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Suppression of Type-I ELMs with Incomplete I-Coil Set on DIII-D

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Recent experiments on DIII-D have demonstrated the ability to suppress edge localized modes (ELMs) using edge-resonant magnetic perturbations (RMPs) produced by an incomplete I-coil set in ITER similar shape plasmas with low pedestal electron collisionality. Robust ELM suppression has been reproducibly obtained on DIII-D using a wide range of toroidal RMP modes during experiments in which various non-axisymmetric coil loops were turned off pseudo-randomly. RMP ELM suppression was achieved on DIII-D with 11, 10, 9, 7, and 5 out of 12 I-coils. In these experiments, using fine I-coil current steps we determined the I-coil current amplitude threshold for RMP ELM suppression in each I-coil configuration. The suppression current threshold showed almost no dependence on the number of the active I-coils between the 11 and 7 coil configurations. These results provide confidence that the ITER ELM coils will likely be able to meet the ELM suppression criterion in case of multiple coil failures.
The experimental results confirmed the previous modeling work predictions [1,2] that ITER ELM coils would be able to meet the ITER coil design criterion even with 19 of 27 loops by adjusting the coil currents within the allowed range of current amplitudes. In the DIII-D experiments, while the dominant n=3 harmonic was reduced due to an overall decrease in the amount of the perturbation, the sidebands assisted in maintaining necessary value of the island overlap region resulting in sufficient level of stochastization of the plasma pedestal region that is believed to be needed for RMP ELM suppression. This was also confirmed in the linear two-fluid plasma response modeling with M3D-C1. The effect of non-purity of the perturbation spectrum on ELM suppression may lead to new ELM suppression strategies and better understanding of the suppression mechanisms.
Sustained RMP ELM suppression with only 7 of 12 I-coils was demonstrated on DIII-D. As the ELM suppression was achieved at constant I-coil current, high pedestal electron toroidal rotation and constant pedestal electron density were maintained for the duration of the ELM suppression phase, as well as good plasma confinement.

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[1] D.M. Orlov, et al., Fusion Eng. Design 87 (2012) 1536
[2] T.E. Evans, et al., Nucl. Fusion 53 (2013) 093029

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