The Anomalous Magnetic Moment of the Electron.

H. Aspden

IBM United Kingdom Ltd., Hursley Laboratories - Winchester, England

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In 1975 the author [1] presented a heuristic method by which the anomalous magnetic moment of the electron could be evaluated. The model portrayed the electron as a spherical charge of finite radius determined by the J. J. Thomson classical formula and centred in a resonant cavity of radius governed by the Compton wave-length. The electric-field energy outside this resonant cavity was presumed to be decoupled from the electron mass energy for spin motion confined well within the resonant cavity with the result that the mass difference between normal motion and spin gives the -$g$factor:

$$g = \frac{2}{1-\delta}, \tag{1}$$

where

$$\delta = \frac{1}{2\pi\alpha^{-1} + 4/3^{\frac{1}{2}}}. \tag{2}$$

The expression $4/3^{\frac{1}{2}}$ arises from the finite size of the electron. It would be zero for a point charge.

The above formulation is extremely simple, as is the theory from which it is derived. The value of g can be derived directly from a knowledge of α^{-1}, α being the fine-structure constant. Independently, in 1972 the author [2], collaborating with Dr. Eagles of the National Standard Laboratory in Australia, presented a method of deriving α^{-1} from first principles. The analysis involved a structured model of the vacuum state and accounted for the familiar $E = h\nu$ radiation law. A critical determination of a odd integral ratio applicable to two fundamental particles required to give a minimum energy state gave uniquely the quantity 1843 and this appears in the value of α^{-1} presented in the paper. It also appears for the same physical reasons in a later paper [3] presenting a theoretical derivation of the proton-electron mass ratio. The formula

(1) H. Aspden: *Int. J. Theor. Phys.*, **16**, 401 (1977).
(2) H. Aspden and D. E. Eagles: *Phys. Lett. A*, **41**, 423 (1972).
(3) H. Aspden and D. M. Eagles: *Nuovo Cimento A*, **30**, 235 (1975).

for α^{-1} is

$$\alpha^{-1} = 108\pi(8/1843)^{\frac{1}{6}} . \tag{3}$$

This gives a value of α^{-1} of 137.0359148 and, although experimental data suggest that the true value of α^{-1} may be higher than this by up to one part per million, recent direct measurements of h/e^2 by a new technique using quantized Hall resistance phenomena are indicating lower values. For example BRAUN, STABEN and VON KLITZING [4] measure α^{-1} as 137.03592 ± 0.00018.

Encouraged by this the author has found it of interest to combine the theoretical value of the fine-structure constant and the theoretical value of the g-factor to obtain a purely theoretical value for this electron g quantity. The result obtained from eqs. (1), (2) and (3) is

$$g = 2(1.001\,159\,646\,913) . \tag{4}$$

Now, digressing a little into the field of cosmology, the author has been struck by the remarkable coincidence that the kinetic energy possessed by the Sun owing to its motion at a speed equal to the measured anisotropy of cosmic background radiation, some 390 km/s, is of precisely the same order as that available from the gravitational coalescence of dispersed matter in forming the Sun. The gravitational potential of the Sun is $-2.3 \cdot 10^{48}$ ergs. In contrast, the kinetic energy is $1.5 \cdot 10^{48}$ ergs attributable to the Sun's translational cosmic motion relative to the preferred frame of the cosmic background. Additionally the Sun has thermal energy derived internally from its nuclear sources. However, the coincidental connection between these two large energy quantities has led the author [5] to speculate on the hypothesis that the minimum energy state of any mass is that which ensures that at least its share of gravitational potential energy is retained by its kinetic behaviour.

The above hypothesis is only tenable if we can discount gravitational interaction on a galactic scale, since the gravitational potential of the Sun's interaction with the rest of the universe outweighs by far its self-interaction. Proceeding tentatively on this basis, it is suggested that a particle of mass m will share equally with other interacting mass, principally the masses of the Earth and the Sun for m on Earth, the mutual gravitational potential energy involving m.

The relevant gravitational potential is given by

$$G(M_s/R_a + M_e/R_e) , \tag{5}$$

where G is the constant of gravitation $6.67 \cdot 10^{-8}$, M_s is the solar mass $1.989 \cdot 10^{33}$, R_a is the astronomical unit $1.496 \cdot 10^{13}$, M_e is the Earth mass $5.977 \cdot 10^{27}$ and R_e is the Earth radius $6.378 \cdot 10^{8}$, all in c.g.s. units. The potential given by (5) is $9.493 \cdot 10^{12}$. Now unit mass will, by the hypothesis presented, have a residual kinetic energy of half this quantity and the mass-equivalent of this, found by dividing by c^2, is $5.281 \cdot 10^{-9}$. If this additional energy augments the normal electron mass but does not add to the spin mass, the result will be an increase in the g-factor by this gravitational factor $5.281 \cdot 10^{-9}$. Multiplying (4) by this and adding to (4) gives

$$g = 2(1.001\,159\,652\,200) . \tag{6}$$

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[4] E. BRAUN, E. STABEN and K. VON KLITZING: *PTB-Mitt.*, **90**, 350 (1980).
[5] H. ASPDEN: *Spec. Sci. Tech.*, **3**, 114 (1980).

When this is compared with the most recent experimental result for g reported by VAN DYCK [6], we find the remarkable result that the comparison is perfect. The experimental value of the anomalous factor $a = (g-2)/2$ is $1159652200(40)\cdot 10^{-12}$ for the electron.

The corresponding latest, but very preliminary QED value, reported at the recent conference on Precision Measurement and Fundamental Constants held at the U.S. National Bureau of Standards is 1159652504(182). As its authors' note [7], the discrepancy between QED theory and experiment for the electron g-factor is ten times as large as the experimental error of the basic measurement. The complexity of QED calculations is also bewildering, bearing in mind that calculation based on 891 Feynman diagrams was needed to derive the eighth-order QED contribution. Hence the simple derivation of the very accurate result presented in (6) does deserve consideration on its merits.

Very probably the adoption of a favoured value for α will govern the situation. If α^{-1} were reduced below the value recommended by WILLIAMS and OLSEN [8], this being 137.03563(15) and used in the above QED analysis, then this would imply further increase in the QED value and a greater departure between theory and experiment. Accordingly, in view of the very remarkable success of QED in its application to other quantities, one must except upward rather than downward revision of recommended α^{-1} values. However, should we see the favoured experimental value of α^{-1} diminish, then QED theory may be in difficulty and the heuristic treatment presented in this work may well justify closer scrutiny. Meanwhile, it is hoped that the reader will keep this alternative approach to QED in mind.

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(6) R. S. VAN DYCK jr.: *Bull. Am. Phys. Soc.*, **24**, 758 (1979).

(7) T. KINOSHITA and W. B. LINDQUIST: paper submitted to *Second International Conference on Precision Measurement and Fundamental Constants, National Bureau of Standards, U.S.A., June 8-12, 1981.*

(8) E. R. WILLIAMS and P. T. OLSEN: *Phys. Rev. Lett.*, **42**, 1575 (1979).