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New Nonlinear Microtearing Mode Transport Model for Tokamak Plasmas*

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Microtearing modes (MTMs) have been identified as a source of significant electron thermal transport in high β tokamak discharges. A model for MTMs that can be installed in integrated whole device predictive modeling codes is needed in order to improve the prediction of electron thermal transport and, consequently, the evolution of the plasma in devices in which MTMs have a significant role. A unified fluid/kinetic approach is used in the development of a nonlinear model for the transport driven by MTMs. The derivation of the model includes the effects of electrostatic and magnetic fluctuations (δB), collisionality, electron temperature and density gradients, magnetic curvature and the effects associated with the parallel propagation vector ($k_\parallel$). The electron momentum, electron density, Maxwell equations, Ampere's law and quasi-neutrality condition are used in the derivation of a nonlinear fluid microtearing dispersion relation. An iterative nonlinear approach is used to calculate distribution function employed in obtaining the nonlinear parallel current and the nonlinear dispersion relation. The third order nonlinear effects in δB are included in the development of microtearing mode model, and the influence of third order effects on a three wave system is considered. For the evolution of the nonlinear microtearing instability in time, the third order effects provide the possibility of saturation of the microtearing instability. In the limit of slab geometry, $k_\parallel = 0$ and strong collisionality, the fluid dispersion relation for nonlinear microtearing modes is found to agree with the kinetic dispersion relation in Ref [1]. An envelope equation for the nonlinear microtearing modes in the collision dominant limit is introduced. The role of MTMs in driving electron transport in the mid-radius region of NSTX-U plasmas is examined, and the dependece of MTMs on plasma parameters including the magnetic shear length, safety factor, electron temperature gradient, electron density gradient, plasma β and collisionality is studied.
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[1] J.F. Drake et al. Phys. Rev. Letters 44, 994 (1980)

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