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Anode Sheath and Double Layer Solutions with Ionization[1]
BRETT S. SCHEINER, SCOTT D. BAALRUD, Department of Physics and Astronomy, University of Iowa — When an electrode in a plasma is biased more positive than the plasma potential it attracts electrons and repels ions forming a region of negative space charge (electron sheath). Ballistic electrons moving towards this anode gain energy equal to the difference in electrostatic potential energy, $\Delta\phi = \phi(x) - \phi_{plasma}$, with a maximum of $\phi_{anode} - \phi_{plasma}$. When ϕ_{anode} is large enough, electrons can gain enough energy to ionize neutral atoms through electron impact ionization. This leads to a layer of increased ion density near the anode, which can exceed the local electron density at large enough anode biases forming a double layer. We model the sheath potential profile using Poisson's equation with a fluid model for the electron density in the case without ionization and formulate an integral equation for the case with ionization where the ion density depends on an integral from $\phi(x)$ to ϕ_{anode}. An analytic form of the sheath electric field is obtained for the case without ionization and we demonstrate that it asymptotically agrees with the Child-Langmuir solution. We numerically obtain double layer solutions when including ionization and show that the potential profile expands beyond that of the Child-Langmuir solution.

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