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非平衡極限 − 直線磁化プラズマにおける ドリフト波・渦・帯状流間の新しい相互作用の観測

Non-Equilibrium and Extreme State – A new mutual-interaction between drift waves, eddy and zonal flow in linear magnetized plasma

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Role of turbulence, zonal flow, mean flow on dynamics of transport is one of the most important issues to be clarified. Dynamic interactions between a solitary drift wave structure and zonal perturbations in a linear cylindrical device have been observed in our previous work [1]. In this study, organization of a long-lived solitary eddy and its mutual interactions with drift-wave and zonal flows in cylindrical magnetized plasma are observed.

Turbulence excitation experiments were performed on the Large Mirror Device Upgrade (LMD-U). Cylindrical helicon plasma with a diameter of approximately 0.1 m and an axial length of 3.74 m is produced by the RF wave in a quartz tube and is radially restricted by the axial magnetic field. The operational conditions are 3 kW RF power, 900 G magnetic field and 5 mTorr argon gas pressure.

The azimuthal cross-section image is reconstructed by using a 64-channel azimuthal probe array and a radially movable probe. Figure 1 shows the reconstructed two-dimensional structure of ion saturation fluctuation (δI_{is}) and floating potential fluctuation (δV_f), where filled contours denote δI_{is} and contour lines denote δV_f (solid line or dotted line indicates positive or negative value). A purple solid circle indicates the organization of a solitary (radially and azimuthally localized) eddy.

The spatiotemporal structure of the solitary eddy is closely related to that of the zonal flow. The solitary eddy is organized around an inner antinode of the zonal flow. No eddy is observed in the outer antinode of the zonal flow. Note that the maximum velocity around the solitary eddy is ~ 1 km/s and is much faster than zonal flow (~ 0.1 km/s). The eddy lives during a phase where the azimuthal flow is accelerated toward the electron diamagnetic direction. The Reynolds stress is evaluated by floating potential measurements. The Reynolds stress is generated around the instantaneous radial location of the eddy. The Reynolds force, acceleration of azimuthal flow, caused by the eddy, is calculated from the radial gradient of Reynolds stress. The Reynolds force indicates that the organization of eddy accelerates electron diamagnetic azimuthal flow.

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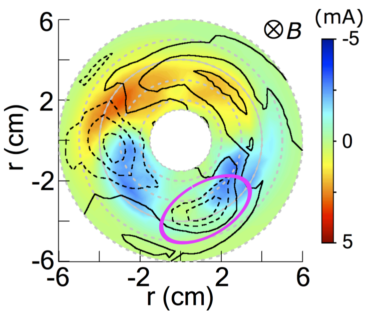

Fig. 1: Two-dimensional structure of the ion saturation fluctuation (filled contour) and floating potential fluctuation (contour line). A purple solid circle indicates the solitary eddy.