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Space Charge Modeling for Negative Ion Beam Transport: A PIC Study

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Large-size, Multi-beam group negative ion-based neutral beam injectors (NBI) are an effective heating and current drive system for fusion reactors such as ITER. Improving understanding of ion beam transport is critical for optimizing the performance and efficiency of such multi-beam group NBI systems. Primary studies on a $1/8^{th}$ size, 2-beam group-based negative ion source (ROBIN: RF-Operated Beam source in India for Negative ions), through comparison of numerical modeling and experimental studies, have shown the impact of space charge (SC) interaction (Coulomb repulsion) on the beam group separation during transport[1]. The IBSimu[2] package is used to design a three-dimensional kinetic model (PIC: Particle In Cell) of two tilted charged beam groups to explore the impact of SC interaction on beam group dynamics downstream of the beam line. Two charged particle beams, characterized by Gaussian transverse profiles and uniform longitudinal distributions, are continuously injected into the simulation domain. The beam current and energy are used as two crucial input parameters for tracking these interactions in the simulation. The spatiotemporal evolution of the transverse particle distribution, both for individual beam groups and the resulting merged beam, is tracked to quantify the effects of the SC interaction field. Integrating secondary particle generation and SC compensation into the simulation code is in progress. This study aids the understanding of SC interactions between partially compensated ion beam groups in a negative ion source and their impact on beam transport.

1. Dash, Sidharth, et al. ``Probing into Space Charge Interactions of Negative Ion Beams through Imaging D
2. Kalvas, Taneli, et al. ``IBSIMU: A three-dimensional simulation software for charged particle optics.'

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