Divertor Plasma Fluctuations during Detachment

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Divertor plasma turbulence levels increase when divertor detachment is approached in DIII-D. The root mean square (RMS) of fluctuation levels of saturation current, J_{sat}, floating potential, V_{fl}, electron temperature, T_e, and electron density, n_e, measured by a divertor scanning probe with a bandwidth of DC-400 kHz, increase to 100% of the average levels as the divertor plasma starts detaching ($T_e < 10\ eV$) . Data from instruments with lower sampling rate, such as divertor Thomson Scattering (DTS) and target probes, also indicate enhanced levels of scatter, near 100% of the mean value, consistent with the higher time resolution probe measurements.

Increased plasma fluctuation levels often lead to enhanced radial particle $\tilde{\Gamma}_r = \langle \tilde{n}\tilde{v}_r \rangle$ and heat $\tilde{Q}_r = 3k\langle \tilde{T}\tilde{v}_r \rangle - 3kT\tilde{\Gamma}_r/2$ transport and, in this case, lead to divertor plasma mixing and longer profile decay lengths. The increased mixing and transport lead to increased plasma-neutral interactions and therefore can accelerate the detachment process. Fast filtered imaging of the divertor plasma shows the region of large fluctuations extends in 2D, consistent with these being volumetric effects.

The upstream pedestal is often affected by divertor detachment, where upstream pressure drops by at least 10-20%, leading to reduced plasma performance [1-2], and the underlying physics mechanisms of the interaction between the detached divertor and the upstream SOL and pedestal is largely unknown although it has been insofar ascribed to neutral fueling. We have compared fluctuation levels at the divertor and at the midplane by using data from the two scanning probes and see increased turbulent transport by ~50% at the midplane during detachment, and a widening of the scrape off layer (SOL) density by factors of 5 and temperature by 30%. Modelling by SOLPS 5.1 with enhanced transport coefficients will be performed and compared to experimental data.

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