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Electron Form and Anomalous Energy Radiation.

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Summary. – This paper correlates data from g-factor measurements and energy radiation theory, both indicating that the electron has a characteristic radius from which radiation is reflected of 1.1547 times the classical radius e^2/mc^2. More important, the paper resolves an existing anomaly by reconciling the energy radiation property of the accelerated electron and the nonradiation hypothesis required to account for inertia according to the law $E = Mc^2$.

In the 1911 edition of his treatise on the theory of electricity and magnetism JEANS (1) summarizes the classical treatment of energy radiation by the accelerated electron. He draws attention to the need for new theory (quantum theory) to meet certain anomalies and we now well know that electrons in atoms observe quantum rules which preclude continuous energy radiation. However, the emergence of quantum theory left open the question of whether, under certain circumstances, the classical analysis leading, for example, to the Larmor energy radiation formula is, in fact, still valid.

It may well be true that the quantum interactions are characteristic of group behaviour in a well-populated electron environment but that where electrons stand in isolation the more classical treatment holds. This, at least, was the note on which JEANS (1) ended his treatise. Also, however, there was a more fundamental and evolving aspect of Jeans' treatment of the accelerated electron. He demonstrated how the classical electron of charge e, radius a and mass m could satisfy the formula

$$mc^2 = 2e^2/3a \,, \tag{1}$$

c being the speed of light *in vacuo*. Then, retaining this expression and considering how energy increases with a decreasing as the electron accelerates to higher speeds, this energy being the work done in assuring this speed change, JEANS argued that « the electron can be held in equilibrium at all velocities, while its motion conforms to the conservation of energy ». Clearly, this is an important concept, since it touches upon the basic nature of inertia. JEANS noted that the Larmor radiation had been neglected

(1) Sir James JEANS: *The Mathematical Theory of Electricity and Magnetism*, 5th Ed. (Cambridge, 1966), p. 591.

from the analysis, thereby overlooking the possibility that energy conservation and charge motion avoiding energy radiation were the key criteria in governing the inertial property of the electron.

In recent years a great deal has been written about the classical problem of radiation by accelerated charge (2-5) with authors having different viewpoints on whether there is any energy radiation at all. This author in particular (6) has argued that the derivation of the Larmor formula, if applied to the locality of the electron charge, will indicate zero energy radiation of the electron manifests an inertial property in accordance with the formula $E = mc^2$, where E is the electric energy of the electron. Thus, if there is energy radiation, this must come from the accelerating field in some less direct way than via the body of the electron charge. Although this basic conclusion was first put forward by the author (7) in 1958, it is only now, with the discovery of a remarkable correlation of theoretical electron properties, that the process by which energy may transfer from the accelerating field to the radiation field can be understood. This is the subject of this paper.

The anomalous magnetic moment of the electron (the g-factor) can be explained (8,9) in terms of a model of the electron as a sphere centred in a resonant cavity of radius governed by the Compton wave-length. The electric energy of the field 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:

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

where

(3) $$\delta = \frac{1}{\Delta + 2\pi/\alpha},$$

where Δ is a dimensionless parameter set by the radius of a spherical form which is opaque to radiation. The value of Δ was determined in ref. (8) and is $4/3^{\frac{1}{2}}$.

Equation (3) may easily be derived, because the radial spacing in the resonant cavity of the electron field is half the Compton wave-length or $h/2mc$. Let r denote the radius of the electron cross-section opaque to radiation. Then the overall radius of the resonant cavity is

(4) $$r + h/2mc\,.$$

The electron-field energy outside this cavity radius is $e^2/(2r+h/mc)$, which is the factor δ of mc^2, that is the portion of the total electron energy that does not contribute to spin. Hence the g-factor $2/(1-\delta)$ requires a δ value of $e^2/(2rmc^2+hc/e^2)$ or $1/(\Delta+hc/e^2)$, where mc^2 is $\Delta e^2/2r$. Thus, with α as $2\pi e^2/hc$, we obtain (3). Argument in ref. (8) gave r

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(2) H. ASPDEN: *Physics Unified* (Southampton, 1980). See bibliography references in chapt. 4.
(3) J. AHARONI: *The Special Theory of Relativity*, 2nd. Ed. (Oxford, 1965), p. 186 and 198.
(4) B. DEWITT and R. W. BREHME: *Ann. Phys.* (*N. Y.*), **9**, 220 (1960).
(5) J. KAPUSTA: *Nuovo Cimento B*, **31**, 225 (1976).
(6) H. ASPDEN: *Int. J. Theor. Phys.*, **15**, 631 (1976).
(7) H. ASPDEN: *Proc. IEEE C*, **105**, 359 (1958).
(8) H. ASPDEN: *Int. J. Theor. Phys.*, **16**, 401 (1977).
(9) H. ASPDEN: *Lett. Nuovo Cimento*, **32**, 117 (1981).

as $3^{\frac{1}{2}}$ times the J. J. Thomson electron radius a in formula (1). Hence Δ is $4/3^{\frac{1}{2}}$, as already noted. However, Δ can also be determined empirically from the measurement of the electron g-factor as 2(1.00115965) and α^{-1} as 137.036. From (2) and (3), these data give Δ as 2.31, in close accord with the value $4/3^{\frac{1}{2}}$ of 2.3094. Thus, empirically, the radius r in terms of the usual classical formula for electron radius e^2/mc^2 is half 2.3094, that is 1.1547, subject to an uncertainty of about two parts in one thousand as the evaluation of Δ is critically dependent upon the last significant digit in the measured values of the g-factor and α^{-1}.

The conclusion we reach is that there is empirical evidence showing that the electron presents a spherical surface of radius r which is opaque to radiation, where r is given by

$$r = (2/3^{\frac{1}{2}})e^2/mc^2 . \tag{5}$$

Now, this same cross-section should obstruct an electromagnetic wave propagating past an isolated electron and we see a basis for explaining how energy conveyed by the wave is transferred to the radiating-field system of the electron. This is very important if one considers the electron charge hypothetically as a hollow charge sphere. We know that there is no field energy within the body of the sphere. Hence, if it is accelerated there can be no energy radiation sourced within the charge. If we analyse the action at the charge surface itself it is found by the analysis of ref. [6] that notion of the charge to comply with the law $E = mc^2$ also means no energy radiation sourced at the charge surface. Yet, were we not to consider the interaction of the accelerating electric field in the analysis, we would find energy radiation in the form of electric field disturbance given by

$$\frac{\mathrm{d}E}{\mathrm{d}t} = e^2 f^2/3c^3 , \tag{6}$$

where t is the time and f is the acceleration. Note that it is usual to recognize that as the disturbance develops into an electromagnetic wave in moving away from the electron charge the energy is augmented by an equal amount of magnetic field energy, so doubling (6) to give the usual Larmor formula.

This, then, sets the problem. We know that remote from the electron and the local accelerating field action there is the energy radiated in measure set by (6), but that none comes from the charge itself. Also, we know that the electron presents an opaque area of πr^2 to a propagating electromagnetic wave which may cause electron acceleration. Can we relate the two aspects of this situation?

Regard the wave as a plane polarized wave propagating in vacuum. This facilitates the analysis and allows us to regard the dielectric constant as unity in the system of units adopted. Let the wave be a simple periodic wave with no harmonics and have an electric field intensity of magnitude V_0. Thus the energy density $V_0^2/8\pi$ is carried by the wave at speed c. The energy blocked by the electron and so absorbed for reradiation is then πr^2 times $V_0^2 c/8\pi$ or, simply, $V_0^2 cr^2/8$. From (5) this is an energy absorption rate of

$$\frac{\mathrm{d}E}{\mathrm{d}t} = V_0^2 e^4/6m^2c^3 . \tag{7}$$

Note then that the electron is subject to an acceleration of amplitude proportional to V_0. They are related by the factor e/m. The mean value of f^2 is, as we know from analysis of periodic signals, precisely half of the square of the acceleration amplitude.

Thus f^2 is $\frac{1}{2}(e/m)^2 V_0^2$. Putting this in (7), we obtain the quite remarkable result that it is identical to (6). The energy supplied by the advancing wave causing electron acceleration is precisely the amount of energy that the author's analysis ([6]) denied from being radiated from the charge sphere itself on the basis of the $E = mc^2$ formula. This means that the conservative energy property of charge by which its motion is caused to satisfy $E = mc^2$, thereby accounting for its inertia, does not deny the Larmor formula its role in energy radiation theory.

This is an interesting correlation, because there is a common indication, both from g-factor measurements and from the theory of electron inertia, that the electron has a cross-section opaque to radiation and of radius $3^{\frac{1}{2}}$ times the Thomson electron radius $2e^2/3mc^2$. The logical interpretation is that the energy radiation attributable to accelerated charge is sourced in the waves which impact the electron and that the energy balance requires the electron to present a spherical surface at which this radiation can be presumed to be reflected.

There are other implications from the analysis. One is that, although magnetic energy is carried along with a wave and can be absorbed with the electric energy, the acceleration of an electron does not generate magnetic disturbances in the immediate vicinity of the electron charge. Thus the electric energy radiated is the total energy radiated in this region, meaning that as the disturbance spreads over a larger range the energy is then shared with magnetic energy as the normal wave pattern develops in the radiation. This needs further study, but it conforms with a feature proposed elsewhere by the author ([10]) that the electromagnetic reference frame may have a lattice structure of dimensional order h/mc. This would imply that normal electromagnetic fields effects, even in a classically-based theory, are not to be expected in the immediate region of the electron charge, this being several hundred times smaller. This is also consistent with the proposition that electromagnetic reaction effects are associated with the mutual and collective behaviour of charge.

Another aspect worth studying is the extent to which the nonquantum energy radiation process implied by Larmor radiation may manifest itslef in Nature. It may have relevance in rarefied regions where charges stand in isolation and so have significance in cosmology. So far as dense matter is concerned, one can understand why the electrons in an atom do not act in concert to assure overall radiation of energy, bearing in mind that they are regulated by the Schroedinger equation so as to belong to an integral unit comprising also the heavy atomic nucleus. This unit is electrically neutral overall and so no overall acceleration can occur. If, however, the atom is ionized, then, as with the electron in isolation, some energy radiation is to be expected. The phenomenon of Larmor radiation may, in the end, prove to be quite independent of the normal quantum processes by which energy is shed by electromagnetic waves in units associated with the photon.

([10]) H. ASPDEN and D. M. EAGLES: *Phys. Lett. A*, **41**, 423 (1972).

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