Possible Origin of the 70MeV Mass Quantum

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The absence of three fundamental entities from the experimental evidence is notable. The search for two, the magnetic monopole and the electric dipole moment, is extensively documented in the literature. The third, the electric flux quantum, is remarkably absent. One is tempted to speculate that these circumstances are related, and that exploration of the electric flux quantum might shed light upon, and beyond, the absence of the magnetic monopole and the electric dipole. This note presents a tentative early effort to find a guidepost or two along the road to such an exploration, or at least a compass that permits the choice of direction. What emerges is a possible origin of the 70MeV platform state. While documentation of this mass quantum (it is simply the mass of the electron divided by the fine structure constant) in the literature is not so starkly absent as for the electric flux quantum, it is surprisingly sparse.

Introduction

An earlier note [1] set out to explore the clearly demonstrated ordering [2,3] of particle lifetimes in powers of alpha, the fine structure constant. This ordering breaks down at the zeptosecond boundary [4], or equivalently at the reduced Compton wavelength of the electron. The expectation was that by matching the photon and quantum Hall impedances at that length scale, one might learn something interesting [5]. As it was, that note looked instead at a factor of alpha smaller, at the scale of the 70MeV platform state [6], where the photon impedance does indeed match the quantum impedance of the electron.

This note returns to the reduced Compton wavelength of the electron, seeking the origin of the 70MeV platform state. Two possible definitions of the electric flux quantum are presented. The Poynting vectors of the resulting fields, when oriented perpendicular to the magnetic flux quantum, are calculated at the reduced Compton wavelength. Integrating these prodigious energy flows over one cycle of the Compton frequency gives the energy stored in the field configurations. Respectively, the stored energies are twice the mass of the electron, and half the 70MeV mass quantum. The origin of the factors of two is not yet understood.

The Flux Quanta defined in terms of Electric Charge

We seek to define both the magnetic and electric flux quanta in terms of electric charge. One definition of the magnetic flux quantum is straightforward and universally accepted [7].

$$\Phi_{B1} = \frac{h}{2e} = 2.0678336668 \cdot 10^{-15} tesla \cdot m^2$$

The possibility of one or more additional definitions might also be given some consideration.

The electric flux quantum is not so familiar. There are at least two ways in which it may be defined. The first applies the ratio of photon field intensities, E=cB.

$$\Phi_{E1} = c \cdot \Phi_{B1} = 6.1992093771 \cdot 10^{-1} mV \cdot mm$$

which can also be written as

$$\Phi_{E1} = \frac{h \cdot c}{2e} = 6.1992093771 \cdot 10^{-1} mV \cdot mm$$

The second makes use of Gauss' law.

$$\Phi_{E2} = \frac{e}{\varepsilon_0} = 1.8095126511 \cdot 10^{-2} mV \cdot mm$$

The ratio of these two electric flux quanta is

$$\frac{\Phi_{E2}}{\Phi_{E1}} = 0.029189410147$$

To eight significant figures this is identical to four times the fine structure constant

$$4\alpha = 0.029189410277$$

Both of these flux quanta are surprisingly large. One might consider measuring them with a Radio Shack voltmeter, although the question of impedance matching [1] in that circumstance appears problematic.

Which definition is 'right'? One might argue that the smaller of the two is more fundamental. Additionally, it results from the application of Gauss' law, a familiar and comfortable procedure. However, it breaks the E=cB relation between the electric and magnetic fields. And perhaps more significantly, it introduces an additional constant, the electric permittivity of free space. To the contrary, the magnetic permeability does not appear in the definition of the magnetic flux quantum.

The Flux Quanta defined in terms of Magnetic Charge

While not essential to arriving at the 70MeV platform state, this note does suggest that the magnetic monopole is somehow woven into this exploration. As a brief aside, it is interesting to look at the flux quanta as defined in terms of that charge. This is done with ease, by virtue of the Dirac quantization condition.

$$e \cdot g = \frac{h \cdot c}{2}$$

We then have both definitions, numerically identical:

$$\Phi_{B1} = \frac{h}{2e} = \frac{g}{c} = 2.067833668 \cdot 10^{-15}\, tesla \cdot m^2$$

$$\Phi_{E1} = \frac{h \cdot c}{2e} = g = 6.1992093771 \cdot 10^{-1}\, mV \cdot mm$$

$$\Phi_{E2} = \frac{e}{\varepsilon_0} = \frac{h \cdot c}{2\varepsilon_0 g} = 1.8095126511 \cdot 10^{-2}\, mV \cdot mm$$

The second of these three equations is particularly interesting. That the electric flux quantum appears identical to the magnetic charge has topological implications.

The Field Strengths

With knowledge of the values of the flux quanta, the field strengths at the reduced Compton wavelength of the electron can be calculated.

The Magnetic Field Strength

The magnetic field strength is

$$B_1 = \frac{\Phi_{B1}}{\pi \cdot \lambda\!\!\!^{-}{}_e^{\,2}} = 4.4140049149 \cdot 10^9\, tesla$$

From the quantum Hall effect, the corresponding magnetic length (or Larmor radius) is $\lambda\!\!\!^{-}{}_e$. This field strength also arises in the consideration of the effective mass of the electron in strong magnetic fields [8].

The Electric Field Strengths

The electric field strength due to the first of the electric flux quanta is

$$E_1 = \frac{\Phi_{E1}}{\pi \cdot \lambda\!\!\!^{-}{}_e^{\,2}} = 1.3232853831 \cdot 10^{18} \frac{volt}{m}$$

and for the second

$$E_2 = \frac{\Phi_{E2}}{\pi \cdot \lambda\!\!\!^{-}{}_e^{\,2}} = 3.8625919788 \cdot 10^{16} \frac{volt}{m}$$

The Field Energies

Considering now the configuration of orthogonal electric and magnetic flux quanta, two Poynting vectors can be calculated, one for each of the two electric field strengths.

$$S_{E1} = \frac{E_1 \times B_1}{\mu_0} = 4.6481107107 \cdot 10^{33} \frac{W}{m^2}$$

$$S_{E2} = \frac{E_2 \times B_1}{\mu_0} = 1.3567560994 \cdot 10^{32} \frac{W}{m^2}$$

As previously mentioned, these are prodigious energy flows. The energy associated with these flows can be calculated by integrating over one cycle of the Compton frequency.

$$W_{E1} = S_{E1} \cdot \frac{\bar{\lambda}_e^{\,2}}{f} = 35.012623252 \ \ MeV$$

$$W_{E2} = S_{E2} \cdot \frac{\bar{\lambda}_e^{\,2}}{f} = 1.0219978204 \ \ MeV$$

where $f = \frac{2\pi \cdot \bar{\lambda}_e}{c}$

The first of the two energies is half the 70MeV platform state, and to ten significant figures the second is twice the mass of the electron.

Conclusion

It could be that all of the above, as well as the bulk of the previous note [1] is just some form of calculational sophistry, a numerical tautology. Or it could be that a simple model is emerging. The model, what there is of it at this point, has orthogonal electric and magnetic flux quanta. In some sense it appears to be a stationary photon [9].

The flux quanta are attractive in this context, as they don't suffer the inevitable infinities of point particles. Yet there is the question of mass. A stationary photon cannot be massless.

Maxwell's equations have dynamics. The fields change in time. In the present model the fields are static. Adding time derivates only replicates the photon, requiring that this object propagate at the speed of light. One might consider adding the time derivative of mass as well [10] as a spin-2 field that shares energy with the time-varying electric and magnetic flux quanta. It appears [11] that the 2-spinors of the Dirac equation might provide a suitable formalism for such an approach.

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References

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[5] ibid., "The main theoretical idea we are trying to establish in the present work is the relevance of the fine structure constant as a coupling constant in quantum chromodynamics", p.307.

[6] ibid., fig. 0.2.2 and thereafter. Extensive references to the presence of the 70MeV mass quantum in the literature may be found here as well.

[7] all fundamental constants are CODATA 2006, excepting the fine structure constant. The most recent value of alpha is taken from G. Gabrielse, "Determining the Fine Structure Constant", available at http://www.itp.uzh.ch/~nurhana/PPP1_HS09/Lecture_Notes/DeterminingTheFineStructureConstant.pdf

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