Gyrokinetic flux-tube code for comparison with experiment in non-axisymmetric systems and application to LHD discharge

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In the last decade, abundant gyrokinetic simulation studies have presented many significant results for the turbulent transport phenomena in fusion plasmas. Nowadays, direct comparisons of numerical results of gyrokinetic simulations with experimental data are strongly demanded for quantitative analyses of the phenomena and for designing fusion reactors. For non-axisymmetric plasmas, however, there are not many studies for validation of gyrokinetic simulation. In our recent work, we developed a gyrokinetic flux-tube Vlasov code, GKV-X [1], to deal with the three-dimensional field configuration corresponding to each experiment shot in non-axisymmetric systems. The GKV-X accurately incorporates complicated flux surface shapes, metric, as well as the Fourier components of the equilibrium configuration obtained from VMEC code which can solve the MHD equilibrium state for given pressure and plasma current profiles in each experiment shot.

Using GKV-X, we first investigate the geometrical and ripple effects of the field in the Large Helical Device (LHD) on linear ion temperature gradient (ITG) mode. A non-negligible difference appears in the growth rates in higher poloidal wavenumber region due to the finite gyroradius effect and the magnetic drift frequencies, while the effect on linear zonal flow response is small.

Next, the GKV-X simulation for the ITG turbulent transport is compared with the fluctuation measurements in the LHD high ion temperature discharge. In the experiment, the density fluctuation measured by two-dimensional phase contrast imaging shows characteristics of the ITG mode, e.g., the fluctuations most likely propagate in the ion diamagnetic direction in the plasma frame and their amplitudes increase with the enhancement of the ion temperature gradient [2]. In the linear calculations, it is found that the ITG modes are most unstable at the regions in radial and wavenumber spaces where the peaks of the fluctuations are observed in the experiment. It also corresponds to the region where the excess of the temperature gradient over its critical value becomes largest [3, 4]. In the nonlinear ITG turbulence simulations, we also obtain the turbulent transport levels and the wavenumber spectra of the potential fluctuation which agree with the observations in the LHD experiment.

[1] M. Nunami, T.-H. Watanabe, and H. Sugama, Plasma Fusion Res. **5**, 016 (2010).
[2] K. Tanaka, C. A. Michael, L. N. Vyacheslavov *et al.*, Plasma Fusion Res. **5**, S2053 (2010).
[3] M. Nunami, T.-H. Watanabe, H. Sugama, Proceedings of the 23rd IAEA Fusion Energy Conference (Daejeon, Korea) THC/P4-20.
[4] M. Nunami, T.-H. Watanabe, H. Sugama, and K. Tanaka, Plasma Fusion Res. **6**, 1403001 (2011).