Classical Radiation Reaction Off-Shell Corrections to the Covariant Lorentz Force

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Abstract:

It has been shown by Gupta and Padmanabhan that the radiation reaction force of the Abraham-Lorentz-Dirac equation can be obtained by a coordinate transformation from the inertial frame of an accelerating charged particle to that of the laboratory. We show that the problem may be formulated in a flat space of five dimensions, with five corresponding gauge fields in the framework of the classical version of a fully gauge covariant form of the Stueckelberg-Feynman-Schwinger covariant mechanics (the zero mode fields of the $0,1,2,3$ components correspond to the Maxwell fields). Without additional constraints, the particles and fields are not confined to their mass shells. We show that in the mass-shell limit, the generalized Lorentz force obtained by means of the retarded Green's functions for the five dimensional field equations provides the classical Abraham-Lorentz-Dirac radiation reaction terms (with renormalized mass and charge). We also obtain general coupled equations for the orbit and the off-shell dynamical mass during the evolution. The theory does not admit radiation if the particle remains identically on-shell. The structure of the equations implies that the mass-shell deviation is bounded when the external field is removed.