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Three dimensional divertor flux control using optimized dynamic resonant magnetic perturbations

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The active divertor flux control can be achieved while maintaining an ELM-control effect by applying a dynamic RMP fields in the EAST. First, the rigid rotating RMP fields with toroidal mode number n=1 and 2 RMP fields make the divertor heat and particle flux synchronously rotate along the toroidal direction. For the contemporary ELM control effect, the RMP spectrum is optimized by choosing proper current phase differences between upper and lower RMP coil currents. Furthermore, the divertor flux variation during the application of RMP fields with a static n=3 field superimposed with a rotating n=2 field is investigated. This kind of modified mix-n dynamic RMPs require smaller variation in coil current, which is more favored in future coil operation if approaching the coils engineering limits need to be avoided. However, the differences between experimental observations and the prediction by the vacuum assumption, in which a full penetration of the applied RMP was assumed, indicates the significance of considering contributions from different plasma responses.

As a result, the numerical simulation of the divertor flux distribution that take the plasma response into account has been performed using the 3D plasma fluid and kinetic neutral transport code EMC3-EIRENE. Here the plasma responses are simulated by the linear magnetohydrodynamic (MHD) code MARS-F. The simulation results show that the response from plasmas has either screening or amplifying effect to the external RMPs. It will then change the extension of the 3D structure formed by the homoclinic tangles near the X-points. The intersection of the 3D structure with the divertor targets will modify the extension of divertor flux patterns on divertor targets. The simulation results with plasma responses have better consistency with the real experimental observations. The change of edge stochasticity after including the plasma responses will modify the edge plasma transport containing the plasma parallel flow, thus further affecting the poloidal asymmetry of the divertor flux distribution and the ratio of the fluxes deposited on the original strike line to that on the secondary strike line. The toroidal averaged flux profiles are calculated for mimicking the integrating effect of a dynamic RMPs. The changes of the peak value and the width of the profile indicate the effectiveness of applying such a kind of optimized dynamic RMPs in making a more evenly distributed heat flux on the divertor targets.

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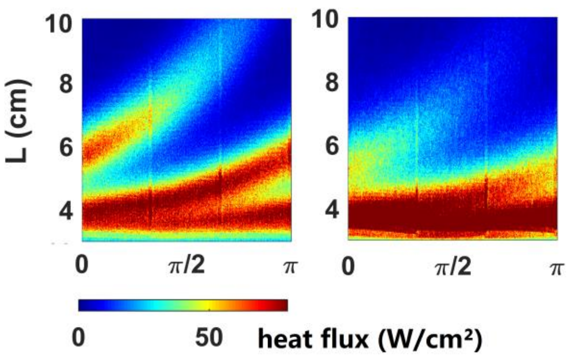

Figure 1. The heat flux simulated by EMC3-EIRENE under vacuum (left) and plasma response (right) model on the lower outer divertor target. The plasma response shows screening effect, which makes the heat flux splitting weaker than the vacuum prediction.