Contribution ID: **750**

Type: **Poster**

Understanding the Blobby Turbulence in Edge Plasma from Gyrokinetic Simulation

Thursday, 20 October 2016 14:00 (4h 45m)

The importance of the nonlinear "blobby" turbulence (or "intermittent plasma objects") in the scrape-off layer (SOL) of the tokamak plasma has been well known. Blobs are usually measured and discussed for L-mode edge/SOL plasmas and inter-ELM SOL plasmas. However, blobs are also known to exist in steep H-mode pedestals. From ITER's perspective, understanding the H-mode blobs may be more important than the L-mode blobs for number of reasons: a) Strong blobby turbulence could limit the pedestal gradient before it reaches the kinetic ballooning mode or edge localized mode (ELM) limits, b) blobby turbulence may interact with ELMs and give rise to precursor activities, c) blobby turbulence can be responsible for expelling the fusion produced heat and helium ash particles across the last closed flux surface, d) it can play an important role in the impurity transport across the separatrix, e) it may contribute to the valuable inward momentum pinch from SOL to core, especially in interaction with the X-point orbit loss physics, and f) it may spread the divertor heat-load width. Here we present the first (to our knowledge) gyrokinetic study in realistic geometry. Importance of the full-function gyrokinetic study for the nonlinear edge blob physics cannot be emphasized enough since the blobs interact with the neoclassical kinetic physics and neutral particles in multi-scale and since the edge plasma is in non-Maxwellian state in contact with material walls. Since blobs are mostly electrostatic fluctuations, as known from experiments, we use XGC1 in its more-established electrostatic mode for this study. The size of the blobs from XGC1 agrees qualitatively with experimental data. The radial and poloidal correlation length is on the same order as the radial width of the whole edge region from pedestal top to SOL. Blobs are born in the steep plasma gradient region just inside the separatrix surface and propagate radially outward into the SOL. Other important properties of the blobs that are relevant to extrapolation to ITER will be discussed. A systematic validation with the existing data will also be attempted and presented. This work is supported by U.S. DOE under DE- AC02-09CH11466. This work used computing resources of ORNL, supported by DE-AC05- 00OR22725.

Paper Number

TH/P6-16

Country or International Organization

USA

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Session Classification: Poster 6

Track Classification: THD - Magnetic Confinement Theory and Modelling: Plasma–material interactions; divertors, limiters, SOL