8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Experimental and Gyrokinetic Studies of ion-scale Turbulence and Transport in NBI Heated L-mode Plasmas on EAST

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Anomalous thermal transport can limit the achievable density and temperature gradients and thus severely degrade energy confinement in the plasma core. ITG, TEM and ETG turbulence have been considered to be possible candidates for the explanation of ion/electron thermal transport [1-7]. Characterizing, understanding through the combination of experimental and numerical studies, and thus controlling the turbulence are very important to future fusion reactors, e.g., ITER. Here, we report a systematical study of ion-scale turbulence [1] and transport in the core of L-mode plasmas through the combination of experimental, linear and nonlinear gyrokinetic analysis under the heating of neutral beam injection (NBI) on EAST. The ion-scale density fluctuation at $k < 3 - 5\ \mathrm{cm}^{-1}$ ($k\rho_s < 0.9 - 1.5$) was measured by an ordinary mode reflectometer with frequency f = 52.6 GHz and f = 48 GHz. The turbulence characterized by obvious off-center spectral power has been observed in each density fluctuation spectra for r/a ≈ 0.265, 0.5, respectively. The TRANSP power balance analysis reveals that both ion and electron thermal transport are anomalous, with the former being dominant. The linear stability analysis conducted using the GS2 gyrokinetic code [2] indicates that the most unstable ion-scale microinstabilities where turbulence was experimentally monitored is ion temperature gradient (ITG) modes. Furthermore, the maximum linear growth rate of ITG modes is not only much larger than the Waltz Miller $E\times B$ shearing rate, but also increases as the radius increases within r/a < 0.5. This is consistent with the experimental observation of obvious turbulence for r/a ≈ 0.265, 0.5, and further inspires us to carry out nonlinear turbulence simulations to clarify the transport capability of the ITG turbulence. The electrostatic global particle-in-cell gyrokinetic tokamak simulation (GTS) code [3] was applied to simulate ion-scale turbulence and transport of EAST plasma for the first time. The results from GTS code not only agree with the obvious turbulence observed in experiments but also show ITG turbulence has a strong capability for driving both ion and electron energy fluxes which are quantitatively consistent with those from TRANSP. The combined analysis of these turbulence transport in experiments and gyrokinetic simulations not only validates the effectiveness of the GTS code in simulating plasma turbulence and transport in EAST, but also further offers insights into increasing ion temperature by the targeted suppression of ITG turbulence under limited NBI power.

This work is supported by the National Natural Science Foundation of China under Grant Nos. 12275316, 11875286, and the Open Fund of Magnetic Confinement Fusion Laboratory of Anhui Province under Grant No. 2022AMF02001.

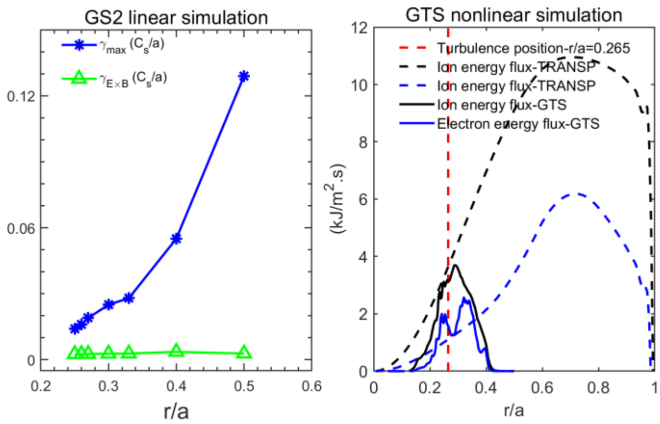

Figure 1. Linear simulation of ITG modes using GS2 code for 0.25<r/a <0.5, and nonlinear simulation of ITG turbulence and transport by the GTS code 0<r/a <0.5.

References

[1] Y. Ren, et al., Nucl. Fusion **57**, 072002 (2017).

[2] M. Kotschenreuther, Comput. Phys. Commun. **88**, 128 (1995).

[3] W. X. Wang, et al., Phys. Plasmas **17** 072511 (2010).