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THE GYROMAGNETIC RATIO OF THE PHOTON.

by

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ABSTRACT

The photon's gyromagnetic ratio in vacuo is shown to be:

$$g_p = \frac{ec}{\hbar\kappa}$$

where e is the quantum of charge; $\hbar$ the Dirac constant, c the speed of light in vacuo and κ the magnitude of the wave-vector in vacuo. Experimental observation of the $\underline{B}^{(3)}$ field therefore occurs through the observation of the photon's spin angular momentum $\underline{S}^{(3)}$ in the Beth effect or in atomic absorption.

1. INTRODUCTION

The only observable spin angular momentum of the photon is $\underline{S}^{(3)}$ {1 - 3}; the spin angular momentum in the propagation axis of the electromagnetic radiation. It is observed mechanically in the Beth effect {4, 5} and spectroscopically in atomic absorption of $\pm\hbar$. In this Letter it is proposed that the $\underline{B}^{(3)}$ field of Evans and Vigier {6 - 14} is observable empirically through the relations:

$$\underline{B}^{(3)} = \frac{\mu_0}{\bar{V}}\underline{m}^{(3)} = \frac{\mu_0}{\bar{V}} g_p \underline{S}^{(3)} \; ; \; g_p = \frac{ec}{\hbar\kappa}, \quad -(1)$$

where g_p is the photon's gyromagnetic ratio. In eqns. (1) e is the quantum of charge; $\hbar$ is Dirac's constant; c is the speed of light in vacuo; κ is the magnitude of the vacuum wave-vector and $\omega = \kappa c$ is the angular frequency. The quantity $\bar{V}$ is a photon volume {15}, and μ_0 is the vacuum permeability, so that $\underline{m}^{(3)}$ is the magnetic dipole moment due to $\underline{B}^{(3)}$. It is seen that the gyromagnetic ratio in eqn. (1) has the required units of C kgm^{-1}, and accordingly, the equation is a self-consistent relation between a magnetic dipole moment and an angular momentum.

In Section 2, it is argued as a preliminary to Section 3 that the charge quantum e is present in electromagnetic radiation. Section 3 then shows that the presence of e is sufficient to define and OBSERVE $\underline{B}^{(3)}$ each time atomic absorption takes place in the laboratory, the key inference being eqn. (1).

2. THE PRESENCE OF e IN ELECTROMAGNETIC RADIATION IN VACUO.

The photon and concomitant field have present in their dual wave/particle structure the quantum of charge e {6-14}. This inference is developed in detail in ref. (8). The electromagnetic field in vacuo is negative under the charge conjugation operator $\hat{C}$ {6,16}, for example:

$$\hat{C}(A_\mu) = -A_\mu \; ; \quad \hat{C}(\underline{B}) = -\underline{B} \; ; \quad \hat{C}(\underline{E}) = -\underline{E} \; ; \qquad - (2)$$

where A_μ is the four-potential in vacuo and $\underline{E}$ and $\underline{B}$ the electric and magnetic component vectors in space. The photon as quantum of energy { 16 }, $\hbar\omega$, is however proportional {8,15} to the square of e, so is its quantized linear momentum $\hbar\kappa$ and angular momentum $\hbar$. The fine structure constant, for instance, is:

$$\alpha = 7.297 \times 10^{-3} = \frac{e^2}{4\pi\hbar c\epsilon_0} \qquad - (3)$$

where ϵ_0 is the vacuum permittivity, showing the quadratic relation between $\hbar$ and e^2 . Therefore the quantized photon energy, linear and angular momenta are quadratic in the charge quantum e and positive to $\hat{C}$.

Therefore the photon is not its own anti-particle because there exists a distinct anti-photon whose particulate (i.e. quantized) properties are unchanged by $\hat{C}$, but whose concomitant field properties (A_μ , $\underline{E}$, $\underline{B}$) are reversed by $\hat{C}$ {6-8 }. The photon is emitted by the oscillating electron in matter; the anti-photon by the oscillating positron in anti-matter. In order to demonstrate the existence of $\underline{B}^{(3)}$ in vacuo it is necessary only to demonstrate that the gyromagnetic ratio g_p is not zero, i.e. that there exists in the field/particle the quantum of charge e. Fields are linear in e; particle properties are quadratic in e. (In a pure wave theory { 15, 17 } the wave properties that define $\hbar$, $\hbar\kappa$ and $\hbar\omega$ are quadratic in e.) If e were not present in the field itself, there would be no transmission of electromagnetic influence in vacuo, one oscillating electron would not cause another to oscillate across the vacuum. Evidently, the charge quantum of the electromagnetic field is not a localised quantity, and should not be confused with the charge on the electron, which is localised on the electron. Therefore charge is a manifestation of the generalized Mach Principle { 17 } - the conceptual relation of field to the traditional "point charge" becomes analogous with the relation of field to point mass in gravitation. Electromagnetism becomes in this view a theory of general relativity and "point charge" and "point mass" become properties of curved spacetime. It is no coincidence that $\underline{B}^{(3)}$ allows a novel unification theory of the electromagnetic and gravitational fields { 9 }.

3. DERIVATION OF THE GYROMAGNETIC RATIO g_p.

In the received view { 1-3 } the spin angular momentum of electromagnetic radiation is defined through the conjugate product of electric field components $\underline{E}^{(1)} \times \underline{E}^{(2)}$:

$$\underline{S}^{(3)} = -\frac{i}{2}\frac{\epsilon_0}{\omega}\int \underline{E}^{(1)} \times \underline{E}^{(2)} \, dV \quad -(4)$$

and in the $\underline{B}^{(3)}$ theory this is equivalent to {6-14}:

$$En \equiv \omega \left| \underset{\sim}{S}^{(3)} \right| = \frac{1}{\mu_0} B^{(0)} \left| \underset{\sim}{B}^{(3)*} \right| \bar{V} \quad -(5)$$

where $B^{(0)}$ is the magnitude of $\underline{B}^{(3)}$. The magnetic dipole moment in vacuo, $\underline{m}^{(3)}$, of the electromagnetic field is deduced from eqn. (5) using:

$$\underset{\sim}{B}^{(3)} = \left(\frac{\omega \mu_0}{\bar{V} B^{(0)}} \right) \underset{\sim}{S}^{(3)} \quad -(6)$$

and is defined by:

$$\underset{\sim}{m}^{(3)} = \frac{\bar{V}}{\mu_0} \underset{\sim}{B}^{(3)} = \left(\frac{\omega}{B^{(0)}} \right) \underset{\sim}{S}^{(3)} . \quad -(7)$$

Therefore one photon has a magnetic dipole moment $\underline{m}^{(3)}$ proportional to its spin angular momentum $\underline{S}^{(3)}$. In the received view {1-3} the photon is asserted to be uncharged and the magnetic dipole moment in consequence is asserted to vanish.

In the new theory however {6-8}, there occur relations between $B^{(0)}$ and the magnitude, $A^{(0)}$, of the potential vector which are developed elsewhere { 8 } and which recognize the existence of e in vacuo. One of these is due to the non-Abelian structure of the new theory:

$$B^{(0)} = \frac{e}{\hbar} A^{(0)2} \quad -(8)$$

and eqn. (8) can be combined with { 6-8 }:

$$B^{(0)} = \frac{\omega}{c} A^{(0)} ; \quad \hbar\omega = ecA^{(0)} = \frac{1}{\mu_0} B^{(0)2} \bar{V} \quad -$$

to give three relations between $B^{(0)}$ and $A^{(0)}$. Using these, the volume $\bar{V}$ occupied by one photon can be deduced in the form:

$$\bar{V} = \frac{\mu_0 c \hbar^2}{e A^{(0)3}} \qquad (10)$$

and is inversely proportional to the cube of $A^{(0)}$. Using these relations gives a link between $\underline{m}^{(3)}$ and $\underline{S}^{(3)}$ in terms of the gyromagnetic ratio, as we set out to construct:

$$\underline{m}^{(3)} = \left(\frac{ec}{\hbar \kappa}\right) \underline{S}^{(3)} \qquad (11)$$

giving the following self-consistent expressions for g_p:

$$g_p = \frac{ec^2}{\hbar \omega} = \frac{c}{A^{(0)}} = \frac{\omega}{B^{(0)}} . \qquad (12)$$

It is notable that $\hbar\kappa / c$ has the units of mass, although it is not the photon mass { 18 }, but simply the photon momentum divided by its velocity c. Eqn. (11) is self-consistent physically and mathematically, and shows that for one photon of energy $\hbar\omega$, g_p is a constant. Finally, using [8] :

$$B^{(0)} = \frac{e \mu_0 c}{\bar{V} \kappa} \qquad (13)$$

we obtain the result first proposed in 1992 { 10 }:

$$\underline{B}^{(3)} = B^{(0)} \frac{\underline{S}^{(3)}}{\hbar} . \qquad (14)$$

The one photon Beth effect therefore demonstrates the existence of $\underline{B}^{(3)}$ through that of $\underline{S}^{(3)}$ and $\underline{m}^{(3)}$. In the received view {1-3} the Beth effect demonstrates only $\underline{S}^{(3)}$ and the link between $\underline{S}^{(3)}$ and $\underline{B}^{(3)}$ is not established. Similarly, in the received view the inverse Faraday effect demonstrates $\underline{B}^{(1)} \times \underline{B}^{(2)}$ but this is asserted not to be equal to $iB^{(0)} \underline{B}^{(3)*}$. At radio frequencies the inverse Faraday effect leads to an induction profile proportional to the square root of intensity, I, and in the new theory this effect is due to the $\underline{B}^{(3)}$ field acting at first order. In this instance the received view interprets the effect as being one in the conjugate product $\underline{B}^{(1)} \times \underline{B}^{(2)}$ divided by $iB^{(0)}$, and asserts that this is not a magnetic field, even through the effect actually observed is indistinguishable from that of a magnetic field. At this point, in our opinion, the received view is self inconsistent.

Finally it is interesting that a novel displacement current occurs in the new theory through the relation:

$$\dot{\underset{\sim}{j}}^{(3)} = \frac{\kappa}{\mu_0} \underset{\sim}{B}^{(3)} \qquad (15)$$

and can be related to the spin angular momentum $\underline{S}^{(3)}$ as follows:

$$\dot{\underset{\sim}{j}}^{(3)} = \frac{ec}{V} \frac{\underset{\sim}{S}^{(3)}}{\hbar} \qquad (16)$$

showing that e produces an electrodynamic quantity from a rotation generator $\underline{S}^{(3)}/\hbar$ {6-8}. This result is an example of the principle that e is the $\hat{C}$ negative scalar that links spacetime to the electromagnetic field. It is simply the constant that makes curved spacetime $\hat{C}$ negative, thus producing the electromagnetic field. Point charge, on the other hand, is to be found only where there is point mass, as in an electron or positron, and point charge to the electromagnetic field is as point mass to the gravitational field. In this way, both the electromagnetic and gravitational fields become expressions of curved spacetime, the former is curved antisymmetrically, the latter is curved symmetrically through the Einstein tensor.

Progress towards field unification in this way can be achieved quite readily using the $\underline{B}^{(3)}$ field (9, 14).

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