Particle-Particle Particle-Mesh Computations Without Self Force

Matthew T Bettencourt
Air Force Research Laboratory
Directed Energy Directorate – High Power Microwave Division
Kirtland AFB, Albuquerque NM 87123

Andrew Christlieb
Michigan State University
Department of Mathematics
East Lansing, MI 48824

Abstract

For computations using particles it has been common to use one of two techniques; map the particles to a mesh and solve for the fields on that mesh, or to perform the direct particle-particle interactions. Traditionally the former is more efficient and the later is more accurate. Many hybrids have been developed in the past which try to keep the efficiency off mesh based techniques with the accuracy of the particle-particle techniques in a class of solvers called Particle-Particle Particle-Mesh (P3M) methods. These schemes solve for long range forces on the mesh, attempt to subtract false short range forces off the mesh and substitute accurate close range particle-particle forces. The issue which traditionally hampers this approach is that the close range forces are not completely subtracted, and thus you have double counting, or worse, self force. This effect can be mitigated by proper disposition of charge onto the mesh. This disposition uses the Green's function for the electric fields on the staggered Yee mesh. The charge is then deposited on the grid by performing the discrete divergence on those fields. Then when one solves Poisson's equation for the potential and reconstructs the fields from the gradient of the potential they exactly match the Green's function on the grid edge. This allows for the subtraction and re-addition process in P3M to work without self forces. This talk will show the differences between traditional P3M and the new charge weighting scheme and how the new scheme reproduces the accuracy of direct particle calculations.