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Gyrokinetic simulation of multi-scale plasma turbulence

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As is well known, spatio-temporal scales of plasma phenomena are characterized by multiple scale-lengths. As the scale-separation may not necessarily hold, multi-scale phenomena have been regarded as a common subject in the space and laboratory plasma studies. Magnetic reconnection is discussed as one of the examples. On the other hand, turbulence involves macro- and micro-scale structures simultaneously, and shows the fluctuation spectrum in a wide wavenumber range. Here, we discuss plasma turbulence with multiple scale-lengths, focussing on turbulent transport in magnetic fusion plasma.

By means of the gyrokinetic simulation, we have investigated transport phenomena in case with the electron temperature gradient (ETG) turbulence and the trapped electron mode (TEM) driven by a density gradient, where two scale-lengths characterizing the turbulence are involved. If both the two modes are unstable, after development of the ETG turbulence with a short spatio-temporal scale, the TEM instability grows with a long spatio-temporal scale. We have found an interesting case where the TEM drives a shear (zonal) flow with a longer spatio-temporal scale by which ETG and TEM fluctuations are regulated. The obtained result implies a possibility of turbulent transport reduction with a different driving source with a help of cross-scale interaction through zonal flows.

Furthermore, we have carried out a large-scale gyrokinetic simulation of multi-scale turbulence including the ion temperature gradient mode, where a turbulence spectrum from ion to electron scales as well as its dynamical evolution is studies. In the presentation, we will discuss characteristics of the multi-scale plasma turbulence and related transport.

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