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O4.105 Energy Transport and Dissipation in DIII-D Detached Divertor Plasmas

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A comprehensive diagnostic set compared against 2D modeling has provided new insight into energy transport and dissipation processes in detached plasmas and their scaling to future devices. Experiments and modeling reveal a detached divertor plasma dominated by plasma convection from the X-point towards the target. While a significant fraction, ~1/3, of the convection is carried by ionization-driven parallel flow, a larger part is carried by ExB plasma drift in the
poloidal direction driven by the radial Te gradient and the resulting radial electric field. This plasma flow allows utilization of the entire divertor volume for dissipation with a hierarchy of radiative processes including higher charge states of the intrinsic carbon impurity, CIV, dominating near the X-point with additional contributions from CIII and CII extending down the divertor leg towards the target. Near the target, Ly-alpha radiation from the deuterium fuel, including a large contribution from plasma recombination, is dominant, but deuterium molecular radiation from the Lyman-Werner bands may also contribute a fraction of the observed radiative dissipation. A power scan carried out to examine scaling of the detached divertor towards color is towards power densities expected in future devices found the upstream separatrix density to increase with the parallel heat flux density as q parallel ^1/2 . Near complete radiative dissipation was achieved even as into the divertor near the X-point was increased from 130 MW/m^2 to 350 MW/m^2 with the power scan. At the higher power levels, radial transport was found to increase the width of the heat flux channel, lambda q, both in the midplane and divertor profiles. This increase in lambda q stands in contrast to the ITPA scaling which found no power dependence in attached plasmas and may be a manifestation of MHD ballooning stability limits being reached at high power. The result of this broadening is a divertor density that does not increase with power as might otherwise be expected. These results, poloidal expansion of the radiating volume due to convection and radial expansion of the divertor plasma at higher power, imply an optimistic scaling of heat flux dissipation in future devices. These observations were made possible by an extensive diagnostic set that included bolometry and VUV spectroscopy for energy balance, Thomson Scattering at the midplane and divertor for plasma profiles and Coherence Imaging Spectroscopy (CIS) for plasma flow, Fig. 1. Interpretation of these data was made possible by the multiple physics processes employed in the 2D fluid code UEDGE, including realistic 2D geometry, comprehensive atomic physics processes and full ExB plasma drifts.

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