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Multisymplectic Integration for Beam and Plasma Simulations[1]
STEPHEN WEBB, RadiaSoft, LLC, RADIASOFT, LLC TEAM — Particle-in-cell methods are a standard tool for simulating charged particle systems such as fusion plasmas, intense beams, and laser- and beam-driven wakefield accelerators. Conventional methods have been successful in studying short-term dynamics, however numerical instabilities and artifacts such as grid heating make long-time simulations unreliable. A similar issue existed in single particle tracking for storage rings in the 1980s, which led to the development of *symplectic algorithms*. The essential insight that if the physical equations of motion derive from a least-action principle, then so too should the numerical equations of motion. The resulting update sequence preserves a symplectic 2-form, which is a strong constraint on the numerical solutions. The resulting algorithms are stable and accurate over very long simulation times. This same structure exists for field theories as well as single-particle dynamics. Such *multisymplectic* integrators have good stability properties and naturally encode conservation laws, making them ideal for simulations over many oscillations of the system. We present here a number of examples where multisymplectic algorithms have been used over very long time scales.

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