

Numerical analysis of resonant magnetic perturbations ELM control in ITER*

D.M. Orlov¹, T.E. Evans², R.A. Moyer¹, M.J. Schaffer², O. Schmitz³ and R. Laengner³

¹*University of California San Diego, La Jolla, California 92093, USA*

²*General Atomics, PO Box 85608, San Diego, California 92186-5688, USA*

³*Forschungszentrum Juelich GmbH, IEF4-Plasma Physics, 52428 Juelich, Germany*

In this work we analyze the effect of the RMP coils on the magnetic topology in ITER since this is known to affect the stability of Type-I ELMs. Resonant magnetic perturbations (RMPs) are used for suppression and mitigation of edge localized modes (ELMs) in DIII-D and other tokamaks. ELMs drive impulsive energy losses and can be detrimental to plasma facing surfaces in future ITER high power experiments. During RMPs the vacuum topology of the magnetic field, excluding the plasma response, changes producing a stochastic region that is formed by overlapping magnetic islands. Experiments have shown that the application of RMPs leads to increased transport in the pedestal and the suppression of Type-I ELMs. Understanding ELM physics and developing the ability to control Type-I ELMs will improve the performance and longevity of ITER plasma-facing surfaces in high energy density tokamak-based fusion confinement. The ITER RMP ELM control approach is based on the successful ELM suppression with DIII-D I-coils. Thus, by comparing the magnetic topology in DIII-D with that in ITER we can extrapolate our knowledge of the DIII-D RMP ELM suppression strategy to the future ITER experiments.

Previously, several preliminary ITER coil designs were studied for the coil mode spectra and magnetic island overlap. In the present work we extended this research to the current design for the ITER internal RMP coils. We have also included the effect of the ITER Error Field Correction coils in the analysis which has not been done in the earlier studies.

Here, RMP ELM suppression is studied for a range of different ITER scenarios (H-mode, Hybrid, Steady-state) for various ITER RMP coils mode spectra such as toroidal mode number $n=3$ and $n=4$ for a range of coil current amplitudes and phasing. The goal is to examine the effect of various RMP configurations on ELM suppression in ITER using vacuum field modeling when compared to DIII-D ELM suppression results with similar vacuum field topologies. This is achieved by calculating field line characteristics such as the Chirikov magnetic island overlap parameter, and the magnetic field line loss which is primarily responsible for connecting field lines from the hot regions of the plasma to the vessel walls. Our results show that we can achieve a desired level of stochastization using nominal ELM control coil currents in ITER that is equivalent to the levels of stochastization in DIII-D RMP ELM suppressed discharges. The results also show that this level of stochastization can be achieved with or without the error field correction coils.

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