X–Point Neutral Density Measurement and Modeling in DIII–D: Consequences for L-H Transition Theories[*]

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L-H transition theories have long predicted that high neutral density in the edge plasma could delay and possibly even suppress the L-H confinement transition. Experiments designed to investigate the effect of neutrals on the transition have been hampered by the lack of a convenient method to measure the neutral density. This work describes results of a method of measuring the neutral density in the X–point region, where 2-D plasma and neutrals simulations indicate it is a maximum. The measurement utilizes D_α light from a TV camera viewing the divertor region and electron densities and temperatures from a divertor Thomson scattering diagnostic. The TV camera data are reconstructed onto a poloidal plane and normalized by calibrated D_α monitors.

The effect of neutrals on the L-H transition is usually associated with the charge-exchange damping of the poloidal ion rotation accompanying the transition. This damping competes with neoclassical viscous damping and can only dominate if the neutral density $\bar{n}_0$ is above a threshold value, $\bar{n}_0 \geq \mu_{neo} V_{\theta i} / \left[\langle \sigma v \rangle_{cx} \left(V_{\theta i} - V_{\theta n} \right) \right]$ where μ_{neo} is the neoclassical poloidal damping, $\langle \sigma v \rangle_{cx}$ is the charge exchange rate, and $V_{\theta i}$, $V_{\theta n}$ are the ion and neutral poloidal velocities. The X–point neutral densities observed in DIII–D are near the predicted threshold value of $\bar{n}_0 \approx 10^{11}$ atoms/cm^3.

Neutral density profiles in the X–point region have been obtained from an L–mode discharge just below the L-H power threshold level and also in the H–mode phase following an increase in the heating power. Several X–point heights were executed in each condition to create a reasonable dataset for comparison with simulations. These discharges have been simulated with the 2-D plasma code, B2.5, and the 2-D neutral transport code, DEGAS. Good agreement is found between the neutral density measurements and data-constrained simulations. Previous simulations[1] in the absence of neutrals measurements indicated that edge neutral density was indeed high enough to affect the poloidal momentum balance and the L-H transition. These discharges are very similar to the ones analyzed in,[1] permitting validation of the data-constrained analysis procedure employed there and corroborating the previous conclusions.

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[1]B.A. Carreras, L.W. Owen, R. Maingi, P.K. Mioduszewski, T.N. Carlstrom, and R.J. Groebner, Phys. Plasmas **5**, 2623 (1998).