Qeios

Peer Review

Review of: "Emergent Quantum Mechanics: How the Classical Laws Can Mimic Non-Local (“Spooky”) Interactions"

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Review of the paper "Emergent Quantum Mechanics: How the classical laws can mimic Non-Local (spooky) interactions" by Theo van Holten

The author of this paper is trying to prove that non-retarded (instantaneous) interactions at a distance (*spukhafte Fernwirkung*) can be explained using classical (non-quantum) laws of physics. For this purpose, he builds a model of an extended stable charge distribution, which he calls a “droplet.” He explains in the third paragraph on page 3 of his paper, and in section 4, that this charged droplet is in fact a “*lump of charges which changes its shape, apart from its translational motion.*” In order to calculate the associated electromagnetic field of this lump of charges (droplet), he starts with the electromagnetic potentials of a point charge.

The calculations intended to support this theory are mainly done in the appendices, where the author claims to calculate the electromagnetic potentials of a moving point charge by using the “matched asymptotic expansion” technique. Although I was aware that the electromagnetic potentials of an arbitrarily moving point charge (the Liénard-Wiechert (LW) potentials) had been calculated a long time ago, I read these appendices with a lot of interest, hoping that the author had found a new, original method to calculate them.

The main irregularity I observed in the calculations in Appendices A and B is that the author adds terms “**by hand**” in equations A.20 (one term) and B.12 (two terms), his only motivation being “to enhance the symmetry.” This addition of terms that do not result from calculations or logical reasoning is acknowledged by the author himself after equation A.20 and before equation B.12.

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Adding terms “by hand” is problematic for several reasons:

1. The result is no longer motivated logically or mathematically; instead, it is constructed according to what the author wants, in order to support the theory he has in mind.
2. Although the author claims in several places that his results satisfy Maxwell’s equations, he nowhere verifies that the resulting electromagnetic field satisfies Gauss’s law, as the Liénard-Wiechert field does (except in the case of hyperbolic motion, where an additional delta-function term must be added to the well-known formula — see, for example, J. Franklin and D.J. Griffiths, “The fields of a charged particle in hyperbolic motion”, arXiv:1405.7729v1). By manually adding terms to the expansions of the electromagnetic potentials, the electric field deviates from the Liénard-Wiechert field and no longer satisfies Gauss’s law.
3. Although the author does not say so explicitly, it follows from his equations (1) and (2) that he is working in the Lorentz gauge. It is well known that in this gauge, the electromagnetic potentials \phi and \vec{A} can only be changed by adding the terms -\partial \Lambda/(\partial t) and \grad \Lambda respectively, where \Lambda is a solution of the wave equation. However, the terms added by the author “by hand” do not appear to be of this type. Therefore, by adding them, the author changes the gauge, which means that his initial equations ((1) and (2)) are no longer valid.

I compared the author’s results in equations A.12 and B.12 with the expansions of the Liénard-Wiechert potentials given in the paper “A simultaneous expansion for the electromagnetic field of a relativistic charged particle” by A.N. Gordeyev, J. Phys. A vol. 8, p. 1048 (1975). In that paper, Gordeyev presents two types of expansions for the Liénard-Wiechert potentials: equation (7) contains expansions valid for low velocities, while equations (16)–(21) provide expansions that converge for any velocity (in powers of R).

To compare Gordeyev’s results with those of van Holten, we must set 4\pi \epsilon_0 = 1 in van Holten’s paper, and note that the distance between the present position of the particle and the observation point is denoted by “R” in Gordeyev’s notation and by “r” in van Holten’s. The validity of Gordeyev’s expansions is, I believe, beyond doubt, as they are based on a rigorous and well-established mathematical framework.

Here is the comparison I made between the two papers:

- If we retain terms up to k=3 inclusive in Gordeyev’s expansion of φ from eq. (7), it coincides with van Holten’s equation A.21, except that van Holten **has manually added the term** -(z_0v^2)/(2c^2)\partial/(partial z)1/r.

- If we retain terms up to k=2 inclusive in Gordeyev's expansion of \vec{A} from eq. (7), Gordeyev's result does **not** coincide with van Holten's equation B.12; Gordeyev's expansion has an additional term $v^3/(2c^3R)$.
- Gordeyev explains in the last paragraph on page 1051 that the expansions in eq. (7) **converge only for low velocities**. If we want expansions valid for any velocity, which remain valid in the immediate vicinity of the charge distribution (as van Holten intends), the terms of the infinite series must be rearranged, yielding the series given in eqs. (16)–(21). In short, Gordeyev's expansion for the Liénard-Wiechert potential near the source is \phi = \phi_0 + terms of order R^1, R^2, etc., where **\phi_0 is given in equation (16) and is precisely the electromagnetic potential of a point charge in uniform motion.**
- Since van Holten wants to use his results to describe zitterbewegung motion (which involves relativistic velocities), he should have used the expansions valid for high velocities (Gordeyev's eqs. 16–21) rather than the low-velocity incomplete expansions he actually employed.
- Comparing Gordeyev's eq. (16) (which can obviously be expanded in powers of v/c) with van Holten's equation A.21, we see that van Holten neglects an infinite number of terms of the same order 1/r. For this reason, **his fields are not even close to the real ones in the vicinity of a point charge.**

When comparing van Holten's paper with other works that use the "asymptotic matching method" to calculate the electromagnetic field near the source (for example, the paper by Labat et al., "Asymptotic modelling of the electromagnetic scattering by small perfectly conducting spheres", hal-01762625v2), we observe that **the matching should not be done by manually adding convenient terms**, but by using boundary conditions at the surface of the studied object (source or obstacle). The use of boundary conditions ensures that Maxwell's equations are satisfied everywhere in space. Since for a point charge, as in van Holten's paper, we cannot speak of boundary conditions, I believe **the author needs to ensure that all of Maxwell's equations are satisfied, especially Gauss's law.**

Taking all these observations into account, **I cannot recommend the publication** of van Holten's paper in its current form. However, I believe improvements can be made to this work by using the correct Liénard-Wiechert fields for a point charge as presented by Gordeyev and by providing a clearer description of the "charged droplet" model used by the author.

Declarations

Potential competing interests: No potential competing interests to declare.