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# Radiative Power Exhaust Research at DIII-D - From Divertor Science to Core-Edge Integration of High Performance Plasmas

*Wednesday 6 November 2019 10:00 (20 minutes)*

Power exhaust research at DIII-D is addressing the need for fusion reactors to integrate high $\beta_N$, high confinement plasmas with a radiating mantle and divertor that are compatible with stringent requirements on fuel dilution, high confinement mode power threshold, plasma stability, and wall heat flux limits. This research program encompasses studies from diagnostic optimized divertor science to compatibility of power exhaust with high performance pedestal and core plasmas [1, 2, 3].

Interaction of radiative divertor with high performance, peeling limited pedestals have been investigated in the super H-mode regime in DIII-D, reaching $2p_{\rm e,ped}$ > 20 kPa. By using a highly shaped configuration with a particular density trajectory, a peeling limited pedestal can be maintained at density levels where ballooning modes would typically reduce the achievable $p_{\rm e,ped}$. Using 3D coils to control $n_{\rm e,ped}$ while increasing gas fueling, $n_{\rm e,sep}$ close to 50% of $n_{\rm e,ped}$ were achieved without compromising $p_{\rm e,ped}$. With $N_2$ injection, the radiative power fraction, $f_{\rm RAD}$, was increased from 40% to 65%, providing a factor of 3 reduction of the outer target electron temperature while $p_{\rm e,ped}$ was maintained. However, increasing $f_{\rm RAD}$ to 85% was observed to lead to strong divertor detachment with a highly localized radiation at the X-point, and about a factor 2 reduction in $p_{\rm e,ped}$.

In hybrid plasmas at high $\beta_N$ > 3.0, divertor peak heat fluxes could be reduced by about 40% with either neon or argon injection. However, fuel dilution and the emergence of harmful tearing modes significantly compromised the performance of these plasmas, in contrast to previous observations at lower $\beta_N$ operation. These findings highlight the need to control impurity transport and tearing mode stability when integrating mantle radiation to a DEMO relevant plasma core.

To test the scaling of impurity densities required for divertor detachment and its compatibility with a high performance core plasma, diagnostic capability to directly measure divertor radiating impurity densities has been developed on DIII-D. By combining divertor Thomson scattering with vacuum ultraviolet spectroscopy, the local emitting ion density can be measured directly.

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[1] A. E. Jaervinen, et al. Nucl. Mat. Ene. 19 (2019) 230-238
[2] P. B. Snyder, et al. Accepted to Nucl. Fusion 2019
[3] T. W. Petrie, et al. Submitted to Nucl. Fusion 2019

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