Seminar

Institute for Plasma Research

Title : Studies in Non-Neutral Plasmas using Particle-in-Cell Simulations

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Date : 18th August 2017 (Friday)

Time : 11.30 AM

Venue : Seminar Hall, IPR

Abstract :

Confinement of Non-neutral plasmas in laboratory is invariably accompanied by continous generation of charged particles due to collisions with very low density background neutrals. This leads to processes which are driven by resonant particle effects leading to instabilities, nonlinear saturation, and transport in magnetized Non-neutral plasmas. Hence a particle level simulation, valid for a variety of trap geometry, and useful at arbitrary densities, is an important tool to understand some of these effects.

As a part of this thesis, an Electrostatic, OPEN-MP parallelized, 2D3v Particle-in-Cell (PIC) code with facility for Monte-Carlo-Collisions (MCC) has been developed to simulate 2D dynamics of plasmas of arbitrary neutrality in cross-sections of magnetic traps, along with 3D collisional interaction of the plasma with a background of neutrals at any given temperature and pressure. The code is written in Cartesian co-ordinates, which makes it flexible to simulate plasma dynamics in trap cross-sections of arbitrary size and shape, as well as large toroidal aspect ratios. To understand the axial dynamics, a downscaled 1D version of the PIC code has also been developed for simulation 1D dynamics of plasmas confined within various types of numerical 1D walls to mimic experimental conditions.

This suite of PIC codes has been successfully utilized to investigate several linear and nonlinear dynamics of non-neutral plasmas. For example, simulations of radial breathing modes, and ionresonance instabilities in cylindrically confined non-neutral plasmas have revealed and explained interesting new phenomena, such as i) formation of density voids and spontaneous triggering of poloidal modes from radial breathing modes, ii) symmetric tearing of electron clouds and reorganization of the torn sections into a single cloud configuration in course of ion-resonance instabilities, and iii) peculiar time-evolution of the frequency of the fundamental azimuthal mode driven by ion-resonance. The MCC part of the code has been used to investigate the process of destabilization of electron plasmas by impact ionization of background neutrals, and the influence of elastic collisions between electrons and background neutrals on an ensuing ion resonance instability. Using the 1D PIC code it has also been successfully demonstrated, that plasmas can be significantly heated, if it is taken through an adiabatic thermodynamic cycle of quasi-static compression, followed by non-quasi-static expansion back to its initial dimensions.

In this thesis talk, crucial aspects of the code development and details of the physics problems addressed will be presented along with future scope of this work.