# THE FLUCTUATING m SPACE AND THE LAMB SHIFT.

by

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ABSTRACT

The fluctuating m space is defined by comparison of m theory with the conventional electron shivering (zitterbewegung) theory used to describe the Lamb shift. This allows the description of any Lamb shift with an m ( r ) function to experimental accuracy. The vacuum force of m theory introduced in UFT417 is shown to be compatible with Lamb shift theory.

Keywords: fluctuating m theory, Lamb shift.

UFT 437

## 1. INTRODUCTION

In immediately preceding papers of this series {1 - 41} the m theory has been applied to various problems in physics and a number of important advances made. In Section 2 of this paper a theory based on a fluctuating m ( r ) function is developed. This is a fusion of m theory and Lamb shift theory, and the self consistency of the vacuum force of m theory and of the Lamb shift is demonstrated.

This paper is a short synopsis of detailed calculations found in the background notes accompanying UFT437 on www.aias.us. Note 437(1) is a development of the separation of variables method and its normalization, Note 437(2) is a relativistic development that shows how the Dirac theory is reduced to the Schroedinger theory. Note 437(3) introduces the fluctuation m ( r ) theory to give the conventional Lamb shift, and Note 437(4) discusses the self consistency of the vacuum force and the Lamb shift.

Section 3 is an application of computational quantum mechanics to the problem of the Lamb shift, utilizing the newly introduced quantization rules of the immediately preceding papers .

## 2. FLUCTUATING m THEORY

In order to forge a self consistent theory of the Lamb shift, assume that the potential energy in the presence of fluctuations is:

$$U = -\frac{e^2}{4\pi\epsilon_0 (r + \delta r)} = -\frac{m(r)^{1/2} e^2}{4\pi\epsilon_0 r} \quad -(1)$$

where $\delta r$ is the vacuum fluctuation used in the Lamb shift theory, e is the charge on the proton, $\epsilon_0$ is the vacuum permittivity, and r is the distance between electron and proton. It follows that:

$$m(r)^{1/2} = \frac{1}{1+\frac{\delta r}{r}} \sim 1 - \frac{\delta r}{r}. \quad -(2)$$

if

$$\delta r << r. \quad -(3)$$

The Lamb shift is given immediately by Eq. ( 2 ) using the calculations given in previous UFT papers and summarized in Note 437(3). The difference in Coulombic potential energy is expanded using a Taylor series:

$$\Delta U = U(\underline{r} + \delta\underline{r}) - U(\underline{r}) \quad -(4)$$

in which:

$$\langle \Delta U \rangle = \frac{1}{6} \langle \delta\underline{r} \cdot \delta\underline{r} \rangle_{vac} \left\langle \nabla^2 \left( \frac{-e^2}{4\pi\epsilon_0 r} \right) \right\rangle \quad -(5)$$

and

$$\langle \delta\underline{r} \cdot \delta\underline{r} \rangle_{vac} = \frac{1}{2\epsilon_0 \pi^2} \left( \frac{e^2}{\hbar c} \right) \left( \frac{\hbar}{mc} \right)^2 \int \frac{d\kappa}{\kappa} \quad -(6)$$

where $\kappa$ is a wavenumber. The integral in Eq. ( 6 ) diverges in general, but its limits are kept finite:

$$\langle \delta\underline{r} \cdot \delta\underline{r} \rangle_{vac} = \frac{1}{2\epsilon_0 \pi^2} \left( \frac{e^2}{\hbar c} \right) \left( \frac{\hbar}{mc} \right)^2 \int_{\pi/a_0}^{mc/\hbar} \frac{d\kappa}{\kappa}. \quad -(7)$$

Here $a_0$ is the Bohr radius, and e and m are the charge and mass of a fluctuating electron. It follows that:

$$\langle \delta\underline{r} \cdot \delta\underline{r} \rangle_{vac} \sim \frac{1}{2\epsilon_0 \pi^2} \left( \frac{e^2}{\hbar c} \right) \left( \frac{\hbar}{mc} \right)^2 \log_e \left( \frac{1}{\alpha\pi} \right) \quad -(8)$$

which is an expression made up entirely of fundamental constants. As in Note 437(3) the calculation of the Lamb shift is completed using the 2S wave function of H:

$$\left\langle \nabla^2 \left( -\frac{e^2}{4\pi\epsilon_0 r} \right) \right\rangle = \frac{e^2}{\epsilon_0} \left| \psi_{2S}(0) \right|^2 = \frac{e^2}{8\pi\epsilon_0 a_0^3} \quad -(9)$$

For the 2P state:

$$\langle \Delta U \rangle = 0. \quad -(10)$$

From Eq. ( 2 ):

$$\delta \underline{r} = \underline{r} \left( \frac{1}{m(r)^{1/2}} - 1 \right) \quad -(11)$$

so:

$$\langle \delta \underline{r} \cdot \delta \underline{r} \rangle = \left\langle \underline{r} \cdot \underline{r} \left( \frac{1}{m(r)^{1/2}} - 1 \right)^2 \right\rangle. \quad -(12)$$

$$-(13)$$

Assume that:

$$\left\langle \underline{r} \cdot \underline{r} \left( \frac{1}{m(r)^{1/2}} - 1 \right)^2 \right\rangle = \langle \underline{r} \cdot \underline{r} \rangle \left\langle \left( \frac{1}{m(r)^{1/2}} - 1 \right)^2 \right\rangle.$$

From UFT340:

$$\langle r \rangle (1S) = \frac{3}{2} a_0 \quad -(14)$$

$$\langle r \rangle (2S) = 6 a_0 \quad -(15)$$

$$\langle r \rangle (3S) = \frac{27}{2} a_0 \quad -(16)$$

$$-(17)$$

where $a_0$ is the Bohr radius. Therefore:

$$\langle \delta \underline{r} \cdot \delta \underline{r} \rangle_{vac} = 36 a_0^2 \left\langle \left( \frac{1}{m(r)^{1/2}} - 1 \right)^2 \right\rangle.$$

From Eq. ( 8 ):

$$\langle \delta \underline{r} \cdot \delta \underline{r} \rangle_{vac} = \frac{2\alpha}{\pi} \left( \frac{\hbar}{mc} \right)^2 \log_e \frac{1}{\pi\alpha} = 36 a_0^2 \left\langle \left( \frac{1}{m(r)^{1/2}} - 1 \right)^2 \right\rangle \quad -(18)$$

from which it follows that:

$$\left\langle \left( \frac{1}{m(r)^{1/2}} - 1 \right) \right\rangle = 2.177 \times 10^{-8} \quad -(19)$$

and from the conventional Lamb shift theory:

$$\langle \delta \underline{r} \cdot \delta \underline{r} \rangle_{vac} = 2.623 \times 10^{-27} \, m^2. \quad -(20)$$

Both Eqs. ( 19 ) and ( 20 ) are universal constants. The fact that there is a Lamb shift in some states and not in others is due to the relevant wave function. The Lamb shift can therefore be explained by combining m theory and vacuum fluctuation theory, with:

$$r_1 = \frac{r}{m(r)^{1/2}} = r + \delta r. \quad -(21)$$

Therefore the vacuum force of UFT417:

$$F(vac) = -\frac{mc^2}{2} \gamma \frac{dm(r)}{dr_1} \quad -(22)$$

becomes rigorously consistent with the Lamb shift through Eq. ( 21 ). The generalized $\gamma$ factor becomes:

$$\gamma = \left( \left( \frac{1}{1 + \frac{\delta r}{r}} \right)^2 - \left( 1 + \frac{\delta r}{r} \right)^2 \frac{v_N^2}{c^2} \right)^{-1/2} \quad -(23)$$

and in the limit:

$$\delta r \rightarrow 0 \quad -(24)$$

the Lorentz factor is recovered, Q. E. D. $$-(25)$$

The vacuum force produced by the Lamb shift is:

$$F(\mathrm{vac}) = -\frac{mc^2}{2}\gamma\frac{d}{dr}\left(\frac{1}{1+\frac{\delta r}{r}}\right)^2\left(1+\frac{d}{dr}(\delta r)\right)^{-1} \quad -(25)$$

which can be developed as:

$$F(\mathrm{vac}) = \frac{mc^2}{2}\gamma\frac{\frac{d}{dr}\left(2\frac{\delta r}{r}+\left(\frac{\delta r}{r}\right)^2\right)}{\left(1+\frac{\delta r}{r}\right)^4\left(1+\frac{d}{dr}\delta r\right)} \quad -(26)$$

as in Note 437(4). Eq. (26) gives the Lamb shift to any precision in any atom or molecule. It is seen that as:

$$\delta r \rightarrow 0 \quad -(27)$$

the vacuum force disappears:

$$F(\mathrm{vac}) \rightarrow 0 \quad -(28)$$

Q. E. D.

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