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Tracking blobs to analyze turbulence in the edge of Tokamak

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Controlling scrape-off layer turbulence is one of the most essential problem to be resolved within this decade to "bring fusion power to the (US) grid". The problem is hard because of multifarious reasons. Primarily, the fluctuations are strongly nonlinear and intermittent. Electromagnetic effects further complexify the amenability of a reduced dimensional modelling. Fortunately, lately though, self-consistent theoretical tools have been devised to analyze such problems. Nonlinear gyrokinetic theory for the evolution of the 'full' distribution function (also called, 'full-f') have been developed [1] and successfully extended to capture electromagnetic effects.

Experimental results obtained from Gas-puff-imaging technique in the SOL of tokamak plasma showed the evidence of turbulence, primarily mediated via toroidally elongated density structures [2]. Recent simulations with electromagnetic full-f continuum gyrokinetic theory in the helical open-field-line region also confirmed the existence of such blob-mediated [3]. These coherent structures propagate in the radially outward direction with significant deformation and dissociation [4]. Thus the dynamics of these structures becomes difficult to track.

Isolating the three dimensional density structures from numerical data on computational grids is challenging. Furthermore, the dissociation and deformation of these structures along toroidal direction during their excursion in SOL, makes the problem of tracking even more complicated. In this work we provide a detailed report on our development of a multi-purpose numerical tool to identify such coherent density structures using a marching-cube algorithm. Identification of coherent structures in three dimensions is quite involved as compared to its two dimensional counterpart. We have delineated our three dimensional ray-tracing algorithm to identify such closed density iso-surfaces [6]. We also describe our 'tracking' algorithm to measure the velocity of these blobs. Finally we employ our algorithm on Gkeyll simulation results for ASDEX-like parameters, to capture and track these toroidally elongated structures [6]. Our study to detect and track the shape-changing multiple plasma blobs simultaneously is crucial to measure the heat load on the tokamak divertors.

Figure: Gkeyll simulation for AUG-like parameters. Density filaments shear-off from the separatrix region and fill-out the SOL area.

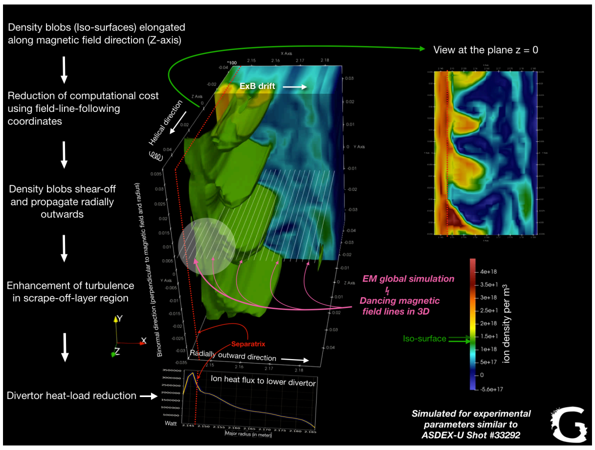

Figure 1: Gkeyll SOL flux-tube-like simulation captures the radial variation of the magnetic field (shown with thin white lines elongated in z-direction).

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