Comprehensive Gyrokinetic Analysis of Fast Ion Effects on Turbulence in KSTAR FIRE mode Discharge

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In this study, a comprehensive gyrokinetic analysis was performed to investigate the effects of fast ions on turbulence in KSTAR FIRE (Fast Ion Regulated Enhancement) mode plasmas, having high performance due to an internal transport barrier correlated with a substantial fast ion fraction ($\gtrsim 0.4$ at $\mathrm{r/a} < 0.47$, where a is a minor radius) [1]. The analysis focused on the fast ion effects on turbulence depending on its spatial scale and characteristics of fast ion relevant mode including its impact on turbulence. The gyrokinetic simulations predicted a significant reduction in thermal energy flux when fast ions were included for both ion scale ($k_\theta \rho_i \leq 1$, where k_θ is a poloidal wave number and ρ_i is an ion gyro radius) and electron scale ($k_\theta \rho_e \leq 1$, where ρ_e is an electron gyro radius) turbulence. When fast ions were included, for ion scale turbulence, the gyrokinetic simulation results show that the dilution effects were dominant turbulence suppression mechanisms [2]. In contrast, for electron scale turbulence, suppression was primarily driven by increased pressure gradient effects. It is interesting to note that the fast ion relevant mode contributes to an increase in the zonal shearing rate [3], potentially influencing turbulence regulation indirectly. Additionally, sensitivity scans of various parameters identified the dependence of fast ion relevant mode on fast ion density and temperature gradient, and equilibrium parameters such as safety factor and magnetic shear.

Reference

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[2] D. Kim et al, *Nucl. Fusion.* **63** 123001 (2023)

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