EUROPHYSICS LETTERS 1 April 2004

Europhys. Lett., **66** (1), pp. 153–154 (2004)
DOI: 10.1209/epl/i2003-10144-9

Comment

Comment on "Observation of scalar longitudinal electrodynamic waves" by C. Monstein and J. P. Wesley

J. R. Bray[1] and M. C. Britton[2,3]

[1] *Department of Computer and Electrical Engineering, Royal Military College of Canada PO Box 17000, Station Forces Kingston ON K7K 7B4 Canada*
[2] *Ellistar Sensor Systems Inc. - 440 Duvernay Drive, Orleans ON K1E 2N8 Canada*
[3] *Department of Electronics, Carleton University, 5170 Mackenzie Building 1125 Colonel By Drive, Ottawa ON K1S 5B6 Canada*

(received 8 August 2003; accepted in final form 29 January 2004)

PACS. 41.20.-q – Applied classical electromagnetism.
PACS. 41.20.Jb – Electromagnetic wave propagation; radiowave propagation.

It was with interest that we received the above-mentioned article [1]; however, a few points appear to violate fundamental principles. The first problem has to do with the following statements concerning the charge density and the current density inside a conductive ball antenna [1]:

> "The result is an oscillating uniform spherical charge density"

and

> "The spherical symmetric current density $\vec{J}$ within the ball, that gives rise to the pulsating surface charge source, is divergenceless, $\nabla \cdot \vec{J} = 0$."

The first statement implies that the charge density varies as a function of time, that is

$$\frac{\partial \rho}{\partial t} \neq 0\,, \tag{1}$$

but the $\nabla \cdot \vec{J} = 0$ statement then contradicts the fundamental continuity of charge equation:

$$\nabla \cdot \vec{J} = -\frac{\partial \rho}{\partial t}\,. \tag{2}$$

Indeed, any oscillating volume or surface charge density within or on the surface of the sphere *requires* a non-zero divergence of $\vec{J}$. The current density is never explicitly given in [1], and we find that no spherically symmetric current density can both satisfy the zero-divergence criterion and the boundary condition at the surface of the sphere, where the radial current density must be zero. This is easily proven by taking the divergence of a general radially directed current density in spherical coordinates and setting it equal to zero, giving

$$\nabla \cdot \vec{J} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 J_r\right) = 0\,. \tag{3}$$

This can be satisfied only if r is infinite or if $r^2 J_r = C$, where C is a constant. In the latter case, the current density must decrease as the square of the radius. However, an inverse square distribution only satisfies the zero-current boundary condition if r equals infinity, which is clearly not what the authors of [1] envisioned.

Our second objection has to do with eq. (1) in the paper, which is reproduced below without the typographical error found in [1] (where the second term has Φ^2 erroneously):

$$\nabla^2 \Phi - \frac{1}{c^2}\frac{\partial^2 \Phi}{\partial t^2} = -4\pi\rho\,. \tag{4}$$

The authors of [1] state that "solutions to this wave equation are scalar waves". Although this may be so, these solutions do not necessarily satisfy all of Maxwell's equations. In fact, (4) results from choosing the Lorentz condition [2]

$$\nabla \cdot \vec{A} + \frac{1}{c}\frac{\partial \Phi}{\partial t} = 0\,, \tag{5}$$

which then yields the simultaneous set of wave equations, (4) and (6):

$$\nabla^2 \vec{A} - \frac{1}{c^2}\frac{\partial^2 \vec{A}}{\partial t^2} = -\frac{4\pi}{c}\vec{J}\,. \tag{6}$$

Only when presented together are all three potential equations (4), (5) and (6) strictly equivalent to Maxwell's equations [2]. As such, a solution to (4) alone is insufficient.

Our third concern is with the particular solution to (4) proposed by the authors (eq. (4) in [1]):

$$\Phi = \frac{q}{r}\sin\left(kr - \omega t\right)\,. \tag{7}$$

The authors then state that $\nabla \cdot \vec{A} = 0$ [1]; but when taken together, $\nabla \cdot \vec{A} = 0$ and (7) clearly violate (5), the Lorentz condition that led to (4) in the first place.

Finally, the authors have failed to prove that a spherical ball antenna cannot generate a classical TEM wave (a commercial electromagnetic simulator could have been used here). Further, the distance measurement involving the two ball antennas appears to have been taken in an uncontrolled environment (*i.e.*, "the northern end of a small street on the bank of the river" [1]) instead of being taken in a proper, shielded anechoic chamber or in a controlled outdoor antenna range. As such, their measured power pattern could very well be due to a TEM wave that has been scattered from the ground, buildings, or other various objects.

Given these inconsistencies, the theoretical justification for scalar waves proposed by the authors appears to be flawed, and the experimental validation has been conducted in an uncontrolled environment. We look forward to receiving clarification from the authors regarding these points.

REFERENCES

[1] Monstein C. and Wesley J. P., *Europhys. Lett.*, **59** (2002) 514.
[2] Jackson J. D., *Classical Electromagnetics* (Wiley, New York) 1962, pp. 179-180.