Application of Electron Cyclotron Heating to the Study of Transport in ITER Baseline Scenario-like Discharges in DIII-D

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Recent DIII-D experiments in the ITER Baseline Scenario (IBS) have shown strong increases in fluctuations and correlated reduction of confinement associated with entering the electron-heating-dominated regime with strong ECH. Properties of discharges in the baseline operating scenario for ITER [ITER-similar shape, β_N~2, q_{95}~3, ELMing H-mode with $H_{98}(y,2)$~1] are the subject of ongoing experiments on DIII-D; the recent work has extended the similarities to include ITER-relevant (low) torque and T_e/T_i~1 (dominant electron heating). The advantage of electron cyclotron heating as a principal heating tool for these studies is the fine control of the power deposition profile that is possible and the fact that all of the power goes to the electrons allows detailed study of the transport properties of the discharge. The addition of 3.2 MW of 110 GHz EC power at ρ~0.42 to IBS discharges with ~3 MW of neutral beam injection causes large increases in low-k and medium-k turbulent density fluctuations observed with Doppler backscatter (DBS), beam emission spectroscopy (BES) and phase-contrast imaging diagnostics, correlated with decreases in the energy, particle, and momentum confinement times. In cases in which the neutral beam power is feedback controlled to maintain a constant stored energy, study of the dynamics upon turn-off of the ECH power shows reduced confinement during ECH, including the well-known reduction in particle confinement (both deuterium and impurities) often associated with ECH. Power balance calculations show the electron heat diffusivity χ_e increases significantly in the mid-radius region $0.4<\rho<0.8$, which is roughly the same region where the DBS and BES diagnostics show the increases in turbulent density fluctuations. Confinement of angular momentum is also reduced during ECH. Significant differences between the character and frequency of the edge localized modes (ELMs) with and without EC are observed; the more frequent small ELMs obtained during ECH have proven to be a useful application in the ITER baseline scenario studies. An initial linear gyrokinetic analysis of these discharges to identify unstable modes and their growth rates is planned. Physics understanding of the mechanisms behind the confinement changes observed during torque-free, non-fueling pure electron heating may ultimately yield tools to improve control of D-T, alpha-heated, low rotation ITER discharges.

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