Symmetry Between Gravitational and Electric Forces

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PACS Numbers: 02.50.Wp, 03.65.Bz, 05.60.Gg

Abstract

The lack of symmetry between the electric field and the gravitational field has been considered. In particular, the fact that the source of an electric field can be described by two types of charge, whereas it has only been possible, so far, to describe the gravitational field by a single type of mass. The consequences of the effects of a so far unobserved, magnetic-like field associated with the movement of mass have also been considered. If a type of "negative" mass were to exist which is repelled by conventional "positive" mass, this could be related to such phenomenon as the ejection, reflection and absorption of particles capable of transmitting energy from one conventional mass to another.

1. Introduction

There is no reason to suppose that there is any essential difference between space and matter. There exist in space primary, directly detectable forces, which behave in such a manner as to lead us to model them as force fields. These are the electric field and the gravitational field. We presume the apparent source of these fields to be respectively charge and mass. When charges move in space, a third force field is observed, the magnetic field. When mass moves in space its movement is associated with momentum. Our modelling of physical matter leads us to assume that other forces exist between subatomic particles, namely the strong and weak forces.

Advances in all branches of science have often been made when scientists have looked for structure in the relationships between similar entities. This paper considers the apparent lack of symmetry between charge and mass, the former with its associated electric field and the latter with its associated gravitational field. The two facts which are immediately striking are that there is no known gravitational equivalent of the magnetic field nor of opposite charges. In addition, there is no known electric equivalent of momentum. A concept that is common to both the electric and gravitational fields is energy, which appears to link the two fields.

2. Gravitational magnetism

When charges move in a linear fashion, they appear to become surrounded by a cylindrical-shaped magnetic filed. This is detected by the effect on other magnetic materials of the effect on other charges. Einstein's famous thought experiment [1] proposes that the forces can be accounted for by relativistic arguments. However, this supposes that an electric current consists of two types of charge moving at relatively different speeds. If the current is attributed to a movement of electrons, for example in two copper wires, the remaining, stationary matter is positively charged. Because of relativistic space dilation, the relative speeds of the different charges account for the attraction or repulsion, depending on whether the current in the wires is in the same or opposite directions. However, this model fails to account for the effects observed when a stream of charged particles moves in space, in isolation from other matter. When charges move in a circular path, or when they "spin", the result is a toroidal magnetic field, which becomes approximately linear between two such sources of magnetic field.

An experiment to detect such an effect for the gravitational field would require a stream of slow moving, electrically neutral particles, travelling between a pair of large masses rotating at a high rotational velocity, with the direction of travel of the particles normal to the axis of rotation. The following comparison is of some relevance here. The force, F, on a charge, e, moving in a magnetic field, **B**, with velocity **v**, is given by

$$\mathbf{F} = e.\mathbf{v}\times\mathbf{B} \qquad 1$$

where e is the charge and **v** the velocity vector. Now, from elementary mechanics, the radius of rotation, r, of a mass, m, constrained by a force, **F**, is given by

$$r = |\mathbf{v}|^2 m/|\mathbf{F}| \qquad 2$$

So, when the velocity is normal to the magnetic field

$$r = m|\mathbf{v}|/e|B| \qquad 3$$

In the case of mass, if this phenomenon were to occur, the force, **F**, would be given by

$$\mathbf{F} = m.\mathbf{v}\times\boldsymbol{\beta} \qquad 4$$

where **β** is the gravitational equivalent of **B.** So

$$r = |\mathbf{v}|/|\boldsymbol{\beta}| \qquad 5$$

The smaller the value of r, the more likely the effect will be detected. By analogy, because **B** depends on the rate of rotation of the charges giving rise to the magnetic field, **β** will be proportional to the mass and rate of rotation of the rotating masses. So the requirement is, as first stated, for a stream of slow moving, electrically neutral particles travelling between a pair of large masses rotating at a high rotational velocity, in a direction normal to the axis of rotation. If such a phenomenon does exist and could be detected, it might also be observed as a small precession of low-orbit satellites in polar orbit, as they pass over the poles.

The role of momentum does not appear to have a corresponding phenomenon for the charges. The question that arises is whether or not the relationship between momentum and mass in some way corresponds to the relationship between magnetic field and charge.

3. Negative mass

Of even greater significance is the apparent absence of a negative form of mass. Let us consider what form negative mass might take, were it to exist. We can do this by using the analogy of charges. We know that normal, “positive” masses attract, whereas like charges repel. So, if negative mass does exist, we might expect that unlike masses would repel. This would mean that a small negative mass would accelerate away from a relatively large positive mass. Now force between two masses in the gravitational field is characterised by

$$|\mathbf{F}| = - Gm_1m_2/r^2 \qquad 6$$

where G is the gravitational constant, m1 and m2 the two masses and r the separation between them. Thus, if a particle with negative mass had a mass magnitude several orders of magnitude smaller than that of a positive mass, m, the acceleration, a, of the negative particle is given by

$$a = Gm/r^2 \qquad 7$$

It can be shown that the radial velocity, v, of such a particle at a distance, r, from the positive mass, starting with an initial zero radial velocity at a distance r_0 from the mass, is given by

$$v = [2Gm(1/r_0-1/r)]^{1/2} \qquad 8$$

In the limit of r = ∞

$$v = [2Gm/r_0]^{1/2} \qquad 9$$

If the maximum value of v is c, the speed of light, this gives

$$r_0 = 2Gm/c^2 \qquad 10$$

It is interesting to note that this is exactly the Schwarzschild radius of the mass. For a mass of the order of a proton, $r_0 = 2.48 \times 10^{-54}$ m, which is an extremely small distance. When r is less than r_0, v becomes imaginary, so r_0 might be considered as the limit of a potential well. We can imagine that any particle within the potential well would have a velocity that is entirely rotational. It is not clear what mechanism could cause the ejection of such a particle, were it to exist, from the potential well, but on ejection, its radial velocity would accelerate to c within 10^{-45} m, which would be, in practical terms, instantaneous.

Howe [2] has postulated that any particle will have a De Broglie frequency, f, given by

$$f = mv^2/2h \text{ s}^{-1} \qquad 11$$

The sign of m is immaterial, because it only governs the direction of rotation of the De Broglie vector. Hence a particle with negative mass would be refracted in the same manner as one with positive mass. A particle with negative mass, a speed of c and a De Broglie frequency of 10^{-15} Hz would have a mass of -1.5×10^{-35} kg, or about five orders of magnitude less than an electron.

But what would happen when a particle with negative interacts with a particle with positive mass? The simplest explanation is that it would be reflected. That is to say the particle with negative mass would decelerate to zero radial velocity at the Schwarzschild radius and then accelerate away again. If the particle with negative mass does not decelerate sufficiently (*e.g.* if the particle with positive mass accelerates towards it because of other interactions) the particle with negative mass will cross the threshold of the Schwarzschild radius and enter the potential well. This corresponds to absorption.

Equation 7 implies that the inertia of a particle with negative mass is of the same sign as that of one with positive mass. Thus, if a particle with negative mass were absorbed into the potential well of a positive mass, the inertia of the positive mass would increase. Also the kinetic energy of the positive mass in the direction of the velocity vector of the negative mass would increase, because the compound entity would have the combined kinetic energy of the two constituents. Similarly, if a negative mass were ejected, the kinetic energy of the positive mass in the direction of the velocity vector of the negative mass would decrease. Thus the propagation of particles with negative mass could describe energy transport.

4. Implications

If particles with negative mass exist, they would have the following properties:

- They would be emitted by particles with positive mass and accelerate almost instantaneously to the speed of light;
- They would be subject to the normal laws of diffraction;
- They would be either reflected or absorbed by particles with positive mass;
- They would act as a means of energy transport between particles with positive mass.

The above properties correspond to the properties of the photon. If this postulate is accepted, we have a universe with positive mass, where energy is transported as negative mass. By symmetry, a universe with negative mass would imply energy transported by positive mass. This is similar to the matter and anti-matter scenarios, but the difference is that both types of mass would co-exist in the same universe. However, their roles would be reversed in a complementary universe.

5. Conclusions

The lack of symmetry between the electric field and the gravitational field has been explored. A format for collecting experimental data to detect a gravitational equivalent of the magnetic field has been proposed. The properties of negative mass have been explored and it is concluded that a particle with negative mass would have the same properties as a photon. This has led to the proposition that their could be complementary universes where the role of mass, as we know it, is assumed by negative mass and energy transport is by means of what we regard as positive mass.

References

[1] A Einstein, H A Lorentz, H Minkovski & H Weyl, *The Principle of Relativity*, Dover
[2] L D Howe *A quantum approach to relativity*, www.innovationgame.com/physics (2000)