An Electron with Compton Radius Rotates at Speed $v_e = \frac{\sqrt{3}}{2}c \sim 260{,}000$ km/s and Frequency $f_e = \frac{\sqrt{3}}{2}\frac{m_e c^2}{h} \sim 10^{20}$ c/s

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Abstract: A bizarre assumption about the electron radius leads to a non-physical rotation speed, and to an even more bizarre conclusion that electrodynamics laws don't apply to the electron, and electron spin magnetic moment needs no electron rotation.

In fact, the electromagnetic mass of the electron by the Abraham model of the electron which the erroneous radius employs, rules out that erroneous radius.

Rotation of the electron is established with the Compton radius of the electron. This is the radius of a photon with energy $h\nu_e$ that equals the electron's energy $m_e c^2$.

For an electron with a Compton radius, the Rotation Velocity is $v_e = \frac{\sqrt{3}}{2}c$, and the Rotation Frequency is $f_e = \frac{\sqrt{3}}{2}\frac{m_e c^2}{h}$.

For a proton with a Compton radius, the Rotation Velocity is $v_p = \frac{\sqrt{3}}{2}c$, and the rotation frequency is $f_p = \frac{\sqrt{3}}{2}\frac{m_p c^2}{h}$

	Compton Radius	Spin Ang. Mom.	Rotation Speed	Rotation Frequency
Electron	$(3.386)10^{-13}$ m	$\frac{\sqrt{3}}{2}\hbar$	260,000 km/s	10^{20} c/s
Proton	$(1.834)10^{-16}$ m	$\frac{\sqrt{3}}{2}\hbar$	260,000 km/s	$2 \cdot 10^{23}$ c/s
U Quark	10^{-30} m	$\frac{\sqrt{3}}{2}\hbar$	260,000 km/s	$5 \cdot 10^{20}$ c/s
D Quark	$(0.468)10^{-30}$ m	$\frac{\sqrt{3}}{2}\hbar$	260,000 km/s	10^{21} c/s
Neutrino	$(1.667)10^{-23}$ M	$\frac{\sqrt{3}}{2}\hbar$	260,000 km/s	$(2.5)10^{13}$

Key Words: Dirac Wave Equation, Fine Structure, Electron Spin, Electron Spin Magnetic Moment, Electromagnetic Mass, Compton Radius, Compton Wavelength. Particle-Photon Equivalence, Proton Spin, Rotation Frequency

Contents

1.

The Bizarre Claim that Electron's Spin is Not due to Rotation

Dirac's Wave Equation predicts that the electron has Spin Angular Momentum $S = \frac{\sqrt{3}}{2}\hbar$. Fine structure of the spectrum confirms the spin angular momentum of the electron. And the electron has magnetic moment due to its spin.

To deny the observed electron's rotation, someone claimed[1] that the electron mass m_e is uniformly spread inside a ball of "experimentally determined" radius

$$r = 5 \times 10^{-17}\,\mathrm{m}.$$

We will see in the next section how the model of the electron used here as a uniformly charged ball, contradicts this erroneous radius.

For now, the Inertia moment of the electron is

$$\frac{2}{5} m_e r^2 .$$

If the equatorial velocity of the electron is v, the electron's spin is

$$\frac{\sqrt{3}}{2}\hbar = \left(\frac{2}{5} m_e r^2\right)\left(\frac{v}{r}\right) = \frac{2}{5} m_e r v .$$

Then,

[1] Presented in Beiser, "Modern Physics"

$$v = \frac{5\sqrt{3}}{4}\hbar\frac{1}{m_e}\frac{1}{r}$$

$$v > \hbar\frac{1}{m_e}\frac{1}{r} \sim 10^{-34}\frac{1}{9\cdot 10^{-31}}\frac{1}{5\cdot 10^{-17}} > 10^{12} \gg c$$

Thus, the electron's rotation speed is non-physical, there cannot be rotation, and the electron spin angular momentum, and the electron spin magnetic moment are generated without rotation.

This bizarre conclusion ignores the observation of the fine structure in the spectrum, and the spin magnetic moment of the electron.

<u>What is non-physical here is the erroneous electron radius.</u>

And that erroneous electron radius is forbidden by the same electron model that it is employing.

2.

Electromagnetic Mass and the Electron Radius

Both Abraham and Lorentz perceived the electron as a electrically charged ball. Accelerating it, generates a radiation- reaction force, and an electromagnetic mass opposed to the acceleration.

Lorentz assumed that the electric charges are uniformly distributed on the surface of a contractible ball, and his radiation-reaction force was $\frac{e^2}{6\pi\varepsilon_0 c^3}\frac{d\vec{a}}{dt}$.

Abraham Assumed that the electric charges are uniformly distributed in the volume of a rigid ball, and his radiation-reaction force was $\frac{e^2}{5\pi\varepsilon_0 c^3}\frac{d\vec{a}}{dt}$.

The effect of the self-force is the same as an increase in the observable mass. Part of the mass is the original bare mass, and part is electromagnetic due to the self-force.

Relativity believers [2] confused the electromagnetic mass that is created by <u>acceleration</u> with the relativistic mass increase that depends on the <u>velocity</u>.

The concept of electromagnetic mass aimed to describe all mass as having an electromagnetic origin. That hope appears in

Feynman's lectures of physics [3] fifty years later, although that attempt already failed.

Had all the electron mass been electromagnetic, the Abraham-Lorentz radiation-reaction force $\frac{e^2}{6\pi\varepsilon_0 c^3}\frac{d\vec{a}}{dt}$ would equal $m_e\vec{a}$.

$$\vec{a} = \frac{e^2}{6\pi\varepsilon_0 m_e c^3}\frac{d\vec{a}}{dt}$$

Denoting $\frac{e^2}{6\pi\varepsilon_0 m_e c^3} \equiv \tau$,

$$\vec{a} = \tau\frac{d\vec{a}}{dt}$$

$$\vec{a} = \vec{a}_0\,\mathrm{e}^{\frac{t}{\tau}},$$

$$\vec{v} = \vec{v}_0 + \vec{v}_1\,\mathrm{e}^{\frac{t}{\tau}}.$$

This "runaway" solution increases indefinitely with time, and is non-physical.

Therefore, the electromagnetic mass cannot be the source of all observable mass.

Einstein and his followers explained it away as a manifestation of the relativistic mass which actually depends on the velocity, not acceleration.

The fault with the electromagnetic mass was placed on the description of the electron as a ball of finite volume, and this led to the description of the electron as a point mass with zero radius and infinite self energy.

In fact, there is no correlation between the assumption of a spherical electron, and the fact that the electromagnetic mass is only part of the total mass.

Furthermore, a point-like electron that occupies no space, has infinite momentum, and infinite energy, and violates the uncertainty principle.

Also, a charge of $-e$ within a sphere is equivalent to a point charge at the center of the sphere. And its physics is enigmatic.

Elimination of the infinities requires mass adjustments, and the complexities of renormalization theory.

Dirac disagreed saying "*….In mathematics, we ignore infinitesimals, not infinities…*" But some quantum electrodynamics predictions agreed with experiment.

We show that whatever is wrong with the electromagnetic mass has nothing to do with the size of the electron, and everything to do with the assumptions that underlie the Abraham-Lorentz derivation of the electromagnetic mass.

Assuming that the electric charges are uniformly distributed on the surface of a spherical electron that contracts by relativity due to the motion, Lorentz [4]

derived the electromagnetic mass,

$$\frac{e^2}{6\pi\varepsilon_0 c^2 r_e}.$$

Assuming that the electric charges are uniformly distributed in the volume of a rigid electron, Abraham [5] derived the electromagnetic mass,

$$\frac{e^2}{5\pi\varepsilon_0 c^2 r_e}.$$

Both derivations were made before Planck's discovery that radiation energy in a cavity is quantized, and before Einstein extended that to all radiation energy.

For Lorentz electromagnetic mass, the observed electron mass is

$$m_e = m_{e-bare} + \frac{e^2}{6\pi\varepsilon_0 c^2 r_e}$$

where m_{e-bare} is the bare electron mass. Then,

$$m_e > \frac{e^2}{6\pi\varepsilon_0 c^2 r_e}.$$

$$r_e > \frac{e^2}{6\pi\varepsilon_0 m_e c^2}.$$

Substituting

$$e = 1.6 \times 10^{-19}\mathrm{C},$$

$$\frac{1}{6\pi\varepsilon_0 c^2} = \frac{2}{3}\frac{\mu_0}{4\pi} = \frac{2}{3} \times 10^{-7}\mathrm{Newton/Ampere}^2,$$

$$m_e \approx 9.1 \times 10^{-31}\mathrm{kg},$$

the electron radius is

$$r_e > 1.8 \times 10^{-15}\mathrm{m}.$$

For the Abraham electromagnetic mass, the electron radius is

$$r_e > 2.2 \times 10^{-15}\mathrm{m}.$$

Both contradict the erroneous 10^{-17}.

In 1972, Weisskopf [6] commented that 20GeV experimental tests of Quantum electrodynamics indicated an electron radius smaller than 10^{-17} m. The predictions of QED may not be all correct.

3.

An Electron with Compton Radius Rotates at Speed $v_e = \frac{\sqrt{3}}{2} c \sim 260{,}000 \text{ km/s}$, And Frequency $f_e = \frac{\sqrt{3}}{2}\frac{m_e c^2}{h} \sim 10^{20} \text{c/s}$

The Compton radius for the electron is the radius of a photon with energy $h\nu_e$ that equals the electron's energy $m_e c^2$

$$m_e c^2 = h\nu_e .$$

Since $\nu_e = \frac{c}{\lambda_e}$,

$$m_e c^2 = h\frac{c}{\lambda_e}$$

$$c = \frac{h}{m_e \lambda_e}$$

The photon circumference is λ_e, and its radius is $\bar{\lambda}_e = \frac{\lambda_e}{2\pi}$.

$\bar{\lambda}_e$ is the Compton radius of the electron r_e. That is,

$$c = \frac{h}{m_e 2\pi r_e} = \frac{\hbar}{m_e r_e} .$$

The electron's Spin $S = \frac{\sqrt{3}}{2}\hbar$ is generated by its mass m_e, moving with speed v_e. Due to electrical repulsion, the electron mass keeps at distance r_e from the center. Therefore,

$$\frac{\sqrt{3}}{2}\hbar = m_e v_e r_e \,,$$

$$v_e = \frac{\sqrt{3}}{2}\frac{\hbar}{m_e r_e} = \frac{\sqrt{3}}{2}c \sim 260,000 \text{ km/s}\,.$$

The frequency of the electron's rotation is

$$f_e = \frac{1}{2\pi}\frac{v_e}{r_e} = \frac{\frac{\sqrt{3}}{2}c}{\lambda_e} = \frac{\sqrt{3}}{2}\frac{c}{\frac{h}{m_e c}} = \frac{\sqrt{3}}{2}\frac{m_e c^2}{h}$$

$$\approx \frac{\sqrt{3}}{2}\frac{(511)10^3\text{eV}}{(4.135)10^{-15}\text{eV}} \sim 10^{20}\text{cycles/s}$$

4.

A Proton with Compton Radius Rotates at Speed $v_p = \frac{\sqrt{3}}{2}c \sim 260{,}000 \text{ km/s}$, And Frequency $f_p = \frac{\sqrt{3}}{2}\frac{m_p c^2}{h} \sim 2 \cdot 10^{23}\text{cycles/s}$

Similarly, the proton equatorial speed is

$$v_p = \frac{\sqrt{3}}{2}c \sim 260{,}000 \text{ km/s}.$$

The frequency of the proton's rotation is

$$f_p = \frac{\sqrt{3}}{2}\frac{m_p c^2}{h} \approx \frac{\sqrt{3}}{2}\frac{(1836)(511)10^3\text{eV}}{(4.135)10^{-15}\text{eV}} \sim 2 \cdot 10^{23}\text{c/s}$$

5.

u Quark with Compton Radius

Rotates at Speed $v_{\mathrm{u}} = \frac{\sqrt{3}}{2} c \sim 260{,}000 \ \mathrm{km/s}$,

And Frequency $f_{\mathrm{u}} = \frac{\sqrt{3}}{2} \frac{m_u c^2}{h} \sim 5 \cdot 10^{20} \mathrm{cycles/s}$

Similarly, the **u** quark equatorial speed is

$$v_u = \frac{\sqrt{3}}{2} c \sim 260{,}000 \ \mathrm{km/s}.$$

The frequency of the **u** quark rotation is

$$f_u = \frac{\sqrt{3}}{2} \frac{m_u c^2}{h} \approx \frac{\sqrt{3}}{2} \frac{(2.2)10^6 \mathrm{eV}}{(4.135)10^{-15} \mathrm{eV}} \sim 5 \cdot 10^{20} \mathrm{c/s}$$

6.

d Quark with Compton Radius

Rotates at Speed $v_d = \frac{\sqrt{3}}{2} c \sim 260,000 \text{ km/s}$,

And Frequency $f_d = \frac{\sqrt{3}}{2} \frac{m_d c^2}{h} \sim 10^{21} \text{cycles/s}$

Similarly, the **u** quark equatorial speed is

$$v_u = \frac{\sqrt{3}}{2} c \sim 260,000 \text{ km/s}.$$

The frequency of the **u** quark rotation is

$$f_d = \frac{\sqrt{3}}{2} \frac{m_d c^2}{h} \approx \frac{\sqrt{3}}{2} \frac{(4.5)10^6 \text{eV}}{(4.135)10^{-15} \text{eV}} \sim 10^{21} \text{c/s}$$

7.

Neutrino with Compton Radius Rotates at Speed $v_\nu = \frac{\sqrt{3}}{2}c \sim 260{,}000 \text{ km/s}$, And Frequency $f_\nu = \frac{\sqrt{3}}{2}\frac{m_\nu c^2}{h} \sim (2.5)10^{13}\text{cycles/s}$

Similarly, the **u** quark equatorial speed is

$$v_\nu = \frac{\sqrt{3}}{2}c \sim 260{,}000 \text{ km/s}.$$

The frequency of the **u** quark rotation is

$$f_\nu = \frac{\sqrt{3}}{2}\frac{m_\nu c^2}{h} \approx \frac{\sqrt{3}}{2}\frac{(0.12)\text{eV}}{(4.135)10^{-15}\text{eV}} \sim (2.5)10^{13}\text{c/s}$$

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