Intrinsic Charges and the Strong Force

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According to a revised quantum electrodynamic theory, there are models of leptons such as the electron which possess both a net integrated electric charge and a much larger intrinsic charge of both polarities. From estimates based on such models, the corresponding Coulomb force due to the intrinsic charges then becomes two orders of magnitude larger than that due to the conventional net charge. This intrinsic charge force can also have the features of a short-range interaction. If these results would generally hold true, the intrinsic charge force could either interact with a strong force of different origin and character, or could possibly become identical with the strong force.

1 Introduction

According to quantum mechanics there exists a nonzero lowest energy level, the Zero Point Energy. The vacuum is therefore not merely an empty space, but includes a "photon gas" of related electromagnetic vacuum fluctuations. The pressure of this gas is a physical reality, as demonstrated by the force between two metal plates proposed by Casimir [1] and first confirmed experimentally by Lamoreaux [2].

These circumstances have formed the starting point of a revised quantum electrodynamical approach by the author [3]. In the latter a *nonzero* electric field divergence $\mathrm{div}\,\mathbf{E}$ is introduced in the *vacuum* state. In its turn, the nonzero electric field divergence admits an additional degree of freedom into the electromagnetic field equations. The latter then possess new solutions both in the steady and the time-dependent states, having applications to modified models of leptons and photons.

In this paper an example is given in Section 2 on the consequences of a nonzero electric field divergence in a steady state. It demonstrates that the local variations of the charge density $\bar{\rho}=\varepsilon_0\mathrm{div}\,\mathbf{E}$ can result in considerable *intrinsic* charges of both signs, being much larger than the total *net* integrated charge. The possible effects of the intrinsic charges on the Coulomb interaction will then be outlined in Section 3, first in respect to the magnitude of the resulting forces, and then to the range of the same forces in a simple "Gedanken experiment". In Section 4 a comparison is finally made to the strong nuclear force.

2 An Example given by the Revised Electron Model

In the revised quantum electrodynamic theory there are steady states which do not exist in conventional theory [3]. These states include net as well as intrinsic electric charges, electric currents, static electromagnetic fields and related forces. To illustrate the resulting charge distributions, an example is here taken from a corresponding electron model. The features of the model will shortly be summarized here, with reference to details in the original descriptions [3].

In the revised theory the field configuration is shown to become derivable from a generating function

$$F = G_0\, G(\rho, \theta) \qquad G = R(\rho)\cdot T(\theta) \tag{1}$$

in spherical coordinates (r, θ, φ) of an axisymmetric case being independent of the angle φ. Here G_0 stands for a characteristic amplitude, $\rho = r/r_0$ with r_0 as a characteristic radial length, and

$$R = \rho^{-\gamma} e^{-\rho} \qquad \gamma > 0 \tag{2}$$

$$T = 1 + a_1 \sin\theta + a_2 \cos 2\theta + a_3 \sin 3\theta + a_4 \cos 4\theta + \ldots \tag{3}$$

with a_1, a_2, a_3, ... as constant amplitude factors. The radial function R has to be divergent at the origin $r = 0$ to result in a net integrated charge. Thereby a revised renormalisation procedure is applied to make this divergence result in a finite net integrated charge. This leads to forms of the net charge q_0, magnetic moment M_0, rest mass m_0, and angular momentum (spin) s_0 as given by

$$q_0 = 2\pi\varepsilon_0 c_{rG} A_q, \tag{4}$$

$$s_0 = \frac{1}{2}\pi\left(\frac{\varepsilon_0}{c^2}\right) C c_{rG}^2 A_s, \tag{5}$$

$$M_0 m_0 = \left(\frac{\pi\varepsilon_0}{c}\right)^2 C c_{rG}^3 A_M A_m. \tag{6}$$

Here $C = \pm c$, c_{rG} is a finite counter factor in the renormalisation process, and

$$A_k = \int_0^{\pi} I_{k\theta}\, d\theta \qquad k = q, M, m, s \tag{7}$$

with $I_{k\theta}$ being functions of the amplitude factors of equation (3) and the variable $s \equiv \sin\theta$. The factor c_{rG} includes the amplitude G_0 which can have either sign and becomes negative in the case of the electron.

Two quantum conditions are considered here. The first is $s_0 = \pm h/4\pi$ on the spin which results in a normalized net charge

$$q^* = \left|\frac{q_0}{e}\right| = \left(\frac{f_0 A_q^2}{A_s}\right)^{1/2} \qquad f_0 = \frac{2\varepsilon_0 ch}{e^2} \tag{8}$$

where e is the experimentally determined elementary charge and $f_0 \cong 137.036$ is the inverted value of the fine-structure constant. The second condition concerns the magnetic moment and becomes

$$\frac{M_0 m_0}{q_0 s_0} = \frac{A_M A_m}{A_q A_s} = 1 + \delta_M \tag{9}$$

with $\delta_M = 1/2\pi f_0 \cong 0.0011614$. Here it has to be observed that the fourteenth term in equation (7.56) of Reference [3] should read $-699.7897637 a_2 a_3$.

In the four-amplitude case (a_1, a_2, a_3, a_4) the normalized charge q^* will here be studied with conditions (8) and (9) imposed, and as functions of a_3 and a_4 in $a_3 a_4$-space. Then q^* is found to have a minimum for large positive values of a_3 and a_4, within a narrow channel positioned around a plateau defined by the experimental value $q^* = 1$. The width of the channel is only a few percent of q^*. At the plateau the amplitude values are therefore replaced by

$$\bar{a}_i = a_i / a_\infty \qquad a_\infty \gg 1 \qquad i = 1, 2, 3 \ldots \tag{10}$$

As an illustration of the resulting intrinsic and net electric charges, we now use an example where $\bar{a}_1 = -1.91$, $\bar{a}_2 =$ -2.51, $\bar{a}_3 = \bar{a}_4 = 1$. The corresponding integrand $\bar{I}_{q\theta}$ of equation (7) in the plateau region then becomes

$$\begin{aligned} \bar{I}_{q\theta} &= 2sT - 4s^3T - sD_\theta T + \\ &\quad + 2s^3 D_\theta T + 2sD_\theta\left(s^2T\right) - sD_\theta\left(s^2 D_\theta T\right) = \\ &= 44.9s + 288s^2 - 2159s^3 - 1320s^4 + \\ &\quad + 7559s^5 + 1120s^6 - 5760s^7 \end{aligned} \tag{11}$$

with the operator

$$D_\theta = -\frac{\partial^2}{\partial\theta^2} - \frac{\cos\theta}{\sin\theta}\frac{\partial}{\partial\theta}. \tag{12}$$

From the corresponding equation (7) this yields $\bar{A}_q \cong 4.600$, $\bar{A}_M \cong 4.37$, $\bar{A}_m \cong 2832$, $\bar{A}_s \cong 2648$ and results in

$$\frac{\bar{A}_M \bar{A}_m}{\bar{A}_q \bar{A}_s} \cong 1.017$$

and $q^* \cong 1.046$.

The obtained value of $\bar{A}_q$ corresponds to the net charge q_0 of equation (4). The detailed charge distribution as a function of s is given by equation (11) and has been plotted in Fig. 1. According to the figure the negative part of the intrinsic charge in the range $0 < \theta < \pi$ is estimated to have the corresponding value $\bar{A}_{q-} \cong 117.3$. The positive part of the intrinsic charge further corresponds to $\bar{A}_{q+} = \bar{A}_{q-} + \bar{A}_q \cong 121.9$.

In the example given here there is thus an outbalanced intrinsic charge proportional to $\bar{A}_{q-} = \bar{A}_{q+} - \bar{A}_q$, plus a net integrated charge proportional to $\bar{A}_q$. The ratio between these charges becomes

$$c_{in} = \frac{\bar{A}_{q-}}{\bar{A}_q}. \tag{13}$$

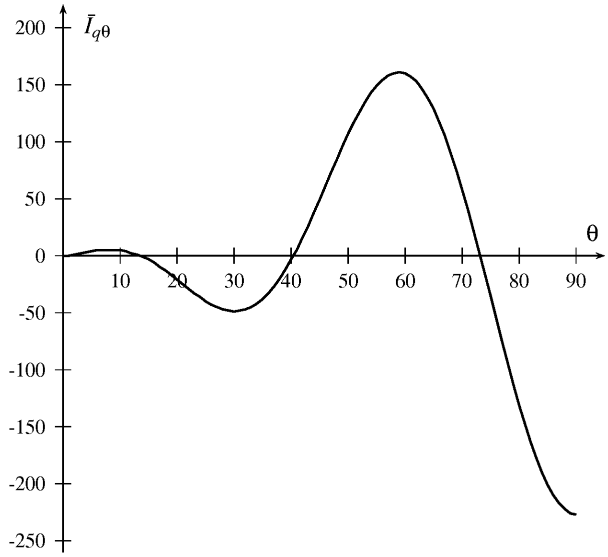

Fig. 1: The local contribution $\bar{I}_{q\theta}$ of equation (10) to the electric charge integral $\bar{A}_q$ as a function of the polar coordinate θ, in the range $0 < \theta < \pi/2$ and with θ given in degrees.

In the example of Fig. 1 it has the value $c_{in} \cong 26.5$, thus indicating that the intrinsic charge considerably exceeds the net charge.

Also the electromagnetic force

$$\mathbf{f} = \bar{\rho}\,(\mathbf{E} + \mathbf{C} \times \mathbf{B}) \tag{14}$$

per unit volume has to be taken into account. It consists of the electrostatic and magnetostatic contributions $\bar{\rho}\mathbf{E}$ and $\bar{\rho}\mathbf{C} \times \mathbf{B}$ where $\mathbf{E}$ and $\mathbf{B}$ are the electric and magnetic field strengths, the velocity vector $\mathbf{C}$ has the modulus $|\mathbf{C}| = \pm c$ and c is the velocity of light. In a cylindrically symmetric case the local electric and magnetic contributions can outbalance each other, but only partly in a spherical axisymmetric case [3]. In the latter case the average radial force can on the other hand be balanced at least for specific solutions of the field equations, but this requires further detailed analysis in every case.

3 Intrinsic Coulomb Forces

The intrinsic charge ratio c_{in} is likely to have consequences when considering the mutual Coulomb forces.

3.1 General Aspects

For any distribution of electric charges the local contribution Δf_{12} to the mutual Coulomb force becomes

$$\Delta f_{12} = \frac{(\Delta q_1)(\Delta q_2)}{4\pi\varepsilon_0 r_{12}^2} \tag{15}$$

where and Δq_1 and Δq_2 are two interacting charge elements separated by the distance r_{12}. The charge ratio of equation

(13) thus predicts that the intrinsic Coulomb forces in some cases even may be represented by a factor c_{in}^2 as compared to those in a conventional analysis. For the values of $c_{in}^2 \cong 702$ in the example of Section 2 these forces could then roughly be estimated to be more than two orders of magnitude larger than the conventional ones. However, the effective magnitude of the intrinsic charge force will also depend on the specific geometry of the charge distribution, as being demonstrated by a simple discussion in the following subsection.

3.2 A Gedanken Experiment

To crudely outline the forces which can arise from the intrinsic charges, a simple "Gedanken experiment" is now performed according to Fig. 2. It concerns the interaction between two rigid mutually penetrable spherical configurations, $(_1)$ and $(_2)$, of charge $+Q$ at their centra and charge $-Q$ at their peripheries. The resulting electrostatic field strengths are $\mathbf{E}_1$ and $\mathbf{E}_2$, and the external space is field-free. When these configurations, being simulated as "particles", are apart as in Fig. 2(a), their mutual interaction force F_{12} remains zero. As soon as particle $(_2)$ starts to penetrate particle $(_1)$, part of the negative charge cloud at the periphery of particle $(_2)$ will interact with the electric field $\mathbf{E}_1$ of particle $(_1)$. This generates an attractive force $F_{12} > 0$, as shown by Fig. 2(b). When particle $(_2)$ further penetrates into the field region of particle $(_1)$, however, the mutual interaction force $F_{12} < 0$ changes sign and becomes repulsive as shown in Fig. 2(c). Between cases (a) and (b) there is an equilibrium with $F_{12} = 0$.

The relative magnitude of the maximum force F_{12} in the case of Fig. 2(b) can be estimated by noticing that it is generated by the fraction g_2 of the charge $-Q$ at the periphery of particle $(_2)$, in the field $\mathbf{E}_1$ of particle $(_1)$. With the charge ratio

$$c_{in} = \frac{Q}{e} \tag{16}$$

of the particles $(_1)$ and $(_2)$ this yields an estimated ratio

$$f_{in} = g_2\, c_{in}^2 \tag{17}$$

between the intrinsic forces and those which would have been present in a conventional case. With an estimated factor $g_2 \cong 1/4$ for the fraction of negative charge of particle $(_2)$ being present in the field $\mathbf{E}_1$ of Fig. 2(b), and with $c_{in} \cong 702$ due to the example of Section 2, this results in the force ratio $f_{in} \cong 176$.

In reality, however, the mutual interaction in Fig. 2(b) and Fig. 2(c) becomes more complex and includes a rearrangement of the charge geometry. Thus, even if these simple considerations are somewhat artificial, they appear to indicate that the intrinsic Coulomb forces can become about two orders of magnitude larger than the conventional ones. The intrinsic forces can also in some cases have the character of a short-range interaction.

Provided that the present model of charged leptons also can be applied in a first crude approximation to a bound

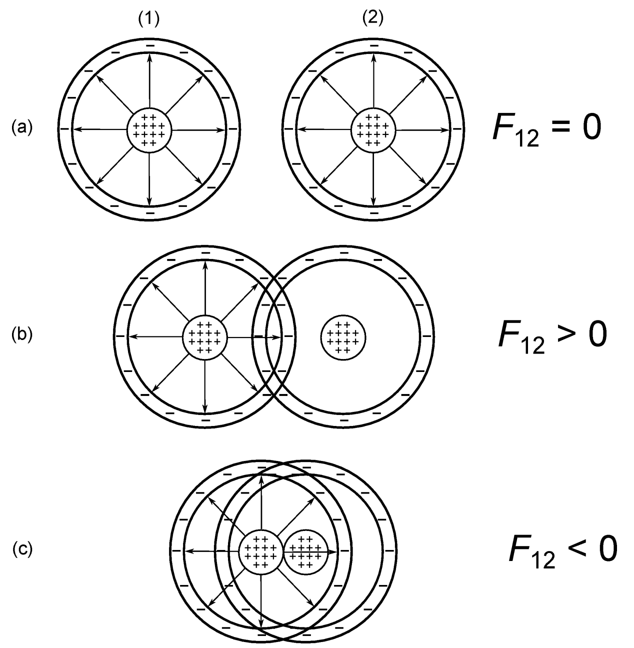

Fig. 2: "Gedanken experiment" where two rigid mutually penetrable spherical configurations ("particles"), $(_1)$ and $(_2)$, are approaching each other. The "particles" have charges $+Q$ at their centra, and $-Q$ at their peripheries, resulting in the internal electric field strengths $\mathbf{E}_1$ and $\mathbf{E}_2$. The mutual interaction force F_{12} is zero when the particles are apart in (a), $F_{12} > 0$ is attractive when they first start to interact in (b), and $F_{12} < 0$ is finally repulsive when they are close together in (c).

quark, its characteristic radius r_ε can be estimated. It would become $r_\varepsilon = c_{rG}/c_G$ where c_{rG} and c_G are counter factors of a revised renormalisation procedure [3]. This results in radii in the range $10^{-16} < r_\varepsilon < 10^{-14}$ m for the u, d and s quarks.

4 A Comparison to the Strong Force

The strong force keeps the atomic nucleus together, and it acts on its smallest constituents, the quarks. As concluded from experiments on deep inelastic scattering of energetic electrons by hadrons, the latter include the quarks. According to reviews by French [4], Walker [5] and others, these strong forces have the following features:

- They are primarily attractive.
- They seem to be essentially the same for neutrons and protons.
- Their range is short and not greater than 2×10^{-15} m.
- Within this range they are very strong, i.e. two orders of magnitude larger than those due to conventional electromagnetics.

The strong force can be compared to the intrinsic Coulomb force discussed in this context, also in respect to a possible quark model being somewhat similar to that of the electron as described in Section 2. The following points should then be noticed:

- The present considerations suggest that the intrinsic charge force can become two orders of magnitude larger than that due to the conventional net charge. The intrinsic charge force thus appears to be of the same order as the strong force, and may also appear in terms of a short-range interaction, on scales of the order of 10^{-15} m.
- It then follows that the intrinsic charge force either will interact with a strong force of different origin and character, or will possibly become identical with the strong force.

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