Mitigation modeling of locked-mode disruptions*

V.A. Izzo[1], D. Shiraki[2], N. Commaux[2], N.W. Eidietis[3]

[1] *University of California San Diego, La Jolla, CA, USA*
[2] *Oak Ridge National Laboratory, Oak Ridge, TN, USA*
[3] *General Atomics, San Diego, CA, USA*

Simulations of disruption mitigation for DIII-D plasmas with pre-existing islands are presented. Since disruption mitigation will be carried out as a last-resort option in ITER when passive or active stabilization cannot be maintained, the disruption mitigation system (DMS) will presumably be fired most frequently into "unhealthy" plasmas, such as those with large pre-existing MHD. Nonetheless, considerable experimental and modeling effort has been devoted to the "mitigation" of stable, healthy plasmas, in which the disruption would not have occurred without the activation of the DMS. Recent experiments on DIII-D and C-Mod have fired the massive gas injection (MGI) and shattered pellet injection (SPI) systems into plasmas with locked-modes in various stages of growth. These experiments did not find significant degradation in 0D mitigation metrics such as radiated energy fraction compared with healthy plasmas.

NIMROD modeling of MGI in DIII-D has been carried out with pre-seeded 2/1 islands. The simulations show that for identical island amplitude, the phase of the 2/1 island (relative to the gas jet) can significantly affect the spatial and temporal localization of the peak radiated power, producing nearly a factor of two variation in the maximum local radiation. This is consistent with previous simulations showing the importance of the n=1 mode phase, as well as experimental results showing that the n=1 phase can be decoupled from the injector phase with pre-existing n=1 perturbations. The simulations also show that after the radiated power peak, but before the thermal quench is completed, magnetic energy is dissipated at a rate comparable to thermal energy. This may in part explain observations of >100% radiated energy fraction—defined as the radiated energy over the pre-disruption thermal energy—seen in some DIII-D experiments.

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