Study of ELM Perturbation Effects on Divertor Heat Loads using Tightly Coupled Kinetic-MHD Simulations

Julian C. Cummings[1], C.S. Chang[2], Ciprian Docan[3], Scott Klasky[4], Manish Parashar[3], Gunyoung Park[5], Norbert Podhorszki[4], and Linda Sugiyama[6]
[1]Center for Advanced Computing Research, California Institute of Technology, Pasadena, CA
[2]Princeton Plasma Physics Laboratory, Princeton, NJ
[3]Center for Autonomic Computing, Rutgers University, New Brunswick, NJ
[4]Oak Ridge National Laboratory, Oak Ridge, TN
[5]National Fusion Research Institute, Daejeon, Korea
[6]Plasma Science & Fusion Center, Massachusetts Institute of Technology, Cambridge, MA

The behavior of divertor heat load profiles during discharges with Type I ELMs is under investigation in present-day tokamak experiments such as DIII-D [1] and NSTX [2]. Such studies have key implications for the ability of the ITER divertor to withstand peak energy fluxes driven by large individual ELMs and the accumulated heat load and surface ablation. We present here simulations of ELM activity and associated divertor heat loads in which we couple the discrete guiding-center neoclassical transport code XGC0 [3] with the nonlinear extended MHD code M3D [4] using the End-to-end Framework for Fusion Integrated Simulations, or EFFIS [5]. In these simulations, the kinetic code and the MHD code run concurrently on the same massively parallel platform. Periodic data exchanges are performed using EFFIS technologies, namely the componentized I/O library ADIOS [6] and the memory-to-memory data interaction substrate DataSpaces [7]. XGC0 starts from the equilibrium reconstruction of a specific discharge, just before the onset of a Type I ELM. M3D models the fast ELM event and sends updates of the magnetic field perturbations to XGC0, which in turn tracks ion and electron dynamics within these perturbed fields and collects divertor particle and energy flux statistics over several time intervals before and during the nonlinear ELM. Magnetic field updates are performed on the Alfvén time scale, allowing us to track ELM effects on the time history of divertor heat loads. In addition, the XGC0 code computes kinetic plasma response in the form of the anisotropic CGL pressure tensor [4] and sends this data back to M3D as the ELM simulation proceeds. Building upon our previously reported coupled simulations [8], we now demonstrate a two-way coupling capability. We report here how EFFIS technologies facilitate these coupled simulations and discuss results for a selection of discharges from the 2010 JRT studies.

[1] C.J Lasnier et al, 36th EPS Conference on Plasma Phys., ECA vol. 33E, p. 140 (2009).
[2] R. Maingi et al, Journal of Nuclear Materials, vol. 363-365, p.196 (2007).
[3] C.S. Chang, S. Ku and H. Weitzner, Phys. Plasmas, vol. 11, p. 2649 (2004).
[4] W. Park et al, Phys. Plasmas, vol. 6, p. 1796 (1999).
[5] J. Cummings et al, Proceedings of the 18th Euromicro Conference on Parallel, Distributed and Network-based Processing (PDP 2010).
[6] J. Lofstead et al, Proceedings of the 6th International Workshop on Challenges of Large Applications in Distributed Environments (CLADE 2008).
[7] C. Docan, M. Parashar and S. Klasky, Proceedings of the 19th ACM International Symposium on High Performance Distributed Computing (HPDC 2010).
[8] J. Cummings et al, Proceedings of the 52nd Annual Meeting of the APS Division of Plasma Physics (2010).