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Plasma Beta Dependence of Microturbulence in JT-60SA Using Global Gyrokinetic Simulations

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For high-performance tokamak reactor, a higher plasma beta is required to increase the fraction of bootstrap current. In such a finite beta plasma, it is known that electromagnetic fluctuations affect the turbulent transport and suppress the ion temperature gradient (ITG) mode, reducing resultant turbulence transport [1]. In addition, the finite beta changes the magnetic equilibrium configuration mainly due to the Shafranov shift, which also affects micro-scale instabilities. According to the previous local simulations [2-4], the Shafranov shift cancels out the electromagnetic stabilization effect of the ITG mode, so that relatively destabilize the ITG mode. However, such effects have not been comprehensively studied based on global simulations.

Motivated by such backgrounds, we analyze the beta dependence of global ITG mode by means of a global gyrokinetic code GKNET [5] with a field aligned coordinate, which is connected to a free-boundary 2D Grad-Shafranov equation solver MEUDAS [6]. In this study, based on the JT-60SA ITER-like equilibrium [7], we do the beta scan tests by self-consistently changing the magnetic equilibrium.

Figure 1 shows the beta dependence of the linear growth rate of global ITG mode in the case with (red) and without (blue) the Shafranov shift. In the absence of the Shafranov shift, the ITG mode is stabilized by the electromagnetic fluctuation, while such a reduction of the growth rate is weakened by the Shafranov shift. We also showed that density distribution plays an important role in both of the electromagnetic stabilization effect and the shaping effects of plasmas. Furthermore, the critical beta value for destabilizing kinetic ballooning mode (KBM) becomes higher due to the Shafranov shift effect. The beta dependence of the growth rate of microinstabilities in JT-60SA is small compared to that from local simulations of CBC. These results imply that shapes of the cross section affect tendencies of the growth rate.

In nonlinear simulations, energy fluxes decrease as increasing beta in both cases with and without Shafranov shift. We will also report results of nonlinear simulations detail in the conference.

References

[1] A. Ishizawa *et al.*, J. Plasma Physics **81**, 435810203 (2015).
[2] A. Ishizawa *et al.*, Phys. Rev. Lett. **123**, 025003 (2019).
[3] A. Ishizawa *et al.*, Nucl. Fusion **64**, 066008 (2024).
[4] M. Niiro *et al.*, Plasma Phys. Control. Fusion **65**, 065004 (2023).
[5] K. Imadera *et al.*, Proc. 25th, FEC TH/P5-8 (2014).
[6] M. Azumi *et al.*, in Proc. 4th Int. Symp. On Comput. Methods Applied Sci. Engineering, Paris (North-Holland, Amsterdam, 1980) p.335.
[7] M. Nakata *et al.*, Plasma Fusion Res. **9**, 1403029 (2014).

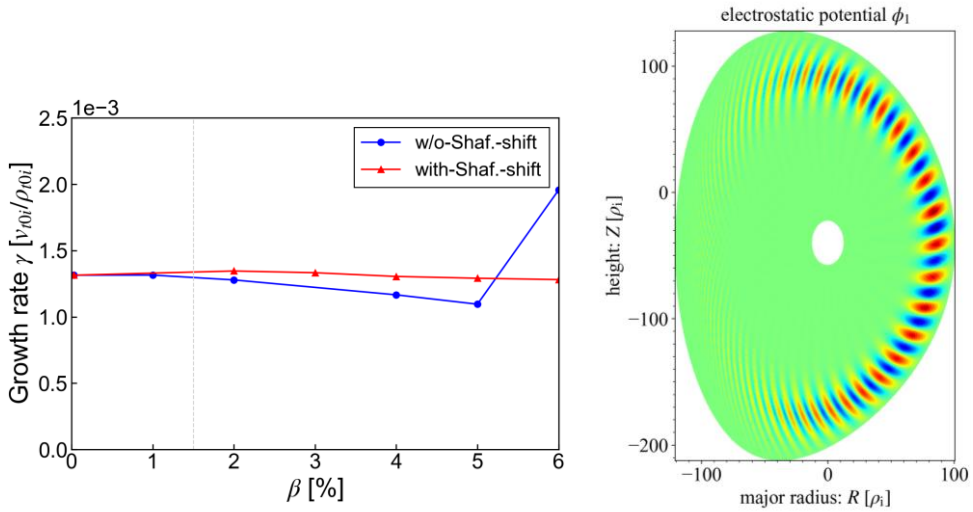

Fig.1 Beta dependence of the linear growth rate of ITG modes (left). The blue line represents the magnetic field fixed cases, and the red line represents the magnetic field changed cases.
Colormap of perturbed electrostatic potential of the ITG mode at β=4% in JT-60SA (right).