Recent sheath physics studies on DIII-D*

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A study to examine the sheath power transmission factor was recently carried out in DIII-D low power Ohmic and L mode plasmas using an IRTV, Langmuir probes, divertor Thomson scattering, a fast thermocouple array, and a new calorimeter triple probe assembly mounted on the Divertor Materials Evaluation System (DiMES). Preliminary results indicate that the measurements of heat flux are in better agreement than in the past, though some discrepancies still remain. The relationship between heat flux and plasma conditions in a tokamak is based on the physics of the plasma sheath formed at the target plates. Experimental determination of this relationship, referred to as the sheath power transmission factor, has previously found cases where the heat flux calculated from Langmuir probe measurements near the outer strike-point were higher (sheath factor drops from 7 to ~1) than the heat flux derived from infrared camera (IRTV) measurements. In the recent experiments field line tracing calculations indicate overlap of the DiMES Langmuir probes with the Divertor Thomson scattering detection volumes along the magnetic field to obtain first measurements of electron density and temperature upstream from the Langmuir probes and above the plasma sheath. Radial profiles of the heat flux, particle flux, electron density, and electron temperature were also obtained using radial sweeps of the outer strike point. Both fixed strike point and swept strike points plasmas were studied to compare constant heat flux conditions for interpretation of calorimeter and fast thermocouple data, and to examine plasma profiles under conditions where the sheath factor drop has been found in previous studies. This study was conducted at several different densities in the range from 2.4 to 3.7×10^{19} m^{-3}.

ITER-style flush mounted Langmuir probes were also examined to determine the role of sheath expansion with bias voltage in the effective collection area of Langmuir probes. The ITER target plate Langmuir probes will almost certainly need to be flush with the target plate to reduce erosion and extend their useful life but interpretation of the data will require corrections to the collection area. The theory for sheath expansion and interpretation of flush probe signals has been established but would benefit from further experimental validation including new measurements with the divertor Thomson. First results from the sheath expansion study show that the effective collection area of the flush probe tip was ≈3 times larger than the calculated projected area in the scrape-off layer but as much as 10 times larger near the strike point. Comparison with the predictions of flush probe theory will be presented.

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