Proof of Einstein's Assertion that Electrons and Electric Charges are Two Different Aspects of *One* Reality

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Einstein is quoted as having remarked that "it is a delusion to think of electrons and fields as two physically different, independent entities. Since neither can exist without the other, there is only *one* reality to be described, which happens to have two different aspects; and the theory ought to recognize this from the outset instead of doing things twice."

It is shown, in the context of the Stoney system of absolute units, which give prominence to the electromagnetic interaction, that Einstein's assertion is supported by the results of a recent electron channeling experiment that was designed to test *de Broglie's* electron internal clock conjecture.

1 Introduction

It has been said that one of the primary lessons to be learned from the long history of physics is that the resolution of inconsistencies is a reliable path to breakthroughs, which is reminescent of Planck's 19th century struggle to preserve the *continuity* principle, whose inconsistencies were imbued in the philosophy of Leibniz. He referred to his derivation of the radiation law as "an act of desperation," and, of course, the rest is history. It is indeed ironic that over a century later we find ourselves confronted with a similar problem, namely the lingering question of the nature of electric charge, whose physical reality is inconsistent with the prevailing view that it is a *structureless* entity. Aside from the fact that it is the source of the electromagnetic interaction, and that its conservation is understood, we have no fundamental understanding of its

magnitude or quantization [1]. Inquires into its structure have encountered numerous paradoxes that are unresolvable within the *scaling* bounds of Planck's "action" constant, which strongly suggests that we consider this problem from a different perspective.

Since electric charges and electrons *cannot* exist as two physically different, independent entities, and both are quantized, it is clearly of interest to consider this problem from the electron's perspective by assuming that the electron's rest mass is *electromagnetic* in origin. We may then pose the question, in its simplest form, what is the *link* between the electron's rest-mass energy and its intrinsic *vibrational* frequency, which, as will be shown in this paper, is key to resolving this century old problem.

2 Conceptualization

What quantities one chooses to regard as fundamental depends on the domain one seeks to investigate. For example, if one seeks to set the scale for atomic and molecular sizes, then the Bohr radius 10^{-9} cm appears as the appropriate fundamental unit of length. However, if one's objective is to set the scale for investigating the elementary charge then one finds that the Stoney scale [2] is the appropiate scale, since in addition to being an order of magnitude *smaller* than the Planck scale, it gives prominence to the electromagnetic interaction. Its base units for mass, length, and time consist of the electric charge (e), the Newtonian gravitational constant (G), and the vacuum velocity of light (c). With the modern values $e = 4.803\times10^{-10}$ esu, $\mathrm{G} = 6.674\times10^{-8}$ dyne-cm$^2/g^2$, and $c = 2.998\times10^{10}$ cm/s, the resulting absolute units are given by

$$M_{\mathrm{G}} = \left(\frac{e^2}{\mathrm{G}}\right)^{1/2} = 1.86\times10^{-6}\ \mathrm{g} \tag{1}$$

$$L_{\mathrm{G}} = \left(\frac{e^2\mathrm{G}}{c^4}\right)^{1/2} = 1.38\times10^{-34}\ \mathrm{cm} \tag{2}$$

$$T_{\mathrm{G}} = \left(\frac{e^2\mathrm{G}}{c^6}\right)^{1/2} = 4.60\times10^{-45}\ \mathrm{s} \tag{3}$$

where, following Stoney, we have employed the CGS system for consistency.

As we shall see below, the mathematical simplicity and cogency of the Stoney system of absolute units provides a consistent framework for a transparent quantum-theoretical description of electric charge. It will be seen at once that its formulation enters it tenets as an "action" constant that has the dimensions of a momentum ($M_{\mathrm{G}}c$) and a length (L_{G}), in the form

$$(M_{\mathrm{G}}c)\,L_{\mathrm{G}} = 7.695\times10^{-30}\mathrm{momentum{\cdot}length} = e^2/c \tag{4}$$

where M_{G} denotes the *gravitational* mass equivalent of the *electrostatic* potential energy e, deriving from eq. (1), which is advantageous since it engenders

the possibility of discovering new physics. A meaningful physical connection must then be made between the *gravitational* mass's momentum ($M_{\mathrm{G}}c$) and the electron mass's momentum ($m_e c$) by means of the relation suggested by eq. (4):

$$\frac{(M_{\mathrm{G}}c)}{(m_e c)} = \frac{L_{\mathrm{G}}}{r_c} \tag{5}$$

where r_c is the electron's *charge* radius, quantitatively equal to 2.819×10^{-13} cm, deriving from the product of the ratio (M_{G}/m_e) and L_{G}, the absolute unit of *gravitational* length of eq. (2). It is then readily seen that the momentum is in *inverse* ratio to the length, which implies that the "action" $(m_e c)r_c$ is equivalent to the *gravitational* mass equivalent of the *electrostatic* quantum of "action" (e^2/c) of eq. (4). We may therefore conclude that

$$(m_e c)r_c = 7.695 \times 10^{-30} \text{ momentum·length} = e^2/c. \tag{6}$$

It is then possible, without difficulty, to formulate a quantum-theoretical description of the elementary charge by assuming that the electron vibrates with an *intrinsic* energy $j\nu_e$ that is equivalent to its mass-energy, in the form

$$m_e c^2 = j\nu_e \tag{7}$$

where, for brevity, j denotes the quantum of "action" on the left-hand side of eq. (6), which *links* the electron's mass-energy to its frequency, ν_e, in the form

$$\begin{aligned} \nu_e &= \frac{m_e c^2}{j} \\ &= 1.064 \times 10^{23}\ s^{-1}. \end{aligned} \tag{8}$$

The momentum, $m_e c$, can be linked to the wavelength, λ_e, of the periodic structure, which corresponds to the electron's *charge* radius r_c (2.819×10^{-13} cm), through the relation

$$\lambda_e = \frac{j}{m_e c}\ . \tag{9}$$

It can then be shown, with the help of eqs. (8) and (9), that the elementary charge can be expressed as a squared value, in the form

$$e^2 = (j\nu_e)\lambda_e \tag{10}$$

where, it is seen at once, that e^2 is equivalent to the product of the electron's intrinsic *vibrational* energy $(j\nu_e)$ and the *wavelength* of the periodic structure. It then immediately follows that

$$\begin{aligned} e &= \sqrt{(j\nu_e)\lambda_e} \\ &= 4.803 \times 10^{-10} \text{ esu} \end{aligned} \tag{11}$$

in quantitative agreement with the experimental value from which it draws its justification.

We have thus achieved an easily interpreted, observationally consistent, fundamental understanding of the elementary charge, as well as the *origin* of the electron's rest mass, which is particularly satisfying since it validates Einstein's assertion that "electrons and electric charges are two different aspects of *one* reality, since neither can exist without the other."

3 The proof of the pudding

It is generally acknowledged that a viable theory should provide an unambiguous test of its correctness. This point is especially illustrated by eq. (8), which associates the electron's intrinsic vibrational frequency, ν_e, with its mass-energy in the form $\nu_e = (m_e c^2)/j$, quantitatively equal to 1.064×10^{23} s^{-1}, which is analogous to de Broglie's 1924 particle *internal* clock conjecture [3] that associated a particle, such as the electron, in its rest frame, with an internal freqauency $\nu_e = (m_e c^2)/h$, quantitatively equal to 1.235×10^{20} s^{-1}. His conjecture fell by the wayside with the development of wave mechanics, only to be revisited many decades later by Gouanère *et al.* in 2005 [4]. They decided to investigate de Broglie's theory by putting his *frequency* in evidence for the electron. Their experiment involved searching for a transmission resonance in a channeled electron beam by scanning an energy window centered at the predicted resonance *momentum* of 80.874 MeV/c. After rigorous analysis of the experimental data they found an unexpected dip of 8% in the transmission centered at 81.1 MeV/c representing a 0.28% difference between the predicted and measured momentum, which fell within the estimated $\pm$ 0.3% calibration error. However, because of the tight limits set by their modeling results, they concluded, in a subsequent paper [5], that what they had observed could not be explained by any known phenomenon.

Fortunately, thanks to their pioneering work it can easily be shown, on the basis of their results, that they had unknowingly tested the validity of both of these two analogous frequencies, that are *scaled* by two different "action" constants. Indeed, as we shall see below, Gouanère's experiment had succeeded in differentiating between these two frequencies in favor of the *higher* frequency prediction of eq. (8). We have only to consider the ratio of the two frequencies in question, namely

$$\frac{\nu_e = (m_e c^2)/h}{\nu_e = (m_e c^2)/j} = 0.00116 \tag{12}$$

which implies that the electron's resonance momentum is quantitatively equal to 80.970 MeV/c. A comparison with the experimental value is then possible, and we have

$$\frac{81.1 \text{ MeV}/c}{80.97 \text{ MeV}/c} = 1.00160 \tag{13}$$

which is consistent with the experimental value.

It can easily be understood, in retrospect, why Gouanère *et al.* could not explain what they had observed. Their experiment was designed to test the validity of de Broglie's theory, which, of course, is based on Planck's quantum of "action" h, that is nearly three orders of magnitude *larger* than the more diminutive quantum of "action" j, deriving from eq. (4). Needless to say, they had no way of knowing since de Broglie's was the only known electron internal clock theory at the time of their experiment, which is ironic, since their pioneering work unknowingly succeeded in testing the validity of the present theory.

4 Summary/Discussion

The fiction of a structureless electric charge was rendered transparent in the context of the *Stoney* scale, whose system of absolute units gives prominence to the electromagnetic interaction. It was shown that Stoney's formalism leads, almost unavoidably, to the emergence of a new, more *diminutive*, quantum of "action" than Planck's, in the form of the *gravitational* mass equivalent of the *electrostatic* quantum of "action" e^2/c, which led to the assumption that the electron *vibrates* with an intrinsic energy $(j\nu_e)$ that is equivalent to the electron's mass-energy $(m_e c^2)$, where j is the new "action" constant that *links* the electron's intrinsic *vibrational* frequency, ν_e, to its mass-energy, analogous to Planck's *larger* quantum of "action" that links a photon's energy to its frequency. It was emphasized that if we consider this interpretation to be correct then the electron must be vibrating at a frequency of $1.064 \times 10^{23}\ s^{-1}$; a prediction that appears to be supported by Gouanère's unexplained results. Nevertheless, the fact that these two analogous frequencies are *scaled* by two different "action" constants, forces us to assume that their mathematical formalism corresponds to something existing in nature, which underscores the urgency of refining and repeating Gouanère's experiment at a higher resolution so that this century old problem can finally be unambiguously resolved.

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