Investigation of fluctuations and transport in Hall plasma devices and their applications for electric propulsion

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This work is dedicated to studies of the instabilities affecting operational regimes and performance of Hall thrusters in an attempt to determine which instabilities may cause observed levels of anomalous transport and lead to large scale coherent structures. Oscillations within a broad range of frequencies are observed for SPT [1–3]. In Hall accelerators, azimuthal structures have been observed already in very early work [4] where it was suggested that ionization processes play important role.

The fluid model for simulation of density gradient driven modes with uniform magnetic field was formulated. This fluid model includes electron inertia and electron neural collisions; therefore the lower hybrid modes destabilized by ExB drift and collisions are also included in the model.

The local model was created. Series of simulation were performed for this model with developed MATLAB based code. Main goal was to simulate parameters typical for PPPL experiments. The series of experiments for different types of ions were conducted for Penning trap and Hall thruster. The number of parameters were changed during experiments. Main difference between experiments for different devices, apart from the field geometry, is a different magnitude of the electric field. Experiments were focused on study of background pressure on rotational structures. Numerical results from parametric study are in partial agreement with experimental results. There is a similarity in effect of background pressure on oscillations. However, there is a large difference between observed effect of magnetic field and theoretical prediction.

Linear, nonlocal cylindrical model for drift modes based on the two-fluid plasma description was developed. The equation for the potential amplitude of azimuthally propagating electrostatic mode in collisional plasma. Radial profile of the collision frequency for ion-neutral and electron collisions are taken into account. This eigenvalue problem was solved numerically by collocation spectral method. This model provides the global structure of unstable mode important for Penning discharge with axial magnetic and radial electric field.

References

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