Two Dimensional Transport Effects in the Tokamak Scrape-Off Layer Plasma*

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The effect of 2D transport and the geometry of the tokamak scrape-off layer (SOL) on relating measured divertor heat flux profiles to midplane plasma profiles is explored with the UEDGE code for a range of assumptions. The relationship between peak divertor heat flux (and the heat flux profile) and the midplane plasma profiles (especially electron temperature) is of particular interest to the ITER project and to discussion of research needs for further development of magnetic fusion energy. Increased effort to extend previous experimental studies [1–3] relating the divertor and midplane profiles is underway in the US, involving the C-Mod, DIII-D, and NSTX facilities. The edge simulation work presented here seeks to inform experimental studies and physical intuition by quantitative solution of 2D transport in simple cases (i.e., no particle drifts) using a realistic tokamak SOL geometry.

The 2D geometry used in this study is taken from EFIT MHD reconstruction of DIII-D H-mode discharges; the exact location of the separatrix is not important for the conclusions reported here. We employ UEDGE to solve for particle and thermal transport in the edge plasma under a range of assumptions regarding transport and radiative losses. Both constant and spatially varying transport coefficients (e.g., $\chi \propto B^{-\alpha}$ with α = 0–3, and varying amounts of private-region diffusion) are used in the simulations, which span a range of pedestal density and SOL power typical of DIII-D H-mode operation. Divertor heat flux profiles are compared to midplane T_e profiles, and to predictions from 1D and 1.5D analytic relations (e.g., $q_{div} = \kappa_0 T_u^{7/2}/L_{||}$, where T_u is the upstream temperature and $L_{||}$ is the parallel connection length in the SOL, or $\lambda_{Q,div} = 2/7\ \lambda_{Te,mid}$).

Results point to the importance of solving the transport problem using the actual magnetic geometry when relating divertor to midplane parameters in the SOL. For example, while the the total power going into SOL is transported along field lines to the target plates, the upstream $q_{||}$ on a given flux surface is much lower than implied by the midplane T_e, and $\lambda_{q,div}$ is ~ twice as wide as expected from $\lambda_{Te,mid}$. Cases with a poloidal variation of χ, strongly peaked on the low field side, show little change in radial profiles and probably can't be distinguished experimentally from cases with uniform χ having the same flux-surface average value. While radial transport into the private flux region below the x-point is responsible for some broadening of the divertor heat flux profile, the peak heat flux is reduced by only about 10%–20% for typical DIII-D divertor configurations. Given the limited SOL data typically available, these results suggest that comparison between experiment and simulation should focus on matching parameter scans rather than detailed diagnostic comparisons.

[1] D.N. Hill, *et al.*, J. Nucl. Mater.
[2] R. Maingi, et al., J. Nucl. Mater. **363–365**, 196 (2007)
[3] A. Loarte, *et al.*, Nucl. Fusion **47**, S203 (2007).

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