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An extended-body approach to self-force in curved spacetime

ISAAC WALDSTEIN, Univ of NC - Chapel Hill, DAVID BROWN, NC State University — Self-force describes the effect of an object's own field on its motion. If we model a physical object as a point particle, then the self-force diverges when evaluated at the particle's location. One way to avoid this difficulty is to model the physical object as an extended body with detailed internal structure. We consider an extended body, modeled as an elastic material, moving in an arbitrary background gravitational field. We express the spacetime coordinates of each point in the body in terms of the Fermi normal coordinates tied to a fiducial observer whose basis vectors are Fermi–Walker transported. We construct the action and equations of motion for the elastic body, expanding in powers of the spatial Fermi normal coordinates $\bar{x}^a$. A center of mass condition ties the motion of the fiducial observer to the motion of the elastic body. We show that (a) the elastic body follows a geodesic at zeroth order in $\bar{x}^a$ and (b) we recover the Mathisson-Papapetrou-Dixon (MPD) equations at first order in $\bar{x}^a$. In each case, the details of the body's elastic interactions are absorbed into the body's multipole moments. In future work, we will remove the restriction to background gravitational fields and derive the gravitational self-force on the extended body.

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