The illusion of acceleration in the retarded Liénard-Wiechert electromagnetic field

Călin Galeriu
Military Technical Academy "Ferdinand I",
Bvd. George Coşbuc 39-49, Bucharest 050141, Romania
calin.galeriu@mta.ro

May 14, 2024

Abstract

While the algebraic formalism of classical electrodynamics is well established, we would also like to have an intuitive geometrical derivation of the electrodynamic forces between electrically charged point particles. From a geometrical point of view, the interacting particles are represented by worldlines in Minkowski space, and we hope that, with the proper theoretical structure in place, "the laws of physics can find their most complete expression as interrelations between these worldlines " [1].

Consider the retarded Liénard-Wiechert electromagnetic field produced at a given place by a given electrically charged point particle. This field depends on the retarded position, on the retarded velocity, and on the retarded acceleration of the source particle. This sequence of terms very much resembles a Taylor series expansion.

Although it is generally accepteded that the retarded Liénard-Wiechert electromagnetic field produced by a point particle depends on the retarded acceleration of that source particle, this dependence is not real, it is an illusion. The true electromagnetic interaction is time symmetric (half retarded and half advanced [2]) and depends only on the retarded and advanced positions and velocities of the electrically charged particles. The dependence on the velocities of the point particles (points only in the 3D Euclidean space) is due to the fact that in the 4D Minkowski space the true interaction takes place not between points, but between corresponding length elements along the worldlines of the particles, that is between infinitesimal segments whose

endpoints are connected by light signals [3, 4, 5]. A different acceleration of the retarded source particle will result in a different position and velocity of the advanced source particle, changing in this way the resulting electrodynamic force (the Lorentz force) felt by the test particle.

We develop our theory [6] by relying on geometrical intuition, as well as on physical and philosophical arguments. We start with the simplest case of electrostatic interaction, then we allow for constant velocities, then we allow for constant accelerations, and finally we allow for variable accelerations. At each step we introduce new axioms, expanding the theoretical framework, until we end up with a time symmetric action-at-a-distance theory that recovers classical electrodynamics as a second order approximation.

References

[1] Hermann Minkowski, *Space and Time, Minkowski's Papers on Relativity*, (Minkowski Institute Press, Montreal, 2012), 40.

[2] John A. Wheeler and Richard P. Feynman, "Classical Electrodynamics in Terms of Direct Interparticle Action", *Rev. Mod. Phys.* **21**, 425 (1949).

[3] A. D. Fokker, "Ein invarianter Variationssatz für die Bewegung mehrerer elektrischer Massenteilchen.", *Z. Phys.* **58**, 386 (1929).

[4] Călin Galeriu, "The geometrical origin of the Doppler factor in the Liénard-Wiechert potentials", . *Eur. J. Phys.* **42**, 055204 (2021).

[5] Călin Galeriu, "The algebraic origin of the Doppler factor in the Liénard-Wiechert potentials", . *Eur. J. Phys.* **44**, 035203 (2023).

[6] Călin Galeriu, "Electric charge in hyperbolic motion: arcane geometrical aspects", arXiv:1712.02213 [physics.gen-ph] (2017).