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Rotational movement analysis for cylindrical plasma images obtained with tomography

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In the PANTA cylindrical device, a turbulence tomography system has been developed and has successfully provided two-dimensional images of plasma emission and its fluctuations[1, 2]. We have also developed analyzing methods for tomography images in order to characterize structure and fluctuations. The Fourier-rectangular function (FRF) transform was proposed to extract the local modal structure of fluctuations by expanding an image using radially localized basis functions[3]. Based on the FRF transform, we have developed novel methods such as Modal polarization analysis(MPA) and Rotational movement analysis(RoMA), to extract plasma rotational motion. Plasma rotation, or azimuthal flow, strongly impacts plasma structure through transport. These techniques enable the evaluation of the local rotational movement by utilizing FRF expansion. In this talk, we present the details of these two methods and results of their application to PANTA plasmas.

MPA classifies the rotational states of each azimuthal mode into three categories: rotating, standing, and random. The amplitude of each component can be obtained as a function of radius. Applying MPA to PANTA tomography data reveals a clear difference of rotational characteristics of fluctuations on azimuthal mode number and radial position[4]. Furthermore, the intermittent evolution of fluctuation amplitude can be explained with a particular combination of these three components.

RoMA can infer the rotational velocity from the azimuthal evolution of fluctuation patterns[5, 6]. The application of RoMA provides new findings of rotational velocity modulation. The target plasma is dominated by $m = 4$ drift wave, as shown in Fig. 1. The $m = 4$ drift wave mode coexists with the $m = 1$ mode and is nonlinearly coupled. One of the advantages of RoMA is that it can obtain temporal evolution of rotational velocity. The frequency spectra of the rotational velocity show peak at $f = 1.6$ kHz, as shown in Fig. 2. The peak frequency at $f = 1.6$ kHz corresponds to the $m = 1$ mode frequency, although a simple pattern deformation due to the m=1 mode cannot cause the modulation if it shows purely the $\cos\theta$ dependence since the estimated velocity is azimuthally averaged. Therefore, these modulations should be caused by an unknown mechanism, which requires further investigation.

Finally, the proposed analyzing methods, such as MPA and RoMA, for tomography images of plasma produce interesting results. These methods can be extended to other imaging diagnostics such as high-speed cameras, electron cyclotron emission imaging.

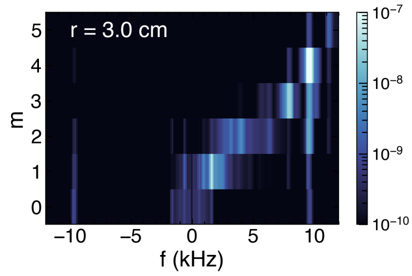

Figure 1. Power spectrum of emission fluctuations decomposed into azimuthal modes at $r = 3.0$ cm.

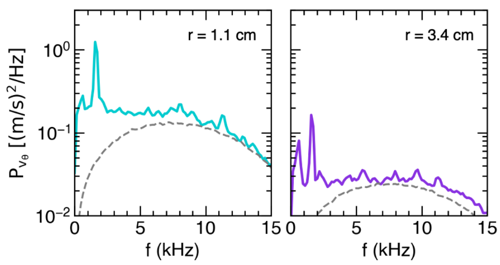

Figure 2. Power spectra of rotational velocity at each radial position. Dashed lines represent estimated noise levels.

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