Review of: "Circuits, Currents, Kirchhoff, and Maxwell"

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When considering the Kirchhoff law in its connection to Maxwell equations, Dr. Eisenberg tries to combine the “real” current ("flux of charges") and the “displacement” one into a general concept based on the Kirchhoff laws.

My opinion is that in most experiments or any physical systems where the real and displacement currents are formally “competing”, the latter is negligibly small by a factor of $\omega d/c$ at least, where ω and d are the characteristic frequency and size of the system, and c is the speed of light. This is the case, for instance, for magnetic flux diffusion in type-II superconductors, where both currents are present. And when we are speaking about the Kirchhoff law, the condition of smallness of the displacement current is implicitly accepted. When we deal with a situation where the real and displacement current coexist and are of the same order, the Kirchhoff law in its classic formulation is not directly applicable. Also, such a case would be most likely relativistic, whereas the author stays within the classical physics.

To my mind, this work does not bring any new physics, but has a methodological value. It can be highly recommended to students studying electrodynamics as an illustration of difficulties and contradictions of classical physics. The author relates the concept of a “whole current” to the Born's (quite early - 1924) interpretation of relativity and correctly notes that later physicists prefered to avoid it. The goal of this paper is actually to revive a “whole current”, which is questionable but challenging.

I might also bring the author's attention to the fact that in a non-stationary state, where circulating electric field is induced by an alternating magnetic one, voltage is not the same as the electric field. As an example one can consider a conducting ring embedded into a variating (in time) magnetic field. Of course, the induced EMF and current will be present in such a ring, but a voltmeter will return zero voltage when connected to any two points of the ring provided the magnetic field does not cross the voltmeter sub-circuit. So we need to be cautious when trying to apply the Kirchhoff law even in a simple non-stationary situation where the displacement currents are negligible or just absent.