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Wave-number spectral characteristics of the drift wave turbulence dominated by zonal flows

Kyoto U. Jiquan Li, Kenji Imadera, Paul Hilscher, Shou Miyata, Yasuaki Kishimoto

The diagnosis of the fluctuations can not only provide insight into a broad range of interesting linear and nonlinear plasma phenomena but also reveal the underlying mechanism of the anomalous transport. Plasma fluctuations are of wide spatio-temporal scale, which is conventionally described by wave-number and frequency spectra. Note that the shape of the wave-number spectrum is of primary importance in the theoretical study of turbulent phenomena since these spectra are the main outcomes provided by turbulence theories. Furthermore, turbulence spectra are some of the measurable quantities in experiments. In drift wave turbulence, a key physical mechanism to suppress the turbulent fluctuations and transport is ascribed to the zonal flow(ZF) dynamics so that the relevant problem is frequently referred to as drift wave-ZF turbulence[1].

In this work, the wave-number spectral characteristics of drift wave turbulence are investigated based on 3D gyrofluid and gyrokineic simulations. The focus is on the back reaction of the self-generated zonal flows on the ambient turbulence through nonlinear mode coupling. Detailed spectral analyses evidently show that the radial wave-number spectra of the drift wave-zonal flow turbulence is characterized by an exponential-law scaling, which is deformed from usual Kolmogorov-like power-law by the back reaction of the zonal flows[2]. These results are qualitatively in agreement with a theoretical prediction and fairly match with the experimental observation of the density fluctuation spectrum. The effect of the zonal pressure on the spectral characteristics of the drift wave turbullence is also discussed.

[1] P. Diamond, et al. Plasma Phys. Control. Fusion 47, R35(2005)

[2] Jiquan Li and Y. Kishimoto, Phys. Plasmas 20, in press(2010)