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Effect of global field perturbations on fast ion redistribution and losses in toroidal plasmas

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The confinement of fast ions is very important for achieving and maintaining high performance of tokamak plasma, However, the global field perturbations, such as the MHD instabilities and the externally applied resonant magnetic perturbation, degrade the fast ion confinement, and induce fast ion losses **[1].** However, the dependence of fast ion redistribution and losses on the mode structure, frequency and amplitude is not yet clear, and requires more investigations. In this presentation, we briefly introduce recent progress of numerical studies on the effects of global field perturbations on fast ion redistribution and losses in toroidal plasmas, carried out in SWIP.

The kinds of perturbations include resistive wall mode (RWM), fishbone-like mode (FLM), fishbone mode and externally applied resonant magnetic perturbations (RMP) [2]. The main conclusions are shown below. (i) As the amplitude of FLM increases, the loss mechanism converts from convective type to diffusion one. The fast ion loss rate is sensitive to the mode frequency. The numerical results agree well with the experimental measurements from DIII-D **[3]**. (ii) The resistive RWM significantly enhances the fast ion losses, compared with the case of ideal RWM. (iii) For ITER device, the internal kink or fishbone mainly induces the fast ion redistribution and has neglectable effect on fast ion losses. (iv) A threshold of RMP coil current for fast ion losses is predicted. In addition, the mixed dominant component and secondary sideband of RMPs greatly enhances the fast ion losses, compared with that for the dominant harmonic alone. The results are in good agreement with the experiment results on ASDEX-U and KSTAR.

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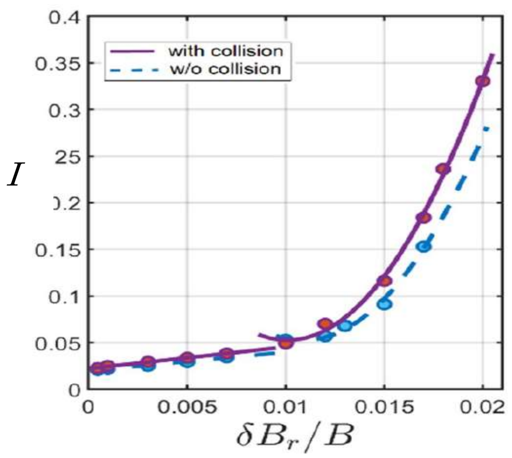

Figure 1. The defined fast ion redistribution factor I versus the external kink perturbation amplitude with (solid curve) and without (dashed curve) pitch angle scattering induced by the Coulomb collision. The filled dots show the calculated results, while the curves are the fitting results. Linear and secondary polynomial fittings are applied in the regions $0 < \delta Br/B < 0.007$ and $0.01 < \delta Br/B < 0.02$, respectively.

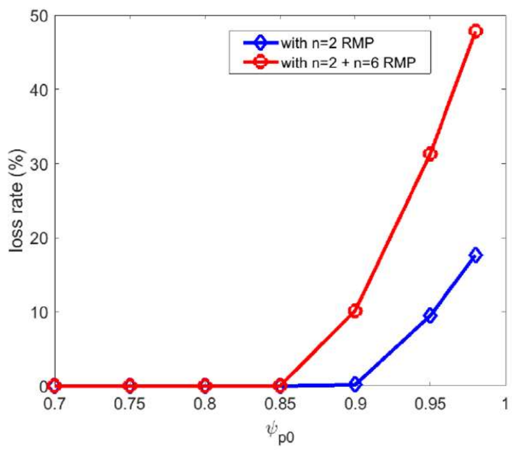

Figure 2. Loss rate of fast ions as a function of the initially launched radial position for the case with only $n = 2$ component (in blue) and with both the $n = 2$ and $n = 6$ components (in red). Here, a double-null reference equilibrium for the HL-2M device is adopted. The resistive plasma response is included in the computation of total RMP fields. A 10 kAt RMP coil current with coil phasing between the upper and lower rows of RMP coils being -90° for the n = 2 RMP component is assumed.