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Turbulence Decorrelation via Controlled ExB Shear in High-Performance Plasmas[1]

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Multi-scale spatiotemporal turbulence properties are significantly altered as toroidal rotation and resulting ExB shearing rate profile are systematically varied in advanced-inductive H-mode plasmas on DIII-D ($\beta_N \approx$2.7, q_{95}=5.1). Density, electron and ion temperature profiles and dimensionless parameters (β_N, q_{95}, ν^*, ρ^*, and T_e/T_i) are maintained nearly fixed during the rotation scan. Low-wavenumber turbulence ($k_\perp \rho_S < 1$), measured with Beam Emission Spectroscopy, exhibits increased decorrelation rates (reduced eddy lifetime) as the ExB shear rises across the radial zone of maximum shearing rate ($0.55 < \rho < 0.75$), while the fluctuation amplitude undergoes little change. The poloidal wavenumber is reduced at higher shear, indicating a change in the wavenumber spectrum: eddies elongate in the direction orthogonal to shear and field. At both low and high shear, the 2D turbulence correlation function exhibits a tilted structure, consistent with flow shear. At mid-radius ($\rho \sim$0.5), low-k density fluctuations show localized amplitude reduction, consistent with linear GYRO growth rates and ω_{ExB} shearing rates. Intermediate and high wavenumber fluctuations measured with Doppler Back-Scattering ($k_\perp \rho_S \sim$2.5-3.5) at ρ=0.7 and Phase Contrast Imaging ($k_\perp \rho_S > 5$) exhibit decreasing amplitude at higher rotation. The energy confinement time increases from 105 ms to 150 ms as the toroidal Mach number (M=$v_{TOR/vth,i}$) increases to $M_o \approx 0.5$, while transport decreases. TGLF calculations match the T_i profile with modest discrepancies in the T_e and n_e profiles. These results clarify the complex mechanisms by which ExB shear affects turbulence.

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