

The spatial structure of flows, Reynolds stress and turbulence in the CASTOR tokamak

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INTRODUCTION

Recently zonal flow like structures have been observed close to last closed flux surface of CASTOR tokamak by electrostatic probe measurement and their spatio-temporal characteristics have been described [1]. In order to obtain information about the underlying complex dynamical behavior of the flow fluctuations we have constructed a new array of electrostatic probes, which is able to measure the time evolution of the radial gradient of Reynolds-stress, what is supposed to be the driving force of zonal flows. In our recent measurements with this new Reynolds-stress probe, we found a strong radial gradient of Reynolds-stress in the same region, where zonal flow like structures appeared. The spatial structure of the basic plasma fluctuation (microsecond scale) was also studied using a poloidal ring of Langmuir probes together with a toroidally separated Reynolds probe. Additionally to radially and poloidally localized high correlation along a flux tube, structures with longer radial correlation and $m=q$ poloidal mode number were observed. Measured characteristics of these features are presented in the paper.

MEASUREMENTS WITH THE DOUBLE RAKE PROBE

CASTOR is a small tokamak with a minor radius of 9cm and relatively low density and temperature, therefore it is possible to use Langmuir probes to diagnose fluctuations up to the 60% of the minor radius.

Recently using autocorrelation width technique, random flow modulations have been observed [1] with relative fluctuation amplitude of about 10 – 20%, radial length of 1 – 2cm and high poloidal elongation. The importance of Reynolds-stress in generation of turbulence induced random flow was recognized by recent theories[2]. In order to investigate turbulent Reynolds-stress experimentally a new kind of rake probe was de-

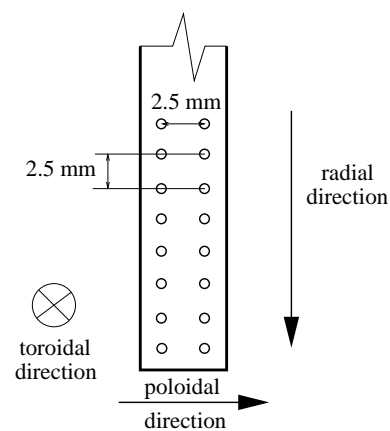


Figure 1: The scheme of the double rake probe.

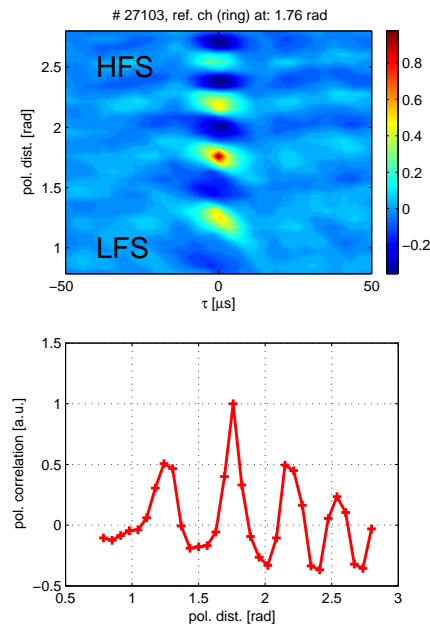


Figure 3: Spatial correlation pattern along the ring probe.

SOL' or long connection length region in CASTOR. As it is clear from Fig. 3, these wave-like structures 'live' on short (microsecond) timescale. Beside these wave-like events, of course the eddy-like structures are also present. The question we would like to address here is the following: Dealing with floating potential raw signals whether any significant differences in the statistical properties of a suitably defined quantity could be found or not? In order to separate wave-like structures from the poloidally and radially localized turbulent eddies it seems to be possible to apply poloidal correlation function for a spatial filtering of the fluctuating raw signal Fig. 4.

This procedure uses the poloidal correlation function (along the ring) at zero time lag as filter-function. Multiplying all raw signals at all time points by this filter-function and averaging over different reference points we can get a new time record which highlights times where the wave-like structure dominates in the original signal. It has to be noted that the filtered signal has a clear bursty behavior in the tokamak regions where the wave-like correlations appear. It is also interesting to note (see Fig. 5) that this difference (see PDFs of different signals) is completely invisible when we look at the raw signals.

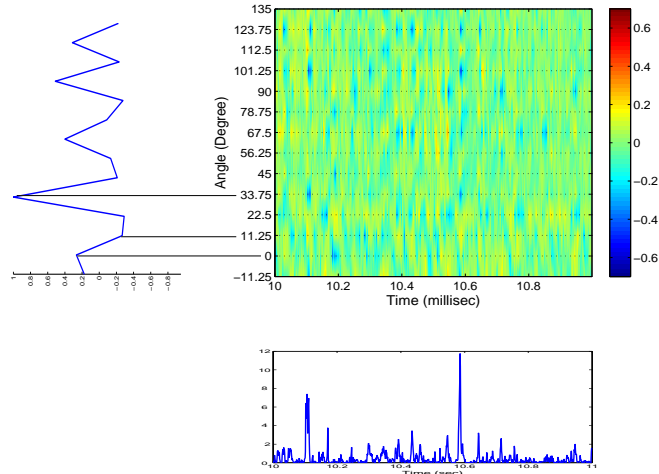


Figure 4: After multiplying the raw signal by the spatial correlation function as a filter, we can get the filtered signal which has a significant bursty behavior when wave-like events are dominant.

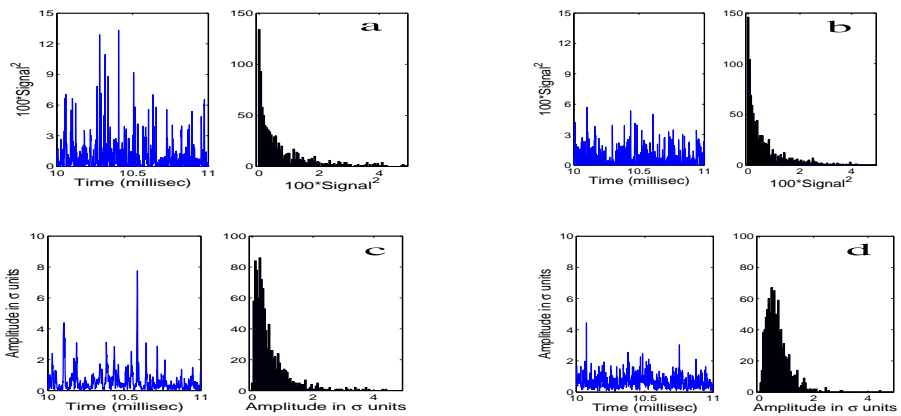


Figure 5: (a) Unfiltered signal and its PDF from the top of the plasma column. (b) Unfiltered signal and its PDF from the bottom of the plasma column. (c) Filtered signal and its PDF from the top of the plasma column. (d) Filtered signal and its PDF from the bottom of the plasma column.

Acknowledgment

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References

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- [2] Diamond P H et al. Plasma Phys. Control. Fusion **47** (2005) R35-R161