Gyrokinetic Turbulent-Neoclassical Projection of the Divertor Heat-Flux Width from Present Tokamaks to ITER*,**

C.S. Chang¹, S. Ku¹, R. Maingi¹, D. Stotler¹, A. Loarte², V. Parail³, F. Köch³,

¹Princeton Plasma Physics Laboratory, Princeton University, Princeton, NJ 08543-451, USA
²ITER Organization, Route de Vinon sur Verdon, 13067 St Paul Lez Durance, France
³Culham Centre for Fusion Energy, Culham Science Centre, Abingdon OX14 3DB, UK
⁴Atominstitut, Technische Universität Wien, Stadionallee 2, 1020 Vienna, Austria

Presenter’s e-mail: cschang@pppl.gov

The total-f edge gyrokinetic code XGC1—with blobby electrostatic turbulence, neoclassical dynamics and neutral particle transport—shows that the divertor heat flux width $\lambda_q$ in the ELM-free period of H-modes in two representative types of present tokamaks (DIII-D like plasma for conventional aspect ratio and NSTX like plasma for tight aspect ratio) is set mostly by the ion neoclassical orbit spread, which is proportional to $1/I_p$, while the blobby turbulent spread plays a less significant role. This explains the $1/I_p$ scaling, with $\gamma\sim1$, of the heat flux width observed in the present-day tokamaks. On the other hand, the XGC1 studies for ITER H-mode like plasmas show that $\lambda_q$ is mostly set by the blobby turbulent spread, with the heat flux width being about 5X wider than that extrapolated from the $1/I_p$ scaling. Gyrokinetic ions, drift-kinetic electrons and Monte-Carlo neutral particles are simulated in realistic diverted edge geometry. This result suggests that the achievement of cold divertor plasmas and partial detachment required for power load and W impurity source control may be more readily achieved and be of simpler control issue than what was predicted on the basis of the $1/I_p$ scaling. A systematic validation study of the XGC1 results is on-going using experimental data from three major US tokamaks⁶ as part of the DOE-OFES 2016 National Theory/Simulation Performance target, including the cross-verification activity of edge turbulence with another participating code BOUT++.³

Fig. 1. Heat-flux footprint from XGC1, mapped back on the outer divertor plate, in a model ITER plasma edge. At 15MA, $\lambda_q$ is $\sim$5.6mm, which is $\sim$5X wider than what was predicted from the $1/I_p$ scaling.

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⁶R. Maingi (experimental coordinator), J.-W. Ahn and T. Gray (NSTX-U), J. Hughes and B. LaBombard (C-Mod), T. Leonard and M. Makowski (DIII-D)
³X. Xu et al., Lawrence Livermore National Laboratory

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