Pakistan Journal of Applied Sciences 2(7): 733-734, 2002

About the Radius of Electron Times Velocity of Light $r_e c$

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Abstract: The calculation of the radius of electron times velocity of light ($r_e c$) is made on the basis of magnetic top model. It is found that the calculated value ($r_e c$)$_{cal}$ is about 200 times larger than the conventional value ($r_e c$)$_{con}$.

Key Words: Magnetic Top Model, Velocity of Light, Radius of Electron

Introduction

In an earlier paper (Saglam and Boyacioglu, 2002) calculated the magnetic flux associated with the electron spin on the basis of the magnetic top model (Rosen,1951; Schulman,1968 and Barut et al 1992). In this model the electron is assumed to be a small hard sphere with radius r_e and a total charge -e of a uniform charge density $\rho = -\frac{3e}{4\pi r_e^3}$. The spin of the electron is assumed to be produced by the electron's rotation about itself with an angular frequency ω_s.

The conventional value of the electron's radius (r_e=2.8 x 10^{-15} m) is found just by setting the potential energy $\frac{3e^2}{5r_e}$ of this spherical top equal to the relativistic mass energy (mc^2). One defect of this model is rather obvious. Nothing is provided to hold the charge together.The aim of this study is to discuss the nesessity of an attractive potential to find the correct value of the radius.

Formalism: The spin magnetic moment $\vec{\mu}$ a free electron is given by

$$\vec{\mu} = -g\mu_B\vec{S} \tag{1}$$

where $\hbar\vec{S}$ is the spin angular momentum of the electron. When we introduce the magnetic field $\vec{B} = B\hat{z}$, the z component of the magnetic moment (in CGS units) becomes:

$$\mu_z = \pm\mu_B = \pm\frac{e\hbar}{2mc} \tag{2}$$

where we put g=2 for a free electron.

As it is stated by (Saglam and Boyacioglu, 2002) we assume that the spin angular momentum of the electron is produced by the point fictitious charge (-e) rotating in a circular orbit with the angular frequency ω_s and the radius R in x-y plane. So in the presence of the magnetic field $\vec{B} = B\hat{z}$. The vectors R(↑) and R(↓) for spin up and down electrons reads:

$$R(\uparrow) = R\cos(\omega_s t + \theta_s)\hat{x} - R\sin(\omega_s t + \theta_s)\hat{y} \tag{3}$$

$$R(\downarrow) = R\cos(\omega_s t + \theta_s)\hat{x} + R\sin(\omega_s t + \theta_s)\hat{y}\,. \tag{4}$$

Here θ_s is the angle at t=0.

The magnetic moments corresponding to Eqs.(3) and (4) will be

$$\vec{\mu}(\uparrow\downarrow) = \pm\frac{I\vec{A}}{c} \tag{5}$$

Here the (+) sign stands for $\vec{\mu}(\downarrow)$ and (-) sign stands for $\vec{\mu}(\uparrow)$ and $\vec{A}$ is the area vector which is defined by (Saglam and Boyacioglu, 2002)

$$\vec{A} = \int d\vec{A} = \int\frac{\vec{R}\times d\vec{R}}{2} = \frac{1}{2}\int_0^{T_s}(\vec{R}\times\frac{d\vec{R}}{dt})dt\,. \tag{6}$$

In this case the z-component of the magnetic moment for a spin down electron will be

$$\mu_z = -\frac{IA}{c} = -\frac{e\omega_s R^2}{2c} \tag{7}$$

where we put $I = \frac{e\omega_s}{2\pi}$ and $A=\pi R^2$.

If we compare Eqs.(2) and (7) we find

$$\omega_s = \frac{\hbar}{mR^2} \qquad (8)$$

which relates the spinning angular frequency to the radius R
Since the velocity of the fictitious point charge can not exceed the velocity of light from Eq.(8) we can write:

$$R\omega_s = \frac{\hbar}{mR} < c \qquad (9)$$

The Eq.(9) can be expressed in two ways:

$$\frac{h}{mc} = \lambda_c < 2\pi R \qquad (10)$$

or

$$Rc > \frac{\hbar}{m}. \qquad (11)$$

where λ_c is the Compton wavelenght of the electron . Eq.(10) states that the circumference of circular orbit of the fictitious point charge can not be smaller than the Compton wavelenght of the electron. More importantly Eq.(11) states that the multiplication Rc should be larger than $\frac{\hbar}{m} = 1.16 \times 10^{-4}\ m^2/s$.

Next we want to write Eq.(11) in terms of the radius of the electron: It can be shown that for a uniform charge distribution of radius r_e the magnetic moment of the spinning electron is :

$$\vec{\mu} = \frac{e\omega_s r_e^2}{5c} \qquad (12)$$

If we compare Eq.(12) with Eq.(7) the relation between R and r_e becomes:

$$R = \sqrt{\frac{2}{5}} r_e \qquad (13)$$

Substitution of Eq.(13) in Eq.(11) gives the lower limit for the calculated value (cal.) of ($r_e c$)

$$(r_e c)_{cal} > \sqrt{\frac{5}{2}} \frac{\hbar}{m} = 1.83 \times 10^{-4}\ m^2/s \qquad (14)$$

If we take the conventional values (con.) for $r_e = 2.8 \times 10^{-15}$ m and c= 3×10^8 m/s we find

$$(r_e c)_{con} = 8.4 \times 10^{-7}\ m^2/s \qquad (15)$$

If we compare Eqs.(14) and (15) we find

$$(r_e c)_{cal} > 200 (r_e c)_{con} \qquad (16)$$

So the calculated value ($r_e c$)$_{cal}$ is about 200 times larger than the conventional value ($r_e c$)$_{con}$.

Results and Discussion

We have calculated the radius of electron times velocity of light ($r_e c$) on the basis of magnetic top model. It is found that the calculated value ($r_e c$)$_{cal}$ is about 200 times larger than the conventional value ($r_e c$)$_{con}$. In this model the electron is assumed to be a small hard sphere with radius r_e and a total charge -e of a uniform charge density $\rho = -\frac{3e}{4\pi r_e^3}$. The spin of the electron is assumed to be produced by the electron's rotation about itself with an angular frequency ω_s. The conventional value of the electron's radius ($r_e = 2.8 \times 10^{-15}$ m) is found just by setting the potential energy $\frac{3e^2}{5r_e}$ of this spherical top equal to the relativistic mass energy (mc^2). One defect of this model is rather obvious. Nothing is provided to hold the charge together. Therefore we express the nesessity of an attractive potential to find the correct value of the radius.

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