IAEA FEC 2014

Contribution ID: **657** Type: **Oral**

Gyrokinetic Study of Edge Blobs and Divertor Heat-Load Footprint

Wednesday 15 October 2014 15:40 (20 minutes)

For a better understanding of the complicated physics of the inter-related “intermittent plasma objects (blobs)” and divertor heat-load footprint, the full-function gyrokinetic PIC code XGC1 has been used in realistic diverted geometry. Neoclassical and turbulence physics are simulated together self-consistently in the presence of Monte Carlo neutral particles. Blobs are modeled here as electrostatic nonlinear turbulence phenomenon. It is found that the “blobs” are generated, together with the “holes,” around the steep density gradient region. XGC1 reasserts the previous findings [1] that blobs move out convectively into the scrape-off layer, while the holes move inward toward plasma core. The blob/hole generation, shape and dynamics are strongly related to the poloidal ErxB shearing. In a DIII-D H-mode plasma (#096333) with B0=2.1T, the median radial size of the density blobs in the scrape-off layer is only about 1 cm. The L-mode type large “blobs” occur only at the tail of PDF. While the blobs move out radially, they are carried toward the outer divertor plate by strong VExB (» Vr) in H-mode, consistently with experimental observation [2]. The measured radial width of the total heat load, mapped to the outer midplane, is only ≈4.4 mm. This width is much less than the median radial size of the intermittent plasma objects (~1cm). It is rather closer to the local banana width (~2.7mm), yielding approximately the 1/Ip -type scaling found from our previous pure neoclassical simulation [3] or a heuristic neoclassical argument Goldston. However, it also shows some spreading by the turbulence. The presentation will be extended to ITER plasma edge, where the ion banana width at separatrix becomes negligible compared to the meso-scale blob size, to report on the limit in the 1/Ip scaling by the intermittent turbulence. Also, detailed XGC1 study of the blob dynamics show that the blobs and their dynamics interact more strongly with presheath than with the Debye sheath. Similarities and differences with results from existing models will be presented. Comprehensive experimental validation on multiple tokamaks (DIII-D, NSTX, C-Mod, JET, etc) will also be presented.

[1] D. D’Ippolito et al., Phys. Plasmas 18 (2011) 060501

[2] J. Boedo et al., Phys. Plasmas 10 (2003) 1670

[3] Report on DOE FES Joint Facilities Research Milestone 2010 on Heat-Load Width, Appendix H

Country or International Organisation

USA

Paper Number

TH/2-3

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Session Classification: Pedestal Physics