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Circular-orbit correction to electron fluxes through the magnetised plasma sheath

The magnetised plasma sheath is a region that forms in front of a solid target and is composed of a magnetic presheath, where the electrostatic potential varies on the scale of the ion Larmor radius, and a Debye sheath, where the potential varies on the scale of the Debye length. The transmission of electrons and of their energy through the magnetised sheath must be calculated to find the wall boundary conditions for magnetised plasmas. Assuming a negligible electron Larmor radius, the transmitted electron particle and heat fluxes depend on a constant velocity cutoff which is related to the combined potential drop across the magnetised sheath. Near the target, the thermal electron Larmor radius is typically smaller than the Debye length, but not negligible, such that the electron parallel velocity cutoff has a correction which depends on the actual size of the electron orbit, i.e., on its magnetic moment. By exploiting the grazing incidence of the magnetic field at the target, we propose an analytical model for this cutoff function. The model is based on a circular-orbit approximation of the electron trajectory, and only depends on the potential drop across the Debye sheath and on an approximate calculation of the wall electric field. We verify the accuracy of the electron particle and heat fluxes thus computed by comparing with results obtained by solving for the self-consistent Debye sheath potential profile.

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