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EX/P5-16: Scaling of the Divertor Heat Flux Width in the DIII-D Tokamak

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DIII-D measurements indicate a systematic narrowing of the divertor heat flux width lambda_q with plasma current in H-mode plasmas and significantly weaker dependence on other parameters. Comparisons of lambda_q with upstream SOL profiles indicate a similar variation, consistent with expectations from flux-limited transport. The inverse dependence of lambda_q on plasma current suggests that physics solutions for heat flux control may be more essential in next step devices to reduce the local heat flux below the maximum steady-state heat load sustainable by material surfaces of ˜10 MW/mˆ2. We find that the heat flux profile is well fit by a two-parameter function with one parameter (lambda_pvt) characterizing the profile in the private flux region and the second (lambda_sol) characterizing the SOL. The heat flux integral width (integral of the profile divided by its peak value) of this function is a weighted linear sum of these two parameters. The integral width scales inversely with I_p, and has weaker dependencies on other parameters. However, lambda_sol is found to have a much simpler scaling, depending only on I_p (or equivalently, the poloidal magnetic field B_p). Measurements of upstream n_e and T_e profiles with an upgraded Thomson scattering diagnostic has made it possible to test parallel and radial transport models. The SOL profiles exhibit a narrowing n_e with increasing I_p consistent with the measured divertor heat flux and a flux-limited parallel transport model. The strong dependence of lambda_q on B_p suggests two possible physics mechanisms setting the heat flux width. A semi-empirical model based on ion orbit drifts is consistent with the measured heat flux width and the dependence of the SOL n_e profile. A critical pressure gradient model was also tested finding the SOL pressure profile width scaling consistently with a calculation of the ideal ballooning stability limit. A density scan from a low density attached state to a high density detached divertor state revealed SOL profile scale lengths related to the heat flux width for attached conditions. This suggests that the upstream profiles can be used to make inferences about radial transport under detached conditions where the divertor heat flux profile no longer represents the upstream SOL transport. This work was supported by the US DOE under DE-FC02-04ER54698 and DE-AC52-07NA27344.

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