APPLICATIONS OF RELATIVISTIC QUANTUM m THEORY: THE RADIATIVE CORRECTIONS

by

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ABSTRACT

Relativistic quantum m theory is used to calculate and compute the radiative corrections, exemplified by the anomalous g factor of the electron and the Lamb shift in atomic hydrogen. In this way it is shown that the well known radiative corrections are the result of m space, the most general spherically symmetric space. The radiative corrections can be expressed in terms of the m parameter of this space, and show that energy is available in the m space.

Keywords: ECE unified field theory, m theory, radiative corrections.

UFT 429

1. INTRODUCTION

In recent papers of this series {1 - 41} the m theory has been developed in classical and quantum mechanics. This means that classical and quantum mechanics have been developed in the most general spherically symmetric space, characterized by the m function. In the preceding paper UFT428, relativistic quantum m theory was used to show that the radiative corrections can be described by the nature of m space. In Section 2 the anomalous g factor of the electron and the Lamb shift are considered within the context of relativistic quantum m theory. It is shown that the electron g factor is the result of a given m function, and the spin orbit interaction in relativistic quantum m theory is changed in detail by the m function.

This paper is a brief synopsis of detailed calculations in the Notes accompanying UFT429 on www.aias.us. Notes 429(1) and 429(2) develop methods of calculation of the g factor of the electron, and develop the theory of the vacuum particle first given in UFT338, giving the m theory of the mass of the universe. Note 429(3) develops the relativistic quantum m theory of spin orbit interaction, showing that m space changes the spin orbit energy levels of the Dirac equation, producing the possibility of a Lamb shift. Self consistently, the latter has already been derived using the spin connection of ECE2 theory.

Section 3 is a computational and graphical analysis using the hydrogenic wavefunctions in the first approximation. Expectation values are computed with the m function.

2. CALCULATION OF THE RADIATIVE CORRECTIONS

As shown in complete detail in Note 429(1) the g factor of the electron in Dirac theory is exactly two, and is calculated from the Zeeman hamiltonian:

$$H_2\phi = \frac{ie\hbar}{2m}\,\underline{\sigma}\cdot\underline{\nabla}\,\underline{\sigma}\cdot\underline{A}\,\phi + \cdots \quad -(1)$$

Here ϕ is the wavefunction, - e is the charge on the electron, m is the mass of the electron, $\hbar$ is the reduced Planck constant and $\underline{A}$ the vector potential. Dirac defined the magnetic field by:

$$\underline{B} = \underline{\nabla} \times \underline{A}. \quad -(2)$$

In this theory the Bohr magneton is defined by:

$$\gamma_B = \frac{e\hbar}{2m} \quad -(3)$$

and the spin angular momentum by:

$$\underline{S} = \frac{\hbar}{2}\underline{\sigma} \quad -(4)$$

with the property:

$$S\phi = m_s\hbar\phi. \quad -(5)$$

It follows that:

$$H_2\phi = 2\gamma_B\hbar m_s\phi \quad -(6)$$

and the electron g factor is the factor two appearing in this well known equation.

In relativistic quantum m theory the hamiltonian (1) is changed to:

$$H_2\phi = \frac{ie\hbar}{2m}\,\underline{\sigma}\cdot\underline{\nabla}\,\frac{1}{n(r)^{1/2}}\,\underline{\sigma}\cdot\underline{A}\,\phi + \cdots \quad -(7)$$

where m (r) is the m function of the m space. In general m is a function of r. Using the Leibnitz Theorem:

$$H_2\phi = \frac{ie\hbar}{2m}\left(\frac{1}{m(r)^{1/2}}\,\underline{\sigma}\cdot\underline{\nabla}\,\underline{\sigma}\cdot\underline{A} + \underline{\sigma}\cdot\underline{\nabla}\left(\frac{1}{m(r)^{1/2}}\right)\underline{\sigma}\cdot\underline{A}\right)\phi + \cdots \quad -(8)$$

and using the Pauli algebra:

$$\underline{\sigma}\cdot\underline{B}\;\underline{\sigma}\cdot\underline{A} = \underline{B}\cdot\underline{A} + i\,\underline{\sigma}\cdot\underline{B}\times\underline{A} \quad -(9)$$

the real and physical part of the hamiltonian is:

$$\begin{aligned} H_2\phi &= \frac{e\hbar}{2m\,m(r)^{1/2}}\,\underline{\sigma}\cdot\underline{\nabla}\times\underline{A}\,\phi - \frac{e\hbar}{2m}\,\underline{\sigma}\cdot\underline{\nabla}\left(\frac{1}{m(r)^{1/2}}\right)\times\underline{A}\,\phi \\ &= -\left(\frac{2}{m(r)^{1/2}}\right)\left(\frac{e\hbar}{2m}\right)m_s B_Z\,\phi - 2\left(\frac{e}{2m}\right)\underline{S}\cdot\underline{\nabla}\left(\frac{1}{m(r)^{1/2}}\right)\times\underline{A}\,\phi \end{aligned} \quad -(10)$$

Therefore the anomalous g factor of the electron is:

$$g = \frac{2}{m(r)^{1/2}}. \quad -(11)$$

Experimentally:

$$g = 2.002319314 \quad -(12)$$

so:

$$m(r) = 0.99942068. \quad -(13)$$

The relativistic quantum m theory gives the g factor of the electron to any accuracy. It is seen that m (r) is very close to unity, so the space is close to being the Minkowski spacetime in which Dirac's theory of the electron was developed.

The theory of the anomalous g factor can also be developed following the methods of UFT338, in which the vacuum particle of ECE2 theory was inferred. As shown in Note 429(2) the classical hamiltonian of m theory in frame (r_1 , ϕ) is:

$$H = m(r_1)\gamma mc^2 + U \quad -(14)$$

where the total relativistic energy is:

$$E = m(r_1)\gamma mc^2 \quad -(15)$$

and where γ is the generalized Lorentz factor of m theory. Here U is the potential energy. In immediately preceding papers it is shown that:

$$E^2 = m(r_1)(c^2 p_1^2 + m^2 c^4). \quad -(16)$$

It follows as in Note 429(2) that:

$$H = \frac{c^2 p^2}{E + m(r)^{1/2} mc^2} + m(r)^{1/2}(mc^2 + U_0) \quad -(17)$$

where

$$U_0 = -\frac{e^2}{4\pi\epsilon_0 r} \quad -(18)$$

is the potential energy due to the interaction of the electron and proton in an H atom.

Now develop the de Broglie / Einstein energy equation of UFT338 to m space

$$E = m(r)\gamma mc^2 = \hbar\omega \quad -(19)$$

It follows that:

$$H = \frac{p^2}{m\left(\frac{\hbar\omega}{mc^2} + m(r)^{1/2}\right)} + m(r)^{1/2}(mc^2 + U_0) \quad -(20)$$

For:

$$m(r) = 1 \quad -(21)$$

Eq. (20) reduces to the theory of UFT338:

$$H = \frac{p^2}{m\left(\frac{\hbar\omega}{mc^2}+1\right)} + mc^2 + U_0 \quad -(22)$$

Q. E. D.

In the SU(2) basis Eq. (20) is

$$H = \frac{1}{m}\,\underline{\sigma}\cdot\underline{p}\,\frac{1}{\left(\frac{\hbar\omega}{mc^2}+m(r)^{1/2}\right)}\,\underline{\sigma}\cdot\underline{p} + m(r)^{1/2}\left(mc^2+U_0\right) \quad -(23)$$

and in the presence of a magnetic field:

$$H = \frac{1}{m}\,\underline{\sigma}\cdot\left(\underline{p}-e\underline{A}\right)\frac{1}{\frac{\hbar\omega}{mc^2}+m(r)^{1/2}}\,\underline{\sigma}\cdot\left(\underline{p}-e\underline{A}\right) + m(r)^{1/2}\left(mc^2+U_0\right) \quad -(24)$$

On quantization it is found that:

$$H\phi = -2\frac{e}{m}\left(\frac{1}{\frac{\hbar\omega}{mc^2}+m(r)^{1/2}}\right)\underline{S}\cdot\underline{B}\,\phi + \cdots \quad -(25)$$

as in Note 429(2). The g factor of the electron is defined as:

$$H\phi = -g\frac{e}{2m}\,\underline{S}\cdot\underline{B}\,\phi. \quad -(26)$$

So from Eqs. (25) and (26):

$$\frac{g}{2} = \frac{2}{\left(\frac{\hbar\omega}{mc^2}+m(r)^{1/2}\right)} \quad -(27)$$

and

$$g = \frac{4}{\frac{\hbar\omega}{mc^2} + m(r)^{1/2}} \quad -(28)$$

In the limit:

$$m(r) = 1 \quad -(29)$$

it follows that:

$$g = \frac{4}{\frac{\hbar\omega}{mc^2} + 1} \quad -(30)$$

and for the rest electron:

$$\hbar\omega_0 = mc^2 \quad -(31)$$

so the Dirac g factor follows:

$$g = 2 \quad -(32)$$

Q. E. D.

The Dirac g factor is a limit of m theory.

For the rest electron with finite m(r):

$$g = \frac{4}{1 + m(r)^{1/2}} \quad -(33)$$

and using the observed g factor (12) it is found that:

$$m(r) = 0.99884 \quad -(34)$$

which is close to the m (r) given in Eq. (13).

The Lamb shift in atomic H can be calculated from the spin orbit hamiltonian. In Dirac theory (Note 330(1)) this is given by:

$$H\phi = \frac{1}{4m^2c^2}\underline{\sigma}\cdot\underline{p}\,U\,\underline{\sigma}\cdot\underline{p}\,\phi \quad -(35)$$

and as shown in all detail in Note 429(3) the hamiltonian (35) gives:

$$H\phi = \frac{e^2}{8\pi c^2\epsilon_0 m^2 r^3}\,\underline{S}\cdot\underline{L}\,\phi \quad -(36)$$

$$= \frac{e^2}{16\pi^2 c^2\epsilon_0 m^2 r^3}\left(J(J+1)-L(L+1)-S(S+1)\right)\phi$$

where ϵ_0 is the vacuum permittivity. The total angular momentum quantum number J is defined by the Clebsch Gordan series: $L-S, \ldots, L+S.$

$$-(37)$$

The expectation value of H____is evaluated with:

$$\left\langle \frac{1}{r^3}\right\rangle = \int \phi^* \frac{1}{r^3}\phi \, d\tau = \left(\frac{Z}{a_0}\right)^3 \frac{1}{n^3 L\left(L+\frac{1}{2}\right)(L+1)}$$

where a_0 is the Bohr radius, and in atomic H:

$$Z = 1 \quad -(38)$$

Here n is the principal quantum number. So the energy levels of atomic H are given by:

$$\langle H_{SO}\rangle = \frac{e^2\hbar^2}{16\pi c^2\epsilon_0 m^2 a_0^3}\left(\frac{J(J+1)-L(L+1)-S(S+1)}{n^3 L\left(L+\frac{1}{2}\right)(L+1)}\right) \quad -(39)$$

where:

$$J = L - S, \ldots, L + S \quad -(40)$$

in which L is the orbital angular momentum quantum number and S the spin angular momentum quantum number.

In this Dirac theory it is well known that there is no Lamb shift, there is no difference between the energy of ${}^2P_{1/2}$ and ${}^2S_{1/2}$, contradicting experiment.

In m theory denote:

$$U_1 = \frac{U}{m(r)^{1/2}} \quad -(41)$$

so the real part of the relevant hamiltonian is:

$$\mathrm{Re}\, H_{so}\,\phi = \frac{e\hbar}{4m^2c^2}\, \underline{\sigma} \cdot \underline{\nabla} U_1 \times \underline{p}\, \phi \quad -(42)$$

Using the Leibnitz theorem:

$$\underline{\nabla} U_1 = \underline{\nabla}\left(\frac{U}{m(r)^{1/2}}\right) = \frac{1}{m(r)^{1/2}}\, \underline{\nabla} U + U\, \underline{\nabla}\left(\frac{1}{m(r)^{1/2}}\right) \quad -(43)$$

and it follows that:

$$\mathrm{Re}\, H_{so}\,\phi = \frac{e^2\hbar}{16\pi\epsilon_0 m^2c^2r^3m(r)^{1/2}}\, \underline{\sigma} \cdot \underline{L}\, \phi + \frac{e\hbar}{4m^2c^2}\, U \underline{\sigma} \cdot \underline{\nabla}\left(\frac{1}{m(r)^{1/2}}\right) \times \underline{p}\, \phi \quad -(44)$$

Therefore the energy levels of the H atom are:

$$\langle H_{so} \rangle = \frac{e^2\left(J(J+1) - L(L+1) - S(S+1)\right)}{16\pi c^2 \epsilon_0 m^2} \left\langle \frac{1}{r^3 m(r)^{1/2}} \right\rangle \quad -(45)$$

$$+ \ldots$$

where

$$\left\langle \frac{1}{r^3 m(r)^{1/2}} \right\rangle = \int \psi^* \frac{1}{r^3 m(r)^{1/2}} \psi \, d\tau \quad -(46)$$

The appearance of $m(r)^{1/2}$ in the expectation value, Eq. (46), may already be sufficient to give the Lamb shift and to lift the degeneracy of $^2P_{1/2}$ and $^2S_{1/2}$. If not, additional terms may be used in Eq. (44).

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