H–MODE THRESHOLD POWER SCALING AND THE ∇B DRIFT EFFECT*

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One of the largest influences on the power threshold (P_{TH}) is the direction of the ion ∇B drift relative to the X-point location, where factors of 2–3 increase in P_{TH} are observed for the ion ∇B drift away from the X-point. It is proposed that the threshold power scaling observed in single-null configurations with the ion ∇B drift toward the X-point location (P_{TH} ~ nB, where n is the plasma density, and B is the toroidal field) is due to the scaling of the magnitude of the ∇B drift effect. Hinton [1] and later Hinton and Staebler [2] have modeled this effect as neoclassical cross field fluxes of both heat and particles driven by poloidal temperature gradients on the open field lines in the SOL. The magnitude of these fluxes scale like $\sim n/r\ T/B\ \partial T/\partial\vartheta$, where r is the minor radius, T the temperature, and ϑ the poloidal angle. Due to the pitch angle of the open field lines near the X-point, the poloidal gradient is maximized in this region. Therefore, conditions that influence the poloidal temperature gradient near the X-point are important. The ∇B drift effect influences the edge conditions needed for the L-H transition but presumably is not essential for the L-H transition itself since transitions are observed with either direction of B. An earlier survey of the power threshold scaling in double-null discharges in the DIII–D tokamak, where the ∇B drift effects should cancel, shows little or no dependence of P_{TH} on n or B [3]. This suggests that the nB scaling observed for single-null discharges may be due to the scaling of the magnitude of the ∇B drift effect. Several observations which qualitatively support this hypothesis include P_{TH} decreasing with heavy gas puffing and small X-point to divertor plate distance, and P_{TH} increasing with divertor cryopumping and divertor attachment. These phenomena affect $\partial T/\partial\vartheta$ near the X-point and therefore the magnitude of the ∇B drift effect. Owing to the large size and toroidal field of ITER, this model suggests that the ∇B drift effects on ITER will be small. Therefore, the P_{TH} scaling based on devices where this effect is large is inappropriate. Assuming the double null results from DIII–D, where the ∇B drift effect was small, can be scaled to ITER by surface area, P_{TH} is predicted to be approximately 50 MW.

[1] F.L. Hinton, Nucl. Fusion **25**, 1457 (1985).
[2] F.L. Hinton and G.M. Staebler, Nucl. Fusion **29**, 405 (1989).
[3] T.N. Carlstrom et al., Plasma Phys. and Control. Fusion **36**, 147 (1994).

*Work supported by the U.S. Department of Energy under Contract No. DE-AC03-89ER51114.