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Influence of energetic ions on neoclassical tearing modes

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In general, energetic ions influence tearing modes through affecting the perturbed parallel current, which reflect in the contributions of energetic ions in the outer region and island region. First, the effects of circulating energetic ions (CEI) on the stability criterion have been studied[1-2]. The stability criterion[1] including the effects of CEI has been derived analytically. These effects depend on the toroidal circulating direction, and are closely related to the momentum of energetic ions. CEI provide an additional source or sink of momentum to affect tearing modes. For co-CEI, tearing modes can be stabilized if the momentum of energetic ions is large enough. On the other hand, the growth of tearing modes can be enhanced by counter-CEI. Based on the above model, the effects of energetic ions on tearing modes are studied by global kinetic/MHD hybrid simulations. The dependence of kinetic effects on energetic ion beta, gyroradius and speed is studied systematically and the results agree in large part with the previous analytic results for the kinetic effects of CEI. For trapped energetic ions, their effects on tearing mode stability are dominated by the adiabatic response due to large banana orbit width and strong poloidal variation of particle pressure.

In addition to the above analysis, we study the effect of an uncompensated cross field current resulting from quasi-neutrality[3]. The corresponding return parallel current may compensate the loss of bootstrap current in the magnetic island. This nonlinear effect depends on the island propagation frequency, the density gradient of energetic ions and magnetic shear. If the island propagation frequency is positive, the effect of the uncompensated current plays a stable role on neoclassical tearing modes. When the magnetic shear is sufficiently small, this effect becomes significant and can partially cancels or even overcome the destabilizing effect of the perturbed bootstrap current. A possibility to suppress neoclassical tearing modes by co-CEI for the operation scenario with weak magnetic shear for ITER is provided.

References

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