Measured signatures of low energy, physical sputtering in the line shape of neutral carbon emission*

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The most important mechanisms for introducing carbon into the DIII-D divertors [Nucl. Fusion **42**, 614 (2002)] are physical and chemical sputtering. Previous investigations have indicated that operating conditions where one or the other of these is dominant can be distinguished by using CD and C_2 emissions to infer C I influxes from dissociation of hydrocarbons and comparing to measured C I influxes. The present work extends these results through detailed analysis of the C I spectral line shapes. In general, it is found that the profiles are actually asymmetric and have shifted peaks. These features are interpreted as originating from a combination of an anisotropic velocity distribution from physical sputtering and an isotropic distribution from molecular dissociation. Fitting theoretical calculations to deconvoluted data profiles offers a means to find the relative fraction of the two release mechanisms.

In deuterium-fueled plasmas under conditions in which low energy, physical sputtering should dominate carbon release at the outer strikepoint, the measured C I profiles show an offset of the profile peak from the rest wavelength only a fraction of that expected from a Thompson velocity distribution. To understand this discrepancy with the Thompson model and to permit more confident interpretation of sputtering during deuterium operation, C I profiles were measured in pure helium plasmas, where carbon release is caused by physical sputtering alone. In a set of discharges in which the incident ion energy on the divertor target was systematically increased from its threshold value, the C I line profile exhibits a clear monotonic increase in blue shift and broadens asymmetrically from an initial, near-symmetric shape. This data is compared with the Thompson velocity distribution model in the regime of low energy sputtering not previously benchmarked by experiment. Extracting a measured velocity distribution from the measured C I Zeeman triplet requires i) measuring an accurate fiducial for the rest wavelength of the carbon line, and ii) unfolding the light received directly by the collection lens from that received following a single reflection off the graphite floor tiles. Although reflection has no effect on line shape in the case of an isoptropic velocity distribution, it causes a reversal of the line profile about the rest wavelength of each Zeeman component in the case of an anisotropic distribution.

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