Seminar

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Institute for Plasma Research

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Title: Computational Characterization of plasma transport in low temperature ExB plasmas using 2D-3V PIC-MCC simulations

Speaker: Dr. Miral Shah
DA-IICT, Gandhinagar

Date: 9th September 2022 (Friday)

Time: 03:30 PM

Venue: Join the talk online:
https://lobby.ipr.res.in/Dr.MiralShah_PDFTalk

Abstract

Low-temperature plasmas (LTP) with a magnetic field in a low-pressure condition has a wide range of applications such as negative ion source, Hall thruster, magnetron discharge, and electron cyclotron resonance source. The presence of an inhomogeneous magnetic field along with a non-uniform electric field in such applications leads to E×B drifts, thereby leading to complex plasma transport. Such a plasma source with a non-thermal equilibrium state, inhomogeneous magnetic and electric field, leads to the asymmetry in the plasma profiles. The gradients in plasma parameters, different drifts, and several collisional processes result in fluctuations or instabilities in the plasma, which can increase the electron cross field mobility that cannot be explained by the physics of classical collisional mobility. Complex plasma transport involving several time and length scales necessitates the need of computationally expensive kinetic simulations, such as Particle-in-Cell Monte Carlo collision (PIC-MCC), to improve the current understanding of anomalous transport in such systems.

In this work, using an in-house parallel 2D-3V PIC-MCC code, we investigate the physics of plasma transport across the magnetic filter in the context of ROBIN negative ion source [1] using actual experimental parameters. Large size negative ion source geometry, small-time step, small grid spacing and high plasma density necessities the sophisticated parallelization of the PIC-MCC code and its execution on advanced HPC facilities for the problem at hand [2,3]. We obtain a good match between simulation and experimental results [1]. Instabilities (recognized as E × B drift instability) are observed near the magnetic field region which significantly effects the plasma transport [4]. Our investigations reveal that these instabilities under some specific experimental conditions (combination of B and bias voltage) may lead to formation of double layers which can induce ion acceleration in the magnetic filter region. Spatio-temporal investigation of Energy Distribution Functions shows Maxwellian EEDF and non-Maxwellian IEDF in the magnetic filter region, in agreement with similar experimental calculations reported in the literature. Several case studies have been performed to understand the role of the magnetic filter profile on plasma transport, which may help in planning future experiments [1].

1. M. Shah, B. Chaudhury, M. Bandyopadhyay, and A. K. Chakraborty, "Computational characteristics of plasma transport across magnetic filter in ROBIN using PIC-MCC simulation," *Fusion Eng. Des.*, vol. 151, p. 111402, 2020.
2. Bhaskar Chaudhury *et al.*, "Hybrid Parallelization of Particle in Cell Monte Carlo Collision (PIC-MCC) Algorithm for Simulation of Low Temperature Plasmas," in *Communications in Computer and Information Science book series*, Springer, 2018, pp. 32–53.
3. H. Shah, S. Kamaria, R. Markandeya, M. Shah, and B. Chaudhury, "A Novel Implementation of 2D3V Particle-In-Cell (PIC) Algorithm for Kepler GPU Architecture," in *Proceedings of 24th IEEE International conference of high performance computing, data, and analytics (HiPC)*, 2017.
4. M. Shah, B. Chaudhury, M. Bandyopadhyay, and A. Chakraborty, "The Feasibility of Resonance Induced Instabilities in the Magnetic Filter Region of Low Temperature Plasma Based Negative Ion Sources," *AIP Conf. Proc.*, vol. 2373, no. Nibs 2020, p. 080003, 2020.