Topic A	**Requested:** ☒ Oral ☐ Poster	**Panel suggestion:** ☐ Oral ☐ Poster

Density Limit Studies on DIII–D*

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In 1996 DIII–D began to study the processes limiting $\overline{n_e}$ and to develop a path to achieve $\overline{n_e}$ above the Greenwald limit (n_{GW}) with H–mode confinement. We have identified several processes: 1) divertor collapse and edge radiative limits, 2) particle confinement and fueling limits, 3) MHD onset, and 4) core radiative collapse. Divertor collapse occurs when external fueling is added to an unpumped discharge with a partially detached divertor. The divertor MARFE formed at the onset of detachment is observed to move from the open field lines to the closed field lines, forming a conventional MARFE near the X–point or the inner midplane, which is accompanied by confinement degradation. Using measured parameters on DIII–D, we have calculated the critical edge n_e/T_e curve for MARFEs to be destabilized; these calculations agree with our observations. These divertor collapse/MARFE limits could avoided by pellet fueling and divertor pumping which prevented detachment. Particle confinement and fueling limits were observed when the T_e edge was high enough to restrict pellet deposition to the edge plasma. In addition, analysis indicated that the density decay time following pellet injection increased as I_p^2. These limits were overcome by using low NBI power < 3 MW and high I_p ~ 1.3 MA. The MHD onset limits were manifested by the occurrence of low m/n rotating modes which slowed down and locked as density was increased. Even n–modes, typically the m/n=3/2 were not disruptive and caused only a small decrease in τ_E. However growth and slowing down of odd-n modes, usually the m/n=2/1, caused an immediate return to L–mode and/or disruption. The odd n–modes could be avoided in some cases by restricting NBI power < 3 MW. By selecting discharge conditions to avoid these limits, we demonstrated $\overline{n_e}$~ 1.5*n_{GW} for ~ 600 ms with H–mode confinement (transiently). These discharges were ELM-free and suffered from impurity accumulation and central radiative collapse; the central radiated power density exceeded the central NBI deposition. Combining the threshold condition for MARFE onset in the low scrape-off layer(SOL) T_e range < 75 eV with the ITER-89P energy confinement scaling law, the critical SOL n_e for MARFE onset scales as $I_p^2/a^{1.9}$, i.e. very similar to Greenwald scaling. Thus we hypothesize that Greenwald scaling in L–mode plasmas is caused by MARFE onset, which subsequently leads to edge radiative collapse or contraction of the edge current channel leading to a disruptive instability.

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