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Local Regulation of Interchange Turbulence in a Dipole-Confined Plasma Torus using Current-Collection Feedback[1]

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Turbulence in a dipole-confined plasma is dominated by interchange fluctuations with complex dynamics and short coherence. We report the first laboratory demonstration of the regulation of interchange turbulence in a plasma torus confined by an axisymmetric dipole magnet using active feedback. Feedback is performed by varying the bias to an electrode in proportion to the electric potential measured at other locations. The phase and amplitude of the bias to the electrode is adjusted with a linear circuit, forming a relatively broad-band current-collection feedback system. Changing the gain and phase of collection results in modification of turbulent fluctuations, observed as amplification or suppression of turbulent spectrum. Significantly, power can be either extracted from or injected into the turbulence. When the gain and phase are adjusted to suppress turbulence, the external circuit becomes a controlled load extracting power from the plasma. This is analogous to the regulation of magnetospheric convection by ionospheric currents. When the gain and phase of the external circuit is adjusted to amplify turbulence, the direction of power flow from the electrode reverses, enhancing the fluctuations. Although we observe significant changes to the intensity and spectrum of plasma fluctuations, these changes appear only on those magnetic field lines within a region near the current collector equal in size to the turbulent correlation length and shifted in the direction of the electron magnetic drift. We conclude that the effects of this feedback on turbulence in a dipole plasma torus is localized. The clear influence of current-collection feedback on interchange turbulence suggests the possibility of global regulation of turbulent motion using multiple sensor and electrode pairs as well as the ability to perform controlled tests of bounce-averaged gyrokinetic theory of turbulence in the geometry of a dipole plasma torus.

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