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Heat Transport Study Using Gyrokinetic Analysis in the KSTAR Plasma

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Understanding anomalous cross-field transport of particles and heat, higher than expected from neoclassical theory, is one of the main challenges in magnetic fusion research. Turbulent transport driven by drift-wave instabilities is recognized as one of the main transport mechanisms in magnetic fusion plasmas. Gyrokinetic theory has been widely used to describe this turbulent transport, and extensive efforts have been made to validate the gyrokinetic model to predict the performance of fusion plasmas accurately [1 and references therein].

KSTAR [2] has a diagnostic suite – including ECEI, BES, and high-k scattering [3] – that facilitates both transport analysis and gyrokinetic model validation. However, quantitative comparisons between measurements and gyrokinetic simulations have not been reported yet. This is the main motivation of this study.

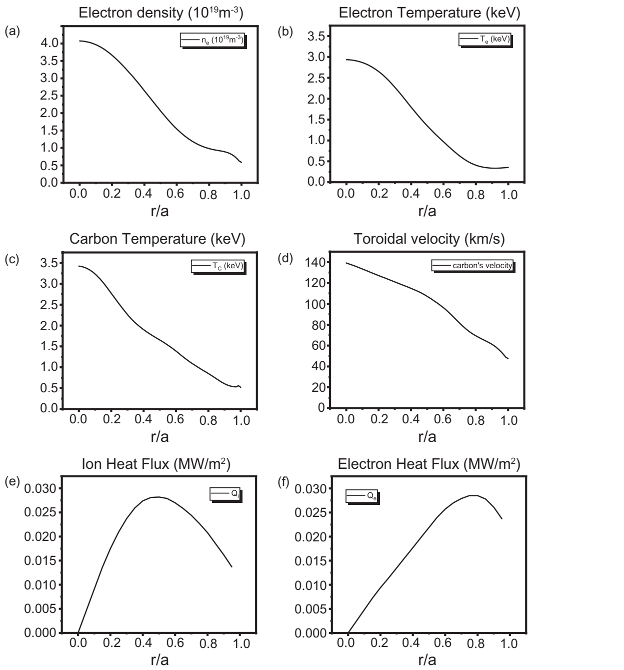

Fig. 1 Preliminary profile and power balance analysis results of a KSTAR L-mode discharge (shot 21631, time=2050ms) (a) electron density profile (b) electron temperature (c) carbon temperature (d) toroidal velocity of carbon (e) ion heat flux (f) electron heat flux

Here, as a first step for validation activity, we will compare the simulated heat transport level from a nonlinear gyrokinetic simulation with the experimental transport level. In this study, a gyrokinetic analysis is performed using the CGYRO code [4], and experimental heat transport levels are estimated from a power balance analysis using TRANSP [5]. The target discharge is an NBI heated L-mode plasma, and we will focus on the core region, r/a~0.5-0.7, where a is the minor radius. In this discharge, Z_{eff} was not measured. Thus, Z_{eff} and the fraction of main ion density, n_D/n_e, are uncertain and must be estimated.

Figure 1 shows very preliminary results of the profile and power balance analysis. In this preliminary analysis, Z_{eff} was set to 2.0 and carbon was used as the main impurity. In the future, we will estimate Z_{eff} based on a neoclassical conductivity calculation. Using the profiles shown in Figs. 1(a)-(d), a linear gyrokinetic analysis was performed. In this analysis, realistic geometry, trapped particles and collisions were taken into account. Both electrostatic and transverse electromagnetic fluctuations were included. Figure 2 shows the spectra of real frequency and linear growth rate of the most unstable mode at r/a=0.6. The horizontal axis is the normalized binormal wavenumber, $k_\theta \rho_s$. The real frequency of the most unstable mode is in the ion diamagnetic direction for $k_\theta \rho_s \leq 0.65$, which is the ion temperature gradient (ITG) mode, while it moves to the electron diamagnetic direction for $k_\theta \rho_s > 0.65$. A sensitivity study revealed that the mode whose real frequency is in the electron diamagnetic direction is the density gradient driven trapped electron mode (TEM).

In the presentation, we will report the revised results of profile and power balance and gyrokinetic analyses – including nonlinear results – as the first step of a more comprehensive gyrokinetic validation study using KSTAR plasmas.

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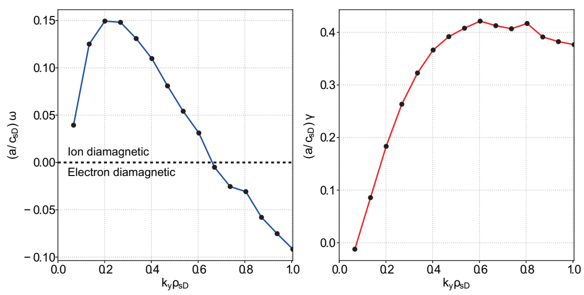

Fig. 2 Linear analysis results at r/a=0.6

References

[1] A. E. White, J. Plasma Phys. **85,** 925850102 (2019)
[2] G. S. Lee *et al.*, Nucl. Fusion **41**, 1515 (2001)
[3] Y. K. Oh *et al.*, J. Korean Phys. Soc., **73**, 712 (2018)
[4] J. Candy *et al.*, J. Comput. Phys., **324**, 73 (2016)
[5] TRANSP webpage, transp.pppl.gov (2020)