Physical Relation between Number of Particle per Cell and Debye number in Particle-in-cell Simulations

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Particle-in-cell simulation method with Monte Carlo Collision (PIC-MCC) is frequently used for simulating a wide range of plasma phenomena [1]. PIC-MCC simulation shows advantage of the collective behavior of charged particles in plasma to model the kinetics of various species by simulating reduced number of computer simulation. This simulation is operating based on the solving Boltzmann or Vlasov equations, and reduced form of Maxwell equation. High accuracy, because of direct solving of these equation without any further physical approximations is also advantage of PIC simulation.

But selecting numerical parameters, like the time step (Δt), the cell size (Δx) and the number of particle per cell (N_c), is very important for preventing numerical heating. There are well-established criteria for the choice of these parameters for particle simulation. Especially, selection condition for the time step and cell size is highly related to physical parameter of plasma, which is plasma frequency and Debye length. But for the choice on the N_c, there is no generally accepted rule, then a sufficiently large number of particles is suggested to prevent any numerical error. As a compromise between numerical accuracy and computational N_c is typically kept between 10 to 100 [2]. Number of particles per Debye length, N_d, is used instead of N_c [3] but physical relation between them is not well established. In this study, we used a PIC-MCC simulation in atmospheric pressure condition for finding physical relationship between N_c and N_d. Simulation is conducted with a variation of both Nc and Nd with satisfaction of another selecting rule for time steps and cell size. Results of this work can be another general selecting rules for PIC-MCC simulation.

References

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