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Classical Interpretation of De-Broglie's Waves

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1. Realm of the Electromagnetic Potential

The Potential in Classical Electrodynamics (CED) has a special status. It defines the electromagnetic field according to the equation:

$$F_{ik} = A_{k|i} - A_{i|k} \quad (1)$$

From (1) it follows that electromagnetic field won't change if we add to the potential a gradient of any differentiable scalar function Φ.

This fact is called "gauge invariance". Since the representation of the physical reality in classical theory has to be unique, one can ascribe to the potential:

a) The meaning of mathematical tool only, unless:

b) The potential is given the unique physical meaning and definition by the another set of physical laws that are not known. In my article[1] I adhered to the meaning (a) and overlooked a very important general requirement:

c) On any disruption surface the tangent components of potential have to be continuous while the normal component can have a jump. The proof of that one can find in my article[2]. This finding is connected to the reformulation of Basic Principles of CED without the interaction term in Lagrangian (see[1,2]).

Now let us adhere to the possibility (b). Could it be that the scalar Φ, while not affecting the electromagnetic field directly, still has influence on it (possibly through the boundary conditions on some disruption surfaces. The example of this one can find in[2])? If this is the case, then Φ can be significant in physical experiment. It can be even unique under some yet not known laws of another physical realm. Ascribing the physical meaning to the scalar function Φ, we call it: "dummy generator" and the potential that is generated -- "dummy potential" (because the potential produced by Φ; won't produce any electromagnetic field). In Lorentz gauge, which we consider a mandatory requirement, this function has to be a solution of the wave equation:

$$\Box\Phi = 0 \quad (2)$$

2. Reinterpretation of De-Broglie Particle-Wave Relation

The first person who found the similar interpretation of De-Broglie's waves in 1993 was Milo Wolff[3]. I found it independently but only now (2005).

It is difficult to imagine an elementary particle without some oscillating electromagnetic field inside it. If we assume that the oscillating field is present inside the particle then the corresponding oscillating electromagnetic field (standing waves) have to be in vacuum that surrounds the particle. It is easy to show that the energy of this vacuum electromagnetic field will be infinite. Though, it is possible (see[2]) that in vacuum only standing waves of the scalar potential take care of the necessary boundary conditions. Since the potential is not present in the energy-momentum tensor (see[1,2]), there won't be any energy connected to its presence.

Let us develop this idea a little bit further. Suppose that any elementary particle in its rest frame S' is accompanied by a standing vacuum wave of a dummy generator that oscillates with a frequency $\omega = mc^2/\hbar$, and $k=mc/\hbar$, where ħ is a Plank's constant. The solution of the wave equation that represents a standing wave in S' is: [sin(kr')/kr']sinωt'). If this particle moves in x direction with respect to another particle or macroscopic device which is at rest in S frame, then in S we have the same function with: $r'=\mathrm{sqrt}\ \gamma^2(x-vt)^2+y^2+z^2]$, $t'\ \gamma\,(t-vx/c^2)$ (Lorentz transformation and the fact that the dummy generator is a true scalar are used). At the origin of coordinates in S we have:

[sin(kγvt|)/kγvt|]sin(ωγt). In the frame S we observe two oscillations: low frequency $\omega_1= k\gamma v=cp/\hbar$ where p is the linear momentum of the particle, and high frequency $\omega_2\omega\gamma$. The low frequency ω_1 is the well known frequency of De-Broglie wave. But the frequency is not yet the wave and the wave length.

It should be noticed that the intensity of De-Broglie's oscillations will be strongest in direct proximity of the particle, and will decrease in intensity after the particle passes the observer. There is also decrease in intensity (and frequency) for the side observer (where y^2+z^2 is different from zero).

3. Theory of Classical Quantization

Suppose we have a charged particle (electron) moving in a given independent of time (in frame S) external electric and magnetic fields. The relativistic dynamics equations are:

$$m\frac{d}{dt}\left(\frac{\vec{v}}{\sqrt{1-v^2/c^2}}\right)=e\vec{E}+\frac{e}{c}\vec{v}\times\vec{H} \qquad (3)$$

We can obtain the first integral of the time component of these equations (energy integral) without any approximations:

$$\vec{E} = -\nabla V; \quad mc^2 \frac{d}{dt}\left(\frac{1}{\sqrt{1-v^2/c^2}}\right) = e(\vec{v}.\vec{E}) = -e(\nabla V.\vec{v})$$

$$or: \quad \frac{mc^2}{\sqrt{1-v^2/c^2}} + eV(\vec{r}) = mc^2 + \varepsilon = const. \qquad (4)$$

This integral is true on the trajectory of the particle. The $mc^2 + \varepsilon$ is the full energy of the particle. Since the electron moves and carries the high frequency standing wave of dummy generator, we have to expect, that the corresponding De-Broglie frequency will be different in different points of space according to the changing velocity of the electron. Using the energy integral (4) we can calculate De-Broglie frequency as a function of the position of the particle:

$$\frac{\omega_1^2}{c^2} = \frac{p^2}{\hbar^2} = \frac{2m}{\hbar^2}(\varepsilon - eV)\left[1 + \frac{\varepsilon - eV}{2mc^2}\right] \qquad (5)$$

If the motion of the particle, for some reason, can be considered stationary then we suppose that it creates a standing wave of a dummy generator Φ (this one is De-Broglie wave). The meaning of a standing wave suggests that the solution has a form of a product of some independent of time amplitude on a dependent of time unite amplitude oscillating factor. We suggest that the local frequency of the oscillations will correspond to De-Broglie frequency of the moving particle when it passes the corresponding point of space (the high frequency ω$_2$ can also create an independent standing wave but we disregard it because it won't bear on quantization). According to this, let us try to represent the standing wave in the form:

$$\Phi = \rho(\vec{r}) \exp(-i\omega_1(\vec{r})t) \qquad (6)$$

This is a far reaching proposition, because some region of space may be never "visited" by the moving particle due to the energy conservation. That will be the region where the right part of the equation (5) becomes negative. In that region case ω_1 becomes imaginary and oscillations in (6) turn to exponential decrease. But let us see how it works. Substituting (6) in the wave equation (2) one can find:

$$e^{-i\omega_1 t}\left\{\Delta\rho + \frac{\omega_1^2}{c^2}\rho - t^2(\nabla\omega_1)^2\rho - it\left[2(\nabla\omega_1 \cdot \nabla\rho) + \Delta\omega_1\rho\right]\right\} = 0$$

At t=0 the amplitude of dummy generator $\rho(x,y,z)$ has to satisfy the equation:

$$\Delta\rho + \frac{2m}{\hbar^2}(\varepsilon - eV)\left[1 + \frac{\varepsilon - eV}{2mc^2}\right]\rho = 0 \qquad (7)$$

We see that the proposition (6) does not lead us to a complete dependent on time solution but it leads us to the equation (7) that should be satisfied by the amplitude at any time since the amplitude (as we supposed) does not depend on time. The equation (7) corresponds to the relativistic Schroedinger's equation for the stationary physical system (if the square bracket is replaced by 1 then it is usual Schroedinger's equation). The important differences are:

1. The amplitude can not be interpreted as a probability and shouldn't be normalized.

2. 2. The actual time dependence can not be claimed periodic with a single frequency.

We are coming to the conclusion that a stationary motion of a particle can only be possible if it is accompanied by a corresponding standing wave of a dummy generator (we can call it De-Broglie's wave) that satisfies the conditions: to be finite everywhere and to be zero at infinity. These conditions lead to the quantization of the total energy of the particle. This conclusion implies that there exists some interaction between the stationary moving electron and De-Broglie's standing wave. When the electron jumps from one energy level to another the standing wave changes and provides assistance in transferring energy from electron to photon (or back). The question about the intensity of these standing waves remains open.

The above given interpretation of De-Broglie's wave suggests that only the elementary particle (not any particle with the mass m, not a molecule, and the nucleus of atom most likely act like a single proton) can be accompanied with De-Broglie's wave.

We have to admit that we know very little about the realm of electromagnetic potential, but we have to try.

REFERENCES

1. Yuri Keilman, Phys. Essays, **15**, #3, (1903).

2. Idem, Phys. Essays, (in Editorial Pipe).

3. Milo Wolff, Phys. Essays, **6**, #2, p.190, (1993).