.

Bending of light

Photons do not feel the force of gravity. Particles feel the force of gravity because gravitational potential drains part of the particle's self energy from its electric fields. If the particle is in free fall, the lost energy is transferred into kinetic energy within the magnetic fields generated by the particle's motion. A photon is all kinetic energy stored equally in electric and magnetic fields and it is always in free fall. Any liberated energy is passed straight back into its fields as kinetic energy so it neither looses nor gains energy with changing gravitational potential.

Photons are not point like objects but have a width. Newton's original analysis for a "corpuscle" of light passing through the boundary between two media of different refractive index applies equally to photons. The same theory has been developed for media of variable refractive index. The same analysis applies to light in a gravitational field. It is well established in optics that Newton's corpuscular theory and Huygens' wave theory are equivalent. We can therefore apply Huygens' analysis to radio waves.

The speed of light through Euclidean space is affected by gravitational potential:

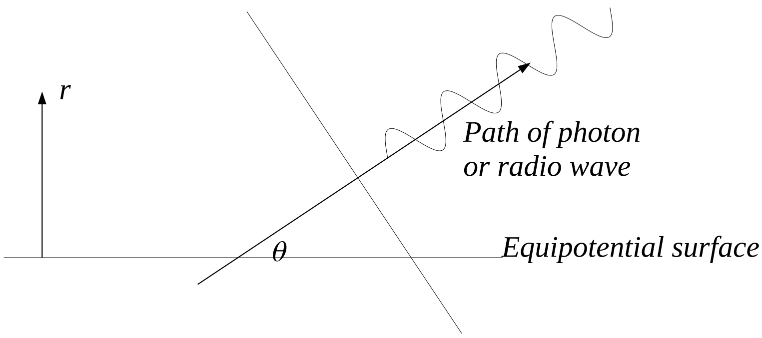
$$c_\Phi\;=\;e^{2\frac{\Phi}{c^2}}\,c$$

We consider a photon or radio wave travelling at an angle θ to the equipotential surfaces and in particular the velocity gradient across a plane perpendicular to its path. This is obviously $cos\theta\,\frac{d}{dr}c$.

$$\frac{d}{dr}c_\Phi\;=\;\frac{d}{dr}e^{2\frac{\Phi}{c^2}}\,c\;=\;\frac{2}{c^2}e^{2\frac{\Phi}{c^2}}\,c\,\frac{d}{dr}\frac{-GM}{r}\;\;=\;\frac{2}{c}e^{2\frac{\Phi}{c^2}}\,\frac{GM}{r^2}$$

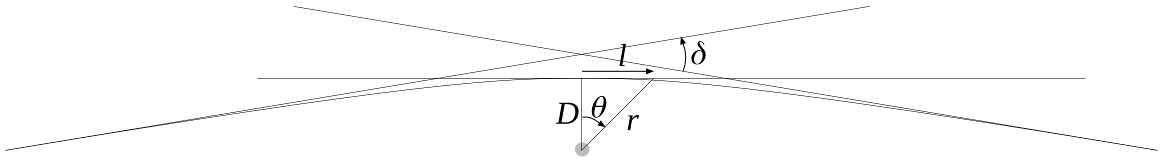
Now $e^{2\frac{\Phi}{c^2}}\;\cong\;1$ and $\frac{GM}{r^2}\;=\;g$, the acceleration due to gravity, so the velocity gradient is $\frac{d}{dr}c_\Phi\;=\;\frac{2g}{c}$ and the velocity gradient across the plane perpendicular to its path is:

$$\frac{dc}{dr}\;=\;\frac{2\,g}{c}\,cos\,\theta$$



If we consider for one moment a spinning disk, the velocity is $\omega\,r$ and the velocity gradient is $\frac{d}{dr}\omega r\;=\;\omega$. The velocity gradient across a photon or wave front is therefore equivalent to the curvature of its path and an angular velocity of the direction of its path.

It is customary to integrate this over the length of the path of a light ray passing a gravitational source at a closest distance D. This is done most simply by expressing everything in terms of D and θ, integrating from 0 to $\frac{\pi}{2}$ and doubling the result. Note that we need to change the rate of change of direction with time $\frac{d\delta}{dt}$ into a rate of change with path length using $\frac{d\delta}{dt} = \frac{1}{c}\frac{d\delta}{dl}$.



$$l = D \tan\theta \qquad \frac{d\delta}{dt} = \frac{1}{c}\frac{d\delta}{dl} \qquad dl = D \sec^2\theta \, d\theta \qquad r = D \sec\theta$$

$$\delta = 2\frac{2}{c}\int_0^\infty \frac{GM}{r^2}\cos\theta \frac{1}{c}dl = \frac{4GM}{c^2}\int_0^{\frac{\pi}{2}} \frac{D\sec^2\theta}{(D\sec\theta)^2}\cos\theta \, d\theta = \frac{4GM}{c^2 D}\int_0^{\frac{\pi}{2}}\cos\theta \, d\theta$$

$$\delta = \frac{4GM}{c^2 D}$$

Light passing within a distance D of a star of mass M will be deflected through an angle of $\frac{4GM}{c^2 D}$ radians.

Massive neutron stars

The metrics of GR coincide with the much earlier prediction of Rev. Michell that light cannot escape from within a radius $r = \frac{2GM}{c^2}$. GR then predicts and defines an event horizon at this radius. However, the logic behind this depends on the use of weak field approximations and the order in which they are applied giving either $\left(1 - \frac{|\Phi|}{c^2}\right)^2$ or $\left(1 - 2\frac{|\Phi|}{c^2}\right)$. We assert that the expression $\left(1 - 2\frac{|\Phi|}{c^2}\right)$ derived through weak field approximations coincides with the first two terms of the exponential function $e^{2\frac{\Phi}{c^2}}$. This is consistent with our previous proof that the effects of gravitational potential are to multiply by powers of $e^{\frac{\Phi}{c^2}}$.

While Einstein would seem to have worked backwards from Rev. Michell's prediction in formulating his theory, our correction to the metric replacing $\left(1 - 2\frac{|\Phi|}{c^2}\right)$ with $e^{2\frac{\Phi}{c^2}}$ leaves no room for the prediction of an event horizon.

From the above discussion in previous sections, it would seem that there are two factors mitigating against the collapse of a neutron star to a singularity. The first is the nature of the function $e^{2\frac{\Phi}{c^2}}$ and the second is the reduction in gravitational mass. The question is whether or not these are enough to prevent the collapse of a sufficiently massive neutron star. This is further complicated by the fact that as the star collapses, potential energy is converted into kinetic energy. The gravitational mass cannot reduce without a dissipation of the kinetic energy. The collapsing star must therefore radiate energy. It is also reasonable to assume that much of the kinetic energy will be stored in the rotation of the star.

A star does not suddenly become a neutron star, but evolves into one as temperatures and pressures favour electron capture and iron nuclei embark on a decay cycle which turns them into a neutron fluid. If the star is massive enough, a point is reached when the gravitational potential at its centre due to its own mass becomes sufficient to significantly increase the density of physical mass per unit Euclidean volume. However, the effect of gravitational potential in reducing gravitational mass prevents this from turning into a runaway process which results in a black hole.

As we have seen, gravitational potential is additive and its effects multiplicative. This gives us a method of modelling the process of constructing a neutron star. This is obviously not the way nature constructs neutron stars, but it is a well proven mathematical technique used in the classical calculation of gravitational potential and force. We start with a small core and then build it up by bringing in shells of material from afar. Each new shell of mass $m_i = \delta m$ will have a constant potential inside it equal to $-\frac{G\,\delta m}{r_i}$, so its effect on the assembly of shells within will be to reduce the dimensions of each of the shells which have already been added by a factor $e^{-\frac{G\,\delta m}{c^2 r_i}}$. But the new shell is influenced by the gravitational potential of the existing star which has so far been built up. This means that both δm and r_i are affected and we must calculate the gravitational potential with care. We have shown that gravitational potential can be calculated in two ways:

$$\Phi = -\frac{G\,M_p}{r_c} = -\frac{G\,M_g}{r}$$

either using physical mass M_p and the radius r_c calculated from the circumference as measured with a ruler or gravitational mass M_g and Euclidean radius r .

The first principle of the classical derivation is that the gravitation potential due to a thin spherical shell is constant within that shell giving $\Phi_{i,int} = \frac{G\,m_i}{r_i}$. If we now surround that shell with another shell of mass m_j and radius r_j, we increase the magnitude of the gravitational potential within by $\Phi_{j,int} = -\frac{G\,m_j}{r_j}$ with the result that every Euclidean length within m_j is reduced by the factor $e^{\frac{\Phi_j}{c^2}}$. But the gravitational mass of every m_i within m_j is also reduced by the same factor, so every Φ_i within m_j remains constant. That is to say that with the addition of the j_{th} shell, the potential due to the existing i shells, as measured at points within the mass, is unaffected.

Because the locally measured value of the radius r_c of each existing shell remains constant, as additional shells are added we may use the locally measured radius r_c as the independent variable. This allows us to work in terms of the physical mass of the shells. If each new shell has a surface area of $4\pi\,r_c^2$ and a thickness δr_c, its volume will be $4\pi\,r_c^2\,\delta r_c$ in local units of volume. Measuring volume in local units gives a constant numerical result because the unit of length is affected in the same way as is length, and likewise for volume. The physical mass is therefore:

$$\delta m_p = 4\pi\,\rho\,r_c^2\,\delta r_c$$

As successive shells are added, a particular shell j is reduced in Euclidean size, however, its numerical thickness, radius, surface area and volume expressed in local units remain constant. The gravitational potential within it, due to its mass also remains constant.

If we were able to wonder around within the star making local measurements with a ruler in order to calculate its volume, we would find everything consistent with the local parameter r_c and would be quite unaware of the distortions of the star's interior relative to Euclidean space. Thus we would find that the volume of the star as the sum of locally measured divisions was equal to $\frac{4}{3}\pi\,R_c^3$ where R_c is the locally measured radius of the star. Our parameter r_c is thus good for calculating the physical mass of the star from its locally measured density ρ (physical mass per local unit volume) and outer radius. This allows us to determine R_c from its physical mass and the density of neutron fluid.

$$R_c = \sqrt[3]{\frac{3\,M}{4\pi\,\rho}}$$

In the classical derivation, the gravitational potentials at the centre and at the surface of a spherical mass of uniform density are:

$$\Phi_c = -\frac{3\,G\,M}{2\,r} \qquad \Phi_s = -\frac{G\,M}{r} \qquad \Phi_c = \frac{3}{2}\Phi_s$$

and the mathematical derivation of them using the Euclidean measurements and the independent variable r have a one to one correspondence with our calculations in terms of our parameter r_c, so we may conclude that:

$$\Phi_c = -\frac{3\,G\,M_p}{2\,r_c} \qquad \Phi_s = -\frac{G\,M_p}{r_c}$$

And we can take the classical result for the gravitational potential at some distance a from the centre of sphere and within its mass and perform the same mapping to give:

$$\Phi_a = -G\,M\,\frac{3\,r^2 - a^2}{2\,r^3} \rightarrow \Phi_a = -G\,M_p\,\frac{3\,r_c^2 - a_c^2}{2\,r_c^3}$$

Thus we can determine the effects of gravitational potential within the star in terms of these parametric values.

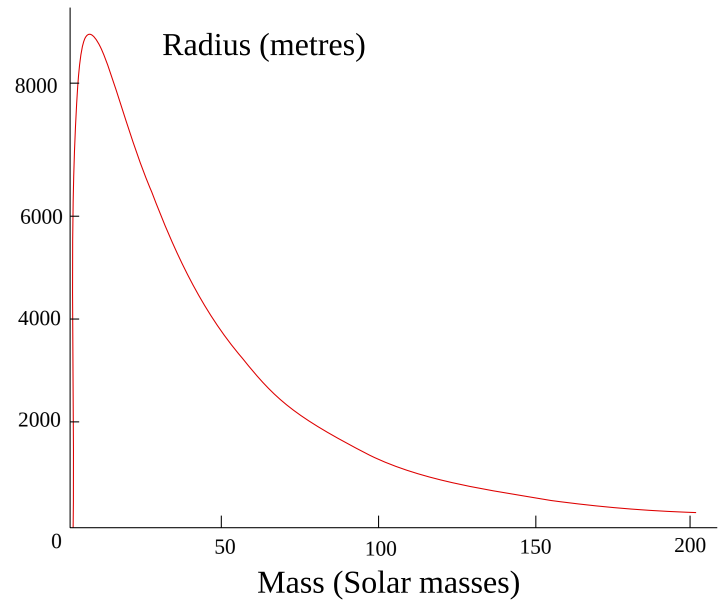
Substituting $R_c = \sqrt[3]{\frac{3\,M}{4\pi\,\rho}}$

$$\Phi_s = -G\,M_p\sqrt[3]{\frac{4\pi\,\rho}{3\,M_p}} = -G\sqrt[3]{\frac{4\pi\,M_p^2\,\rho}{3}}$$

The Euclidean radius of the star is thus:

$$R = e^{\frac{-G\sqrt[3]{\frac{4\pi\,M_p^2\,\rho}{3}}}{c^2}}\sqrt[3]{\frac{3\,M}{4\pi\,\rho}}$$

This is a well behaved function, however the nature of the exponential function means that as a neutron star increases in mass, a point is reached when its Euclidean radius starts to decrease. Because of the power of the exponential function, very massive stars will collapse towards a very small, but finite size. The maximum Euclidean diameter of neutron star is just under 19 km for 5.26⊙ (⊙ unit equal to mass of sun is read "solar masses") and one of 883⊙ would have the Euclidean size of a golf ball. The following graph was copied form one generated by Mathcad.



Conclusion

Our theory of gravity passes the traditional experimental tests which have been used to justify Einstein's theory.

We do not predict the existence of black holes and singularities, but do predict that massive neutron stars will have properties which make them appear very similar to black holes.

Unlike Einstein's theory, its mathematics is within the grasp of any engineering graduate and should be a joy for physics undergraduates. These derivations are within the grasp of the more able students to understand and be able to reproduce under examination conditions!