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Observation of Coherent, Radially-Sheared Turbulence Flows in the DIII-D Tokamak[1]

G.R. MCKEE, University of Wisconsin - Madison

Self-generated turbulence flows are predicted to play a crucial role in mediating the nonlinear state of plasma turbulence. These flows, expected to be radially-localized, toroidally and azimuthally symmetric electrostatic potential structures, regulate the saturated turbulent state through time-varying E×B flows. Application of time-delay-estimation techniques to two-dimensional measurements of density fluctuations, obtained with beam emission spectroscopy in DIII-D plasmas, have provided time-resolved measurements of the turbulence flow-field, which exhibits features that are characteristic of such self-generated flows. These features, observed in the radial region near $0.85 \leq \rho \leq 1.0$, include a coherent oscillation (approximately 15 kHz) in the poloidal flow of density fluctuations that has a long poloidal wavelength, possibly m=0, and narrow radial extent ($k_r \rho_i \approx 0.2$). The normalized RMS magnitude of the oscillation is $v_{\theta,flow}/v_{th,I} \approx 1\%$ while their approximate effective shearing rate, $dv_{\theta,flow}/dr$, is of the same order of magnitude as the measured nonlinear decorrelation rate of the density fluctuations. Thus, these flows are of sufficient amplitude to affect the ambient turbulence. Furthermore, some phase coherence is observed between the larger wavenumber density fluctuations and low frequency poloidal flow fluctuations, suggestive of a nonlinear generation mechanism. The mode frequency increases approximately linearly with the square root of local temperature, suggesting a dependence on the sound speed. These characteristics are consistent with many predicted features of E×B flows observed in 3-D Braginskii simulations of turbulence in the core/edge transitional regime, where the flows have been specifically identified as geodesic acoustic modes.

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