Two Ion Species Plasma-Wall Transition Characteristics in the Presence of Non-uniform Magnetic Field

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The magnetized plasma-wall transition properties have been investigated for two ion species plasmas with a uniform background of neutral gas density using fluid theory. The magnetic field is parallel to the surface and its magnitude varies in the direction perpendicular to the material surface. The governing equations of ion and electron fluids include electron impact ionization source term and collision with neutral atoms. It is found that the applied non-uniform magnetic field has a significant effect on the plasma-wall transition properties. With the increase in magnitude of magnetic field, the ion flux collected by the surface decreases and hence, thickness of the Debye sheath region increases. The variation of electric potential and density distribution of particles affect the ion and electron velocities in the transition region. In addition, the effect of magnetic field on the space charge density, current-voltage characteristics and drift velocity has been studied. The comparative study of transition parameters when the multicomponent plasma exposed with non-uniform and uniform fields shows that the Debye sheath region shrinks for the case of non-uniform magnetic field. The density distribution of electrons close to the surface deviates from the Boltzmann equilibrium due to the influence of a strong magnetic field.

We have estimated the thickness of the sheath region which increases from about 2.33 mm to 3.04 mm with the increase in the magnetic field from 100 Gs to 550 Gs. This widening of sheath region is nearly 1.5 times the electron Debye length. The net current density sharply increases in the presheath region and is almost constant in the sheath region for both cases. However, the magnitude of ion current density towards the surface decreases for the case of uniform magnetic field, which explicitly indicates that, the ion flux collected by the surface decreases. The non-uniform and uniform magnetic fields give qualitatively similar results for the small magnitude of the magnetic field, although they alter the plasma characteristics for the higher magnitude of magnetic fields. For strongly magnetized plasmas, the density distribution of electrons deviates from the Boltzmann distribution due to the influence of the magnetic field close to the surface. We have estimated the percentage deviation in electron density profile that the results are obtained from the exact solution and the assumption of Boltzmann distribution for electrons. It is found that the deviation is very small in the presheath region and the deviation increases towards the surface, which in terms of magnitude for magnetic field 100 Gs, the electron density profile is deviated by less than 0.5% close to the surface; however, the profile is found to be deviated by 12% for 500 Gs magnetic fields.

References

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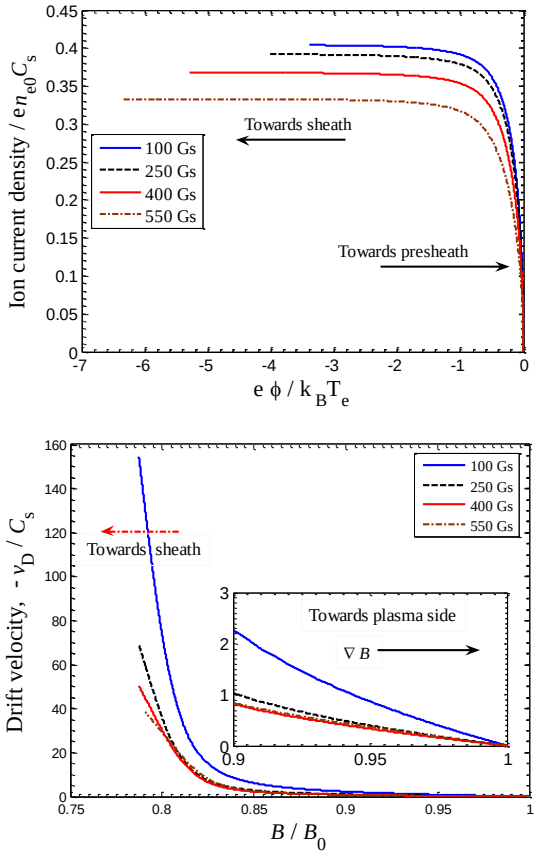

Figure 1: Current-voltage characteristics and plasma drift in the non-uniform magnetic field for four different magnitudes of magnetic field.