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# *Particle-in-cell simulation method for macroscopic degenerate plasmas*

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Nowadays hydrodynamic equations coupled with external equation of states provided by quantum mechanical calculations is an widely used approach for simulations of macroscopic degenerate plasmas. Although such an approach is proven to be efficient and shows many good features, specially for large scale simulations, it encounters intrinsic challenges when involving kinetic effects. As a complement, we here have invented a fully kinetic numerical approach for simulations of macroscopic plasmas with arbitrary degeneracies.

This approach is based on first principle Boltzmann-Uhling-Uhlenbeck equations coupled with Maxwell's equations, and is eventually achieved via an existing particle-in-cell simulation code named LAPINS. In this approach, degenerate particles obey Fermi-Dirac statistics, and non-degenerate particles follow the typical Maxwell-Boltzmann statistics. The equation of motion of both degenerate and non-degenerate particles are governed by long range collective electromagnetic fields and close particle-particle collisions. Especially, Boltzmann-Uhling-Uhlenbeck collisions ensure that evolutions of degenerate particles are enforced by the Pauli exclusion principle.

The code is applied to several benchmark simulations, including electronic conductivity for aluminium with varying temperatures, thermalization of cold fuel shell by alpha particles in inertial confinement fusion and rapid heating of solid sample by short and intense laser pulses.

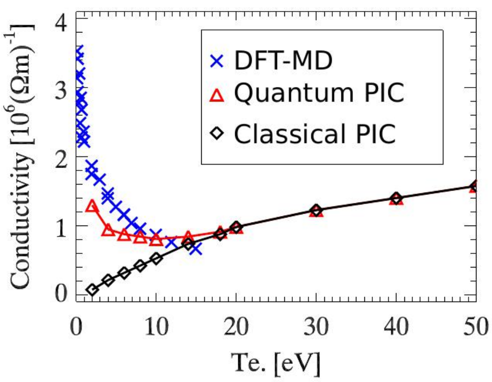


***Figure 1: Electrical conductivity of solid aluminium. Our results of quantum PIC and classical PIC are compared with full quantum mechanical calculations, i.e., Kubo-Greenwood DFT-MD method.***

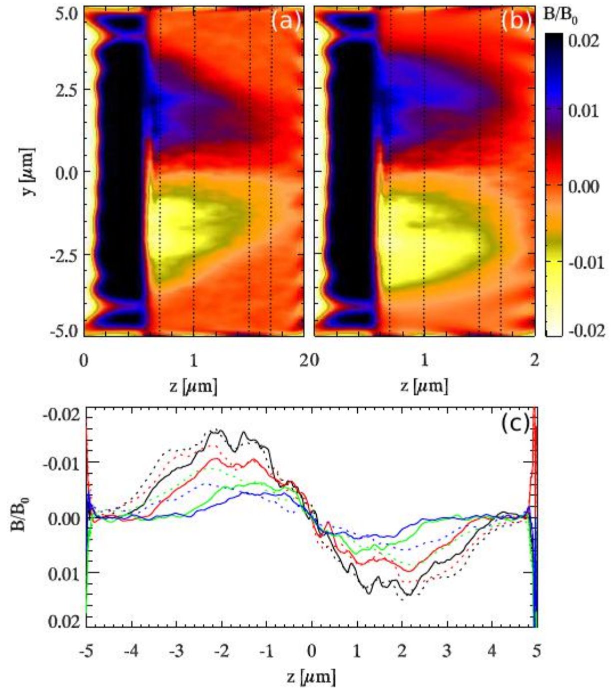


***Figure 2: Self-generated magnetic fields for quantum-LAPINS code (a) and classical-LAPINS code (b) at t = 40 fs. In (c), we display the magnetic field along the dashed-line as marked in (a) or (b). Values along z = 7, z = 10, z = 15 and z = 17 μm are plotted in black, red, green and blue, respectively. As a comparison, dashed lines in (c) are the corresponding values from classical-LAPINS code.***

***References***

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