Understanding the Self-Acceleration Paradox

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Background:

In a classical electrodynamic calculation, the acceleration of a moving charge is "damped:" the charge loses energy via radiation. The damping force (**F**) is proportional to the rate of change of the acceleration $(\dot{\mathbf{a}})$:

$$\mathbf{F} = \frac{q^2}{6\pi\varepsilon_0 c^3}\dot{\mathbf{a}}, \tag{1}$$

where q is the charge, c is the speed of light, and ε_0 is the permittivity of free space. If no other external forces are applied, the equation of motion for the charge may be written:

$$\mathbf{F} = m\mathbf{a} = \frac{q^2}{6\pi\varepsilon_0 c^3}\dot{\mathbf{a}}. \tag{2}$$

A solution to this differential equation is:

$$\mathbf{a}(t) = a_0 e^{\frac{t}{\tau}} \tag{3}$$

where:

$$\tau = \frac{q^2}{6\pi\varepsilon_0 m c^3}. \tag{4}$$

This "runaway" solution describes an exponential increase in acceleration with time, a result that is decidedly unphysical. A great many attempts have been made to understand and resolve this paradox. A good starting point is the discussion and references provided by Smith [Glenn S. Smith, An Introduction to Classical Electromagnetic Radiation, (New York: Cambridge University Press: 1997), pp. 436-446].

Action-Reaction:

Elsewhere, the author has argued that the source of energy radiated from an accelerated charge lies in the energy of the static field which is the cause of the acceleration [H. Schantz, "On the Localization of Electromagnetic Energy," EuroEM 2000 (May 2002)]. If this is the case, then the traditionally accepted classical analysis rests on a false premise: that action-reaction must be considered only for ***two*** entities, the charge and the radiation.

The present paper will review prior understanding of the self acceleration paradox and re-consider the problem of charge self-acceleration explicitly including all three participants: 1) the charge, 2) the radiation, and 3) the applied field responsible for the charge's acceleration.