Theory of Everything

Gravitational attraction and mass as electromagnetic phenomena

When Einstein attempted to find the link between gravity and electromagnetism, neutrons were hard balls of mass with no charge. We now know that neutrons and protons all consist of 3 charged particles. The task of explaining gravity in terms of the electric and magnetic properties of matter is made possible by this discovery.

In my paper "Theory of Everything - Inertial Mass as an Electromagnetic phenomena", I show how spherical electric charges posses the property of inertia quite apart from any magic ingredient called mass. It is possible to model real matter with atoms assembled of nothing but spherical electric charges of the appropriate charge and radius. Such matter will obey Newtons Laws of motion and will have the property of inertial mass. The fact that such a model works is strong evidence for the suggestion that the mass of real matter derives from the effects described in this theory. In this paper I will show that in a universe composed of this model matter, gravitational attraction will exist and the matter will have the property of gravitational mass.

We start with some simple mechanics. Imagine a room with a solid floor and a ceiling supported by wood joists. We fix two rails to the ceiling and the floor on which frictionless sliders are free to move. We now stretch a powerful spring between floor and ceiling hooking it to these sliders. We will imagine that our primary purpose was to store energy in the spring. We find that as we carry out this process, the rail attached to the ceiling bends slightly as the ceiling joists deflect under their increased load. The result is that we stretch the spring slightly less than we expected to storing less energy in the spring than was expected. We do however store energy in the ceiling. If the amount of energy stored in the ceiling is $\mathcal{E}$, then the amount by which the energy stored in the spring fell short of its expected value is $2\mathcal{E}$. The amount of work we have to do to extend the spring is less by an amount $\mathcal{E}$ than it would have been if the ceiling was perfectly rigid. This is a very general principle. I call it the "Brace Principle" and state it thus

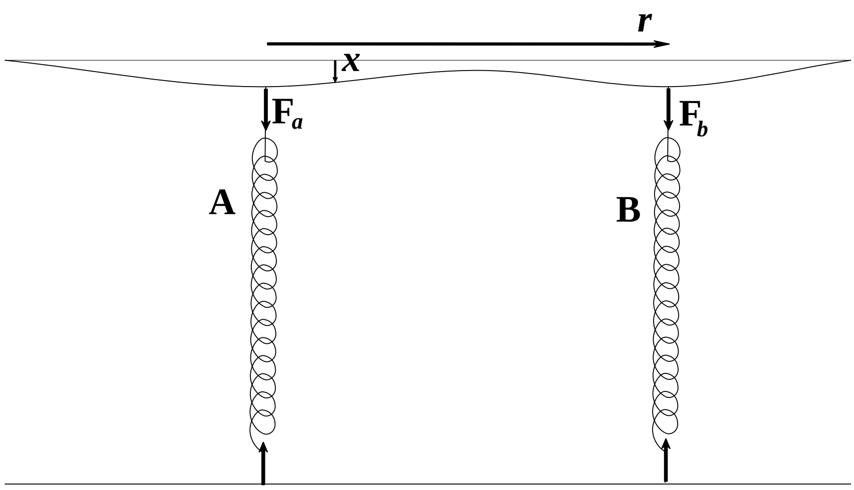
It is impossible to store energy in a single component. The component must always be braced against one or more other components which act as a brace. Energy will also be stored in the brace.

If we stretch a second spring between the rails immediately beside the first, the distortion of the ceiling will increase by a factor of 2 resulting in $4\mathcal{E}$ being stored in the ceiling. There are now two springs and the shortfall in the energy stored in each is doubled giving $8\mathcal{E}$. Thus the total energy stored is $4\mathcal{E}$ less than it would have been if the ceiling was perfectly rigid. If we had stretched the second spring between the rails a long way from the first spring, the deficit would only be $2\mathcal{E}$.

If we stretch the springs between the rail close to each other and then wish to pull the springs apart, we have to do work equal to $2\mathcal{E}$. We conclude from this that a force exists pulling the springs together against which we have to do work. When we look closely at the top rail, we see that the distortion of the rail caused by each spring gives the rail a slight gradient in the region where the other spring is attached. This gradient results in the tension of the spring being directed at a slight angle to the perpendicular to the rail giving it a component towards the other spring.

This situation is an analogue of gravitational attraction.

Let us formalise the mathematics. Two springs are connected between the rails.



We show only the forces exerted by the springs. The total displacement of the ceiling is x_t and we assume this to be the sum of two displacements, one caused by each force.

$$x_t = x_a + x_b$$

Where x_a and x_b are each functions of the distance along the rail from the point of application of each force.

If y is some arbitrary measure of distance along the rail and spring A is at y_a and B at y_b, then x_a and x_b can be expressed as arbitrary functions of y.

$$x_a = f_a(y - y_a) \ : \ x_b = f_b(y - y_b)$$

The only requirement of these functions is that they can be differentiated once. We simplify this further by assuming that $f_a()$ and $f_b()$ can be expressed in terms of the forces F_a and F_b, the modulus λ of the ceiling and a more universal function.

$$f_a() = \frac{F_a}{\lambda} f() \ : \ f_b() = \frac{F_b}{\lambda} f()$$

Following the usual definition of a modulus, the magnitude of λ would be such that $f(1) = 1$. If we imagine spring A to be fixed and measure the distance r along the rail from it towards spring B. The displacement at the point of attachment of spring B is

$$\begin{aligned} x_{tb} &= x_{ab} + x_{bb} \\ &= \frac{F_a}{\lambda} f(r_b) + \frac{F_b}{\lambda} f(0) \end{aligned}$$

where r_b is the distance from spring A to spring B. We read the first line as "Total displacement at B = displacement due to A at B plus displacement due to B at B".

We assume that x is small compared with the extension of the springs so that the forces F_a and F_b remain fairly constant over the range of the distortions of the ceiling. As the springs are stretched and hooked onto the ceiling, we have to do less work than would be the case if the ceiling were rigid. This is because the energy needed to displace the ceiling is one half of the force times the displacement, whereas if the spring had to be stretched that very small extra distance, the work would be equal to the force times the distance since the force remains fairly constant during this small extra extension. Let us call this saving in energy $\mathcal{E}_s$, then

$$\mathcal{E}_s = F_b x_{tb} - \frac{1}{2} F_b x_{tb}$$

$$= \frac{1}{2} F_b x_{tb}$$

$$= \frac{1}{2} F_b \left(x_{ab} + x_{bb} \right)$$

We can now calculate the rate of change in energy stored in the system as B moves relative A. If we move B away from A, we do work equal to the distance moved times the force attracting B to A. Thus the rate of change, $\frac{d\mathscr{E}_s}{dr}$, is equal to a force on B caused by A. As we move B, x_{ab} varies but x_{bb} remains constant.

$$F_{ab} = \frac{d\mathscr{E}_s}{dr}$$

$$= \frac{1}{2} F_b \frac{d}{dr} x_{ab}$$

$$= \frac{1}{2} F_b \frac{d}{dr} f_a \left(r_{ab} \right)$$

$$= \frac{1}{2} F_b \frac{d}{dr} \frac{F_a}{\lambda} f \left(r_{ab} \right)$$

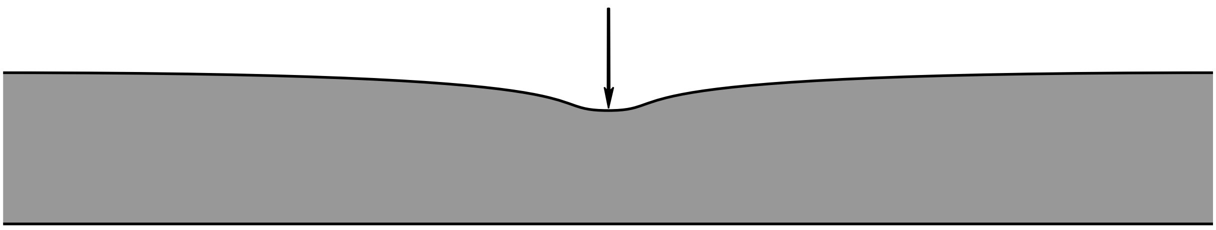
$$= \frac{1}{2\lambda} F_a F_b \frac{d}{dr} f \left(r_{ab} \right)$$

This is one of the most significant results in theoretical physics and it comes from the consideration of a simple mechanical system. Note how general the result is for it depends on very few factors.

- That the energy is stored in something
- That the force which has to be exerted to keep the energy stored is braced against something
- That the brace is distorted slightly and that the distortion extends over a region
- That where energy is stored in more than one thing hooked to the same brace, the distortions are addative.

There is then a force, perpendicular to the two forces required to keep the energy stored, between the things the energy is stored in.

There is one aspect of the analogue model of the springs hooked between two rails which we have so far overlooked. It works because the rail attached to the ceiling possesses stiffness and the force exerted on it by the spring is transmitted to the ceiling along a considerable length of the rail. We need models to aid our development of concepts. In the General Theory of Relativity, we have used the model of the stretched rubber sheet to show in one plus two dimensions how gravity works in one plus three dimensions. I want us to imagine a similar model, but this time instead of deriving its mechanical properties from a stretched rubber membrane, I want us to imagine a sandwich of foam between two sheets of stiff plastic sheet. Away from the immediate vicinity of the impressed force, the model exhibits exactly the same features as the rubber sheet model, but in the vicinity of the impressed load, the shape of the distortion is controlled by the mechanical properties of the components of the sandwich.



We have every reason to believe from experimental evidence that the force of gravity obeys an inverse square law over distances ranging from a few centimetres to the radius of the outer planets, but how far can we extend that range. Newton as a mathematician saw no limits, but the range from $\frac{1}{\infty}$ to ∞ is very considerable. Clearly, the shape of the surface in the diagram is different from the shape we would need to give us an inverse square law over such a range. There is experimental evidence in the form of the measured velocities the stars of our galaxy that the galaxy is not rotating fast enough to generate the centrifugal force needed to overcome the force of gravity as predicted by the inverse square law. Cosmologists assume the correctness of the inverse square law and deduce the presence of dark matter beyond the stars of the galaxy. It would be just as logical to cast doubt on the range over which the inverse square law is maintained.

We already have an example in classical physics which points us in the right direction. If we take a glass rod with a metal cap at each end, mount it in a rig to measure its length and then generate a strong electrostatic field between its ends, the rod will contract in length. Some ionic crystals will show considerably greater effects and a class called piezoelectric crystals are used to generate ultrasonic noise. The point to be made is that when we store energy in a dielectric medium, we generate internal electric forces which would crush the medium if it were not a rigid structure. The storing of electrical energy in the dielectric has to be braced against its crystal structure. It is impossible to store electrical energy without also storing mechanical energy in the crystal structure which acts as a brace.

The electric polarisation of a dielectric medium stores energy in the medium because it is corpuscular in nature. Within each atom or molecule, the average position of electric charge is displaced and this is the mechanism for energy storage. Space on the other hand does not have a corpuscular nature and we cannot immediately assume that the storage of energy in an electric field in space is similar. Space is able to support electric polarisation because it possesses both electric positiveness and electric negativeness throughout all space which can be displaced relative to each other.

To describe the electric field surrounding an electric charge, we need to describe three things. The energy density of the field; the ability of the field to exert a force on another charge and the electric potential of the field. The energy density and the electric potential are fundermental properties of the field while its ability to exert a force on another charge is side effect of them. We need at least four dimensions to describe the electric field. To the three dimensions of length width and height, we must add a fourth dimension in which electric potential exists. The experiments originally performed by Reiss and by Kohlraush in which a parallel plate capacitor is charged with static electricity and connected to an electrostatic voltmeter and the distance between the plates varied, affecting the potential difference between them, indicates that electric potential is not simply a mathematical artefact, but is a real physical presence. This is because the electric field at the surface of the plates remains unchanged and no charge is moving between the plates. Unless electric potential has a real existence, the plates and their surface charge should be unable to sense that the distance between them has changed. We thus require a fourth dimension which is perpendicular to the three dimensions of length, height and width. Only three extended dimensions can be fitted together perpendicular to each other, so this fourth dimension must be non-extended.

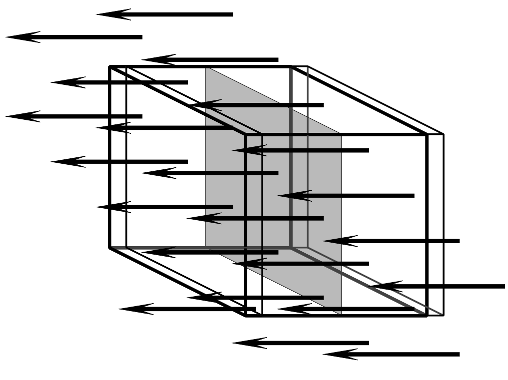
An electric field is transmitted through space geometrically in rather a strange fashion quite unlike any mechanical process with which we might try to model it. A gas is able to transmit pressure in every dimension while a steel bar can transmit a force along its length. The electric field from a charge is transmitted outwards in such a way that the total force transmitted remains constant. This is the mechanism by which electric forces obey an inverse square law. We might imagine a small spherical hole in the middle of a large mass of steel and consider what would happen if we could create great pressure within it. The pressure would cause the hole to expand putting the steel under local stress which would stretch the steel circumferentially and compress it radially. A physical constant called Poisson's ratio determines the way in which the steel transmits the total outward force. We can see what happens if we imagine a thin spherical shell of the steel. The circumferential tension acts as a soap bubble exerting a pressure. The sum of this pressure over the area of the shell reduces the total outward force transmitted through the shell. So as we move away from the hole, the pressure falls faster than it would with an inverse square law. So we are unable to model the outward transmission of electric field from a charge in a simple mechanical model. Any attempt to see the electric field as braced against the three dimensional structure of space just produces silly results.

To understand the force of gravity, we need to understand that the energy held in the electric field of a charge is held in place by an electric potential which is hooked to the fabric of space in the dimension in which the potential exists. We can only think of this in terms of models of not more than three dimensions because we are creatures of three dimensions who have such difficulty in understanding perspective in painting that we probably have only two dimensional minds!

The Brace Principle gives us the basis for a possible explanation of the mechanism by which gravity acts, but the problem is to find a mathematical model for the way in which the electric field of a charge is braced against the fabric of space. It is very easy to be seduced by the geometry of the transmission of the electric field and to see the $\int \vec{E} \cdot dA$ over the surface of the charge as the equivalent of the force exerted by the spring. Such models will only predict a gravitational force proportional to the modulus of charge which should give the electron neuron and proton gravitational masses in the ratio $1 : \frac{4}{3} : \frac{5}{3}$. A clear nonsense. The seduction is aided by the simplicity of the model we used to derive the Brace Principle. The image of a spring stretched between the two rails leaves us with a conceptual legacy of the point of attachment of the spring. In looking for an equivalent in the nature of the charge, we are tempted to think that the bracing of the electric stress takes place at the centre of the charge. It does not: it takes place at every point in the electric field of the charge.

There are three concepts which have to be understood before we can proceed. The first is the idea that an electric field has an internal tension which must be braced against the fabric of space. Then we must understand that this is spread throughout the electric field and lastly cope with idea that this does not occur in the three extended dimensions of space but in a further non-extended dimension which is perpendicular them.

Space has two electric properties which we cannot separate. They are the charge density ρ of the positiveness and negativeness of space and the modulus λ with which they resist being pulled apart. We can only observe the combined effect which manifests itself in the constant we call the permittivity of space ε_0. If we consider a volume element of space of area δA and thickness δr with an electric field through it perpendicular to δA. The pulled apart-ness gives us the electric displacement D associated with the electric intensity E.



This is an actual amount of charge per unit area which passed through the plane in the middle of the volume as the field was formed. This charge density per unit area everywhere feels the electric field *E* and the force per unit area is:

$$S_i = DE$$

This is an internal stress which exists in the fabric of space due to the presence of the field. The equation is not dimensionally correct, but only numerically correct because the right hand side omits the division by the unit of length. This is consistent with the result in classical physics for the tension on a conductor which terminates an electric field

$$S_s = \frac{1}{2} D E$$

which can be derived from either the work done in moving capacitor plates apart or by considering the the force exerted by the field E on the surface charge density *D*. The surface charge layer having a finite thickness, the magnitude of *E* falls to zero as we move through this layer into the conductor and the average value of *E* is $\frac{1}{2} E$ giving a tension at the surface equal half the internal stress.

The beauty is that the internal stress of the electric field is numerically twice the energy density of the electric field. We are only familiar with the electric displacement *D* because the actual charge density of the positiveness and negativeness of space does not reveal itself. We may assume that the electric displacement results from a movement of the two charge densities ρ of space through a relative distance of σ. At the site of the plane in the middle of the cube in the diagram we would see positive charge of density ρ moving one way through the plane by a distance $\frac{1}{2} \sigma$ and the same density of negative charge moving the same distance in the opposite direction. We can write

$$D = \rho \sigma$$

Left over from the old days is a way of explaining the energy stored in an electric field which imagines the electric displacement *D* being pulled from one end of the field to the other. This is wrong. What happens is that the charge density ρ which exists throughout the electric field moves through the small distance σ. This is an important concept to grasp because we need to see work as being done throughout the volume of the electric field as it is formed and not simply at its terminal surfaces. This means that when we try to sum the total force *F* which the electric field exerts on the structure of space, we have to form a volume integral

$$F = \int D E \, d\tau$$

We are used to the idea of forces as nice little arrows we can draw on diagrams and perform vector additions. This force is not like that!! This is an analogue of the force exerted by the spring on the rail in the brace model of gravity. That force was one dimensional. We now have a situation where the dimension of up-down in the diagram of the rail and springs model corresponds to the three dimensions of space and the force *F* does not exist as a simple unidirectional entity in three dimensional space. Perhaps the best analogy we can have is the multiple of pressure times area in sphere of compressed gas where we might say that the total outward force is say 5 tons.

Again there is beauty in the situation because this almost exactly the same integral that we perform to find the energy content of an electric field.

$$F = 2 \int Q_e \, d\tau$$

$$= 2 \mathscr{E}$$

$$= \frac{q^2}{4\,\pi\,\varepsilon_0\,r_0}$$

We must understand that the 2 has the dimensions of $[L]^{-1}$.

The brace principle tells us that the internal stress of an electric field is braced against the fabric of space and that we can expect space to be distorted and we can expect that distortion to result in forces between the electric fields. Is this the phenomena which we experience as gravity? The answer lies in the nature of the function $f\,(\;)$ in the brace equation

$$F_{ab} = \frac{1}{2\,\lambda} F_a F_b \frac{d}{dr} f\left(r_{ab}\right)$$

If we are to explain the phenomena of gravity, then we need to get an inverse square law

$$\frac{d}{dr} f\left(r_{ab}\right) \doteq \frac{1}{r^2}$$

[The sign $\doteq$ should be read "must hopefully be equal to"]

$$f\left(r_{ab}\right) = -\frac{1}{r}$$

The best reason for assuming this to be the case is to consider the concept of gravitational potential. In the rail and spring model of the brace principle, the distortion of the rail is a direct measure of the analogue of gravitational potential. That is why we differentiate it to get the sideways force between the springs. Think now of the sandwich model, and then take this into three dimensions. We get a model of a three dimensional space which is distorted in a fourth dimension and that distortion is a direct measure of gravitational potential. This is exactly the situation with electric fields and electric potential. When we consider the electric field of a charge, we find that it obeys the inverse square law and the electric potential is proportional to $\frac{1}{r}$. We do not usually stop to ask why this might be so. When we do, we are probably quite satisfied with the answer that the electric displacement D is transmitted continuously; but this is a consequence and not a cause. The real answer is because space is made that way. We know that space has the real properties of electric permittivity and magnetic permeability. We know that the internal stress of an electric field does not crush space. We just add the ability to transmit electric fields according to their known properties to the list of known properties of space. Electric potential is proportional to $\frac{1}{r}$ because of the structure of space. It would not then be very surprising if gravitational potential behaved in exactly the same way as electric potential.

The gravitational potential created by a charge is proportional to the energy content of the electric field of the charge. We can even calculate the gravitational potential of a charge from its electric potential by multiplying the potential by its charge. The one striking difference is that while electric charges have positive and negative potential, their gravitational potential is always negative. We can thus with a fair degree of confidence conclude that the distortion of the fabric of space caused by its bracing the internal stress of electric fields is proportional to $\frac{1}{r}$ over a considerable range.

We may now consider the gravitational force between two charges.

$$F_{ab} = \frac{1}{2\,\lambda} F_a F_b \frac{d}{dr} f\left(r_{ab}\right)$$

$$= \frac{1}{2\,\lambda} \frac{q_a^2}{4\,\pi\,\varepsilon_0\,r_{a,0}} \frac{q_b^2}{4\,\pi\,\varepsilon_0\,r_{b,0}} \frac{d}{dr} f\left(-\frac{1}{r}\right)$$

Newton's law of gravity has it that

$$F = \frac{G\, m_a\, m_b}{r^2}$$

It makes no difference to this theory of gravity wether we use Einstein's $E = m\, c^2$ or my result for the inertial mass of a charge derived in my paper "Theory of Everything - Inertial Mass as an Electromagnetic phenomena", so I shall use the inertial mass of a charge.

$$F = G\, \frac{\mu_0\, q_a^2}{6\, \pi\ r_{a,0}}\, \frac{\mu_0\, q_b^2}{6\, \pi\ r_{b,0}}\, \frac{1}{r^2}$$

Now $\mu_0 = \dfrac{1}{c^2\, \varepsilon_0}$ and with a little rearranging of the numbers

$$F = \frac{4\, G}{9\, c^4}\, \frac{q_a^2}{4\, \pi\, \varepsilon_0\, r_{a,0}}\, \frac{q_b^2}{4\, \pi\, \varepsilon_0\, r_{b,0}}\, \frac{1}{r^2}$$

$$\lambda = \frac{9\, c^4}{8\, G}$$

$$= 1.362 \times 10^{44}$$

Or thereabouts depending on the exact relationship between real electrons and quarks and the way we have modelled them as simple spherical charges.

While this analysis has been carried out for electric fields, magnetic fields also have an internal stress and magnetic forces can be modelled in terms of the energy required to modify the magnetic field. It follows that the energy density of a magnetic field also distorts the fabric of space and that both electric and magnetic energy density fields generate gravity fields and are affected by them.

The requirement that gravitational mass and inertial mass are the same thing is really only dependent on the their being in the same ratio for electrons, up quarks and down quarks. The assignment of units is quite arbitrary and simply effects the value of *G*. The fact that it is the total energy content of the electric field of a charge which is responsible for generating its inertia, its gravitational potential and the force it experiences from a gravitational field ensures that the two are equivalent.

