ACCELERATOR SEMINAR

"Using the Grid-Free Fast Multipole Method in Collective Effect Simulations"

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Currently the most popular algorithm for the simulations on collective effects in accelerators is the Particle-In-Cell (PIC) method. The PIC method is based on a grid, which makes it difficult to deal with highly non-uniform charge distribution and/or complex geometry. Also the information of the fine structure of the charge distribution is lost when distributing the charges on the grid points for field calculation. In this presentation will be introduced the grid-free fast multipole method (FMM), which does not have the above problems, and its application in collective effect simulations. The FMM has an efficiency of O(N) for calculation of the Coulomb forces between N charged particles with any arbitrary distribution. Using FMM, the whole charged domain is decomposed into small boxes of various sizes according to the charge density, so that each box contains no more than a pre-specified maximum number of particles. Taking advantage of the fact that the long-range Coulomb force decreases fast as the distance between the charges increases, the force contributed from a box to the region far away was represented by a multipole expansion, while the forces to the region nearby is calculated directly with Coulomb formula. The force on each particle is calculated as the summation of contributions from its near region and its far region. The adaptive box structure makes the FMM suitable for any charge distribution and geometry, and it can simulate the fine structure in a highly correlated system since the near region interaction is calculated accurately. Specifically the differential algebra (DA) based FMM will be discussed and simulations on space charge dominated photoemission process, in which the DA based FMM is implemented, will be presented.

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CEBAF Center, Auditorium

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