PHYSICAL REALITY OF ELECTROMAGNETIC POTENTIALS?

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Received 16 June 1967

Although the force c^{-2} (di/dt) § $V\delta I$ we have shown [1] to be exerted on a varying current by a constant electric field $E = \operatorname{grad} V$ is gauge independent, it would be hard to deny the existence of the local force c^{-2} (di/dt) $V\delta I$.

We have proved recently [1] that a closed circuit C carrying a current of variable intensity i(t) undergoes, in a time independent external electric field $E \equiv \operatorname{grad} V$, a force

$$F = c^{-2}(di/dt) \iint_{S} E \times \delta s \equiv c^{-2}(di/dt) \oint_{C} V \delta I(e,m,u)$$
(1)

the first expression of which is in terms of the equivalent magnetic layer. An alternative proof is as follows. According to the well-known Ampère formula $i=\oint H\cdot \mathrm{d}I$ where the integral is along an arbitrary closed contour circling C once, and due to the fact that the H and δs vectors are collinear when S is varied inside the class of the equipotentials of the magnetic layer, formula (1) may be rewritten as

$$F = e^{-2} \iiint E \times \partial H / \partial t \, dv \qquad (2)$$

where the integral is over all space with $dv = \delta s \cdot dI$. The force F is thus expressed as the time derivative of the integrated Poynting vector - a quite standard explanation.

The point we intend to stress is that, although formula (1) is gauge independent, it would be hard to understand it if it were denied that formula

$$\delta F = c^{-2} \left(\frac{\mathrm{d}i}{\mathrm{d}t} \right) V \delta I \qquad (3)$$

has local validity. Consider for instance (fig. 1) a circuit C consisting of two straight parallel branches L of common length L connected by two small semi-circles R, the two L branches being inside the cylindrical plates, of equal diameters a and length L, of a charged capacitor. For given charges +q and -q per unit length of the capacitor and a given di/dt in the circuit, the force F of formula (1) (precisely opposite to the force -F exerted on the capacitor) is here proportional to L. As the electric field E (which is non-zero

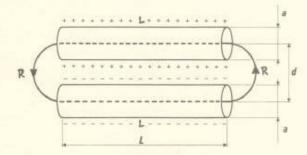


Fig. 1. Conservation of linear momentum: variable current and charged capacitor (a ≪L, d ≪L).

only outside the cylinders) is, on the R sections of C, L independent, the latter result can hardly be understood if it is denied that the gradientless potential inside the cylinders exerts the elementary force (3) [2]. Then, the principle of conservation of linear momentum selects the Coulombian gauge of V for, if V is generated by a point charge Q and has the Coulomb value $(4\pi r)^{-1}Q$, the elementary force exerted on Q by the induced electric field is precisely $-\delta F$.

The foregoing argument belongs to the same general family as de Broglie's [3] which, using the relativistic equivalence of energy and mass and the expression of the electromagnetic mass defect in the action-at-a-distance formulation of electromagnetism, selects the Liénard-Wiechert gauge. Also, the (gauge independent) Aharonov-Bohm [4] and Mercereau [5] effects have in this line a kinship with the present one, because in them the significant magnitude is the potential momentum Q/A.

Obviously, the essential difference between the classical version of electromagnetism and the one we tentatively present here consists in the nonexistence or existence of the *local* force

- [3]. Unfortunately, due to the presence of the c-2 factor in eq. (3), the crucial experimental test is practically not feasible in this form *.
- O. Costa de Beauregard. Physics Letters 24A (1967) 177. It is unfortunate that a factor c⁻² (in coherent units) has been dropped before the expressions of the force F.
- Explicit formulas are given in O. Costa de Beauregard. Compt. Rend. 263B (1966) 1047.
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- R.C. Jaklevic, J.J. Lambe, A.M. Silver and J.E. Mercereau, Phys. Rev. Letters 12 (1964) 274.
- * Conservation laws associated with the torque 2c⁻²VdM/dt which, according to the present theory, is applied to an Amperian current or dipole of moment M by an external potential V will be discussed in an other paper.

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