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Modelling of Spatial Structure of Divertor Power Loads Caused by Edge-Localized Modes Mitigated by Magnetic Perturbations

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Resonant magnetic perturbations (RMPs) can mitigate the edge-localized modes (ELMs), i.e. cause a change of the ELM character towards smaller energy loss and higher frequency. During mitigation a change of the spatial structure of ELM loads on divertor was observed on DIII-D and MAST: the power is deposited predominantly in the footprint structures formed by the magnetic perturbation. In the present contribution we develop a theory explaining this effect, based on the idea that part of the ELM losses is caused by parallel transport in the homoclinic tagle formed by the magnetic perturbation of the ELM. The modified tangle resulting from the combination of the ELM perturbation and the applied RMP has the expected property of bringing open field lines in the same areas as the tangle from the RMP alone. We show that this explanation is consistent with features of the mitigated ELMs on MAST.
We in addition validated our theory by an analysis of simulations of mitigated ELMs using the code JOREK. We produced detailed laminar plots of field lines on the divertor in the JOREK runs with an ELM, an applied RMP, and an ELM mitigated by the presence of the RMP. The results for an ELM clearly show a high-n rotating footprint structure appearing during the nonlinear stage of the ELM, which is not present in the precursor stage of the ELM. The results for a n=2 RMP from the ELM control coils show the expected n=2 footprint structure. The results for the mitigated ELM show a similar structure, modulated by a higher n perturbation of the ELM, consistent with our theory.

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