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Kinetic Analysis of the collisional layer

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To understand plasma behaviour in the scrape-off layer (SOL), we need to know the boundary conditions for the plasma and electromagnetic fields near a divertor. At the plasma-wall boundary, in the direction perpendicular to the wall, there are four length scales of interest. These are the Debye length λ_D, the ion gyroradius ρ_i, the projection of the collisional mean free path in the direction normal to the wall $\lambda_\perp$ and the device size L. Assuming that the plasma near the divertor satisfies the scale separation $\lambda_D \ll \rho_i \ll \lambda_\perp \ll L$, we can split the plasma-wall boundary into three separate layers. The layer closest to the wall is the Debye sheath of width λ_D, then follows the magnetic presheath of width ρ_i and then the collisional layer of width $\lambda_\perp$. Plasma dynamics in the first two layers are well understood [1-3]. In the SOL, at distances much greater than $\lambda_\perp$ from the wall, collisionality is high and Braginskii fluid equations are often used to model the plasma behaviour [4-6], here the ion distribution function is assumed to be approximately Maxwellian. The collisional layer, which we analyse in this work, connects this region of high collisionality with the collisionless magnetic presheath, where the ion distribution function is far from Maxwellian.

For analysis of ion dynamics in the collisional layer, we solve the steady state drift kinetic equation in one spatial dimension with the full Fokker-Planck collision operator, together with the quasineutrality equation and the assumption of adiabatic electrons. We can neglect the asymptotically small magnetic presheath and apply the wall boundary conditions at the entrance of the magnetic presheath. For our boundaries we assume that all ions that reach the wall are absorbed (negatively charged wall) and we set the distribution function far away from the wall to be approximately a Maxwellian. From the magnetic presheath analysis [3], it is known that the distribution function must satisfy the Chodura condition at the entrance of the magnetic presheath. We show that this condition is also obtained from the collisional presheath analysis. We show that the scaling of the potential here is $\phi \sim \sqrt{x}$, where x is distance from the wall, and the distribution function is exponentially small at small velocities parallel to the magnetic field. The latter is not true if neutral-ion collisions are included, however the potential scaling seems to remain valid. We also show that at the entrance of the collisional layer the flow of ions has to be supersonic. To analyse the collisional layer numerically we use the Galerkin method with quadratic finite element basis to solve the equations. To numerically determine the particle trajectories next to the wall we need to impose the derived potential scaling.

References:

[1] K -U Riemann, J. Phys. D: Appl. Phys. 24 493 (1991)
[2] A. Geraldini, F. I. Parra, and F. Militello, Plasma Phys. Control. Fusion, 60:125002 (2018)
[3] R. Chodura, The Physics of Fluids 25, 1628 (1982)
[4] P. Ricci, et al, Plasma Phys. Control. Fusion 54 124047 (2012)
[5] P. Tamain, et al, Journal of Computational Physics Volume 321, Pages 606-623 (2016)
[6] B. D. Dudson and J. Leddy, Plasma Phys. Control. Fusion 59 054010 (2017)

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