Maxwell Current Must be Conserved Always Including in Molecular Dynamics

Bob Eisenberg

April 10, 2015

$$\nabla \times \mathbf{B} = \mu_0 \left(\mathbf{I}_{\text{mass}} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) \tag{1}$$

where $\mathbf{I}_{\text{mass}}$ is the current (coulombs per sec, NOT particles per second) carried by mass, often by the flux of charged particles.

So

$$\nabla \cdot \left(\nabla \times \mathbf{B} \right) = 0 = \nabla \cdot \mu_0 \left(\overbrace{\mathbf{I}_{\text{mass}} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}}^{\mathbf{I}_{\text{maxwell}}} \right) \tag{2}$$

$$\text{Maxwell Current is } \mathbf{I}_{\text{maxwell}} = \mathbf{I}_{\text{mass}} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \tag{3}$$

$$\boxed{\nabla \cdot \mathbf{I}_{\text{maxwell}} = \nabla \cdot \left(\mathbf{I}_{\text{mass}} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) = 0} \tag{4}$$

Thus the “Maxwell Current” is conserved. Everywhere. Everytime. Inside atoms. Between stars. Most importantly for us, it is conserved in liquids and ionic solutions everywhere.

It must be conserved in Molecular Dynamics.