Poloidally and radially resolved parallel D^+ velocity measurements in the DIII-D boundary and comparison to neoclassical computations

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Abstract

First measurements of the D^+ parallel velocity, $V_{\|}^{D+}$, in L-mode discharges in the DIII-D [J.L. Luxon, Nucl. Fusion **42**, 614 (2002)] tokamak boundary region at two poloidal locations, $\theta \sim 0$ deg and $\theta \sim 255$ deg, made using Mach probes, feature a peak with velocities of up to 80 km/s at the midplane last closed flux surface (LCFS), as high as 10 times the charge exchange recombination (CER) C^{6+} toroidal velocity, V_{ϕ}^{C6+}, in the same location. The $V_{\|}^{D+}$ profiles are very asymmetric poloidally, by a factor of 8-10, and feature a local peak at the midplane. This peak, 1-2 cm wide, is located at or just inside the LCFS and it suggests a large source of momentum in that location. This momentum source is quantified at ~ 0.31 Nm by using a simple momentum transport model. This is the most accurate measurement of the effects of so called "intrinsic" edge momentum source to date. The $V_{\|}^{D+}$ measurements are quantitatively consistent with a purely neoclassical computational modeling of $V_{\|}^{D+}$ by the code NEO [E.A. Belli and J. Candy, Plasma Phys. Control. Fusion **50**, 095010 (2008)], using V_{ϕ}^{C6+} as input, for $\rho \sim 0.7-0.95$ at the two poloidal locations, where $V_{\|}^{D+}$ measurements exist. The midplane NEO-calculated $V_{\|}^{D+}$ grows larger than $V_{\|}^{C6+}$ in the steeper edge gradient region and trend to agreement with the probe-measured $V_{\|}^{D+}$ data near $\rho \sim 1$, where the local $V_{\|}^{D+}$ velocity peak exists. The measurements and computations were made in OH and L-mode discharges on an upper single null (USN), with ion $\nabla \mathbf{B}_T$ drift away from the divertor. The rotating layer finding is similar in auxiliary heated discharges with and without external momentum input, except that at higher density, the edge velocity weakens.

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