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Mini Review

Electron Mass Calculation Based on Simple Physical Assumptions

LI Buravov*

Federal Research Center of Problems of Chemical Physics and Medicinal Chemistry RAS (Chernogolovka), Russia

Abstract

In this article, the electron mass is calculated based on simple physical assumptions, taking into account its electrostatic and magnetic energy. This approach aims to derive the electron mass from fundamental principles and constants, offering insights into the intrinsic properties of the electron and potentially resolving some of the theoretical challenges in physics.

More Information

***Address for correspondence:** LI Buravov, Federal Research Center of Problems of Chemical Physics and Medicinal Chemistry RAS (Chernogolovka), Russia, Email: buravov@icp.ac.ru

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Introduction

At one time, Poincaré suggested that the electron structure contains a certain elastic element, due to which the charge is retained and stabilized in a small volume [1]. This model was subsequently used by many authors. Following [2,3], we assume that the virtual rest energy of an electron consists of the surface energy $Ws = \sigma 4\pi r^2$ and the electrostatic energy of the charged surface $We = e^2/2r$, where σ is the surface tension of the elastic shell, r is its radius, $e^2 = q^2/4\pi\varepsilon_0$, q is the electron charge, ε_0 is the permittivity of the vacuum. The virtual rest energy of such a system is

$$E = \sigma 4\pi r^2 + e^2/2r \qquad (1)$$

The rest mass of an electron m_0 corresponds to the minimum of the virtual energy of the system; minimizing the virtual energy (1) with respect to r, we find

$$m_0 = 3\,(\pi\sigma/4)^{1/3}\, e^{4/3}/c^2 \qquad (2)$$

and the radius a of the electron is

$$a = 0.5(e^2/2\pi\sigma)^{1/3} \qquad (3)$$

and

$$m_0c^2 = \frac{3}{4}e^2/a = 12\,\sigma\pi a^2 \qquad (4)$$

To determine the radius and mass of the electron, it is necessary to know the energy constant σ, which will be defined below. In [4] it was assumed that each elementary particle emits virtual Higgs bosons in the form of spherical waves and, as a result of the recoil of momentum during the emission of bosons, creates its own confining potential, due to which its mass is stabilized during its lifetime. It was shown that this confining potential is proportional to R^2 or R^3, depending on the spectrum of the emitted Higgs bosons, discrete or continuous. We assume that the value of $\sigma 4\pi r^2$ in the Poincaré model exactly corresponds to this holding potential (~ R^2).

As is known, an electron, when moving, produces a moving magnetic field and magnetic field energy proportional to the square of the electron velocity v^2. This magnetic energy turns out to be equal to [3]:

$$W_m = \frac{2}{3}e^2/a\,(v^2/2)\,(1/c^2) \qquad (5)$$

Thus, the kinetic energy for a moving electron at v << c turns out to be

$$E = m_0(v^2/2) + \frac{2}{3}e^2/a\,(v^2/2)\,(1/c^2) \qquad (6)$$

and the dynamic mass of the electron, which is measured in the experiment, is

$$m_{0din} = \frac{3}{4}e^2/a\,(1/c^2) + \frac{2}{3}e^2/a\,(1/c^2) = \frac{17}{12}e^2/a\,(1/c^2) \qquad (7)$$

The value of the energy constant σ was determined in [5] using the mass of the neutral pion M_0 = 134.963 Mev/c^2 based on the initial model assumption that the elementary particles muon, pion, and kaon in the stopped state can be represented as spherical resonators for quanta of virtual neutrinos, excited inside an elastic lepton shell with surface tension σ and radius R. The number and type of these quanta are determined from the decay scheme of these particles: 2 for a muon, 3 for a pion, and 21 minimal quanta for a kaon. As shown in [5], it follows from this assumption that the virtual rest energy of a neutral pion is written as:

$$E = \sigma 4\pi R^2 + 4.5\hbar\pi c/R \quad (8)$$

where the value 1.5 $\hbar\pi c/R$ is the energy of one virtual quantum of a neutrino, taking into account the zero-point energy. In [5], it was assumed that the value of σ is the same for all leptons (i.e. neutrinos, e, μ, τ), as well as for pions and kaons. Minimizing the virtual energy (8), we obtain an equation for the mass of a neutral pion

$$M_0 = 3\pi\sigma^{1/3}(4.5\hbar c)^{2/3}/c^2 \quad (9)$$

from which we find the value of σ:

$$\sigma = 4 \times 3^{-7}\pi^{-3}\hbar^{-2}c^4M_0^{\,3} = 3.724 \times 10^{23}\ \mathrm{Mev/cm^2} \quad (10)$$

Substituting this value of σ into equation (3), we find the radius a = 1.974 x 10^{-13} cm, and then the dynamic mass of the electron m_{0din} = 1.033 Mev/c^2, which is 2.022 times greater than the experimental value m_{exp} = 0.511 Mev/c^2. Note that in the proposed model, an almost correct value of the muon mass was obtained earlier in [5] $m_{\mu calc}$ = 105.707 Mev/c^2, while the experimental value is 105.66 Mev/c^2. It can be assumed that the overestimated value of m_{0din} is obtained due to the fact that in our consideration, the polarization of the vacuum by the electron charge [6], which reduces the electric field of the electron in its near zone, was not taken into account. Apparently, to take this effect into account, it is necessary to introduce the effective permittivity $\varepsilon_{eff} = (2.022)^{3/2} = 2.875$ into the original equations (1)-(7), that is, replace the value of e^2 with e^2/ε_{eff}.

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