Comment on "Intense Nonlinear Magnetic Dipole Radiation at Optical Frequencies: Molecular Scattering in a Dielectric Liquid"

In the theoretical section of their Letter, the authors claim the result that "the magnetic current density is minus one half the total current density" [1]. In this Comment, I argue that their argument is flawed and their conclusion is invalid.

The authors consider an incident plane wave of angular frequency ω that propagates in the z-direction with its electric field linearly polarized along $\hat{\mathbf{x}}$ and its magnetic field oriented along $\hat{\mathbf{y}}$. They then assert that, in conductors and insulators alike,

$$\nabla \times \mathbf{H} = \varepsilon_0 \dot{\mathbf{E}} + \mathbf{J}_c + \mathbf{J}_p + \mathbf{J}_M \tag{1}$$

where the $\mathbf{J}$'s are the conduction, polarization, and magnetic current densities. Integrating Eq. (1) over a surface perpendicular to the electric field gives

$$\int_S (\nabla \times \mathbf{H}) \cdot d\mathbf{s} = \int_S \varepsilon_0 \dot{\mathbf{E}} \cdot d\mathbf{s} + \int_S (\mathbf{J}_c + \mathbf{J}_p + \mathbf{J}_M) \cdot d\mathbf{s}. \tag{2}$$

The authors then invoke Faraday's law $\mathbf{H} = (\nabla \times \mathbf{E})/i\omega\mu_0$ and conclude that the integral on the left side of Eq. (2) is identical to the first integral on the right. The theoretical result claimed in the Letter is directly predicated on this conclusion. This conclusion, however, is valid only because the authors use plane wave fields, which satisfy $\nabla \times \mathbf{H} = \varepsilon_0 \dot{\mathbf{E}}$ *in the absence of currents*. If, as the authors assert, there are bound and free electrons present, currents will be induced, and the fields will not be simply those of the incident plane wave. In this case, the two integrals will not be equal, and the conclusion will not be valid.

In summary, the authors' assumption of plane wave fields is inconsistent with the presence of currents. Their conclusion, that the magnetic current density is minus one half the total current density, is therefore invalid.

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[1] Samuel L. Oliveira and Stephen C. Rand, Phys. Rev. Lett. **98**, 093901 (2007).

