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ITR/P1-24: Three-dimensional Fluid Modeling of Plasma Edge Transport and Divertor Fluxes during RMP ELM Control at ITER

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Application of resonant magnetic perturbation (RMP) fields is one option for control of edge-localized modes (ELMs) at ITER. During RMP ELM suppression at DIII-D the measured heat and particle fluxes are rearranged into a three-dimensional (3D) pattern. In this contribution, the consequences of this 3D boundary formation on the divertor heat and particle loads during RMP application at ITER are studied. We use EMC3-Eirene, a 3D fluid plasma and kinetic neutral transport code. An n=3 RMP field at 90kAt maximum coil current was applied in (a) the vacuum limit and (b) including plasma response from non-linear MHD.

A low recycling divertor regime is addressed at an input power of PH=100MW without impurity radiation losses. This represents an extreme case to test the upper bound for the 3D heat fluxes. A clear reduction of the electron temperature Te field is seen with vacuum RMP field. The outer boundary of the temperature field is set by the perturbed separatrix, which forms a finger like 3D boundary structure. These fingers reach out to the divertor target and the divertor fluxes are not axisymmetric anymore but deposited in a helical pattern reaching out as far as 70 cm from the unperturbed strike line. This yields spreading of the heat flux with a reduction of the peak heat flux from qpeak=28 MW/m2 without RMP field to qpeak=9 MW/m2 with RMP where the integral heat flux is reduced by 30%. This is induced by an increase of the divertor recycling flux by a factor of 10, which is necessary to maintain the density with RMPs applied. The increasing divertor density and enhanced ionization power losses reduce the divertor heat load. A comparison of these ionization losses with impurity radiation shows that they determine the actual divertor heat fluxes.

The plasma response to the n=3 field applied was investigated based on a non-linear MHD plasma response modeling. For the case studied, all modes inside normalized flux of ΨN<0.96 are shielded out while in the edge for ΨN>0.96 a vacuum like penetration is predicted. This has a strong impact on the modeling result. The electron temperature is restored to the no-RMP value and the extension of the finger like structure at the separatrix is reduced. The maximum reach out of the helical heat fluxes are reduced to 30 cm and the heat flux deposition is more localized with increasing peak heat flux to q_peak=17 MW/m2.

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