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The Determination of Absolute Gravitational Potential.

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Summary. – The scope for determining absolute gravitational potential φ is discussed. It is shown by two quite distinct methods, one relying on data from electron g-factor measurements and the other on the $3K$ cosmic background data, that the absolute value of φ at the Earth's surface is only 8% greater than that due to the mass of the solar system. It is inferred that gravitation has a range of action limited to a distance of a few hundred light years.

If gravitation has a range of action traversing the whole ambit of the visible universe, the gravitational potential at the Earth's surface should outweigh by far that attributable to mass local to the solar system. This assumption is the basis of Mach's Principle, which requires the gravitational potential φ to be an absolute scalar quantity referenced on matter constituting the whole universe. Evidently, therefore, if the local value of φ could be measured, this would be of primary importance, because it could resolve many questions in cosmology, including the dependence of local inertia upon the presence of distant stars.

A direct measurement of φ would enable us to assess the range of gravitational action. For example, if φ were found to be only slightly greater than that attributable to the solar system, this would signify a range encompassing relatively few stars and so of the order of a hundred or so light years. On the other hand, if φ were about three times greater than this, the range of gravitation would be local to our Galaxy, whereas significantly greater values of φ do imply the universal range of gravitational force.

Changes of φ as between separated positions can be measured, as by the Pound and Rebka experiment [1,2], so allowing us to isolate the Earth's component of φ. The question, however, is whether φ can be measured on an asbolute basis by a test at a single position. Most scientists would say that this is impossible, even though φ is taken to have a physical influence at that position. This is based on practical considerations rather than fundamental philosophical reasoning, but the measurement of the absolute φ may well be possible.

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(1) R. V. Pound and G. A. Rebka jr.: *Phys. Rev. Lett.*, **3**, 439 (1959).
(2) R. V. Pound and G. A. Rebka jr.: *Phys. Rev. Lett.*, **4**, 337 (1960).

Indeed, experimental evidence is already available which suggests a viable method of approach. This is reviewed below in the hope that it will encourage a research program aimed at verifying the assumptions implicit in the following interpretation of the data. It is found that the absolute value of φ is only about 8% greater than that due to mass in the solar system.

The governing experiment is the accurate measurement of the anomalous magnetic moment of the electron. The electron g-factor has been found by VAN DYCK [3] to be given by

$$\frac{1}{2}g = 1.001\,159\,652\,200 \tag{1}$$

to an accuracy of 40 parts in 10^{12}.

The accurate experimental determination of the fine-structure constant α or $2\pi e^2/hc$ is also important. WILLIAMS and OLSEN [4] have found that

$$\alpha^{-1} = 137.035\,963 \tag{2}$$

to an accuracy of 11 parts in 10^8.

In some theories the inertial and radiant properties of the electron are taken to depend upon interactions with the rest of the universe. Though the theoretical basis of the argument applied here does differ from the conventional method adopted, this connection between the rest of the universe and the electron is incorporated in the following formulation:

$$\frac{1}{2}g = \left(1 + \frac{1}{2}\varphi/c^2\right)\left(1 + \frac{1}{hc/e^2 - 1 \pm 4/\sqrt{3}}\right). \tag{3}$$

The plus term in the denominator applies to the electron g-factor and the minus term applies to the muon g-factor [*]. The derivation of this formula is quite simple It involves a resonant-cavity model of the electron with radial field oscillations in the field cavity at the Compton frequency λ_C. It is a model similar in many respects to that proposed by JENNISON and DRINKWATER [5] for explaining inertia as a local property of mass. A full analysis has been presented elsewhere by the author [6,7] based on a work first reported in 1977 [8].

The g-factor depends upon the difference between the normal mass of the electron and the spin mass, the latter being lower because the spin motion is one confined well within the cavity and so it excludes the effects of field energy located outside, that is beyond a radius of approximately $\frac{1}{2}\lambda_C$. The φ term arises if one accepts the hypothesis that the gravitational energy φ per unit mass, being negative, sets a threshold for the thermal-energy content of the interacting masses. For equal partition of energy

(3) R. S. VAN DYCK jr.: *Bull. Am. Phys. Soc.*, **24**, 758 (1979).
(4) E. R. WILLIAMS and P. T. OLSEN: *Phys. Rev. Lett.*, **42**, 1575 (1979).
(5) R. C. JENNISON and A. J. DRINKWATER: *J. Phys. A*, **10**, 167 (1977).
(6) H. ASPDEN: *Lett. Nuovo Cimento*, **33**, 481 (1982).
(7) H. ASPDEN: *Lett. Nuovo Cimento*, **33**, 213 (1982).
(*) The muon g-factor formula presupposes an alternative resonant mode to that applicable for the electron. If the muon is created by charge pair annihilation, then its g-factor involves the same resonance mode:

$$\frac{1}{2}g = \left(1 + \frac{1}{2}\varphi/c^2\right)\left(1 + \frac{2}{hc/e^2 - 1} - \frac{1}{hc/e^2 - 1 + 4\sqrt{3}}\right). \tag{4}$$

(8) H. ASPDEN: *Int. J. Theor. Phys.*, **16**, 401 (1977)

between similar mass elements, an electron of mass m would have a kinetic energy of $\frac{1}{2}\varphi m$ at its equilibrium temperature. This energy would, on a quantum electrodynamic interpretation, not be assigned to the spin mass and so, being wholly outside the cavity boundary, would contribute directly to the g-factor, as the term $\frac{1}{2}\varphi/c^2$ in eq. (3).

Both g and hc/e^2 are known with precision for the electron and from the measured values quoted above the equation should give a direct estimation of the absolute energy potential term φ/c^2. With c as $3\cdot10^{10}$ cm/s, φ is found to be $10.25\cdot10^{12}$ c.g.s. The value for the solar system is $9.49\cdot10^{12}$ c.g.s., being almost wholly due to the Sun of mass M_S of $1.989\cdot10^{33}$ g distant R_a of $1.496\cdot10^{13}$ cm and the Earth of mass M_E of $5.977\cdot10^{27}$ g and radius R_E of $6.378\cdot10^8$ cm. With G as $6.67\cdot10^{-8}$ c.g.s. the value of φ at the Earth's surface, or $G(M_S/R_a + M_E/R_E)$ becomes $9.49\cdot10^{12}$ c.g.s. This is about 8% smaller than the measured value of φ.

The muon g-factor is not yet known to sufficient accuracy to be used to test the alternative eqs. (3) and (4) and so is less reliable as a means for determing φ, but the results are consistent with those obtained from electron g-factor data.

There is scope, nevertheless, for alternative estimation of φ. This depends upon measurements of the temperature of the cosmic background. Research is also needed to confirm the mass of the hidden charge carriers which soustain Maxwell's displacement currents, whether in the vacuum proper or in materials with few electrons. The author, in collaboration with Dr. EAGLES (9), has given a theoretical basis for determining the fine-structure constant as a vacuum property associated with the basic charge carriers permeating space. In theory, these have a mass 0.0408 times that of the electron. Experimental evidence from the dual resonances in p-type germanium crystals suggest that these hidden particles do reveal themselves when the local electron population is limited. EHRENBERG (10) reports measurements showing that their measured mass m^* is 0.04 times that of the electron. Recently, GRAHAM and LAHOZ (11) have found that Maxwell's displacement theory is upheld by their experimental achievement of imparting angular momentum to the vacuum itself and establishing reaction forces on the apparatus. Accordingly, further research should establish the mass property of vacuum charges.

Meanwhile, assuming a value for m^*/m of 0.04, one can explain the sustained cosmic-background temperature T from an equation such as

$$\varphi m^* = kT\,, \tag{5}$$

where k is Boltzmann's constant $1.38\cdot10^{-16}$ erg/°C.

The traditionally quoted temperature of the so-called 3 K cosmic background is 2.7°. With electron mass as $9.1\cdot10^{-28}$ g, (5) then gives a value of φ of $10.24\cdot10^{12}$ c.g.s., in exact accord with the value found from the electron g-factor data.

Thus we do have good reason for proposing that the absolute value of gravitational potential can be determined experimentally. Since it appears to be about 8% larger than that due to the solar system, we can infer that gravitation has a limited range of action which assures that enough nearby stars are within range to account for this additional 8%.

Apart from the cosmological implications involved in such a conclusion, there is the pointer from the duality of the result obtained affirming the evident presence of

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(9) H. ASPDEN and D. M. EAGLES: *Phys. Lett. A*, **41**, 423 (1972).
(10) W. EHRENBERG: *Electric Conduction in Semi-conductors and Metals* (Oxford, 1958), p. 145.
(11) G. M. GRAHAM and D. H. LAHOZ: *Nature*, **285**, 154 (1980).

vacuum charges with a mass of 0.04 m. The author is currently projecting experimental work aimed at tracing these electrodynamically.

Finally, though it is really outside the scope of this paper, it is mentioned that the apparent gravitational potential φ_G of stars acting on the Earth and central to our Galaxy may be shown to contribute to φ by

$$\varphi = \varphi_G(\Delta^2/\delta R)\,, \tag{6}$$

where R is the distance to our galactic centre, Δ is the approximate range of gravitational action and δ/Δ is a measure of the concentration of galactic mass density in progressing over a distance Δ towards the centre of the Galaxy. A value of φ/φ_G of 0.1, Δ/R of 0.01 and δ/Δ of 0.1 present a reasonable galactic interpretation and infer a range of gravitational action over a distance of a few hundred light years.

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