Numerical modeling of neutralization mechanisms and nonlinear beam-plasma interactions in high-energy negative hydrogen ion beam transport through plasma and gas targets

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Abstract:

This work studies the transportation of high-energy negative ion beams within both plasma targets and gas targets, by employing a 2D3V Particle-in-Cell (PIC) model coupled with Monte Carlo (MC) collision method.The simulations demonstrate strong nonlinear beam-plasma interactions, unveiling short-pulse formation of ion beam induced by background plasma oscillation[1]. Meanwhile, a comprehensive investigation was conducted on the neutralization mechanisms of negative hydrogen ion beams, revealing distinct dominant mechanisms between high-energy and low-energy ion beams. Besides, it was also discovered that high-energy ion beams can spontaneously excite low-density plasma in pure gas targets by various collision processes. Although the excited plasma density remains insufficient to induce significant nonlinear effects, it exhibits a notable focusing effect on the ion beams, effectively improving their collimation characteristics.These studies not only enrich the theoretical foundation of neutralization mechanisms for high-energy ion beams but also demonstrate the complex interplay between ion beam transport dynamics and plasma/gas target interactions.

References

[1] Igor D. Kaganovich, et al. Physics of Plasmas (1994-present) 8, 4180 (2001)