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Dynamic ELM and divertor control using resonant toroidal multi-mode magnetic fields in DIII-D and EAST[1]

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A rotating n =2 Resonant Magnetic Perturbation (RMP) field combined with a stationary n =3 RMP field has validated predictions that access to ELM suppression can be improved, while divertor heat and particle flux can also be dynamically controlled in DIII-D. Recent observations in the EAST tokamak indicate that edge magnetic topology changes, due to nonlinear plasma response to magnetic perturbations, play a critical role in accessing ELM suppression. MARS-F code MHD simulations, which include the plasma response to the RMP, indicate the nonlinear transition to ELM suppression is optimized by configuring the RMP coils to drive maximal edge stochasticity. Consequently, mixed toroidal multi-mode RMP fields, which produce more densely packed islands over a range of additional rational surfaces, improve access to ELM suppression, and further spread heat loading on the divertor. Beneficial effects of this multi-harmonic spectrum on ELM suppression have been validated in DIII-D. Here, the threshold current required for ELM suppression with a mixed n spectrum, where part of the n =3 RMP field is replaced by an n =2 field, is smaller than the case with pure n =3 field. An important further benefit of this multi-mode approach is that significant changes of 3D particle flux footprint profiles on the divertor are found in the experiment during the application of a rotating n =2 RMP field superimposed on a static n =3 RMP field. This result was predicted by modeling studies of the edge magnetic field structure using the TOP2D code which takes into account plasma response from MARS-F code. These results expand physics understanding and potential effectiveness of the technique for reliably controlling ELMs and divertor power/particle loading distributions in future burning plasma devices such as ITER.

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