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Book Review

Weber's Electrodynamics. By André Koch Torres Assis. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1994, xvi + 274 pp., $125.00 (hardcover).

Assis provides the reader with the opportunity to become familiar with Wilhelm Weber's 1847 electrodynamics, which is now again recognized as highly successful and most important. No other electrodynamic theory satisfies Newton's third law and the consequent conservation of energy for a system of moving point charges. In addition to this fundamental superiority of Weber's electrodynamics over the traditional Maxwell theory, there are crucial experimental results that are correctly predicted by Weber's electrodynamics, but that are incorrectly predicted by the Maxwell theory, as follows: Weber's electrodynamics yields Ampere's original empirically correct law for the force between current elements. It predicts the observed force on Ampere's bridge. It yields localized electromagnetic induction. It specifies the inverse force of induction, the force on accelerated charges due to stationary charges, the back emf specified by Lenz's law, but denied by the Lorentz force. Weber's electrodynamics explains the rupture and fragmentation of wires carrying heavy currents due to Ampere tension. It explains the force that drives the current carrying mercury in Hering's pump. It explains the force that drives the Graneau copper submarine down a trough of current carrying mercury. It predicts correctly the observed zero self-torque on the Pappas-Vaughan Z-shaped antenna (not considered by Assis). Since energy is conserved for a system of moving point charges; the Weber theory predicts a nonradiating hydrogen atom.

Assis shows that the Maxwell theory can be derived as a special limiting case of Weber's electrodynamics, where extended continuous closed current loop sources must be assumed, instead of moving point charges. The Maxwell theory is, thus, shown to be valid for some special situations, but not valid in general.

Weber's electrodynamics is based upon the astonishingly

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simple velocity potential, $W = (qq'/R)[1 - (dR/dt)^2/2c^2]$, where $\mathbf{R} = \mathbf{r} - \mathbf{r}'$ is the separation distance between charges q and q'. As Assis points out, the Weber theory is independent of the incorrect Fechner hypothesis that currents in wires consist of an equal number of positive and negative charges flowing in opposite directions. He also demonstrates the fact that the Weber theory conserves energy; and he reviews the historical "comedy of errors" on this point.

Assis presents a wealth of interesting information about the early history of electrodynamics and the early investigators. Some of this material is not generally known. Assis provides very good references for anyone interested.

Assis shows how Grassmann derived the Biot-Savart law from Ampere's original empirically correct law for the force between current elements under the assumption that the force on a circuit element is produced by current flowing in an entire mechanically rigid closed circuit. Needless to say, in general, charges need not form continuous closed current loops in mechanically rigid circuits; so the Biot-Savart law for current elements (or moving point charges) is in general not valid. Nor is the Maxwell theory, which is based upon the Biot-Savart law, in general valid. A particularly simple situation where the Grassmann-Biot-Savart conditions are not satisfied is provided by the Ampere bridge experiment. The force on one portion of a circuit due to the remainder of the circuit is measured. The entire closed current loop is no longer mechanically rigid. The one portion is allowed to be mechanically independent of the rest of the circuit by connecting it through mercury cups. The Weber-Ampere law predicts correctly quantitatively the observed force on Ampere's bridge. The Maxwell-Biot-Savart law, violating Newton's third law, is incapable of predicting a unique force; and, whatever value that might be chosen, it is too small. Assis describes some of the many experiments that have been done to determine the force on a portion of a circuit due to the remainder of the circuit.

Assis considers one of the most important fundamental open questions in modern physics. If both the mechanics as well as the electrodynamics for a fast moving particle with both mass and charge are to be empirically determined simultaneously, what can be concluded from the experiments that have been performed? Assis shows that the Kaufmann-Bucherer experiments yield an ambiguous result. Weber's electrodynamics is sufficient to explain the results when no mass change with velocity is assumed; while the traditional

Maxwell theory requires a mass change with velocity, $m = m_0/\sqrt{1 - v^2/c^2}$. Assis does not discuss the extremely important Bertozzi experiment, which apparently rquires mass change with velocity.

Assis considers the general two body problem for Weber electrodynamics. The Weber theory is seen to be thereby limited to relative velocities less than $\sqrt{2}c$. Rutherford scattering using the Weber theory is shown to differ from pure Coulomb scattering.

Assis wisely avoids any discussion of "special relativity," which with the failure of the Maxwell theory may now, in our view, be properly regarded as defunct.

One of the astounding successes of the Weber theory is its application in gravitation, where qq' is replaced by $-Gmm'$, G being the universal gravitation constant and m and m' being the masses of the interacting bodies. Mach's principle is confirmed. The mass times acceleration force is the inverse force of induction, the back emf of Lenz's law. Assis shows that, if the gravitational potential at the origin produced by the distant masses of the universe is Φ, then the Weber force on an accelerating body of mass m at the origin is given by $\mathbf{F} = -m(\Phi/c^2)\mathbf{a}$, where $\mathbf{a}$ is the acceleration. The resulting cosmological condition that $\Phi/c^2 = 1$ is not considered by Assis.

Despite the great value of this book, the reader should be aware of its limitations. It is intended primarily for the undergraduate or first year graduate student. It is not written for the mature researcher; although the mature researcher can find much useful material in the book. The book is limited essentially to action at a distance; so rapidly varying effects and radiation, requiring fields, are not considered. Wesley's extension of the Weber theory to fields is briefly mentioned. One of Assis' goals is to present an account of Weber's electrodynamics that will be palatable to those already taught to believe the Maxwell tradition. The book, thus, tends to give the impression that Weber's electrodynamics is always compatible with the Maxwell theory, which is, of course, far from the truth; as the numerous detailed examples presented in the book itself amply confirm.

Assis is aware of the fact that Weber's electrodynamics does not seem to be entirely satisfactory for fast charges.

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