Poloidally and radially resolved parallel $\text{D}^+$ velocity measurements in the DIII-D boundary and comparison to neoclassical computations


1University of California-San Diego, La Jolla, California 92093, USA
2Princeton Plasma Physics Laboratory, Princeton, NJ  08543-0451, USA
3General Atomics, PO Box 85608, San Diego, California 92186-5608, USA
4Sandia National Laboratories, Albuquerque, New Mexico 87185, USA
5Lawrence Livermore National Laboratory, Livermore, California, 94551, USA
6Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA

Abstract

First measurements of the $\text{D}^+$ parallel velocity, $V_{||}\text{D}^+$, 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) $\text{C}^6+$ toroidal velocity, $V_{\phi}\text{C}^6+$, in the same location. The $V_{||}\text{D}^+$ 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 $\sim 0.31$ 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 $V_{||}\text{D}^+$ measurements are quantitatively consistent with a purely neoclassical computational modeling of $V_{||}\text{D}^+$ by the code NEO [E.A. Belli and J. Candy, Plasma Phys. Control. Fusion 50, 095010 (2008)], using $V_{\phi}\text{C}^6+$ as input, for $\rho \sim 0.7-0.95$ at the two poloidal locations, where $V_{||}\text{D}^+$ measurements exist. The midplane NEO-calculated $V_{||}\text{D}^+$ grows larger than $V_{||}\text{C}^6+$ in the steeper edge gradient region and trend to agreement with the probe-measured $V_{||}\text{D}^+$ data near $\rho \sim 1$, where the local $V_{||}\text{D}^+$ velocity peak exists. The measurements and computations were made in OH and L-mode discharges on an upper single null (USN), with ion $\mathbf{VB}_T$ 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.

PACS numbers: 52.55.Fa, 52.30.-q, 52.25.Fi