Intrinsic toroidal velocity near the edge of DIII-D H-mode plasmas

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Abstract

The intrinsic toroidal velocity, V_ϕ, in DIII-D [J. Luxon, Nucl. Fusion, **42**, 614 (2002)] H-modes is measured to be nonzero in the pedestal region, in the direction of the plasma current, co-I_p. Intrinsic, or spontaneous, velocity is that which arises with no known external momentum injection. This intrinsic velocity is measured to scale roughly linearly with the local ion temperature, T_i, $V_\phi \sim T_i$, in the pedestal and in the edge region just inside the pedestal. With either co-I_p, or counter-I_p neutral beam injected (NBI) torque the pedestal velocity is accelerated in the direction of the torque; it is not a fixed boundary condition. A simple model of thermal ion orbit loss predicts the sign of V_ϕ, a relevant magnitude for V_ϕ, and the approximate scaling $V_\phi \sim T_i$. This model for a boundary condition on the intrinsic toroidal velocity gives a result of approximate diamagnetic form, $V_\phi \sim \varepsilon_p T_i / LB_\theta$, where L is a scale length, B_θ the poloidal magnetic field, and ε_p a small numerical parameter. This model is a local calculation of velocity, an approximation to the inherently nonlocal region of the pedestal where the thermal ion banana width is comparable to the pedestal width. In this model we also assume that the loss cone in velocity space is empty; no collisions are considered. A recent particle simulation of the pedestal region of a DIII-D NBI-driven H-mode discharge that includes collisions indicates that thermal ion orbit loss results in a co-I_p velocity just inside the last closed flux surface (LCFS) [C.S. Chang and S. Ku, Phys. Plasmas **15**, 062510-1 (2008)]. Thus, we do not expect that nonlocality nor finite collisionality wash out the effect. Inside the pedestal our model shows that thermal ion orbit loss is negligible. In this region of the edge we also measure a similar scaling for the intrinsic velocity several pedestal widths inside the pedestal location, $V_\phi \sim T_i$. One mechanism that could maintain the T_i scaling inward from the pedestal is the model of an inward momentum pinch velocity proportional to the gradient of T_i.

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