Effect of Separatrix Magnetic Geometry on Divertor Behavior in DIII-D*

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We report on recent experiments on DIII-D that examined the effects of variations in the parallel connection length in the scrape-off layer (SOL), $L_{||}$, and the radial location of the outer divertor target, R_{TAR}, on divertor plasma properties. This study is aimed at exploring divertor configurations that offer potential for radiative heat dispersal at lower core density and improved stability of divertor detachment. Two-point modeling of the SOL plasma predicts that larger values of $L_{||}$ and R_{TAR} should lower temperature and raise density at the outer divertor target for fixed upstream separatrix density and temperature, i.e., $n_{\mathrm{TAR}} \propto \left[R_{\mathrm{TAR}}\right]^{2} \left[L_{||}\right]^{4/7}$ and $T_{\mathrm{TAR}} \propto \left[R_{\mathrm{TAR}}\right]^{-2} \left[L_{||}\right]^{-6/7}$. Such conditions would favor radiative heat dispersal at large R_{TAR}. In the lower-density (n_e/n_G = 0.4), H-mode cases, the dependence of n_{TAR} and T_{TAR} on $L_{||}$ was consistent with our data, but the dependence of n_{TAR} and T_{TAR} on R_{TAR} was not. The surprising result that the divertor plasma parameters did not depend on R_{TAR} in the predicted way may be due to convected heat flux, driven by escaping neutrals, in the more open configuration of the larger R_{TAR} cases. Preliminary modeling results using the SOLPS code support the postulate that even small differences in the divertor geometry can change the divertor neutral trapping sufficiently to explain some of the discrepancy between experiment and two-point model predictions. The plasma conditions for the single-null H-mode plasmas used in this study are characterized by $n_{\mathrm{e}}/n_{\mathrm{G}}$ = 0.4–0.8, P_{inj} = 4–6 MW, and q_{95} = 4–5; for the single-null L-mode cases, $n_{\mathrm{e}}/n_{\mathrm{G}}$ = 0.2, P_{IN} = 1.5 MW, and q_{95} = 4. The ion $\boldsymbol{B} \times \nabla B$ drift direction is toward the X-point in both L-mode and H-mode cases. Variation in poloidal length of the outer divertor leg for these experiments was 25–75 cm and variation in radial placement of the outer divertor separatrix was 1.2- to 1.7 m. The results of this study are relevant to some key tenets of divertor configurations with extended outer divertor legs, such as the "Super-X" concept.

*Work supported by the U.S. Department of Energy under DE-FC02-04ER54698, DE-AC05-00OR22725, DE-AC52-07NA27344, DE-AC04-94AL85000, and DE-FG02-07ER54917.