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Acceleration of plasma electrons by intense nonrelativistic ion and electron beams propagating in background plasma due to two-stream instability

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In this paper we study the effects of the two-stream instability on the propagation of intense nonrelativistic ion and electron beams in background plasma. Development of the two-stream instability between the beam ions and plasma electrons leads to beam breakup, a slowing down of the beam particles, acceleration of the plasma particles, and transfer of the beam energy to the plasma particles and wave excitations. Making use of the particle-in-cell codes EDIPIC and LSP, and analytic theory we have simulated the effects of the two-stream instability on beam propagation over a wide range of beam and plasma parameters. Because of the two-stream instability the plasma electrons can be accelerated to velocities as high as twice the beam velocity. The resulting return current of the accelerated electrons may completely change the structure of the beam self - magnetic field, thereby changing its effect on the beam from focusing to defocusing. Therefore, previous theories of beam self-electromagnetic fields that did not take into account the effects of the two-stream instability must be significantly modified. This effect can be observed on the National Drift Compression Experiment-II (NDCX-II) facility by measuring the spot size of the extracted beamlet propagating through several meters of plasma. Particle-in-cell, fluid simulations, and analytical theory also reveal the rich complexity of beam- plasma interaction phenomena: intermittency and multiple regimes of the two-stream instability in dc discharges; band structure of the growth rate of the two-stream instability of an electron beam propagating in a bounded plasma and repeated acceleration of electrons in a finite system. In collaboration with E. Tokluoglu, D. Sydorenko, E. A. Startsev, J. Carlsson, and R. C. Davidson. Research supported by the U.S. Department of Energy.