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High Energy Confinement With Density Above the Greenwald Limit in DIII-D Gas Fueled Discharges[1]

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Tokamak discharges with electron densities up to 1.4x the Greenwald density and good energy confinement, $H_{ITER89P} = 1.9$, were obtained with D_2 deuterium gas puffing on DIII-D. An important operational requirement for obtaining these discharges was control of the divertor configuration. Low triangularity and pumping of the private flux region allowed higher edge density without a transition to the energy confinement degraded L-mode or Type III ELM regimes. Previous experiments had found that energy confinement in gas fueled H-mode discharges typically decreases as the density approaches the Greenwald density. However, in these high-density discharges, following a brief decline in confinement at the beginning of the gas injection there is a continuous rise in both density and energy content associated with a spontaneous peaking of the density profile. The density peaking compensates for a decrease in the edge pressure pedestal at high density. Analysis of helium particle transport indicates an increase in the measured particle pinch with density peaking, which is comparable to the diffusive loss. The density profile peaking occurs under conditions which enhance the neoclassical Ware pinch. The Ware pinch can account for the peaking near the axis, but additional physics is required over much of the plasma. The increase in density is terminated by an internal MHD event that has the characteristics of a neoclassical tearing mode, at $\beta_N < 2$. Both the neoclassical drive term (increasing pressure gradient and bootstrap drive) and the classical drive term (Δ, peaking of the current profile) increase with peaking of the density profile. The simultaneous achievement of high density and good confinement is favorable for burning plasma experiments, and establishes that the Greenwald density is not a fundamental physics limitation of magnetic confinement plasmas.

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