Multi-fluid Sheath Model for Electric Propulsion Devices

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Sheath formation at the plasma-boundary interface separating the quasi-neutral plasma is ubiquitous in a bounded plasma. The physics governing the formation of the sheath layer between the wall and the plasma have been studied for past many decades and are yet to be fully understood. The interest in the subject has been revived recently due to its wide ranging applications in plasma processing; in the ion cyclotron heating; in electric propulsion devices; in fusion plasmas; in high-speed air vehicles. In the electric propulsion devices, built up of sheath potential and its stability may severely affect the thruster efficiency. In the present work, a finite element discretized one-dimensional formulation of plasma–sheath dynamics, using multi-fluid equations for a partially ionized plasma, is given. Based on the experimental data for multiple ionization of xenon gas, a third order polynomial has been used as a fit to describe ionization processes. Such a polynomial has been used to self-consistently calculate the rate of ionization in the plasma dynamic equations. The electron and ion number densities decrease in the plasma-sheath region as expected (beyond x>0.8 in Fig. 1). The neutral number density decreases in the bulk plasma and increases in the sheath region pointing to the dominant role of recombination near the wall at x = 1 in Fig.2. The ion velocity, sheath potential and electron temperature profiles exhibit the expected behavior.

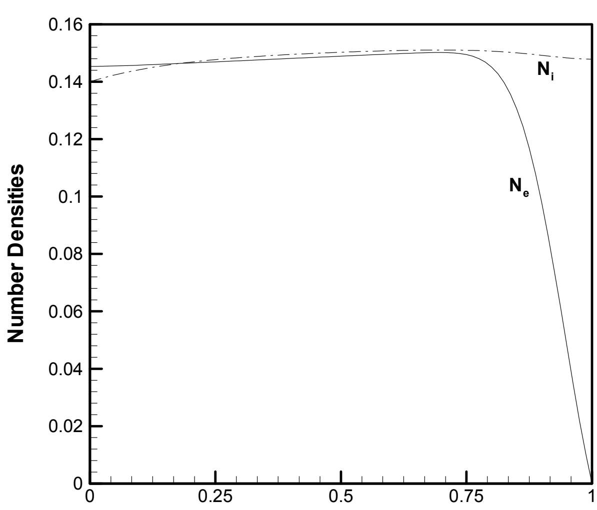

Fig. 1. Electron and ion number density distributions.

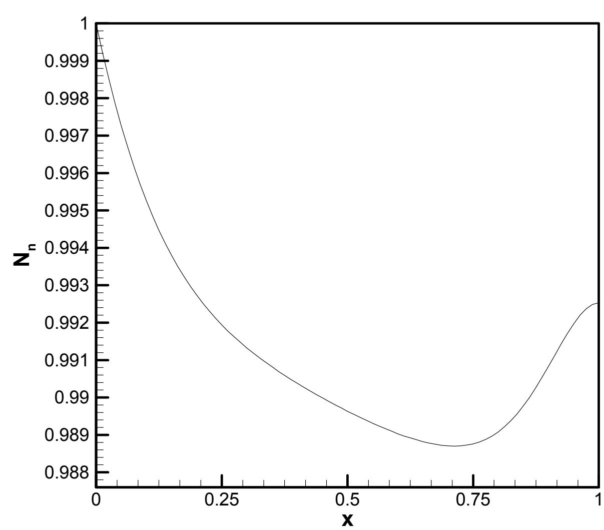

Fig. 2. Normalized neutral number density.