34th EPS Conference on Plasma Phys. Warsaw, 2 - 6 July 2007 ECA Vol.31F, P-1.086 (2007)

Study of the statistical properties of fluctuations in the plasma boundary region of the TJ-II stellarator

J. Brotankova[1], R.O. Orozco[2], M.A. Pedrosa[2], C. Hidalgo[2], E. Sanchez[2], J. Stockel[1]

[1]*Institute of Plasma Physics, Association Euratom/IPP.CR, AS CR, Prague, Czech Republic*

[2]*Laboratorio Nacional de Fusion, Euratom-Ciemat, 28040 Madrid, Spain*

Introduction.

Improved confinement regimes are reached whenever turbulent transport is reduced and a highly sheared plasma flow is observed. This behaviour is interpreted as turbulence suppression occurring when the shearing rate of ExB velocity drift exceeds a critical value related to broadband turbulence frequency. The investigation of the influence of ExB sheared velocities and magnetic topology on the statistical properties of turbulence in the plasma boundary region of fusion devices is a topic of great interest.

The statistical properties of fluctuations have been investigated in different toroidal and linear devices [1]. Analysis of skewness and time asymmetry of floating potential and ion saturation current is described in [2]. This analysis was performed for several fusion devices (tokamaks, stellarators) and non-fusion low temperature devices. A clear deviation from Gaussianity was observed in the SOL, while in the proximity of the velocity shear layer (VSL), the statistical properties of the fluctuations show near Gaussian character. It was concluded in [2] that this behaviour was probably caused by ExB shear effects. This conclusion was later called into question in [3], showing that magnetic topology might play a leading role to explain the modification in the statistical properties of fluctuations in the proximity of the last closed flux surface.

The goal of this work is to assess the role of both magnetic topology and sheared flows on the statistical properties of fluctuations in the plasma boundary region of fusion plasmas.

Experimental set-up and analysis tools

In order to investigate the statistical parameters of TJ-II stellarator, data from reciprocating Langmuir probe system [4] were investigated. This system consists of three groups of Langmuir probes at two radial and two poloidal positions. Each group includes one tip collecting ion saturation current and two tips measuring floating potential. A boron-nitride probe head supports these tungsten tips (~0.7 mm in diameter and 2.5 mm in length) which can be either exposed to the plasma in one radial position, or they can be quickly moved in and out of the plasma, scanning the plasma boundary during one shot.

A graphite electrode was used for the biasing of edge plasma. The electrode head is mushroom shaped and made of 2-D Carbon composite, with height (radial extension) of 12 mm and a diameter of 25 mm. The electrode was inserted typically 2 cm inside the LCFS and biased with respect to one of the TJ-II limiters (typically +300V).

Probability distribution function (PDF) and its moments were investigated for ion saturation current and floating potential signals. Skewness and kurtosis are defined as the second and third moment of PDF, respectively. The third important quantity is the time asymmetry, which is defined as the second moment (skewness) of the time derivative of the fluctuating part of the signal [2].

Experimental results

Previous experiments have shown that the plasma density (or density gradient) plays a crucial role in establishing the ExB shear in TJ-II stellarator. A threshold density has been identified to trigger the development of edge sheared flows [5, 6]. During shots with density above this threshold value, a natural edge velocity shear is established. On the contrary, in plasmas with density below this threshold value, there is no natural shear. These regimes were used to obtain the answers for the main questions:

- What is the role of the natural ExB shear in the statistical parameters?
- How is the situation changed by the imposed ExB shear (via electrode biasing)?
- What is the role of the magnetic topology?

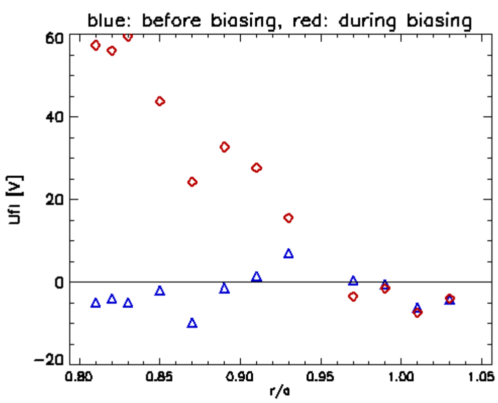

Figure 1. Radial profile of floating potential.

Plasmas with different magnetic topology, with plasma densities above and below the threshold value to trigger edge sheared flows, with and without biasing were investigated (fig.1). A broad spectrum of statistical properties was investigated: skewness, kurtosis and time asymmetry of both ion saturation current and floating potential. The clearest results come from the time asymmetry of the floating potential $A(U_{fl})$, thus only this parameter will be discussed in the present paper.

Figure 2 shows the time evolution of time asymmetry of floating potential ($A(U_{fl})$) at different radial positions for high and low density regimes and during the biasing time window. It is concluded that:

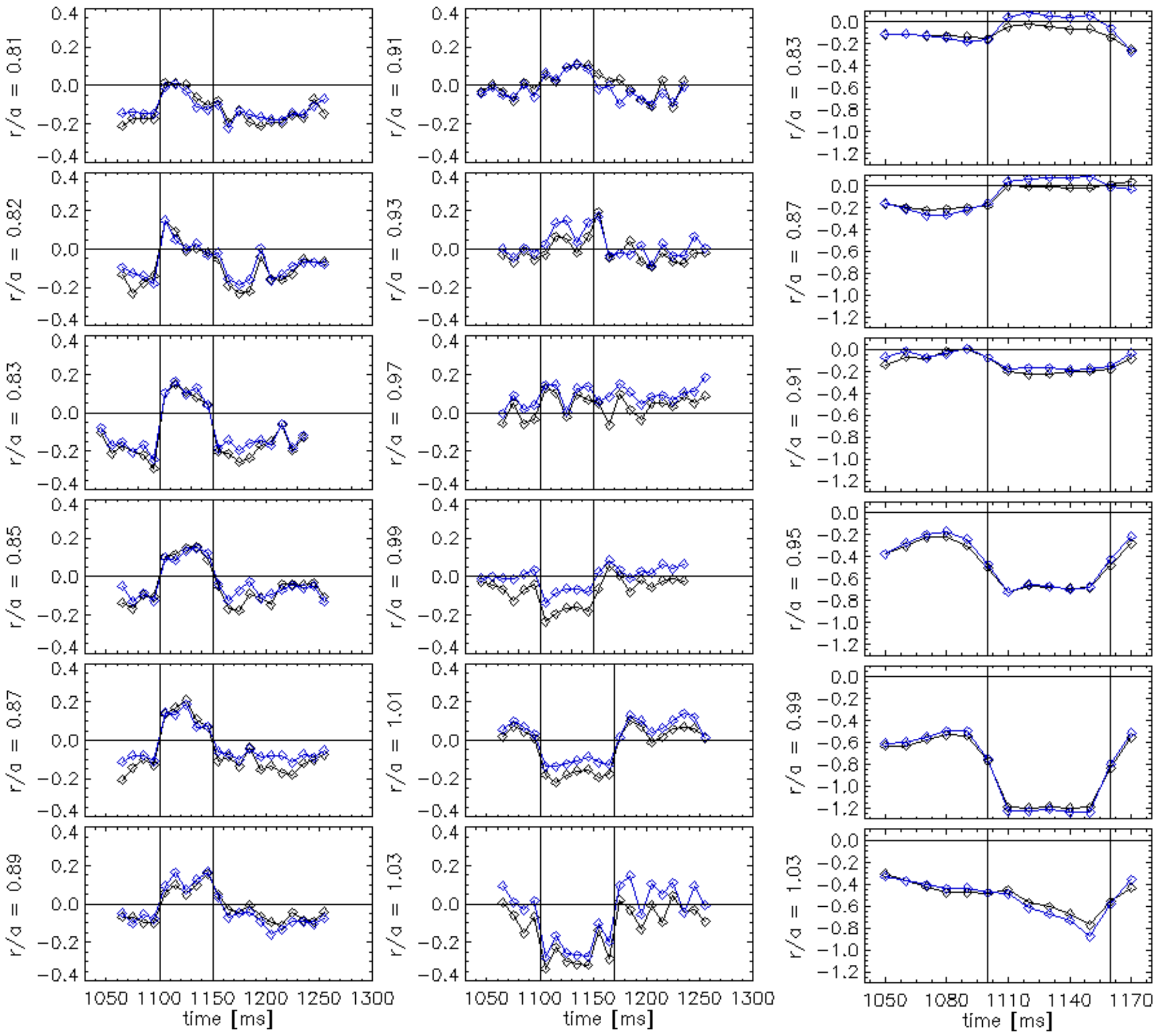

Figure 2. Time evolution of time asymmetry of floating potential ($A(U_{fl})$) for different radial positions (r/a). Left and center: regime with high density shots ($n > n_{threshold}$) with biasing (vertical black lines). Right: regime with low density shots ($n < n_{threshold}$) with biasing.

a) <u>*Natural shear – high density regimes*</u> ($n > n_{threshold}$): $A(U_{fl})$ is negative inside (i.e. radially inwards) of the edge shear layer location and tends to zero around the shear location.

b) <u>*No natural shear – low density regimes*</u> ($n < n_{threshold}$): $A(U_{fl})$ is negative at all the radii, inside the plasma it tends to come to zero.

c) <u>*Biasing induced shear flow –*</u> For the high density shots ($n > n_{threshold}$), the characteristics of $A(U_{fl})$ changes systematically radially. In the plasma region (r/a ≈ 0.83 – 0.91) it rises to positive values whereas outside (r/a ≈ 0.99 – 1.03) it drops into negative as is showed in fig.2. Around the shear layer, $A(U_{fl})$ remains constant. Similar trends have been found at low density. These experiments clearly show the importance of electric fields on the statistical properties (A parameter) of fluctuations.

<u>*The role of magnetic topology*</u>: Previous investigations in [3] were well reproduced, showing that the time asymmetry of floating potential changes with the magnetic topology, increasing significantly from the open field lines region (SOL) to inside the LCFS (closed flux surfaces) as is shown in fig.3. Inside the plasma bulk, the development of ExB shear does not change the behaviour of $A(U_{fl})$.

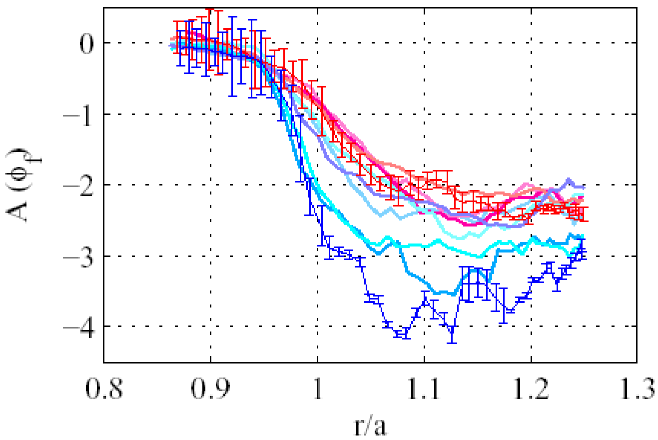

Figure 3. Radial profile of time asymmetry of floating potential [3]. Blue lines: low density (no shear). Red lines: high density (shear).

Conclusion

In conclusion, the investigation of the statistical properties of fluctuations in the plasma boundary region of the TJ-II stellarator shows that the time asymmetry of turbulent bursts is affected both by magnetic topology and radial electric fields. This means that the mechanism leading to changes in the shape of turbulence in the edge plasma is caused not only by the ExB shear, but is also related to the magnetic topology.

References

[1] S. Zweben et al., Plasma Physics and Controlled Fusion 49 (2007) S1.

[2] E. Sanchez et al., Physics of Plasma, 2000, vol.**7**, no.5.

[3] R.O. Orozco et. al., EPS proceedings, Vol.**29C**, P-5.031 (2005).

[4] M. A. Pedrosa et. al., Review of Scientific Instruments, 1999, vol. **70**, no. 1.

[5] C. Hidalgo et al., Phys. Rev. E, 70 (2004) 067402.

[6] M.A. Pedrosa et al., Plasma Phys. Control. Fusion **47** (2005) 777.