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Study of shaping effect on ITG/TEM instabilities through full-f gyro-kinetic simulation

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In Tokamak plasmas, the modification of magnetic shaping can cause significant influence on both magneto-hydrodynamic (MHD) and drift-wave instabilities, and thus affects the confinement performance to a large extent. For instance, the effect of elongation has been proved to increase the global energy confinement time as seen in the ITER IPB98(y, 2) H-mode confinement scaling: τ_E∝κˆ0.78. In the past decades, people found that the D-shaped plasma can give a much better core confinement, which has a high edge pressure limit and is consistent with the reduced edge transport by the H-mode operation. Due to this advantage, such a magnetic shaping is utilized in most present and being constructed Tokamaks including ITER.

On the other hand, a negative triangularity shape which exhibits better confinement even under the L-mode has been frequently discussed recently. Characteristics of plasma instabilities in such a geometry have been widely studied numerically and experimentally [1˜3]. Since this shaping can have larger power handling area at the low-field side, it is considered to be a possible scenario of Tokamak reactor. However, lacking of theoretical analysis and global full-f simulation, its effect on turbulent transport in the toroidal system due to multi-scale ion temperature gradient (ITG) and trapped electron mode (TEM) instabilities is still not fully understood.

In this work, the effect of plasma shaping on linear ITG/TEM instabilities is studied based on the full-f GKNET (Gyro-Kinetic Numerical Experimental Tokamak) code. Utilizing the fixed boundary equilibrium code, elongations and triangularity (positive and negative) are scanned to study their influence on ITG/TEM instabilities and corresponding heat transport. At first, linear growth rate and corresponding mode structures are discussed based on the parameter scan. Then, dynamics of linear TEM instability is studied in the negative triangularity shaped plasma. It is found that the tilting of eigenmode structure may be responsible for the reduction of turbulent transport. This work can greatly help us to understand underlying physics of confinement performance change in the shaped plasmas. Hopefully it will be interested in the fusion community.

References:

[1] Y. Camenen et al., Nucl. Fusion 47 510 (2007)
[2] G. Merlo et al., Plasma Phys. Control. Fusion 57 054010 (2015);
[3] M. Fontana et al., Nucl. Fusion 58 024002 (2018)

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