Large time steps & grid size implicit particle in cell simulations applied to large plasma devices

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We demonstrate the usability of the implicit particle in cell (PIC) method for the simulation of high density large dimensions plasma devices. A wide variety of situations are studied such as high versus low pressure conditions or the inclusion of a static magnetic field over some region of the simulation domain acting as a filter for the low energy electrons. We compare the calculation results in one dimension to an analytical description of an unmagnetized discharge allowing us to estimate the error introduced by the PIC method and the criterion to reach a satisfactory converged solution. In two dimensions, the implicit method is compared to explicit particle in cell solutions. Using the scalability condition, i.e., plasma density being proportional to the input power when only linear collisions occur in the system, we recover as expected similar macroscopic profiles (density, temperatures, etc.) for low and high plasma density simulations. Lastly we simulate large volume devices (for simplified physical chemistry conditions) such as the negative ion source similar to the one used in the future neutral beam injector of the International Thermonuclear Experimental Reactor (ITER), demonstrating the strong reduction in total computational time needed in order to reach convergence. The sheath is calculated self-consistently without using ad-hoc analytical solutions even when not spatially resolved, that is using a grid size large compared to the Debye length.

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