Progress in Electromagnetic Research Symposium 2004, Pisa, Italy, March 28 - 31

Extended Electromagnetic Theory: New Solutions of Old Problems

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1 INTRODUCTION

There are important areas of physics within which conventional electromagnetic theory and its combination with quantum mechanics does not provide fully adequate descriptions of physical reality. As pointed out by Feynman\(^1\), these difficulties are not removed by and not directly associated with quantum mechanics. Therefore electromagnetic field theory is a far from completed area of research. During recent years a number of modified and extended theories leading beyond Maxwell’s equations have thus been elaborated by several research workers.

Among these new theories, there is an approach by the author being summarized in this report. For detailed deductions reference is made to earlier published results\(^2\)\(^-\)\(^8\).

2 BASIS OF PRESENT THEORY

The vacuum state is not merely to be conceived as an empty space. It can under certain circumstances become electrically polarized, such as when an energetic photon gives rise to the pair formation of two charged particles of opposite polarity, i.e. a positron and an electron. The present theory is based on the idea of a vacuum state in which there can arise a nonzero electric charge density, and an associated electric field divergence. A preserved Lorentz invariance then leads to an additional space-charge current density which appears along with the conventional displacement current. In the resulting extended field theory Maxwell’s equations then become a special case.

The nonzero electric field divergence introduces an additional degree of freedom which gives rise to a number of new electromagnetic features. The related fields of application can be listed as follows:

- There are steady electromagnetic equilibria which have no counterpart in conventional theory. These include particle-shaped states with models of the electron and the neutrino, as well as string-shaped states.
- The time-dependent phenomena include new wave modes in both plane and axisymmetric geometry, and corresponding photon models.

3 NEW ASPECTS ON OLD PROBLEMS

The present theory debouches into new aspects on a number of problems which have so far not been provided with satisfactory solutions in terms of conventional theory. We shall here give some examples related to the physic of the electron and the photon.

3.1 Momentum Balance of the Electron

*Conventional Theory:* The electron is expected to ”explode” under the action of its negative self-charge.
Present theory:
- In a steady state the curl of the magnetic field is generated by the space-charge current density.
- There is then also a steady momentum balance, in the form of an "electromagnetic confinement".

3.2 The Point-Charge-Like State of the Electron

Conventional Theory: The point-charge-like behaviour cannot be explained.

Present Theory:
- For the particle-shaped states a general form of solutions is obtained in terms of a generating function.
- This yields expressions for an integrated electric charge, magnetic moment, mass, and angular momentum.
- A nonzero integrated (total) charge requires the generating function to become divergent at the origin.
- Still all the integrated quantities can become finite, by having a characteristic radius which shrinks to very small values. This leads to a self-consistent point-charge-like equilibrium state.

3.3 The Infinite Self-Energy Problem of the Electron

Conventional Theory: The infinite self-energy of the point charge is a serious problem. It has so far been solved in terms of a renormalization procedure, where the difference between two "infinities" gives a finite result. However, a more satisfactory procedure from the physical point of view is being called for, as stated by Ryder⁹.

Present Theory:
- The shrinking characteristic radius outbalances the divergence of the generating function. The finite integrated quantities thus result from the product of a "zero" and an "infinity", in a more surveyable way from the physical point of view.
- In this limit the Lorentz invariance of the radius becomes satisfied.

3.4 The Elementary Electronic Charge

Conventional Theory: There is so far no explanation why the elementary electronic charge has the discrete minimum value \( e \), as first found in the experiment by Millikan.

Present Theory:
- A variational analysis has been performed on the integrated charge, with imposed subsidiary quantum conditions on the angular momentum, magnetic moment, and the total magnetic flux.
- This results in a deduced minimum value of the charge which deviates from the experimental value by about three percent only.
- There are proposals for minor quantum mechanical corrections which may remove this deviation. If the deduced value would then come out to fully agree with the experimental one, the elementary charge would no longer remain an independent constant of nature, but would be determined by the velocity of light, Planck’s constant, and the electric permittivity of the vacuum state.

3.5 The Nonzero Angular Momentum of the Photon

Conventional Theory: The plane electromagnetic wave does not have an angular momentum, and the axisymmetric wave leads to divergent solutions which are physically unacceptable.
Present Theory:

- The general solutions of axisymmetric wave modes can be derived from a generating function. These solutions include helical electric and magnetic fields, and they possess an angular momentum.
- Solutions which are convergent within the entire coordinate space can be obtained, and corresponding integrated field quantities be deduced.
- In connection with the nonzero angular momentum there are also nonzero electric and magnetic field components in the axial direction of propagation, as well as a very small but nonzero photon rest mass. The latter is small enough for not getting into conflict with the Michelson-Morley experiments.

### 3.6 The Wave and Particle Nature of the Photon

**Conventional Theory:** The wave and particle natures of the photon appear to remain as two separate concepts which have so far not been unified.

**Present Theory:**

- The axisymmetric wave packet solutions are somewhat similar to those earlier proposed by de Broglie, where the photon is conceived as a "pilot wave" upon which a "particle part" is "surfing".
- The present wave packet model is, however, to be considered as a physical entity. It has both a particle nature due to its limited spatial extent in the transverse direction, and a wave nature due to its ability to give rise to interference like a plane wave.

### 3.7 Photoelectric Effect and Two-Slit Experiments with Photons

**Conventional Theory:** The sometimes occurring needle-shaped behaviour of individual photons cannot be explained. This is the case with the photoelectric effect where a photon "knocks out" an atomic electron, and with the double-slit experiments where every single photon impact on a screen has the form of a dot-shaped mark.

**Present Theory:**

- There are finite axisymmetric modes with a divergent generating function and a shrinking transverse radius which have the form of "needle radiation". This radius can become small enough to match atomic dimensions.
- The theory embraces several types of wave modes, such as plane waves and different forms of axisymmetric waves and wave packets. It is thereby suggested that "photon oscillations" can arise between these modes when being considered as different quantum states, and being similar to neutrino oscillations which can take place in the case of a nonzero but small neutrino mass. In this way the photon could behave differently in different physical situations.

### 4 REFERENCES