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Relationship between Physical Constants and the Electron Mass

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We assume a specific relationship between the different characteristic radii of the electron and from this we obtain another relation between the physical constants e, G, $\alpha = e^2/\hbar c$ and the mass of the electron.

G. Rosen (1978) has given the following expression for the experimental electron mass m in terms of physical constants:

$$m = \frac{|e|}{G^{1/2}} f(\alpha) \tag{1}$$

where e denotes the electron charge, G is Newton's constant, $\alpha = e^2/\hbar c = (137.036)^{-1}$ means the fine-structure constant, and he has found for $f(\alpha)$

$$f(\alpha) = \frac{1}{\pi^{1/2}} \frac{3}{4} \exp\left[-\left(\frac{\pi}{9\alpha} + \frac{3}{8} \right) \right] \tag{2}$$

Now we shall "derive" another expression for $f(\alpha)$.

First we consider the three well-known characteristic lengths associated with the electron:

the Bohr radius

$$r_B = \frac{\hbar^2}{me^2}$$

the Compton length

$$r_C = \frac{\hbar}{mc} = \alpha r_B$$

and the classical electron radius

$$r_0 = \frac{e^2}{m_0 c^2} = \alpha r_C$$

It is well known that the above three radii are the (first three) elements of a geometrical series whose quotient equals α.

Let us assume that the gravitational electron radius $r_G = Gm/c^2$ is also a member of the aforementioned series, i.e., it satisfies the equation

$$r_G = r_0 \alpha^r \tag{3}$$

for some integer r.

This assumption is equivalent to

$$\frac{Gm}{c^2} = \frac{e^2}{m_0 c^2} \alpha^r \tag{4}$$

At this point we introduce Rosen's "equipartition law"

$$m/m_0 = 4/3 \tag{5}$$

according to which the electrostatic mass, m_0, is attached to the three spatial degrees of freedom and the "real" (i.e., gravitating) mass, m is connected with the four-dimensional space-time dynamics.

Equations (4) and (5) yield

$$m = \frac{|e|}{G^{1/2}} \frac{2}{3^{1/2}} \alpha^{r/2} \tag{6}$$

and inserting the experimental values of m, e, G, α we get

$$\frac{r}{2} = 10.0019 \pm 0.0001 \tag{7}$$

REFERENCE

Rosen, G. (1978). *International Journal of Theoretical Physics*, **17**, 1.