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Turbulence Behavior and Transport Response Approaching Burning Plasma Relevant Parameters

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Multi-scale turbulence properties are significantly altered and typically exhibit increased amplitude in high-beta inductive plasmas as parameters approach those anticipated in burning plasmas. These increases, observed with multiple fluctuation diagnostics in high performance H-mode plasmas on DIII-D, explain the consequent local transport and global energy time confinement response. Burning plasmas will exhibit equilibrated ion and electron temperatures, low average injected torque and toroidal rotation, as well as low ρ, *low ν* and low q95. Increased fluctuation amplitudes are observed as a result of reducing core toroidal rotation (and consequent ExB shear) and increasing Te/Ti. Density and temperature fluctuation measurements were obtained over a broad wavenumber and radial range, and provide a basis for quantitative comparisons with nonlinear simulations to test turbulent transport models. The energy confinement time is reduced by about 40% as the toroidal rotation is decreased by nearly a factor of three, while core turbulence increases in matched advanced-inductive plasmas (β≈2.7, q95=5.1). Density, electron and ion temperature profiles, as well as relevant dimensionless parameters (β, ρ*, q95, Te/Ti, and ν*) were maintained nearly fixed. Low-wavenumber (ion gyroradius scale) density fluctuations near mid-radius show significant amplitude reduction along with a slight reduction in radial correlation length at high rotation, while fluctuations in the outer region of the plasma, ρ>0.6, exhibit little change in amplitude. In related experiments, low-k density fluctuations are observed to increase over the radial range 0.3<ρ<0.8 as the Te/Ti ratio is raised by 25% towards unity via application of 3.5 MW of off-axis electron cyclotron heating. The spatial correlation properties are modified, suggesting a change in the dominant underlying instability driving the observed turbulence. Transport likewise increases in all channels while the energy confinement time is reduced by 30%. Initial modeling with TGLF shows significant changes to linear growth rates and saturated turbulence levels as Te/Ti is increased.

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