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Studies of anode sheath phenomena in a Hall-effect thruster discharge[1]

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Crossed electric and magnetic fields devices (plasma thrusters, magnetrons, coaxial plasma guns, plasma opening switches, etc.) are routinely used for plasma production and in other applications. Despite these numerous applications, the fundamental anode sheath phenomena in many of these devices have received surprisingly little experimental scrutiny. We chose a Hall-effect thruster (HT) discharge for our study of the anode sheath. It has been typically assumed in most fluid models of an HT that its steady-state operation requires the presence of a negative anode fall (electron-repelling anode sheath). Such anode fall behavior, opposite to that in typical glow discharges or hollow-anode plasma sources, is the result of a relatively high degree of ionization in HTs, achieved by applying a radial magnetic field transverse to the direction of the discharge current. Our data from non-perturbing probe measurements showed for the first time that the anode fall in HTs can be either negative or positive (electron-attracting anode sheath), depending on conditions at the anode surface. The path for current closure to the anode turns out to be quite subtle in HTs. This path determines the mechanism of the anode fall formation. In varying the magnetic field topology in the channel from a more uniform to a cusp-like one, we uncover intriguing results. For cusp configurations, in which the radial magnetic field changes polarity somewhere along the channel, the anode fall is positive, whereas it is negative for a more uniform field. This polarity difference could be attributed to the decreased electron mobility across the magnetic field in the cusp-like configuration. Our theoretical modeling of the anode sheath correlates well with the experimental results in describing how the magnitude of the sheath varies with the discharge voltage and mass flow rate.

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