Property of Microturbulence in Small-aspect-ratio Tokamak and its Implication to Conventional Aspect Ratio Tokamak

S. Ku, J. Lang, C.S. Chang, S. Kaye, A. Diallo, W. Guttenfelder, Y. Ren, V. Soukhanovskii
Princeton Plasma Physics Laboratory
sku@pppl.gov

In NSTX, it has been a long-standing observation that the ion thermal transport rate is closer to neoclassical rate, especially in H-mode plasmas, than that in conventional tokamaks [1,2]. Higher $E_r \times B$ shearing rate or decreased amount of bad curvature [3,4] in a tight aspect-ratio tokamak has often been quoted as possible explanation. A recent computational study using the full-f gyrokinetic code XGC1 reveals a new turbulence-reduction effect in a tight aspect-ratio plasma, when the turbulence physics is self-consistenty simulated together with neoclassical physics. The new effect is from the fact that most of the particles are trapped in a tight aspect-ratio plasma and that most of the radial banana orbit excursion occurs at the high magnetic field side, hence enhancing the ∇B/curvature-drift driven charge-separation activities at the good curvature side and reducing it at the bad curvature side. This new effect is related to the latter mechanism discussed above [3,4]: It goes one step further by adding a detailed kinetic neoclassical driver to the simple picture of the "decreased amount of bad curvature." In a conventional aspect ratio tokamak, this new effect can appear when the electrostatic potential is higher at the low-B side from plasma rotation, impurity particles, and ICRH. Since the thermo-nuclear fusion cross-section is sensitive to ion temperature, it is critical to have a more complete understanding of the ion thermal transport phenomenon, together with the electron transport phenomenon. This presentation will comprehensively review all three effects and discuss its implication to the conventional aspect ratio plasmas including ITER. Effect on the electron turbulence and transport will also be presented. Experimental validation results will be a strong part of the presentation.

[1] S. Kaye et al., Nucl. Fusion 53 (2013) 063005
[2] W.X. Wang et al., Phys. Plasmas 13 (2006) 092505
[3] G. Rewoldt et al., Phys. Plasma 3 (1996) 1667
[4] M.A. Beer et al., Phys. Plasmas 4 (1997) 1792
[5] C.S. Chang et al., Nucl. Fusion 23 (1983) 935
[6] J.E. Menard et al., Nucl. Fusion 45 (2005) 539