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Constant Density, ELM-free, Steady-State Divertor Plasmas in DIII-D[1]

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By utilizing cyropumping to control the edge plasma density, ELM-free and sawtooth-free H-mode plasmas have been produced using neutral beam counter-injection in single-null divertor plasmas in DIII-D. Stabilization of edge localized modes (ELMs) in H-mode plasmas in divertor tokamaks has several beneficial effects. Stabilization breaks the coupling between edge and global MHD modes which limits the performance of advanced tokamak plasmas. In addition, stabilization prevents the large pulsed divertor heat load that can be caused by ELMs. The key problem in the past with ELM-free discharges has been uncontrolled density rise and impurity influx into the core plasma. These shots exhibit density values, impurity levels and radiated power levels which are constant in time throughout the ELM-free phase. This ELM-free and sawtooth-free state has lasted for up to 2500 ms, limited only by the neutral beam durations chosen. A critical input power above about 7.5 MW and critical line averaged density below about $3\times10^{19}\,\mathrm{m}^{-3}$ are required to reach this state. The presence of substantial edge pedestals and steep edge gradients in electron density and temperature and in ion temperature and rotation clearly indicates these discharges are in H-mode. The good particle and impurity control in the absence of ELMs may be due to the continuous, low frequency, edge MHD detected in these plasmas. Comparison of this MHD mode in shots with and without ELMs suggests this MHD is a saturated ELM precursor. The mechanism which produces the saturation is under investigation; one candidate is ExB shear effect on the MHD modes owing to the extremely deep E_r well ($E_r \leq 100\,\mathrm{kV/m}$) at the edge of these counter-injected H-mode plasmas. Rotational wall stabilization may also be playing a role, since the ExB drift is never zero in counter-injected plasmas except at the magnetic axis.

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[2]for the DIII-D Team