5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

# Translational and rotational dynamics of ELM filaments on NSTX

M. Lampert[1], A. Diallo[1], S. J. Zweben[1], J. R. Myra[2]
[1] Princeton Plasma Physics Laboratory
[2] Lodestar Research Corporation
e-mail (speaker): mlampert@pppl.gov

ELMs pose a high threat to future fusion energy production devices because their associated heat and particle loads on the plasma facing components exceed the tolerances of the currently available state-of-the-art materials. It is believed that the dynamics of the structures occurring during this instability, the ELM filaments, have a strong connection to the fast cross-field heat and particle transports. Gas-puff imaging (GPI) on NSTX can provide high temporal (2.5us) and spatial (10mm) resolution 2D measurements of these ELM filaments in the SOL and the plasma edge. Novel analysis techniques were developed for the analysis of the translational and rotational dynamics of this phenomenon [1]. These methods were applied to single ELM events to characterize the ELM crash dynamics, and then extended to a database of 159 ELM events. Statistical analysis was performed to assess the characterizing dynamics of the ELM crash [2].

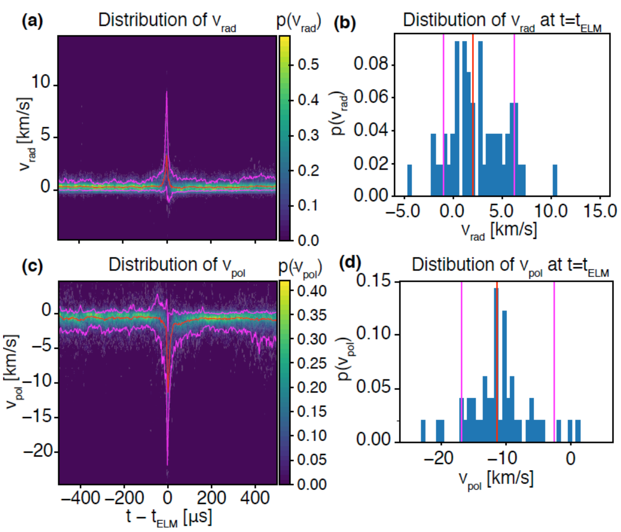


**Figure 1:** Evolution of the velocity distributions characterizing the filament propagation. Red: median velocity, magenta: 10th and 90th percentiles. (a) Radial velocity distribution evolution (b) Distribution of $v_{rad}$ at the ELM crash; (c) Evolution of the poloidal velocity distribution; (d) Distribution of $v_{pol}$ at the ELM crash.

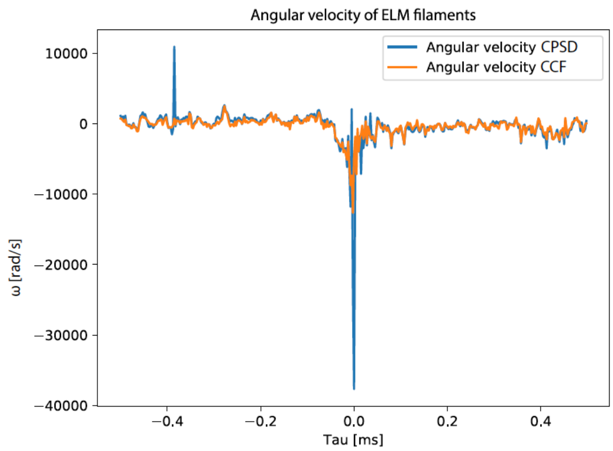


**Figure 2:** Angular velocity of ELM filaments calculated with cross-correlation based (orange) and cross-power spectral density based (blue) displacement estimation. Notice that the ELM filament experiences strong spinning up at the ELM crash.

Our results show that the ELM filament is characterized by outwards propagation with a peak velocity of 3.3km/s (3.7 $*v_{blob}$) and ion-diamagnetic poloidal propagation with 11.4 km/s (4.1$*v_{i,diam}$) (see Fig. 1). The analysis of the filament rotation revealed a spinning-up effect on the filaments during the ELM crash (see Fig. 2). The radial velocity of the filament was found to be linearly dependent on the distance of the filament from the separatrix which is an indication of exponential dependence of the velocity on time which has never been seen before.
The experimental findings were compared with analytical theory. The identified current filament model can explain most of the observations qualitatively, however, the linear dependence of the radial velocity on the radial distance or the spinning up of the filaments remains unclear. These effects were investigated with numerical modelling, as well, using non-linear MHD simulations.

**References**:

[1] M. Lampert et al: Novel 2D velocity estimation method for large transient events in plasmas, accepted for publication in Review of Scientific Instruments
[2] M. Lampert et al: Dynamics of filaments during the edge-localized mode crash on NSTX, Phys. Plasmas **28**, 022304 (2021)