Effect of multi-charged ions on cross-field drift instability in Hall thruster plasma

Dhananjay Verma* and Hitendra K. Malik
Plasma Science and Technology Laboratory, Department of Physics, Indian Institute of Technology Delhi, New Delhi – 110 016, India
*Email- dhananjayverma3510@gmail.com

Hall thrusters are very common plasma propulsion devices, which use **E**X**B** fields for ion accelerations and thrust production [1, 2]. The electrons cross-field drift led instabilities in these devices are affected by various factors like electron temperature, ion temperature, electrons collision frequency and charge number of ions. The propagating frequency and growth rate of these instabilities can be manipulated by controlling various parameters [3, 4]. Since the charged ions provide restoring force to the electrons' oscillations, the charge on the ions drastically modifies the wave propagation and instabilities in the Hall plasmas.

In the present work, the effects of multi-charged ions on the cross-field drift instability are included and this instability is analyzed by using a fluid model considering the continuity equation and the equation of motions for two kinds of the ion fluids and the electron fluid. The effects of the densities and temperatures of the ions and their multi-charged ions with collision are evaluated on the growth rate of the instability, which is obtained by solving the dispersion equation numerically. The variation of growth rate of this cross-field drift instability is analyzed for the wave number of the oscillations, mass of the ions and the electron-neutral collisions.

The growth rate and frequency of cross-field instability can be optimized for the thrust and efficiency of Hall thrusters. Here this is worth examining the role of multi-charged ions keeping in mind their density and temperature in comparison with that of the singly charged ions present in the acceleration chamber of the thruster. The radial distribution of the electric field in acceleration regions is influenced by the charged particle densities and plasma turbulence in addition to the magnetic field configuration and wall boundary conditions. Hence, the redial electric field generated by the cross-field instability and the effect of ion flux to the wall by this electric field can be used to the study the wall erosion rate under the realistic conditions of heavily charged ions. The results can be utilized for the efficiency enhancement [5].

References

[1] Boeuf, J. P. (2017). Tutorial: Physics and modeling of Hall thrusters. *Journal of Applied Physics*, *121*(1), 011101.
[2] Singh, S., & K Malik, H. (2011). Resistive instabilities in a Hall thruster under the presence of collisions and thermal motion of electrons. *The Open Plasma Physics Journal*, *4*(1), 16-23.
[3] Malik, H. K., & Singh, S. (2013). Resistive instability in a Hall plasma discharge under ionization effect. *Physics of Plasmas*, *20*(5), 052115.
[4] Tyagi, J., Singh, S., & Malik, H. K. (2018). Effect of dust on tilted electrostatic resistive instability in a Hall thruster. *Journal of Theoretical and Applied Physics*, *12*(1), 39-43.
[5] Ahedo, E., & Escobar, D. (2004). Influence of design and operation parameters on Hall thruster performances. *Journal of Applied Physics*, *96*(2), 983-992.