TAYLOR SERIES METHOD FOR CALCULATING VACUUM SHIFTS

by

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ABSTRACT

A Taylor series method is developed for calculating the effect of the vacuum on material matter. The method is exemplified by calculating the Lamb shift in atomic hydrogen and then applied to material matter in general, in any area of physics. The method is illustrated by calculating the effect of the vacuum on the dipole vector potential responsible for effects in NMR.

Keywords: ECE2 theory, Taylor series method for calculating vacuum effects.

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1. INTRODUCTION

In immediately preceding papers of this series {1 - 41} the effect of the vacuum on material matter has been calculated by considering the fluctuation induced by the vacuum in the position vector, the well known zitterbewegung or shivering due to the vacuum. In section two this method is developed into a Taylor series in which the change in an scalar function due to coordinate fluctuations $\delta \underline{r}$ in the vacuum can be calculated to any order. The method is first applied to the Lamb shift in hydrogen, and gives an accurate description of the shift. It is applied thereafter to find the effect of the vacuum on any scalar function of material matter in any area in physics, and is exemplified by calculating the vacuum correction of the dipole vector potential.

This paper is a short synopsis of detailed calculations in the notes accompanying UFT395 on www.aias.us and www.upitec.org archived on the Wayback Machine www.archive.org. Note 395(1) calculates the effect of the vacuum on the chemical shift in NMR, using the methods of UFT392 - UFT394. Notes 395(2) and 395(3) calculate the effect of the vacuum on electron electron spin spin interaction, considering dipole and contact terms. Notes 395(4) to 395(6) develop the methods summarized in Section two.

Section 3 is a numerical and graphical discussion.

2. TAYLOR SERIES METHOD

Consider the well known vector Taylor series expansion in three dimensions:

$$\begin{aligned} f(\underline{r}+\delta\underline{r}) = {} & f(\underline{r}) + (\delta\underline{r}\cdot\underline{\nabla})f(\underline{r}) \\ & + \frac{1}{2!}(\delta\underline{r}\cdot\underline{\nabla})^2 f(\underline{r}) + \frac{1}{3!}(\delta\underline{r}\cdot\underline{\nabla})^3 f(\underline{r}) \\ & + \frac{1}{4!}(\delta\underline{r}\cdot\underline{\nabla})^4 f(\underline{r}) + \cdots \qquad -(1) \end{aligned}$$

The change in any scalar function f ($\underline{r}$) due to the vacuum fluctuation $\delta\underline{r}$ is given by:

$$\Delta f(\underline{r}) = f(\underline{r} + \delta\underline{r}) - f(\underline{r}) \quad -(2)$$

In tensorial, or component, format the vector Taylor expansion is given by:

$$\Delta f = \frac{\partial f}{\partial r^{i}} (\delta r)^{j} + \frac{1}{2!} \frac{\partial^2 f}{\partial r^{j} \partial r^{k}} (\delta r)^{j} (\delta r)^{k} + \frac{1}{3!} \frac{\partial^3 f}{\partial r^{j} \partial r^{k} \partial r^{l}} (\delta r)^{j} (\delta r)^{k} (\delta r)^{l} + \cdots \quad -(3)$$

In vector notation this becomes:

$$\Delta f = \delta\underline{r} \cdot \underline{\nabla} f + \frac{1}{2!} (\delta\underline{r} \cdot \underline{\nabla}) (\delta\underline{r} \cdot \underline{\nabla} f) + \frac{1}{3!} (\delta\underline{r} \cdot \underline{\nabla}) ((\delta\underline{r} \cdot \underline{\nabla}) (\delta\underline{r} \cdot \underline{\nabla} f)) + \cdots \quad -(4)$$

using the fact that $\underline{\nabla}$ is a vector operator. The vector format is interpreted in Cartesian coordinates as follows. The first term is:

$$(\delta\underline{r} \cdot \underline{\nabla}) f = \left(\delta X \frac{\partial}{\partial X} + \delta Y \frac{\partial}{\partial Y} + \delta Z \frac{\partial}{\partial Z} \right) f. \quad -(5)$$

The second term is:

$$
\begin{aligned}
(\delta\underline{r}\cdot\underline{\nabla})(\delta\underline{r}\cdot\underline{\nabla}f)
&= \left(\delta X\frac{\partial}{\partial X}+\delta Y\frac{\partial}{\partial Y}+\delta Z\frac{\partial}{\partial Z}\right)\left(\delta X\frac{\partial f}{\partial X}+\delta Y\frac{\partial f}{\partial Y}+\delta Z\frac{\partial f}{\partial Z}\right)\\
&= (\delta X)^2\frac{\partial^2 f}{\partial X^2}+(\delta Y)^2\frac{\partial^2 f}{\partial Y^2}+(\delta Z)^2\frac{\partial^2 f}{\partial Z^2}\\
&\quad+(\delta X)(\delta Y)\frac{\partial f}{\partial X}\frac{\partial f}{\partial Y}+(\delta X)(\delta Z)\frac{\partial f}{\partial X}\frac{\partial f}{\partial Z}+(\delta Y)(\delta Z)\frac{\partial f}{\partial Y}\frac{\partial f}{\partial Z}\\
&\quad+(\delta Y)(\delta X)\frac{\partial f}{\partial Y}\frac{\partial f}{\partial X}+(\delta Z)(\delta X)\frac{\partial f}{\partial Z}\frac{\partial f}{\partial X}+(\delta Z)(\delta Y)\frac{\partial f}{\partial Z}\frac{\partial f}{\partial Y} \qquad -(6)
\end{aligned}
$$

and has nine terms in general. The third term has twenty seven components and the fourth term has eighty one components. These higher order terms will be considered in the following paper. In general it is seen that the vacuum has an intricate effect on all material matter in any branch of physics.

In the standard model of physics the effect of the vacuum is considered only in the context of a radiative correction such as the Lamb shift. The effect of the vacuum on the rest of physics is never considered in the standard model.

If the vacuum is considered to be isotropic:

$$\langle \delta\underline{r} \rangle = \underline{0} \qquad -(7)$$

and it follows that:

$$\langle \delta\underline{r}\cdot\underline{\nabla}f \rangle = \langle \delta\underline{r} \rangle\cdot\underline{\nabla}f = 0. \qquad -(8)$$

In the isotropic vacuum:

$$\langle \delta X^2 \rangle = \langle \delta Y^2 \rangle = \langle \delta Z^2 \rangle = \frac{1}{3}\langle \delta\underline{r}\cdot\delta\underline{r} \rangle \qquad -(9)$$

where:

$$\langle \delta\underline{r}\cdot\delta\underline{r} \rangle = \langle \delta X^2 \rangle + \langle \delta Y^2 \rangle + \langle \delta Z^2 \rangle \qquad -(10)$$

The isotropic vacuum also has the properties:

$$\langle \delta x \delta y \rangle = \langle \delta x \delta z \rangle = \langle \delta y \delta z \rangle = 0. \quad -(11)$$

Therefore the isotropically averaged second term of the Taylor expansion (1) is

$$\langle (\delta \underline{r} \cdot \underline{\nabla})(\delta \underline{r} \cdot \underline{\nabla} f) \rangle = \langle (\delta x)^2 \rangle \frac{\partial^2 f}{\partial x^2} + \langle (\delta y)^2 \rangle \frac{\partial^2 f}{\partial y^2} + \langle (\delta z)^2 \rangle \frac{\partial^2 f}{\partial z^2} \quad -(12)$$

It follows that to second order in the Taylor expansion:

$$\Delta f(\underline{r}) = \frac{1}{6} \langle \delta \underline{r} \cdot \delta \underline{r} \rangle \nabla^2 f(\underline{r}) + \dots \quad -(13)$$

whch is true for any scalar function $f(\underline{r})$.

The Lamb shift is calculated using mode theory in Eq. (13), as in previous UFT papers and in the notes accompanying UFT395. There is accurate agreement between this theory and experiment for the Lamb shift, whcih implies that the theory is suitable for application to the rest of physics. In the context of ECE2 physics it may be used to calculate the spin connection, or vacuum map, in any area of physics.

Eq. (13) can be applied to the well known dipole vector potential (see UFT392 to UFT395):

$$\underline{A}(\underline{r}) = \frac{\mu_0}{4\pi} \frac{\underline{m} \times \underline{r}}{|\underline{r}|^3} \quad -(14)$$

which is considered in detail in the accompanying notes and which is used for the theory of fine and hyperfine interaction. Here $\underline{m}$ is the magnetic dipole moment, $\underline{r}$ the radial coordinate, and μ_0 the permeability in vacuo. The scalar components in Cartesian coordinates are:

$$A_X = \frac{\mu_0}{4\pi} \frac{(m_Y Z - m_Z Y)}{(X^2+Y^2+Z^2)^{3/2}} \quad -(15)$$

$$A_Y = \frac{\mu_0}{4\pi} \frac{(m_Z X - m_X Z)}{(X^2+Y^2+Z^2)^{3/2}} \quad -(16)$$

$$A_Z = \frac{\mu_0}{4\pi} \frac{(m_X Y - m_Y X)}{(X^2+Y^2+Z^2)^{3/2}} . \quad -(17)$$

The effect of the vacuum on the complete vector potential is:

$$\langle \Delta \underline{A} \rangle = \langle \Delta A_X \rangle \underline{i} + \langle \Delta A_Y \rangle \underline{j} + \langle \Delta A_Z \rangle \underline{k} . \quad -(18)$$

By definition:

$$\langle \Delta \underline{A} \rangle = \underline{A} - \underline{A}_0 \quad -(19)$$

and the spin connection is defined by:

$$\underline{A} - \underline{A}_0 = -\underline{\omega} \times \underline{A}_0 . \quad -(20)$$

3. NUMERICAL AND GRAPHICAL ANALYSIS.

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