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P2.4014 Cross-field chaotic transport of electrons by E X B electron drift instability in Hall thruster

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In Hall thruster geometry, the electric and magnetic field configuration creates a huge difference in drift velocity between electrons and ions, which generates electron cyclotron drift instability or E × B electron drift instability[1]. Unstable modes generated from this instability have an important role in cross-field anomalous transport of electrons. One special interest for the industrial development of Hall thruster is characterizing the anomalous cross-field electron transport observed after the channel exit. Since the ionization efficiency is more than 90%, the neutral atom density in that domain is so low that the electron collisions cannot explain the high electron flux observed experimentally. Here we are focusing on collision-less chaotic transport of electrons by the E × B drift instability generated unstable modes.
The dynamics of electrons are studied numerically in a slowly time varying (w c) potential profile in presence of a constant axial electrostatic field E and a radial magnetic field B, using Boris numerical integration scheme. The time varying potential is associated with the unstable modes generated by E × B drift instability which follow a dispersion relation [1] and their frequencies w are very small compared to the gyration frequency c. In presence of those unstable electrostatic modes, the electron trajectories become chaotic, whereas without the wave they are regular with a constant drift motion along E × B direction. We consider a Cartesian coordinate system with x along B direction, y along E × B direction and z along E direction. Their y- and z-components of velocity vy and vz, respectively, oscillate with the gyration frequency. vy oscillates around the drift velocity vD. Since the background electrostatic wave, in the x - y plane, has very slow phase velocity (w/k vD), the electrons strongly interact with the background electrostatic wave when their vy becomes very small, vy w/k. Depending upon the interaction time they exhibit different dynamical behaviours. During the interaction, their x-component of velocity (vx) suddenly changes to higher/lower velocity which depends on the potential of the wave at the particle location, and if the bounce frequency is larger than the gyration frequency be c, sometimes the electrons are trapped within the potential deep and again with increase of vy they become untrapped. Due to this strong interaction, their motion becomes chaotic. We characterize this three dimensional chaotic motion and associated transport in the perpendicular direction.

[1] T. Lafleur, S. D. Baalrud and P. Chabert, Phys. Plasmas 23, 053503 (2016)

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