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ITR/1-1: Scaling of the Tokamak near Scrape-off Layer H-mode Power Width and Implications for ITER

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The presence of a steep edge pedestal gradient in H-mode divertor plasmas implies that strong gradients should also exist across the separatrix, forcing most of the PSOL˜ 100 MW of power arriving in the SOL at QDT = 10 in ITER to flow inside a narrow channel on open field lines connecting to the divertor target plates. Recent results (coordinated in part through ITPA DivSOL group) indicate that the ITER assumed value is too large. Scaling from the new database provides a clear dependence on the poloidal magnetic field, little variation with other key variables found in previous scalings and suggests λSOL ≅ 1 mm for ITER. Measurements from DIII-D, C-Mod and NSTX indicate a systematic narrowing of the inter-ELM divertor heat flux width with plasma current in H-mode plasmas. For the near SOL power width, the data indicate λSOL ∝ (q95/Btor)˜1 ˜ a/Ip ∝ 1/Bpol, with little or no dependence on PSOL or R (major radius). Analysis of data obtained in the same way from JET and ASDEX Upgrade yields λSOL (mm) =0.73·Btˆ(−0.78)·qcylˆ1.2·PSOLˆ0.1·Rˆ0, again with no dependence on R. Data are consistent in absolute magnitude with a recent heuristic drift-based theory. These new findings are based on IR analysis of strongly attached H-mode discharges. Key improvements here have been the avoidance of ELM effects, accounting for changes in the deposition profile due to heat diffusion across the divertor legs into the private flux region. Experimentally, essentially the full operational range of plasma current and toroidal field in each device was scanned. The value of λSOL ≅1 mm obtained jointly from these scalings for ITER at 15 MA in the Baseline Inductive Scenario, is about a factor 3 shorter than the lowest values predicted on the basis of earlier studies. Such narrow power channels are a concern for ITER, though preliminary SOLPS simulations indicate that they could be tolerated, since volumetric power dissipation in the divertor can still be sufficient to maintain heat flux densities at acceptable levels provided the outer divertor leg is partially detached. Simple estimates show that for ITER, if λSOL ≤ 2 mm the implied upstream pedestal pressure gradient would exceed ideal ballooning stability by some margin, assuming that the SOL pressure width is a measure of that in the pedestal. This issue will be examined in the context of the current database.

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