# Role of heating power mix (NBI:ECH) and ECH deposition location on the inter-ELM pedestal recovery and ELM frequency in DIII-D

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A 40% reduction in the ELM frequency ($f_{ELM}$) is observed when the majority of NBI heating is replaced by core ($\rho = 0.2$) electron cyclotron heating (ECH) in ITER similar shape plasmas in DIII-D, at similar total input power. The ECH induced reduction in $f_{ELM}$ is accompanied by an increase in the magnetic and density fluctuations along with the excitation of several quasi-coherent modes in the pedestal. These observations suggest that increased electron heating and $\nabla T_e$ in the pedestal leads to increased turbulent transport and thus keeps the plasma away from the ELM threshold for a longer period of time. Modulations of the $D_\alpha$ signal baseline, with the growth of the quasi-coherent modes, support this hypothesis. $\dot{B_\theta}$ fluctuations show three distinct modes in the range of 13~116 kHz during the inter-ELM period only when ECH is applied. Density ($n_e$) fluctuations measured ($k_\vartheta \rho_s \sim 0.9$) by Doppler backscattering show two modes evolving in the inter-ELM period of the ECH dominated shots. These two modes are a low frequency quasi-coherent mode and high frequency broadband fluctuations, appearing alternately. Growth of these $\dot{B_\theta}$ and $n_e$ fluctuation modes is correlated with the $\nabla T_e$ evolution and may be increasing the turbulent transport when ECH is applied. TRANSP analysis for the ECH dominated shot show that the particle diffusivity ($D_e$) << heat diffusivity ($\chi_e$) in the steep gradient region indicating that TEM and/or MTM may be possible candidates for the observed fluctuations. Based on these observations, we infer that, slower pedestal recovery due to increased transport, leads to reduced $f_{ELM}$ in the ECH dominated shots. To test the hypothesis that reduction of $f_{ELM}$ is associated with dominant electron heating, a scan of ECH/NBI power was performed and indeed $f_{ELM}$ only decreases (when compared to discharges heated with NBI only) when the ECH/NBI fraction is greater than one. On the contrary, when ECH is applied close to the pedestal top, a 50% reduction in $f_{ELM}$ can be achieved even with the ECH/NBI fraction ~ 1. Analysis of pedestal turbulence and transport and their effect on the pedestal gradient recovery in different ECH vs NBI heating scenarios will be presented. These observations on the role of turbulence driven transport, may help in refining predictive simulations for the pedestal and ELM behavior. This work is supported by US DOE under DE-SC0019302, DE-FG02-08ER54999, DE-FG02-08ER54984, DE-AC02-09CH11466 and DE-FC02-04ER54698.