High Density H–mode Discharges with Gas Fueling and Good Confinement on DIII–D*

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H–mode discharges with line-averaged density exceeding the Greenwald density, n_{GW}, while maintaining good energy confinement, have been obtained on DIII–D. Discharges with n_e/n_{GW}=1.4 and energy enhancement over L–mode scaling $H_{ITER89P}$= 1.9 were made possible by a combination of gas puffing with divertor pumping. Divertor pumping of the private flux region, by reducing divertor neutral density and avoiding a MARFE in the X–point region, helps to avoid degradation of the H–mode pedestal which could result in a transition to the L–mode or Type III ELM regime in which energy confinement is significantly reduced. This divertor configuration allows the pedestal pressure to remain robust even as the density increases. In these experiments gas puffing increases the pedestal density to ~$0.7 \times n_{GW}$ with little or no change to the pedestal pressure. At pedestal densities above this level the pedestal pressure begins to degrade as the pedestal T_e drops below about 200 eV. This initially results in a drop in main plasma confinement due to stiffness in the T_e and flattening of the density profile. However, at the higher densities the density profile spontaneously repeaks to the pre-gas puff shape on an energy confinement timescale, compensating for the reduction in pedestal pressure and reestablishing good confinement. The density profile peaking occurs under conditions which enhance the neoclassical Ware pinch.

An additional advantage to high density operation is a reduction in the ELM amplitude. A previous study of ELMs at low to moderate density on DIII–D and JET finds the energy released at each ELM scales with the magnitude of the edge pressure pedestal. However, on DIII–D we find the previous low density scaling is invalid at higher densities. On DIII–D the energy released at each ELM is > 30% of the pedestal electron energy for a pedestal density ≤ 40% of n_{GW}. The pedestal electron energy is defined as the electron pressure at the top of the pedestal multiplied by the plasma volume. As the pedestal density increases to ≥ 70% of n_{GW}, the ELM energy decreases to < 5% of the pedestal electron energy. At low density both the pedestal n_e and T_e are strongly perturbed by the ELM. However, at high T_e is unaffected while the density perturbation remains constant. The smaller ELMs are also characterized by a much lower magnetic fluctuation level. These characteristics are consistent with a higher toroidal mode number *(n)* ELM instability that is more localized to the edge region. The higher *n* number ELMs might result from changes to edge stability caused by a lower edge bootstrap current at higher edge density and collisionality. Resistive corrections to ideal MHD may also slow the growth rate of the ELM.

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