Studies of H-Mode Electron Transport and Turbulence in DIII-D Using Modulated ECH *

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We have conducted a series of DIII-D QH-mode experiments to study the degradation of confinement with strong electron heating in regimes relevant to burning plasmas [1]. Density gradient driven TEM turbulence dominates the inner core, and is highly sensitive to Tₑ/Tᵢ. Prior to ECH, shear in the parallel flow doubles the linear TEM growth rate [2]. Adding 3.4 MW ECH raises Tₑ/Tᵢ from 0.5 to 1.0, which halves the linear TEM critical density gradient from GYRO. Density fluctuations from Doppler backscattering (DBS) increase markedly at TEM wavenumbers during ECH, where the density profile locally flattens. DBS measurements near ρ~0.3 show that during ECH, a band of coherent fluctuations intensifies, with adjacent toroidal mode numbers in the TEM range. The simulated fluctuation spectrum from GYRO, using a new synthetic DBS diagnostic, closely reproduces the measured DBS spectrum over four orders of magnitude variation in intensity, identifying these as coherent TEM fluctuations. Simulated particle and energy fluxes match experiment in a tightly constrained comparison. Finally, the collisionality dependence of a new nonlinear upshift in the TEM critical density gradient was confirmed [1]. The results suggest α-heating will degrade confinement in H-Modes, which could be mitigated by broadening the current density profile while maintaining q_min>1.

A separate experiment scanned the electron temperature gradient in the outer half-radius at two densities. Density fluctuations from both BES and DBS respond to ECH modulated at 28 Hz, lagging the modulated electron temperature gradient by roughly 90 degrees. Fourier analysis of ECE data revealed a sudden increase in electron temperature profile stiffness in the middle of the temperature gradient scan, indicating a threshold was crossed. Spatially coherent mode structures are observed at each frequency in the ECE Imaging data, aided by wavenumber decomposition by the strong Doppler shift.

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