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Predict-first experimental analysis using automated and integrated MHD modeling[1]

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The success of ITER and future fusion reactors would benefit significantly from theoretical predictions of stability and performance that have been validated against contemporary tokamaks. We present results of a predict-first analysis of transient-stability experiments using OMFIT [Meneghini, Nucl. Fusion 2015] integrated-modeling workflows. In particular, we look at the effect of shape variation on plasma response to 3D magnetic perturbations in order to predict access to ELM suppression. Beginning from equilibrium reconstructions of past experiments, we use EFIT [Lao, Nucl. Fusion 1985] to modify the shape of equilibria while other plasma parameters (e.g., beta, pedestal density) are held constant. Additional complexity in the workflows are considered, including using EPED [Snyder, Nucl. Fusion 2011] and NEO [Belli, PPCF 2012] to create pedestals with self-consistent pressure and bootstrap current profiles. We then use the autoC1 script, developed to automate linear M3D-C1 [Jardin, Comput. Sci. Discovery 2012] extended-MHD simulations, to assess the plasma response of each predicted equilibrium as though it is a reconstruction of a future experiment. Results from these workflows are used to guide subsequent experiments on DIII-D and KSTAR, and are then validated against 3D magnetics and ELM-suppression observations from the completed experiments. The validation is then used to develop workflows that would have more accurately predicted the experiment. In doing so, the physics models and ELM-suppression metrics considered are improved with every iteration of prediction and experiment. Lessons learned for best practices in predict-first studies and plans for future areas of application (e.g., disruption avoidance) are discussed.

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