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TH/6-4: Global Gyrokinetic Simulations of High-performance Discharges in View of ITER

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One of the key challenges for plasma theory and simulation in view of ITER is to enhance the understanding and predictive capability concerning high-performance discharges. The goal of this contribution is to shed light on central open issues by means of physically comprehensive ab initio simulations with the global gyrokinetic code GENE (including electromagnetic effects, collisions, and real MHD equilibria), applied to discharges in TCV, AUG, and JET –with direct relevance to ITER.
First, we address the nature of anomalous transport in high-β plasmas. GENE simulations of AUG H-mode discharges reveal that microtearing modes tend to be unstable over the outer half of the plasma, inducing magnetic electron heat diffusivities up to several m2/s. Moreover, ITG turbulence is able to excite linearly stable microtearing modes, which may in turn dominate the electron heat transport at high β.
Second, we present new investigations regarding the stiffness of ion temperature profiles in standard and improved H-modes in AUG and JET, in particular in relation to nitrogen seeding and toroidal rotation. According to nonlinear GENE simulations, the former effect tends to be small in the plasma core, confirming the conjecture that the main effect is coming from the edge region. Triggered by recent JET results, studies of the effect of toroidal rotation on profile stiffness are performed, examining the competition between (stabilizing) perpendicular and (destabilizing) parallel flow shear physics under realistic conditions, showing that conventional attempts to model flow shear effects need to be somewhat revised.
Third, we investigate what determines the residual anomalous transport in barriers. Global GENE simulations of electron-ITB discharges in the TCV tokamak exhibit a strong profile effects on the TEM turbulence. Meanwhile, ETG turbulence generally carries a large fraction of the overall heat flux and seems to help determine the properties of the established barrier. A related investigation regarding the pedestals of AUG H-mode discharges confirms this scenario. Moreover, by means of the recently developed flux-surface global version of GENE, the influence of resonant magnetic perturbations on the edge turbulence is studied, including effects mediated by subtle changes in the MHD equilibrium.

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