Numerical investigation of high-frequency azimuthal wave in Hall thrusters

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Due to its strong correlation with the anomalous electron cross-field transport, the physics of high-frequency azimuthal wave is one of the research hotspots on Hall thruster subject at present. Plenty of experimental and theoretical works have been done to reveal its features. In this paper, the high-frequency azimuthal wave is systematically investigated from the viewpoint of numerical simulation. A 2D3V full Particle-in-Cell model is developed to simulate the charged particle behaviors in the radial and azimuthal thruster plane. The simulation results show that the azimuthal wave is Hall drift-driven and has a wavelength on the order of millimeter and a frequency on the order of megahertz; however, the wavelength as well as the frequency and the oscillation amplitude is not constant but vary in a wide range relying on the thruster circumference. It is further found that the azimuthal wave has a dispersion relation close to that of ion acoustic wave, which accords well with recent experimental findings. In addition, an analysis on ion mass effect shows that the practical frequency of the azimuthal wave is in the range of 1-5MHz in Hall thrusters.

Table I. Case settings on fields and SEE for determining the condition on azimuthal wave appearing

CASE	B_x applied	E_z applied	SEE considered
1	NO	NO	YES
2	YES	NO	YES
3	YES	YES	YES
4	YES	YES	NO

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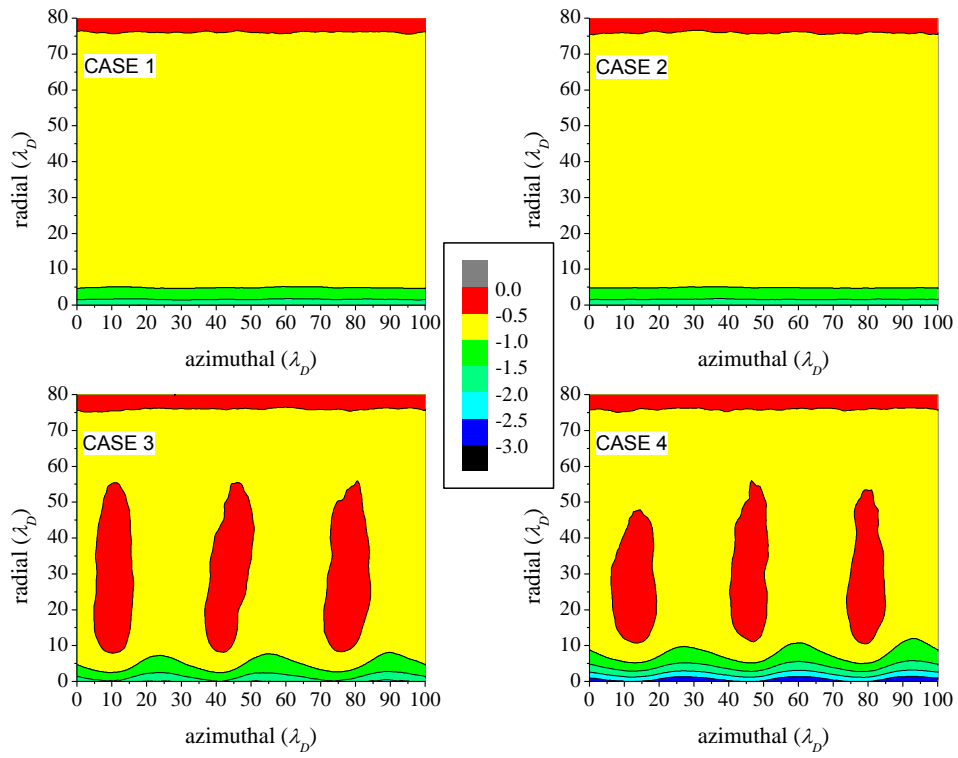
Fig. 1 Spatial distributions of electric potential (normalized with T_{e0}).
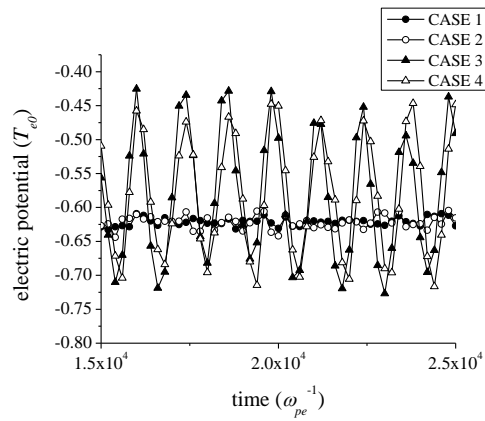

Fig. 2 Temporal variation of electric potential (normalized with T_{e0}) of the domain center point.