An Extended SU(2) Electrodynamics based on Lehnert's Revised Quantum Electrodynamics: A Preliminary Report

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Abstract

Historically, electromagnetic theory was developed for situations described by the U(1) group. The dynamics equations describing the transformations and interrelationships of the force field are the well known Maxwell equations, and the group algebra underlying these equations are U(1). There was a need to extend these equations to describe SU(2) situations and to derive equations whose underlying algebra is SU(2). In this paper, we will start with Terence W. Barrett's SU(2) symmetric form of electrodynamics based on topological considerations. Meanwhile, in a series of papers Bo Lehnert proposed a novel and revised version of Quantum Electrodynamics (RQED) based on Proca equations. Therefore, we will write down a combination between Barrett's SU(2) electrodynamics with Lehnert's RQED. It is hoped that this paper may stimulate further investigations and experiments in particular for finding physics beyond Standard Model. This is a preliminary report, so it is far from being a complete description of SU(2) electrodynamics.

Key Words: SU(2) electrodynamics, topology, Maxwell equations, Proca equations, Revised Quantum Electrodynamics.

1. Introduction

Conventional electromagnetic theory based on Maxwell's equations and quantum mechanics has been successful in its applications in numerous problems in physics, and has sometimes manifested itself in a good agreement with experiments. Nevertheless, as already stated by Feynman, there are unsolved problems leading to difficulties with Maxwell's equations that are not removed by and not directly associated with quantum mechanics [2]. Therefore QED, which is an extension of Maxwell's equations, also becomes subject to the typical shortcomings of electromagnetic in its conventional form. This reasoning makes a way for Revised Quantum Electrodynamics as proposed by Bo Lehnert.[1-5]

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Historically, electromagnetic theory was developed for situations described by the U(1) group. The dynamics equations describing the transformations and interrelationships of the force field are the well known Maxwell equations, and the group algebra underlying these equations are U(1). There was a need to extend these equations to describe SU(2) situations and to derive equations whose underlying algebra is SU(2).[13] In this paper, we will start with Terrence W. Barrett's SU(2) symmetric form of electrodynamics based on topological considerations [14]. Meanwhile, in a series of papers Bo Lehnert proposed a novel and revised version of Quantum Electrodynamics (RQED) based on Proca equations. Therefore, we will write down a combination between Barrett's SU(2) electrodynamics and Lehnert's RQED-Proca equations. Such a combination has never been discussed before in the literature. It is hoped that this paper may stimulate further investigations and experiments in particular for finding physics beyond Standard Model. This is a preliminary report, so it is far from being a complete description of SU(2) electrodynamics.

2. Barrett's SU(2) Symmetry Form of Electrodynamics

It is known that there are several different attempts in the past few decades to write down SU(2) electrodynamics, for example by Asim Barut et al. [15], Lawrence Crowell [16], and Sanchez-Monroy & Quimbay [17]. But in the present paper, we will start with Barrett's SU(2) Symmetry Form because of their simplicity.[13][14]

Barrett showed that the spacetime topology defines electromagnetic field equations – whether the fields be of force or of phase. That is to say, the premise of this enterprise is that a set of field equations are only valid with respect to a set of defined topological description of the physical situation. In particular, he has addressed demonstrating that the A_μ potentials are not just mathematical convenience, but - *in certain well-defined situations* - are measurable, i.e. physical. Those situations in which the A_μ potentials are measurable possess a topology, the transformation rules of which are describable by the SU(2) group; and those situations in which which the A_μ potentials are not measurable possess a topology, the transformation rules of which are describable by the U(1) group. [13]

According to Barrett, using Yang-Mills theory, the non-Abelian Maxwell equations which describe SU(2)-symmetry conditioned radiation can be written as follows: [14, p.70]

a. Gauss' Law: $\nabla \bullet E - J_0 + iq(A \bullet E - E \bullet A) = 0$ (1)

b. Ampere's Law: $\frac{\partial E}{\partial t} - \nabla \times B + J + iq[A_0, E] - iq(A \times B - B \times A) = 0$ (2)

c. $\nabla \bullet B + iq(A \bullet B - B \bullet A) = 0$ (3)

d. Faraday's Law: $\nabla \times E + \frac{\partial B}{\partial t} + iq[A_0, B] + iq(A \times E - E \times A) = 0$ (4)

After writing down the above equations, now we will discuss Lehnert's RQED.

3. Lehnert's Revised Quantum Electrodynamics

In a series of papers, Bo Lehnert proposed a novel and revised version of Quantum Electrodynamics, which he calls as RQED. His theory is based on the hypothesis of a nonzero electric charge density in the vacuum, and it is based on Proca-type field equations [2, p. 23]:

$$\left(\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2\right)A_\mu = \mu_0 J_\mu, \mu = 1,2,3,4 \quad (5)$$

Where

$$A_\mu = \left(A, \frac{i\phi}{c} \right), \tag{6}$$

With A and ϕ standing for the magnetic vector potential and the electrostatic potential in three-space. In three dimensions equation (5) in the vacuum results in [2, p.23]:

$$\frac{curlB}{\mu_0} = \varepsilon_0 (divE) C + \frac{\varepsilon_0 \partial E}{\partial t}, \tag{7}$$

$$curlE = -\frac{\partial B}{\partial t}, \tag{8}$$

$$B = curlA, divB = 0, \tag{9}$$

$$E = -\nabla\phi - \frac{\partial A}{\partial t}, \tag{10}$$

$$divE = \frac{\bar{\rho}}{\varepsilon_0}. \tag{11}$$

These equations differ from the conventional form, by a nonzero electric field divergence equation (11) and by the additional space-charge current density in addition to displacement current at equation (7). The extended field equations (7)-(11) are easily found also to become invariant to a gauge transformation.[2, p.23]

The main characteristic new features of the present theory can be summarized as follows [2, p.24]:

a. The hypothesis of a nonzero electric field divergence in the vacuum introduces an additional degree of freedom, leading to new physical phenomena. The associated nonzero electric charge density thereby acts somewhat like a hidden variable.

b. This also abolishes the symmetry between the electric and magnetic fields, and then the field equations obtain the character of intrinsic linear symmetry breaking.

c. The theory is both Lorentz and gauge invariant.

d. The velocity of light is no longer a scalar quantity, but is represented by a velocity vector of the modulus c.

e. Additional results: Lehnert is also able to derive the mass of Z boson and Higgs-like boson.[3-5] These would pave an alternative way to new physics beyond Standard Model.

4. An extended SU(2) Electrodynamics based on RQED

Now let us extend Lehnert's RQED to SU(2) case. First, we shall recall that Lehnert's additional current density is quite similar to Harmuth's ansatz [14, p. 71]. And according to Barrett, they can be added to SU(2) symmetry form. Therefore now we will combine equations (1)-(4) and (7)-(11) using simple addition rule. The results are as follows:

e. Gauss' Law: $\nabla \bullet E - \frac{\bar{\rho}}{\varepsilon_0} - J_0 + iq(A \bullet E - E \bullet A) = 0$ (12)

f. Ampere's Law:

$$\frac{\varepsilon_0 \mu_0 \partial E}{\partial t} + \varepsilon_0 \mu_0 (\nabla \bullet E) C - \nabla \times B + \mu_0 J + \mu_0 iq[A_0, E] - \mu_0 iq(A \times B - B \times A) = 0 \quad (13)$$

g. $\nabla \bullet B + iq(A \bullet B - B \bullet A) = 0$ (14)

h. Faraday's Law: $\nabla \times E + \frac{\partial B}{\partial t} + iq[A_0, B] + iq(A \times E - E \times A) = 0$ (15)

These last four equations (12)-(15) can be called: Extended SU(2) electrodynamics based on Lehnert's RQED. Their full implications should be investigated further.

Concluding remarks

The dynamics equations describing the transformations and interrelationships of the force field are the well known Maxwell equations, and the group algebra underlying these equations are U(1). There was a need to extend these equations to describe SU(2) situations and to derive equations whose underlying algebra is SU(2).[13] In this paper, we will start with Terrence W. Barrett's SU(2) symmetric form of electrodynamics based on topological considerations [14]. Meanwhile, in a series of papers Bo Lehnert proposed a novel and revised version of Quantum Electrodynamics (RQED) based on Proca equations. Therefore, we will write down a combination between Barrett's SU(2) electrodynamics and Lehnert's RQED-Proca equations. Such a combination has never been discussed before in the literature.

It shall be noted that the present paper is not intended to be a complete description of SU(2) non-abelian electrodynamics or new physics beyond Standard Model. Instead, this paper is intended to stimulate further investigations and experiments, and their implications to hadron model.

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