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METHOD FOR OBSERVING FILAMENTS OF EDGE LOCALIZED MODES OF THE GLOBUS-M2 TOKAMAK USING HIGH-SPEED CAMERA *)

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The study of edge localized modes (ELMs) and associated plasma filaments is an important task in connection with the problem of limiting the peak heat fluxes to the plasma facing elements of tokamaks [1]. High-speed camera diagnostics is an effective technique for visualization of the spatial structure and temporal dynamics of filaments. For this purpose, a diagnostic complex for high-speed plasma imaging, consisting of three fast cameras, was created on the Globus-M2 spherical tokamak. Also, a software package for processing the resulting images was developed.

The difficulty in filaments imaging lies in their high speed and low brightness relative to background plasma radiation. The typical exposure used is 2–5 μs. At the same time, the frame rate required to observe their dynamics is at least 100 kHz. To achieve a high frame rate, a significant narrowing of the working area of the camera matrix is required, which makes it difficult to analyze the spatial structure of the filaments. To solve this problem, simultaneous imaging with two cameras was used. The first one is a “survey” camera with a relatively low frame rate and a wide viewing angle for analyzing the spatial characteristics of filaments (localization, mode, size). The second one is “fast” with a high frame rate and a relatively small field of view for analyzing temporal characteristics (speed, lifetime).

Pre-processing of images consists of median and bilateral [3] filtering. Next, to increase the contrast of filaments, an algorithm for removing stationary background radiation from images is implemented. The standard algorithm for calculating the background by simply averaging neighboring frames produces significant distortions that complicate further image analysis. Therefore, a new algorithm was developed that eliminates the effects of background inhomogeneity caused by filaments from adjacent frames.

To spatially calibrate the camera's viewing area and compare the observed filaments with magnetic field lines, the CalCam [4] code was used. The magnetic configuration is calculated either by the pyGSS code [5] followed by the field line tracing using the PLEQUE code [6], or only the FreeGS code is used [7]. The observed filaments coincide well with the field lines lying close to the separatrix. The characteristic sizes of 2–3 cm and velocities of 5–10 km/s of the observed filaments were determined.

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