Gravitational Energy and the Flatness Problem

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Abstract

The frequency of an atomic clock is driven by the energy difference between excited states of an atom. Since the frequency of an atomic clock is a function of the gravitational potential, the energy difference must likewise be a function of the gravitational potential. Thus, the Pound-Rebka experiment rather than showing that a falling photon picked up energy, simply showed a higher frequency by comparison to a lower reference frequency. The frequency (energy) of a falling photon is unchanged. This shows that the General Theory of Relativity is wrong—gravity does not act on all forms of energy. This revision of gravitational effects is explored. Significant implications arise and potential explanations for significant ongoing problems in cosmology are developed.

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1.0 Clocks and Energy

Atomic clocks are driven by the difference in the energy level between an excited electron orbital state and its base, unexcited state. Since the frequency is given by the change in energy divided by Planck's constant, this energy difference determines the frequency of the atomic clock. But it is well known that the clock frequency is a function of the gravitational potential. Einstein [1] defined a gravitational scale factor, which when evaluated for a spherical gravitational source, is given by:

$$s = 1 - \frac{GM}{rc^2} \tag{1}$$

For a given mass source, this scale factor becomes increasingly smaller as the gravitational potential is decreased. Einstein indicated that this factor scaled the lengths, the time and the speed of light in the following fashion:

$$l_i = sl_o \tag{2}$$

$$t_i = t_o / s \tag{3}$$

$$c_i = s^2 c_o \tag{4}$$

where the subscript, i, is used to indicate the value within the gravitational potential and the subscript, o, is used outside the gravitational potential.

Larger intervals between ticks, equation (3), is equivalent to a clock operating at a lower frequency. Thus:

$$f_i = sf_o \tag{5}$$

Assuming that Planck's constant, h, is not affected by the gravitational potential, the energy of atomic transitions is given by:

$$E_i = hf_i = shf_o = sE_o \tag{6}$$

But if the energy levels of the orbital electrons vary as a function of the gravitational potential—and atomic clocks prove they do—the entire rest-mass energy of the atom presumably also changes with the gravitational potential. Thus:

$$E_i = m_i c_i^2 = sm_o c_o^2 = sE_o \tag{7}$$

From equations (4) and (7), the mass must vary as the inverse third power of the gravitational scale factor; i.e.

$$m_i = m_o / s^3 \tag{8}$$

This change in mass with gravitational potential confirms that the combined units of Planck's constant do not change with gravitational potential.

Before incorporating the scale factor into the expression for the rest-mass energy in equation (7), note that the units in the numerator and denominator of the second term cancel each other. Therefore, the scale factor can also be written as:

$$s = 1 - \frac{G_o s^8 M_o s^{-3}}{r_o s (c_o s^2)^2} = 1 - \frac{G_o M_o}{r_o c_o^2} \tag{9}$$

Incorporating this "invariant units" version of the scale factor of equation (1) into the rest-mass energy of equation (7) gives:

$$s m_o c_o^2 = m_o c_o^2 - \frac{G_o M_o m_o}{r_o} \tag{10}$$

This equation shows that the source of the gravitational potential energy is the rest-mass energy. Furthermore, it shows that the source of the gravitational force is the radial gradient of the rest-mass energy. Taking the radial derivative gives Newton's inverse square law of force.

$$F = \frac{G_o M_o m_o}{r_o^2} = \frac{GMm}{r^2} \tag{11}$$

2.0 A Problem with Newton

However, there is a problem with the above development. Specifically, equations (1) and (9) are only approximations to the gravitational scale factors which actually apply. The Schwarzschild solution to Einstein's gravitational equations for a spherical mass uses a gravitational scale factor given by:

$$s = \sqrt{1 - \frac{2GM}{rc^2}} \approx 1 - \frac{GM}{rc^2} - \frac{G^2 M^2}{2r^2 c^4} + \ldots \tag{12}$$

But this factor does not give an equal scaling to the radial and transverse dimensions. In addition, breaking the sphere into multiple shells requires that the individual scale factors yield the final scale factor as a product. Converting the Schwarzschild solution to isotropic coordinates with equal length scaling results in the necessary exponential scale factor:

$$s = e^{-\frac{GM}{rc^2}} \approx 1 - \frac{GM}{rc^2} + \frac{G^2M^2}{2r^2c^2} + ... \tag{13}$$

When this scale factor is converted to the external, invariant units, the rest-mass energy of the particle is given as:

$$sm_oc_o^2 = m_oc_o^2 \exp\left(-\frac{G_oM_o}{r_oc_o^2}\right) \tag{14}$$

Taking the radial gradient of this rest-mass energy gives the gravitational force as:

$$F = \frac{G_oM_om_os}{r_o^2} = \frac{GMms}{r^2} \tag{15}$$

This revised force law deviates slightly from Newton's inverse square law. The force is increasingly weaker than the inverse square law as the gravitating mass is increased or the distance to the central mass is decreased. This modified force law could help explain a couple of lingering cosmological problems. First, the large, bright blue OB stars have an anomalous red shift that has never been explained. But these stars are "weighed" by using the inverse square law on orbiting binaries. Weighing via the new force law would increase the mass and explain the anomalous red shift as a gravitational red shift. Second, the same phenomena of increased central mass could help explain the anomalous orbital velocity at the edges of galaxies. Finally, since the gravitational scale factor would approach zero as the central mass increased, black holes are excluded.

3.0 Problems with Einstein

Einstein [2] in some of his initial gravitational work gave three arguments for the gravitation of energy. Only the second argument is addressed here. He argued that the frequency and hence energy of a photon is increased when it falls in a gravitational field. On the basis of the conservation of energy, the following steps must yield a net zero change in energy: 1) an excited atom in a gravitational potential emits a photon downward; 2) the atom is then lowered, doing work (yielding energy); 3) it then absorbs a photon to bring it back to the same excited state; and, finally, 4) it is carried back to the original higher energy by doing work on it. Einstein argues that the inertial mass of the photon causes the mechanical energy in carrying the atom up to exceed the mechanical energy made available when lowering the atom; and that a net zero energy change requires that the photon increase in energy (and frequency) during its fall.

This result was seemingly verified by the Pound/Rebka experiment [3] many years later. However, as stated above, we now know that the frequency (and energy) of the photon does not change when it falls. What gives the appearance of a change in frequency is that the gravitational potential affects the reference frequency with which the falling photon is compared; i.e. atomic clocks at lower potentials run slower. Thus, the falling photon has more energy than required to raise the lowered atom to an excited state because the energy in the excited state of the atom is itself decreased when moved to a lower gravitational potential. The excess energy of the photon at the lower potential equals the difference in energy used to move the mass up and down. The fact that the frequency of a falling photon does not change shows that gravity does not act on electromagnetic energy. This is contrary to Einstein's conclusion and to his General Relativity Theory (GRT).

A variation of the above thought experiment is even more enlightening. Let a particle of mass fall in a gravitational potential. After it has fallen a given distance and picked up some kinetic energy, let both the kinetic and rest-mass energy be converted into electromagnetic energy and beamed upward. When the electromagnetic energy has reached the original height convert it back into mass. The conservation of energy requires that the original mass be restored. However, since the electromagnetic energy does not change as it rises in the gravitational potential, the energy of the particle must be conserved as it falls in the gravitational potential. But that requires that the gravitational potential energy be obtained from the structural (rest-mass) energy of the particle. When a particle falls in the gravitational field, the structural energy is converted into kinetic energy and vice versa when it rises. This compounds the disagreement with Einstein's claim for the gravitation of energy. Since the gravitational force arises from the gradient of the structural energy, the kinetic energy of a particle, like electromagnetic energy, cannot be acted upon by gravity.

This disagreement with GRT has multiple implications. One of the most important current problems is the inability to explain the apparent smallness of the vacuum energy density. This apparent smallness is a direct result of the GRT relationship between energy and the curvature of space-time. However, if only the structural energy of matter is the source of the gravitational force, then only the structural energy will affect the curvature of space-time. All other forms of energy do not react to or cause gravitation and hence do not result in curvature of space-time. This neatly solves the apparent smallness of the vacuum energy density. The actual vacuum energy density is huge; it simply does not cause a gravitational force and does not result in a curvature of space-time.

References

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3. R. V. Pound and G. A. Rebka Jr., "Apparent weight of photons," *Phys. Rev. Lett.* **4** pp 337-341 (1960).