Nonlinear gyrokinetic simulations of microtearing modes in NSTX and NSTX-U plasmas*

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Abstract:

Understanding and controlling turbulent transport driven by microtearing modes (MTMs) is crucial for achieving sustainable fusion in spherical tokamak-based reactors. MTMs, a type of electromagnetic instability, play a significant role in electron heat transport and can impose limits on plasma performance. In this study, we present a detailed investigation of MTM-driven turbulence and transport in NSTX and NSTX-U plasmas through nonlinear gyrokinetic simulations using the fully electromagnetic gyrokinetic code CGYRO [1]. The simulations encompass a wide range of plasma conditions, including low, moderate, and high collisionality NSTX discharges, to capture the diverse operational scenarios of the device. To assess the predictive capability of gyrokinetic modeling, the simulation results are systematically compared with experimental data and the results from the multi-mode model (MMM) [2]. This comparison provides insights into the role of MTMs in setting transport levels and their dependence on key plasma parameters such as collisionality, beta, and magnetic shear. By extending our analysis to projected NSTX-U discharges, we provide a comprehensive understanding of how MTM-driven transport scales with future NSTX-U operational conditions. These findings have important implications for transport modeling and turbulence suppression strategies, ultimately contributing to the optimization of high-performance spherical tokamak plasmas.

[1] J. Candy et al., J. Comput. Phys. 324, 73 (2016).

[2] T. Rafiq et al., Phys. Plasmas 20, 032506 (2013).

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