NUMERICAL MODELING OF ROTATING SPOKES IN HALL THRUSTER DISCHARGE PLASMA

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Rotating spoke is a coherent structure observed in cross-field devices, such as Hall effect thrusters (HETs), magnetrons, and Penning discharges. In spite of being frequently observed in the experiments, it has been numerically challenging to perform stable calculations using electron fluid models to model rotating spokes. It is suggested that the electron fluid model using drift-diffusion approximation is mathematically ill-conditioned due to the differences (e.g. 100-1000 times) in the characteristic speeds of the electron velocity in the axial and azimuthal directions[1]. We have developed a robust pseudo-time stepping method that solves the diffusion equation to model magnetized electron fluid[2], which uses the drift-diffusion model but can be calculated more robustly and stably by adding time derivative terms. The steady-state solution is the converged solution of the diffusion equation. This model has been used to model the discharge plasma in HETs in the radial-axial direction.

In this talk, we present the numerical simulations of low-frequency rotating spokes in the discharge channel of a HET. The numerical simulation shows that rotating spoke is a low-frequency ionization oscillation mode in the ExB direction. We observed that the speed of the rotating spokes is on the order of 2000 m/s, which agrees with experimental observations, and that the direction of the spoke propagation can be either ±E×B direction depending on the numerical conditions, i.e. the profile of the plasma parameters, such as the plasma density and electron temperature. The results obtained from the simulations are compared with theories related to gradient drift waves.

1. K. Hara and I. D. Boyd, "Axial-azimuthal hybrid-direct kinetic simulation of Hall effect thrusters", 34th International Electric Propulsion Conference, IEPC-2015-286, 2015.
2. R. Kawashima, K. Komurasaki, and T. Schönherr, "A hyperbolic-equation system approach for magnetized electron fluids in quasi-neutral plasmas", *Journal of Computational Physics*, Vol. 284, 2015, pp. 59-69.