Measurement of the X-Point Neutral Density in DIII–D and Consequences for the L-H Transition*

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It was recognized soon after the discovery of the L-H transition that charge-exchange losses associated with recycling must be reduced for the transition to occur†. Subsequent experiments designed to measure 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 new method of measuring the neutral density near the X–point, where simulations (using DEGAS and B2.5) indicate that 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. Good agreement is found between the neutral density measurements and data-constrained simulations. 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, $\bar{n}_0 \geq \mu_{neo}\bar{V}_{\theta i} \Big/ \left[\langle\sigma v\rangle_{cx}\left(\bar{V}_{\theta i} - \bar{V}_{\theta n}\right)\right]$ where μ_{neo} is the is the neoclaassical poloidal damping, $\langle\sigma v\rangle_{cx}$ is the charge exchange rate, and $\bar{V}_{\theta i}$, $\bar{V}_{\theta n}$ 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.

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