Validation of EDGDE2D-EIRENE predicted 2D distributions of electron temperature and density against Divertor Thomson scattering measurements in the low-field side divertor leg in DIII-D

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EDGDE2D-EIRENE predictions of the 2D electron temperature ($T_e$) and density ($n_e$) distribution in the low-field side (LFS) divertor leg show, for high-recycling conditions in DIII-D, significantly broader radial $T_e$ profiles in the region directly above the divertor plate than measured with the Divertor Thomson Scattering system (DTS). The simulations replicate, however, the radial $T_e$ and $n_e$ profiles above the ionization front, above ~10 eV, including the low-field side midplane region, challenging the assumptions of plasma recycling, carbon sputtering, and radial plasma and energy transport across and below the ionization front. Conversely, the EDGE2D-EIRENE predictions are quantitively consistent with DTS measurements for low-recycling conditions when the ionization front is at the LFS plate. The discrepancy between the predicted and measured plasma profiles directly impacts deuterium and carbon radiation, and thus the power conducted to the target plate, and is therefore important to elucidate toward understanding the physics of divertor detachment.

2D distributions of $T_e$ and $n_e$ were measured with DTS in DIII-D low-confinement (L-mode) and high-confinement (H-mode) plasmas [1] in both attached and detached conditions at the LFS plate, and compared to predictions using the edge fluid code EDGE2D-EIRENE. Radial profiles of $T_e$ and $n_e$ at five vertical positions monitored by DTS were obtained with divertor strike point sweeps encompassing the vertical extent of the LFS divertor leg. The EDGE2D-EIRENE simulations include the full suite of cross-field drifts, up-to-date carbon sputtering and carbon (non-coronal) transport models, and presently the most comprehensive plasma-atom and plasma-molecule interaction model.

Inclusion of the cross-field drifts and reducing the imposed radial transport in the LFS divertor leg does not lead to significant steepening of the $T_e$ profile within and below the ionization front. Furthermore, the observed discrepancies are insensitive to the carbon sputtering model (i.e., Haasz-Davis versus Roth chemical sputtering yields). While deuterium Lyman and Balmer emission across the LFS divertor leg is reproduced by the simulations within 50% of the measurements, the predicted CIV emission (1550 Å) falls short by a factor of 2, indicating a potential deficiency in the carbon recycling model, resulting in lower radiative power dissipation due to carbon line emission in the far scrape-off layer.


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