Electron-Positron Matter Waves as Oscillations of Minkowski Spacetime

Alexander Gritsunov
Department of Microelectronics, Electronic Devices and Appliances
Kharkiv National University of Radio Electronics
14, Lenin Ave., Kharkiv, 61166, Ukraine. E-mail: gritsunov@gmail.com; gritsunov@list.ru

Abstract: *An attempt is made to generalize the basic idea of the self-sufficient potential formalism in electrodynamics (interpretation of electromagnetic phenomena as natural or forced oscillations of the Minkowski spacetime treated as a distributed electromagnetic oscillating system) on the De Broglie waves. Both electrons and positrons are considered as excited modes (oscillations) of a distributed electron-positron oscillating system, not as "hard" particles. Thus, the matter waves are treated as real oscillations of the Minkowski spacetime, not as Born's "probability waves".*

Keywords: De Broglie wave; distributed oscillating system; four-vector of generalized coordinates; Lorenz gauge; Lagrange function; Klein-Gordon equation.

Introduction

Self-sufficient potential formalism treating electrodynamics as theory of a distributed electromagnetic (EM) oscillating system (DEMOS) was suggested in [1,2]. EM phenomena are considered there as natural or forced oscillations of the Minkowski spacetime. The main achievement of that theory is explanation of the Aharonov-Bohm effect from the position of the locality principle [3,4]. A "crazy" development of that idea is described in this paper.

Our main hypothesis is as follows. The Universe has to be uniform. So, all matter is only oscillations of the spacetime. E.g., discovered by Davisson and Germer fringes in coherent electron beams are caused by the superposition of real waves in some distributed electron-positron oscillating system (DEPOS), not by the interference of obscure "mathematized" complex-valued wavefunctions Ψ. The distinguishing feature of DEPOS is nonzero lower cutoff wavenumber $k_e = cm_e/\hbar$ (relativistic scalar), where m_e is the electron rest mass, while DEMOS has zero one.

There are no "hard" particles in atomic world, only vibrations and waves. Electron is neither small sphere nor any other clot of charged substance. All observable effects produced by "electrons" are results of DEPOS oscillations. Coordinates and velocities of wavepackets ("electrons") have no strict sense, the occupation numbers for DEPOS eigenmodes must be considered instead. Thus, there is no large difference between "photons" and "electrons".

The detection of an "electron" means, in fact, exchange with the quantum of energy-momentum between the DEPOS mode initially having occupation number of 1 and another DEPOS mode originally having occupation number of 0 (through DEMOS as a coupling system accepting or supplying with the difference in energy-momentum). The actual coordinates of this process cannot be ascertained in principle, so ones have no sense. Orthogonality or non-orthogonality of DEPOS modes does matter only. In particular, the interplay between electron as quantum object and classical apparatus is, in fact, interaction between a "poor-localized" DEPOS mode (e.g., mode of free space) and its "well-localized" mode (e.g., mode of crystal lattice) using DEMOS as intermediate. The interaction is a random process based on the Einstein coefficients.

The dispersion of wavepackets does not matter, because the DEPOS mode regardless of its spatial extension always becomes excited or unexcited (i.e., receives or gives back the energy-momentum quantum) as a single whole. E.g., if a "wide" (almost planar) electron wavepacket creates a small light spot on a fluorescent screen, this means that the poor-localized DEPOS mode has interacted with the well-localized electron shell of an atom. If a wide wavepacket runs into another wide wavepacket, the interchange of both wavepackets with a DEMOS mode of small k_ξ is more probable, so the momenta of the wavepackets vary slightly ("electrons pass too far one from another"). Only in rare cases, k_ξ for the intermediate DEMOS mode is large and the momenta of the wavepackets change greatly ("electrons collide"). Here $\mathbf{k} = \{k_t, k_x, k_y, k_z\}$ is the eigenmode 4-wavenumber; ξ is a generic symbol for *x*, *y*, or *z*.

Main Part

There are no known physical variables that are suitable as generalized coordinates of DEPOS [like components of EM potential $\mathbf{A}(t,x,y,z)$ for DEMOS]. Let us introduce 4-vector $\aleph^e(t,x,y,z)$ as a set of three real-valued spatial components $\aleph^e_x, \aleph^e_y, \aleph^e_z$ (generalized coordinates describing local deviation of DEPOS from its "undisturbed" state) and temporal component $\aleph^e_t$ supplementing ones to 4-vector. These components are constrained with the Lorenz gauge condition $\nabla \cdot \aleph^e = 0$, where $\nabla \cdot \aleph^e$ is the 4-divergence of $\aleph^e$, and $\aleph^e_t \equiv 0$ in the rest system of coordinates.

The Lagrange function 3-density for DEPOS (taking no into account its interaction with DEMOS) is postulated as

$$\lambda^e = \frac{R_e}{2}\left[k_e^2(\aleph^e)^2 - (\nabla\aleph^e_t)^2 + (\nabla\aleph^e_x)^2 + (\nabla\aleph^e_y)^2 + (\nabla\aleph^e_z)^2\right], \quad (1)$$

where $\nabla \aleph_\tau^e$ is the 4-gradient of $\aleph_\tau^e$; τ is a generic symbol for $t \equiv ct$, x, y, or z; R_e is a "rigidity" factor for DEPOS, coupling its local deviation with 3-density of energy-momentum (like as $R_\gamma \equiv 1/\mu_0$ factor does for DEMOS).

The Lagrange equation for DEPOS in assumption that there is no interaction between this and DEMOS is the Klein-Gordon equation applied to all components of $\aleph^e$:

$$\nabla^2 \aleph^e + k_e^2 \aleph^e = 0, \qquad (2)$$

where ∇^2 is the D'Alembertian. Components of the energy-momentum density tensor $\left[w^e \right]$ for DEPOS are:

$$w^e_{\tau\tau'} = g_{\tau\tau} \sum_{\tau'} \frac{\partial \aleph^e_{\tau'}}{\partial \tau} \frac{\partial \lambda^e}{\partial (\partial \aleph^e_{\tau'} / \partial \tau')} - g_{\tau\tau'} \lambda^e, \qquad (3)$$

where $[g]$ is the diagonal metric tensor for the pseudo Euclidian space. Substituting (1) in (3), one can obtain:

$$\begin{aligned} & w^e_{\tau\tau'} = -g_{\tau\tau} g_{\tau'\tau'} R_e \\ & \times \left(\frac{\partial \aleph^e_t}{\partial \tau} \frac{\partial \aleph^e_t}{\partial \tau'} - \frac{\partial \aleph^e_x}{\partial \tau} \frac{\partial \aleph^e_x}{\partial \tau'} - \frac{\partial \aleph^e_y}{\partial \tau} \frac{\partial \aleph^e_y}{\partial \tau'} - \frac{\partial \aleph^e_z}{\partial \tau} \frac{\partial \aleph^e_z}{\partial \tau'} \right) \qquad (4) \\ & - \frac{g_{\tau\tau'} R_e}{2} \left[k_e^2 (\aleph^e)^2 - (\nabla \aleph^e_t)^2 + (\nabla \aleph^e_x)^2 + (\nabla \aleph^e_y)^2 + (\nabla \aleph^e_z)^2 \right]. \end{aligned}$$

Let's introduce a 4-vector of "particle" group velocity, that in the absence of the electromagnetic potential ($\mathbf{A} \equiv 0$) is of $\mathbf{v}_g = \mp \mathbf{k} / k_e$, and a "matter flow density" 4-vector as $\mathbf{j}^m(t,x,y,z) = \mathbf{v}_g \, \mathrm{Tr}\left[w^e \right]$. Here $k_e \le k_t < \infty$, $-\infty < k_\xi < \infty$ for non-virtual "particles"; the plus sign is for positrons. Note that particle "visible" velocity 3-vector $v_\xi = k_\xi / k_t$ is the same for both electrons and positrons. Our guess is as follows. The electric current density 4-vector $\mathbf{j}^q(t,x,y,z)$ is similar to $\mathbf{j}^m$ with a factor of $cq/\hbar k_e$, where $q > 0$ is the elementary charge, i.e., $\mathbf{j}^q = (cq/\hbar k_e)\mathbf{j}^m$.

Calculating $\mathbf{j}^m$ from (4) and then $\mathbf{j}^q$ doing, one can add the interaction (between DEPOS and DEMOS) term to the Lagrange function 3-density as $\lambda^{ye} = -\mathbf{A}\mathbf{j}^q$ (λ^γ is the Lagrange function 3-density for DEMOS [1,2]). Then, the Lagrange equation for DEPOS taking into account its interaction with DEMOS can be derived as a second-order alternative to the Dirac equation.

The full set of solutions of (2) consists of three orthogonal subsets: *TM*, *TE*, and *TEM* [2]. The *TEM* subset is physically unrealizable because of the zero 3-density of its energy-momentum. So, the actual solutions of (2) for, e.g., an idealized planar (x,y) wave are eigenmodes:

$$\begin{aligned} & \aleph^e_{TMx} = \aleph^e_0 \, \mathrm{e}^{-i(k_t t - k_z z)}; \\ & \aleph^e_{TEy} = i\aleph^e_0 \, \mathrm{e}^{-i(k_t t - k_z z)} \end{aligned} \quad \text{or} \quad \begin{aligned} & \aleph^e_{TMx} = \aleph^e_0 \, \mathrm{e}^{-i(k_t t - k_z z)}; \\ & \aleph^e_{TEy} = -i\aleph^e_0 \, \mathrm{e}^{-i(k_t t - k_z z)} \end{aligned}$$

(doubly degenerate electron mode for spin of $\pm 1/2$) and

$$\begin{aligned} & \aleph^e_{TMx} = \aleph^e_0 \, \mathrm{e}^{+i(k_t t - k_z z)}; \\ & \aleph^e_{TEy} = i\aleph^e_0 \, \mathrm{e}^{+i(k_t t - k_z z)} \end{aligned} \quad \text{or} \quad \begin{aligned} & \aleph^e_{TMx} = \aleph^e_0 \, \mathrm{e}^{+i(k_t t - k_z z)}; \\ & \aleph^e_{TEy} = -i\aleph^e_0 \, \mathrm{e}^{+i(k_t t - k_z z)} \end{aligned}$$

(doubly degenerate positron mode for spin of $\pm 1/2$). Only complex notation is used here, no complex deviation. The second quantization procedure must be applied to these eigenmodes obtaining occupation numbers of 0 or 1.

For a "poor-localized" DEPOS mode, the "electron" rest mass and charge are distributed over a large 3-volume. The total interaction energy-momentum between DEPOS and DEMOS is negligible small in this case. Practically, all energy of such "electron" must be of "mechanical" nature. For small wavepackets, having well-defined coordinate, the relative part of the "electromagnetic" (interaction) energy increases. This unconventional consequence and other outcomes of the proposed idea (e.g., there are no "positive" and "negative" electric charges, the DEMOS deviation direction depends on $\mathbf{j}^q$ sign only) must be examined in depth before the acceptance of our "crazy" hypothesis.

Conclusion

Generalization of the self-sufficient potential formalism principal idea (interpretation of the Minkowski spacetime as a kind of distributed oscillating system) on the De Broglie waves enables elimination of both the most "odious" concepts of contemporary quantum theory:

- Complex-valued wavefunctions Ψ and concerned with those first-order differential equations (instead typical for classical physics second-order wave equations). There are no imaginary values in nature – why the quantum theory cannot exist without ones?
- Born's probabilistic interpretation of $|\Psi|^2$. Nature does not know how to calculate probabilities ("He doesn't play dice with the world") but can only exist and act in accordance with some physical laws.

References

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