

## **Advanced particle methods for collisionless plasma simulations**

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In this talk we review the advances made in adaptive fully Lagrangian electrostatic plasma simulations. The method is based on hierarchical fast summation, the Boundary Integral Treecode (BIT), and dynamic point insertion. The approach provides an adaptive way to resolve ultra fine structures which result from phase space stretching and folding well beyond the solution obtainable with mesh based methods. The approach has been applied to a range of interesting problems, including 1d virtual cathode formation, 1d two stream instability and the 2d simulations of a Penning trap.

In the last part of the talk, we will discuss current work on the extension of these ideas to the electromagnetic case. In particular, we will discuss the development of an implicit Maxwell solver that combines ideas of BIT with other novel fast methods for the efficient evaluation electromagnetic effects while avoiding the CFL restriction associated with the speed of light. In the limit of the ratio of the speed of light to relevant plasma frequencies goes to infinity, the new method is designed to recover the Darwin limit of electromagnetics. Time permitting, a sketch of a proof for convergence in the case of the wave equation for this new method will be outlined.