What gives Vector Bosons Electric Charge?

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Abstract

We propose a simple modification of Newton's Second Law which treats mass and electric charge on completely equal grounds. As a consequence, existence of electrically-charged massless spin-0 particles is predicted.

1 Introduction

In the context of classical physics, a fundamental difference exists between the concepts of mass and electric charge: Mass appears in the most fundamental law of physics, i.e. Newton's Second Law and from there it makes its influence passed to Electromagnetism, Relativity and Quantum Theory. The fact that in the classical law of motion, i.e. Newton's Second Law only mass exists accounts for Einstein's (Weak) Equivalence Principle, viz.

$$m\mathbf{g} = m\mathbf{a}, \tag{1}$$

allows for the cancellation of m and identification of the gravitational field with acceleration, which in turn makes possible the identification of metric tensor components with the gravitational potential through the comparison of (1) and the geodesic equation.

Yet as we think deeply no fundamental reason exists as to why we should differentiate these two concepts; It might be said that mass is a criterion for existence of a particle while charge is not, but then no massless particle should exist, which we know is in stark contrast with empirical evidences. In light of such logical similarity, since vector bosons are electrically charged, it would then be justified to ask if vector bosons were massless in the primordial universe and it was the Higgs mechanism which gave them mass[1], what did give them *electric charge*? No satisfactory answer to this questions exists so far.

In what follows we pave the way to approach answering this question.

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2 Modification of Newton Second Law

For purely historical reasons, in order to make the addition of electric charge to Newton's Second Law possible, we must convert it to dimension of mass; we do this by a simple dimensional analysis, using the fundamental constants of an illusive theory of gravitoelectromagnetism, i.e. ϵ_0, μ_0 and G:

$$[\text{electric charge}][\epsilon_0]^\alpha[\mu_0]^\beta[G]^\gamma = [\text{mass}]$$

Note that to follow our initial goal of treating mass and charge completely equal, we must take the power of electric charge to be the same as of mass, i.e. 1. We therefore have

$$\alpha = \frac{-1}{2},\ \beta = 0,\ \gamma = \frac{-1}{2}$$

up to a constant which we choose to be $1/\sqrt{4\pi}$ to make the Coulomb constant appear[1]. Therefore

$$\mathbf{F} = \left(m + \frac{q}{\sqrt{4\pi\epsilon_0 G}}\right)\mathbf{a} \tag{2}$$

3 Charge-Energy equivalence

A logical conclusion of the modification is the charge energy-equivalence, i.e. energy possessed by merely the electrically charged aspect of a particle is given by,

$$E = \frac{qc^2}{\sqrt{4\pi\epsilon_0 G}}. \tag{3}$$

4 Electrically-Charged Massless Spin-0 Particles

Now we are ready to answer the question:
What gives vector bosons ***electric charge****?* For the mere existence of the equation (3) predicts (by induction) the existence of *an electrically-charged massless spin-0 particle*; it only remains to determine the electric charge of this new particle.
This can be done by two alternative approaches:

1. Accept that the since the quantum of electric charge is e (or $e/3$, from QCD), this new particle must has electric charge of order e, hence its energy

$$E = \frac{ec^2}{\sqrt{4\pi\epsilon_0 G}} \approx 1.67 \times 10^8 \text{ Joules},$$

[1] There are other theoretical considerations which *can* suggest that the factor might be 8 or 16 instead of 4. Here we chose to prefer formalistic harmony and leave the final decision to experiments.

Would be of order 10^8 Joules. Since this energy is currently far beyond the reach of experimental tests, this prediction is not much better than those of String theory. Although the logical possibility still remains.

2. Assume that this new mechanism which oughts to give vector bosons electric charge, should occur at same energy level where Higgs mechanism occurs. Therefore the electric charge of this new particle would be

$$q^0 = m_{\mathrm{H}^0}\sqrt{4\pi\epsilon_0 G} \approx 1.89 \times 10^{-35} \text{ Coulombs}, \tag{4}$$

   Hence of order 10^{-35} Coulombs.

The second possibility is more appealing to experimental physicists, for it means one is dealing with the same energy level as one does currently in CERN. Therefore this possibility can be immediately tested.

References

[1] Mandl, F.; Shaw, G. (2010). "Quantum Field Theory (Second Edition)". John Wiley & Sons. Page 410. ISBN 978-0-471-49684-7.