Topic: TH-S

# Kinetic stability modification of resistive wall mode in tokamaks by drift-kinetic orbit effects

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Toroidal nonaxisymmetry, which can be either internally generated by magnetohydrodynamic (MHD) activity or turbulence, or externally applied by nonaxisymmetric coils, can substantially modify global stability and performance of tokamaks. The importance of the kinetic particle response to such nonaxisymmetry has been continuously emphasized, since perturbed particle orbits due to nonaxisymmetric magnetic perturbations can drive anisotropic pressures, and change neoclassical particle transport and the associated kinetic energy. This presentation extends the understanding of neoclassical transport and stability in perturbed tokamaks with drift-kinetic particle simulations through a unification of neoclassical toroidal viscosity (NTV) and kinetic potential energy [1]. An essential physics is the resonance of perturbed orbits with toroidal ExB rotation, called the bounce-harmonic resonance. It changes trapped bounce orbits to closed circuits, and dominantly contributes to perturbed pressures and NTV torque in the rotating plasmas with nonaxisymmetric magnetic perturbations, while random phase-mixing reduces the nonambipolar particle transport for off-resonance particles [2]. Such driving mechanism of NTV also plays an important role in the kinetic stabilization of slowly growing MHD modes such as the resistive wall mode (RWM), but acts differently due to a shift of resonance frequency condition. For the real part of the kinetic potential energy, a large contribution is expected to come from open orbit particles where conventional closed orbit assumption of semi-analytic MHD theory might be broken. Analyses with the drift-kinetic particle code, POCA [3] for a NSTX discharge marginally stable to the RMW, where the kinetic stabilization effect was previously calculated to be too large to explain the experimental marginal stability [4], show that plasmas approach marginal stability as toroidal rotation decreases, due to the reduced kinetic potential energy from the phase-mixing effect of open bounce orbits. This presentation will further show benchmarking studies of NTV and kinetic potential energy between POCA, PENT, MISK, and MARS-K codes. Analysis on the kinetic stability modification of RWM in NSTX using the particle simulation will be discussed with focus on the role of realistic perturbed orbit dynamics. This work was supported by US DOE Contract DE-AC02-09CH11466.

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