Coexistence of the drift wave spectrum and low-frequency zonal flow potential in cylindrical laboratory plasmas

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Understanding physics of turbulent transport and exploring control methods of the transport in fully-developed turbulence inside confined plasmas are left as crucial challenges in plasma physics and controlled nuclear fusion research. In linear magnetized plasma device of Kyushu University [i.e. the Large Mirror Device (LMD)], we investigate spontaneous development of drift-wave fluctuations and their nonlinear processes. We focus on realization of large amplitude fluctuations by producing helicon plasma with high density up to $10^{19}\,\mathrm{m}^{-3}$ and by reducing ion-neutral collisional damping: By reducing filling working gas pressure in discharges with fixed magnetic field strength, we observe a development of drift wave spectrum from weak turbulence to (developing) strong turbulence. The observation of turbulence development is similar to previous reports given in basic plasma experiments [1, 2]. Especially in the vicinity of critical filling gas pressure, the weak turbulence composed of coherent spectral peaks changes gradually in time into a signature of broadband spectrum. In the experimental condition, we observe drift wave fluctuations as well as a low-frequency ($\sim$400 Hz) potential oscillation. The low-frequency potential oscillation has azimuthally and axially symmetric structures, and has finite radial wavenumbers. In addition, Time Delay Estimation analysis [3] shows that the low-frequency potential oscillation is strongly correlated with an oscillation of poloidal phase/group velocity of the drift wave fluctuation. These observations do not contradict the picture that the low-frequency potential oscillation is the zonal flow potential [4]. By use of the bispectral analysis [5] based on the vorticity equation, significant nonlinear energy transfers between the zonal flow potential and the drift wave fluctuation are identified.

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