Analysis of 3D filament structures in various magnetic configurations of the W7-X stellarator

A. Buzas[1,2], C. Biedermann[3], G. Cseh[1], B. Csillag[1], G. Kocsis[1], T. Szepesi[1], S. Zoletnik[1] and the W7-X Team *

[1] *Centre for Energy Research, Budapest, Hungary*

[2] *Institute of Nuclear Techniques, BME, Budapest, Hungary*

[3] *Max-Planck-Institute for Plasma Physics, Greifswald, Germany*

Filaments in fusion plasmas are high-density structures aligned with magnetic field lines and can be responsible for a significant portion of particle transport in the plasma edge. Their origin is often linked to density perturbations caused by interchange modes, in which curvature and ∇B drifts result in charge separation. This polarized structure is moved by E $\times$ B drift [1]. Such filaments have been observed on W7-X by multiple diagnostics, including fast-cameras [2], alkali beam emission spectroscopy [3] and reciprocating probes [4].

Due to the complex magnetic geometry, the 2-D description of filaments in W7-X, as it is common on tokamaks, is insufficient, a 3-D treatment is necessary. Most diagnostics offer a 1 or 2-D view on filaments, focusing on radial or poloidal motion. To reveal 3-D behaviour, the W7-X fast-camera system [5] offers a tangential vantage point, from where both poloidal movement and toroidal structure are visible, including toroidal turn around.

In this study, an analysis of W7-X fast-camera images from various divertor configurations is presented. The gathered light is filtered to different atomic emission lines, such as H_α and C III (due to the carbon divertors, it is a common impurity in the edge plasma). Pixel-wise correlations of images from various shots of standard, high and low ι configurations are compared to highlight differences in filament geometry and dynamics. Shape and toroidal extent is examined and showcased in the context of the magnetic geometry by overlaying the projection of magnetic field lines and flux surfaces. Poloidal rotation of filaments is often seen. Localization and direction of movement is mapped, its velocity estimated. Results are compared to those of other diagnostics.

References

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