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The Creation and Propagation of Radiation: Fields Inside and Outside of Sources

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(Submitted on 19 Jul 2011)

We present a new algorithm for computing the electromagnetic fields of currents inside and outside of finite current sources, for arbitrary time variations in the currents. Unexpectedly, we find that our solutions for these fields are free of the concepts of differential calculus, in that our solutions only involve the currents and their time integrals, and do not involve the time derivatives of the currents. As examples, we give the solutions for two configurations of current: a planar solenoid and a rotating spherical shell carrying a uniform charge density. For slow time variations in the currents, we show that our general solutions reduce to the standard expressions for the fields in classic magnetic dipole radiation. In the limit of extremely fast turn-on of the currents, we show that for our general solutions the amount of energy radiated is exactly equal to the magnetic energy stored in the static fields a long time after current creation. We give three associated problem statements which can be used in courses at the undergraduate level, and one problem statement suitable for courses at the graduate level. These problems are of physical interest because: (1) they show that current systems of finite extent can radiate even during time intervals when the currents are constant; (2) they explicitly display transit time delays across a source associated with its finite dimensions; and (3) they allow students to see directly the origin of the reaction forces for time-varying systems

Comments:	25 pages, 5 figures
Subjects:	**Classical Physics (physics.class-ph)**
Cite as:	**arXiv:1107.3813 [physics.class-ph]**
	(or **arXiv:1107.3813v1 [physics.class-ph]** for this version)

Submission history

From: John Belcher [view email]
[v1] Tue, 19 Jul 2011 19:25:29 GMT (298kb)

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