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Fast Parallel Particle Methods: Angstroms to Gigaparsecs
MICHAEL WARREN, Los Alamos National Laboratory — Fast multipole methods have become an ubiquitous tool for the simulation of physical systems with long-range interactions. Since their introduction they have been applied to a vast range of problems. Our own parallel hashed oct-tree code (HOT) has been applied to a number of physical systems with long-range interactions, including gravitational and smoothed particle hydrodynamic interactions in astrophysical systems, fluid flows with vortex-particle methods, electromagnetic scattering and aerodynamics. Several these simulations were recognized with Gordon Bell prizes for significant achievement in parallel processing. We will discuss some recent work which used a series of 1-billion particle dark matter simulations to accurately determine the mass function of galaxy halos. These simulations required over 4×10^{18} floating point operations (4 exaflops). Another focus of our current research is extending the HOT framework to biological systems, with the goal of simulating systems using over ten times as many atoms as the current state-of-the-art. This requires addressing several issues with current multipole algorithms, such as spatially-correlated errors and the ability to handle disparate time scales efficiently.

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