Obtaining reactor-relevant divertor conditions in tokamaks

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Abstract

It is argued that the paramount boundary plasma issue for DT reactors is likely to be the erosion-wear of the plasma facing components, PFCs, and that a number of potential solutions all require the achievement of - not only low temperature $< \sim 10$ eV - but also high density $> \sim 10^{21}$ m^{-3} in the divertor. Estimates are made of the minimum heating power, P_{heat}, required to achieve a divertor target temperature of $T_t = 5$ eV and density $n_t > 10^{21}$ m^{-3}, based on four recent hypotheses or scalings for the width of the power footprint on the target, λ_{qt}. Each of these result in predictions of how the required minimum P_{heat} depends on device size, namely as R, $R^{3/2}$ or R^2. The absolute magnitude for the required values of minimum P_{heat} were found not to vary greatly among the four power-scalings, for the most part a factor of order ~ 2 for a significant range of R. The four hypotheses/scalings for λ_{qt} are empirically based; however, they draw on measurements made in tokamaks that did not have divertors operating primarily in these conditions. In order to establish if any of these power-scalings are applicable, they were compared with measurements from a set of DIII-D discharges with high $n_t \sim 0.35 \times 10^{21}$ at 5 eV. It was found that all four power scaling matched the experimental measurements to within the uncertainties. The main objective is to determine what power is needed to achieve the required divertor conditions in future devices, for both reactor and simulator tokamaks, and therefore the approximate agreement of the four, strongly empirical, power-scalings increases confidence that this may be possible.

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