ELM SUPPRESSION BY RESONANT MAGNETIC PERTURBATIONS ON DIII-D

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Type-I edge localized mode (EML) instability heat pulses are predicted by empirical and theoretical modeling to severely limit divertor target lifetime in ITER [1,2]. Therefore, method(s) are needed to strictly control or suppress them. The complete suppression of Type-I ELM instabilities by application of weak ($dB/B_0 \sim 3x10^{-4}$) non-axisymmetric magnetic perturbations was first achieved in the DIII-D tokamak [3]. Continued research has extended the scope of this technique [Ref. 4 and references therein]. The original suppression [3] was extended to the low edge collisionalities expected in ITER and an ITER-similar plasma shape. A resonant window effect for suppression, between the tokamak safety factor q and a peak in the helical Fourier spatial spectrum of the magnetic perturbation resonant magnetic perturbation (RMP), was found and is most effective. The RMP locally increases the plasma loss across the high-gradient H-mode edge layer. Quantitative theoretical stability analysis using measured edge data shows that subtle modifications to the edge pressure and current profiles reduce the ballooning and peeling terms that drive ELM instability. The fundamental nature of the RMP-modified transport is not yet understood. However, an empirical correlation is found between magnetic island overlap (calculated from vacuum RMP and error magnetic fields) and ELM suppression in the low collisionality, ITER-relevant plasmas. Also, the perturbation coils must be close to the plasma in order to suppress ELMs without adversely affecting the plasma interior. The resonant magnetic perturbation method of Type-I ELM suppression is now being incorporated into the ITER design, and the DIII-D results are being used to guide the in-vessel ITER RMP coils specification. Research continues in order to understand ELM suppression by non-axisymmetric magnetic perturbations from first principles and to define with confidence its necessary and sufficient requirements.

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[1] A. Loarte *et al.*, Plasma Phys. Controlled Fusion **45,** 1549 (2003).
[2] G. Federici *et al.*, Plasma Phys. Controlled Fusion **45,** 1523 (2003).
[3] T.E. Evans, *et al.*, Phys. Rev. Lett. **92**, 235003 (2004).
[4] T.E. Evans *et al.*, Fusion Energy 2008: Proc. 22nd IAEA Fusion Energy Conf. (Geneva, Switzerland, 2008) paper EX4/1.