Divertor Heat and Particle Fluxes in DIII-D RMP ELM suppression Experiments at ITER-like Conditions

D.M. Orlov¹, T.E. Evans², R.A. Moyer¹, I. Bykov¹, A. Loarte³, M.E. Fenstermacher⁴, C.J. Lasnier⁴, H. Wang², A. Wingen⁵, S. Munaretto², F. Effenberg⁶, M. Becoulet⁷, G. Hujismans⁷

¹University of California-San Diego, San Diego CA, United States of America
²General Atomics, PO Box 85608, San Diego, CA 92186, USA
³ITER Organization, Cadarache, France
⁴Lawrence Livermore National Laboratory, Livermore, CA 94550 USA
⁵Oak Ridge National Laboratory, Oak Ridge, TN 37831 USA
⁶Princeton Plasma Physics Laboratory, Princeton, NJ 08543 USA
⁷CEA, IRFM, 13108 Saint-Paul-Lez-Durance, France

orlov@fusion.gat.com

RMP ELM suppression experiments at ITER-like conditions (shape, collisionality, RMP spectrum) in DIII-D show little splitting of the heat flux to the divertor targets, despite robust splitting in the particle flux. This lack of divertor heat flux splitting is a potentially important result for ITER because splitting of the divertor heat flux into multiple lobes displaced from the primary strike point could complicate heat flux handling during RMP ELM suppression in ITER and other tokamaks with tight divertor baffling. In DIII-D, strike point splitting is routinely observed in the divertor particle flux during operation with RMP.

On DIII-D we use small modulations in the in-vessel (I-coil) n=3 RMP current amplitudes or toroidal rotation of n=2 RMP fields in order to modify the poloidal spectrum of applied perturbation fields and to affect the position and the size of the divertor footprints. The measured separation of the divertor particle flux lobes exceeds predictions of vacuum (TRIP3D, MAFOT) or linear and nonlinear plasma response (VMEC-XPAND, M3D-C1, JOREK) models by factors of 3-5, under the assumption that the footprints are directly connected to plasma topology within the last closed flux surface. In this work we also examine the possibility of near-SOL field lines affecting the formation of the measured footprints.

Splitting in the heat flux profile would have serious consequences for heat flux handling during RMP ELM suppression in ITER. However, there is little impact of these particle flux lobes on the measured divertor heat flux that often does not show significant splitting. One hypothesis suggested by observations is that the lack of splitting in heat flux may be related to the CIII volumetric radiation immediately above the surface that washes out the lobe structure. We performed fully 3D plasma-fluid and kinetic edge neutral transport Monte-Carlo EMC3-EIRENE simulations to investigate the effect of different levels of carbon impurity radiation near the strike point.

*This work is supported by the US Department of Energy under DE-FG02-07ER54917, DE-FG02-05ER54809, DE-FC02-04ER54698, DE-SC0012706, DE-AC52-07NA27344, DE-NA0003525, DE-AC02-09CH11466 and DE-AC04-94AL85000.