High Time-Resolved, 2D Imaging of Type-I ELMs in DIII–D Using a Gain-Intensified CID Camera*

M. Groth,[a] J.A. Boedo,[b] M.E. Fenstermacher,[a] C.J. Lasnier,[a] A.W. Leonard,[c]
G.D. Porter,[a] J.G. Watkins,[d] and the DIII–D team

[a]Lawrence Livermore National Laboratory, Livermore, California, 94551 USA
[b]University of California, San Diego, La Jolla, California, 92093-0417 USA
[c]General Atomics, P.O. Box 85608, San Diego, California, 92186-5608, USA
[d]Sandia National Laboratory, Albuquerque, 87185 New Mexico

Divertor target plate heating due to edge localised modes (ELMs) is a critical issue in the design for future large tokamaks. The amount of energy deposited during the very short time period of an ELM, τ_{ELM} ~1 ms, can lead to serious divertor surface ablation and, therefore, can limit the lifetime of the divertor target plates in future machines. To understand the ELM perturbation of the scrape-off layer (SOL), in particular the propagation of an ELM in space and time in the SOL domain, is a fundamental piece of knowledge for the ultimate mitigation of ELM heat pulses to the target.

Over recent years a comprehensive set of diagnostics has been developed at DIII-D that can measure plasma boundary quantities with time resolution well below the duration of an ELM. Recently, a fast-gated, intensified and filtered camera has been added to the DIII-D divertor diagnostics. This camera provides images of the two-dimensional emission distribution of various plasma species in the visible wavelength range, with exposure times as low as 1 μs. The camera views the lower divertor of DIII-D tangentially and takes advantage of the charge-injected device (CID) technology to avoid disturbance from high neutron fluxes in DIII-D ELMy H-mode discharges. The camera's intensifier is externally triggered using a D_α-signal from the main chamber midplane. By varying the delay between the midplane D_α-signal and the intensifier's gate trigger, the spatial distribution of the line emission at different stages of the ELM evolution is obtained.

Two-dimensional emission profiles of deuterium and carbon at multiple stages of the ELM evolution, taken in lower single null, low-frequency ELMy H-mode discharges, will be presented and interpreted using 2-D fluid code simulations. Analysis to date of preliminary CIII emission profile measurements at 465 nm from random samples of the ELM evolution show a wide variety of spatial distributions during ELMs, including localised emission near the X-point, similar to the time-averaged profiles during divertor detachment. Some images taken in D_α during ELMs show significant broadening of the radiation profile along the target plate on the common flux side of the outer separatrix strike zone. The data obtained from this fast diagnostic, as well as measurements from the target and reciprocation probes with fast acquisition, and fast line-scan infrared thermography, are compared with results of time-dependent UEDGE simulations of the ELM evolution. Here, a novel approach in ELM modeling will be pursued, in which ELMs are simulated by the combination of periodic fluctuations in density and temperature at the UEDGE core boundary and in the transport coefficients. This approach will be benchmarked with the changes in the density and temperature at the top of the pedestal associated with ELMs, and with the temporal variation in the pedestal width.

*Work supported by U.S. Department of Energy under Contracts DE-AC03-99ER54463, W-7405-ENG-48, DE-AC04-94AL85000, and Grant DE-FG03-95ER54294