Gyrokinetic Simulation Study of Magnetic Island Effects on Neoclassical Physics and Micro-Instabilities in a Realistic KSTAR Plasma

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We perform gyrokinetic simulations to study the effects of a stationary magnetic island on neoclassical flow and micro-instability in a realistic KSTAR plasma condition. Two gyrokinetic codes are employed for the study, one is a global full-f gyrokinetic PIC code, XGC1[1] and the other is a delta-f gyrokinetic PIC code gKPSP[2]. The former is used to study the global kinetic equilibrium with a 3D magnetic island perturbation. The latter code is used to analyze the effects of the modified 3D equilibrium and plasma flows on micro-instabilities around the magnetic island. Through the simulations, we aim to analyze a recent KSTAR experiment, which was to measure the details of poloidal flow and fluctuation around a stationary (2, 1) magnetic island[3]. From the simulations, it is found that the magnetic island can significantly enhance the equilibrium $E \times B$ flow. The corresponding flow shearing is strong enough to suppress a substantial portion of ambient micro-instabilities, particularly $\nabla T_e -$driven trapped electron modes. This implies that the enhanced $E \times B$ flow can sustain a quasi-internal transport barrier for T_e in an inner region neighboring the magnetic island. The enhanced $E \times B$ flow has a (2, 1) mode structure with a finite phase shift from the mode structure of the magnetic island. It is shown that the flow shear and the fluctuation suppression patterns implied from the simulations are consistent with the observations on the KSTAR experiment.

References

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