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Evolution of intermittent filaments in the scrape-off layer of NSTX

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Filamentary structures emerge from the background turbulence in scrape-off layer (SOL) plasmas and cause significant particle and heat transport while degrading plasma confinement. This transport can also contribute to intolerable heat loads on plasma facing components, can erode, melt, or permanently damage them [1]. Therefore, it is important to study their physics to predict and mitigate their behavior in future fusion reactors such as ITER. Plasma filaments (a.k.a. blobs) on the National Spherical Torus Experiment (NSTX) were studied by analyzing gas-puff imaging (GPI)[2,3] data measured in the edge and SOL plasmas.

Filaments were identified by a novel, watershed [4] segmentation-based algorithm (see Fig. 1) which finds their characterizing outlines and tracks them based on their intersection over union, their shape change and pair-wise spatial correlation. Their characterizing outlines were used to estimate the position (centroid), the angle, and the so-called shape descriptors (e.g., convexity, elongation, solidity) of the filaments (see Fig. 2). These metrics can be used to characterize the temporal evolution of the velocity, the rotation, and the shape of filaments.

The trends between plasma parameters (e.g., edge Thomson-profile fitted parameters, collisionality, edge current, divertor heat flux) and the estimated filament parameters were investigated. The connection between global plasma shape descriptors (elongation, triangularity, aspect ratio) and filament shape descriptors were analyzed, as well, to uncover how the plasma shape influences scrape-off layer transport.

These results extend the comprehensive research of blobs in Refs. [5,6] and the currently available SOL turbulence and transport models, e.g., in Ref. [7]. Subsequently, our research could also support the development of novel mitigation techniques to lower the heat load of the filaments on the plasma facing components.

References:
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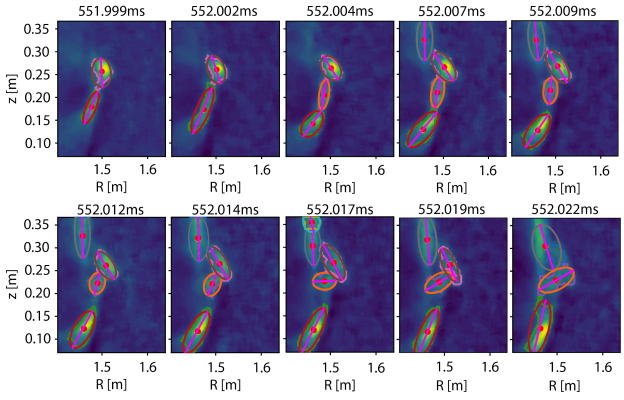

Figure 1: Individually tracked and identified blobs in NSTX shot #141319. The different colors depict the fitted ellipses on the tracked blobs while the magenta lines denote their major semi-axes.

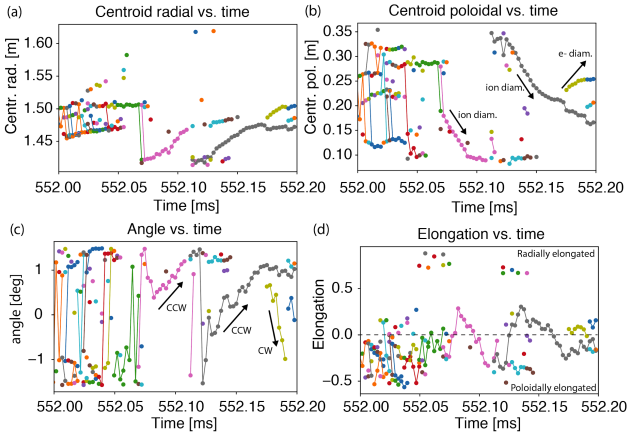

Figure 2: (a) Radial centroid vs time of the tracked blobs; (b) poloidal centroid vs time; (c) Angle of the major semi-axis vs time; (d) elongation vs time in NSTX shot #141319.