Thermal Ion Orbit Loss and Radial Electric Field in DIII-D

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A simple neoclassical model for the return current balancing thermal ion orbit loss appears to agree with measurements of the edge radial electric field just inside the outboard last closed flux surface (LCFS), as indicated in Fig. 1. Here, a Mach probe measures the bulk ion toroidal velocity, $V_{\text{tor}}$, and the electrostatic potential in a discharge shortly after the L-H transition with electron cyclotron heating, when the density is up only $\sim$10% of the total rise. It has been found that a simple empty loss cone model of the thermal ion orbit loss agrees surprisingly well with the $V_{\text{tor}}$ profile measured [1], and simulations have borne out the existence of a depleted loss cone near the LCFS in low collisionality steady-state conditions [2]. We use this non-Maxwellian, empty loss cone model distribution, to compute the friction-induced return current driven by the co-$I_p$ $V_{\text{tor}}$ layer on the trapped ions, which is proportional to the difference in $V_{\text{tor}}$ and the toroidal electric precession of the trapped ions, $V_{\text{tor}} - E_r/B_{\text{pol}}$. The model is applied near the LCFS where the loss boundary in phase space is relatively simple, allowing semi-analytical treatment of the variation of the relevant phase space boundaries with $E_r$. In the model, as the ion temperature is increased, $E_r$ must become more negative for the return current to balance the orbit loss current [3], equilibrating on the ion-ion collision timescale. This suggests a possible connection with the H-mode trigger mechanism and also any coupling to interior intrinsic rotation which we are exploring further.


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