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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 ($\beta_N$, $q_{95}$, $\nu^*$, $\rho^*$, 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 ($\rho \approx 0.5$), low-k density fluctuations show localized amplitude reduction, consistent with linear GYRO growth rates and $\omega_{ExB}$ shearing rates. Intermediate and high wavenumber fluctuations measured with Doppler Back-Scattering ($k_{\perp}\rho_S \approx 2.5-3.5$) at $\rho=0.7$ 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 ($M=v_{TOR}/v_{th,i}$) 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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