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Iterative Solution Method for an Implicit Orbit Averaged Particle-in-Cell Model

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Present kinetic simulations of turbulence in magnetized plasmas employ models from gyrokinetic theory, which is based on a number of ordering assumptions used to reduce the Vlasov-Maxwell system to eliminate high frequency phenomena. Recently, a second order accurate, implicit particle-in-cell (PIC) model using ions which evolve according to the exact Newton-Lorentz equations of motion has been developed to study low-frequency phenomena in magnetized plasmas. This model promises to be physically reliable in regimes where the ordering assumptions of gyrokinetics may be in question, but presents some additional computational challenges to produce numerically stable results while retaining important kinetic effects.

This talk will focus on orbit averaging algorithms applied to the Lorentz ion model. Orbit averaging is a time stepping method based on advancing particles over several micro time steps for each macro time step over which the fields are advanced. An implicit scheme is applied to the orbit averaging algorithm to eliminate a time stepping constraint due to a high frequency compressional Alfven wave present in the Lorentz ion model. The implicit algorithm requires the solution of a large system of nonlinear equations at each macro-time step. A solution method for this system based on Picard iterations will be presented. An "inner" iteration is used for the particle advances at the micro time steps and an "outer" iteration in which the particle system and the field equations are alternately updated is used to provide a self-consistent coupling at the macro time step. A preconditioner may provide a means of increasing the rate of convergence in this iterative process. Numerical results will be presented along with a discussion on the convergence of the iterative method.

[1] Y. Chen, S.E. Parker, Phys. Plasmas 16 (2009) [2] J. Cheng, S.E. Parker, Y. Chen, D. Uzdensky, J. Comput. Phys. 245 (2013), 364