Kinetic modeling of plasma response to RMPs for a tokamak in full toroidal geometry

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The successful application of external non-axisymmetric magnetic perturbations (resonant magnetic perturbations or RMPs) for the mitigation and suppression of edge-localized modes in medium-sized tokamaks [1] has left a number of open questions with regard to models that include plasma response currents in a 3D equilibrium. Kinetic modeling in straight cylindrical geometry [2] shows a collisionality-dependent difference of plasma response currents compared to predictions of commonly used MHD models, in particular a shift of electron fluid resonances depending on the temperature gradient. Therefore a predictive model should include kinetic effects. Because cylindrical geometry cannot account for poloidal mode coupling and guiding-center orbit effects pertinent to a toroidal configuration, a model in full toroidal geometry is necessary. Since resonant plasma response localized around resonant flux surfaces and non-resonant (NTV) response in the whole plasma volume cannot be decoupled, a predictive model should take both of them into account. Here results from a kinetic Monte-Carlo model in full toroidal geometry and with realistic magnetic perturbations [3] are presented for the case of ASDEX Upgrade with ELM mitigation coils. Namely the perturbed pressure tensor and current density are compared to results from a corresponding MHD model. It is shown that the pressure perturbation is strongly anisotropic not only in vicinity of resonant surfaces, but in the whole plasma volume. While parallel pressure agrees well with ideal MHD predictions, perpendicular pressure might be affected by orbital resonances, which are usually important for ion NTV at low-collisional reactor-relevant conditions [4, 5]. This means that perturbations of diamagnetic currents caused by external non-axisymmetric perturbations cannot always be described by ideal MHD theory, and kinetic modeling may be required for the calculation of perturbed plasma equilibria even in absence of resonant flux surfaces.

References

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