

Structure of the edge fluctuations in the W7-AS stellarator

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1. Introduction. The turbulent fluctuations in the SOL and the outer confinement zone of the W7-AS stellarator are spatially and temporally resolved using Langmuir probe arrays. The main topic is the investigation of the structure of these fluctuations both perpendicular to and along the magnetic field.

Perpendicular to the magnetic field we apply two different techniques to obtain a 2d - representation of the fluctuations' structure. A right angled probe array, with legs in the radial and the poloidal direction, allows the calculation of a 2d - correlation function under the assumption of poloidal homogeneity of the turbulence. A 2d - representation is also derived using one poloidal probe array and one single probe toroidally separated for conditions where a high correlation along the connecting field line exists as in our earlier experiments [1]. Generally, a 2d - analysis is necessary for the investigation of radial properties of the fluctuations like the radial size or the radial propagation velocity.

Formerly, a very high correlation of about 90% for floating potential and ion saturation current fluctuations over a distance of about 6 m along a magnetic field line [1] was found. In these experiments two toroidally separated Langmuir probes were connected by a field line that stayed on the outside of the torus, where fluctuations are known to be driven unstable, over the whole connection length. In this paper, measurements along a field line that passes the inside, where fluctuations are partly suppressed, are presented. In general the maximum correlation is observed along the wavefront which is nearly parallel to the magnetic field since k_{\parallel} is usually very small. The inclination between wavefront and magnetic field can be observed in our experiments and therefore k_{\parallel} can be calculated.

2. Structure in the radial-poloidal plane. The derivation of a 2d-correlation function from a measurement using an angled probe array is described in [1]. The second method uses an experimental setup with two toroidally separated probes connected by a field line of 6 m connection length. One of them is a single probe, while the other is a poloidally resolving probe array. Since for this configuration a correlation of about 90% was observed along the field line [1] the fluctuations undergo nearly no change along the field. Thus the signal observed by the single probe is nearly the same as it would be in the toroidal plane of the probe array at the point where the projection of the single probe along the field line is situated. This point is used as a reference point and therefore defines the

origin of the 2d-correlation function. During the shot the probe array is moved radially about 6 cm into the plasma. This movement is relatively slow (400 ms) so that the probe movement is negligible within time windows of 10 ms, which are necessary to obtain a statistically stable correlation function. All the correlation functions between the single probe and the probe array that can be calculated for the different radial positions of the array can be combined into a 2d-correlation function depending on time-delay, the radial distance and - due to the poloidal resolution of the array - also on the poloidal distance from the reference point. The experimental flexibility of this method is quite restricted since it needs a specific magnetic field geometry to connect both probes. Nevertheless it is possible to measure 2d - correlation functions that are extended across the LCFS in the radial direction.

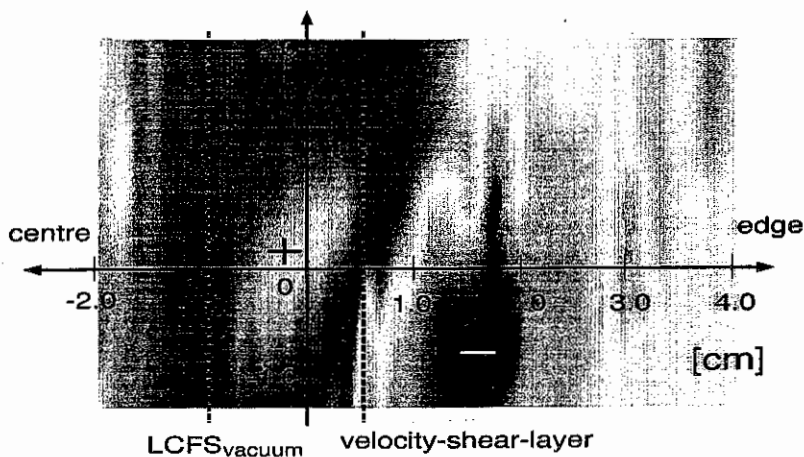


Figure 1: 2d-correlation function that extends over the LCFS for constant time-delay $\tau=0$. Radial-poloidal plane.

In the case shown in fig. 1 the origin is very close to the LCFS indicated both by the LCFS from a vacuum-field calculation which is typically 1 cm inside the LCFS corrected for finite β and by the velocity-shear-layer which is typically 0.5 cm outwards respectively. The fluctuating structure of fig. 1 is clearly extended both into the confinement zone and the SOL.

The 2d correlation analysis in the SOL by use of an angled probe array [1] shows quite similar structures for both floating-potential- and ion-saturation-current-fluctuations. Both

have the well known oblique structure in the radial-poloidal plane as it has been observed before in case of floating-potential-fluctuations [1]. Setting up the probe array such that the radial probe tips measure floating-potential and the poloidal ones ion-saturation-current, the 2d cross-correlation between potential and density fluctuations can be obtained. The maximum correlation is hereby shifted in time and space indicating a phase shift between potential and density which causes transport due to these fluctuations. The obliqueness in the radial-poloidal plane means that the particle flux by fluctuations is not purely radial but that it has a significant poloidal component.

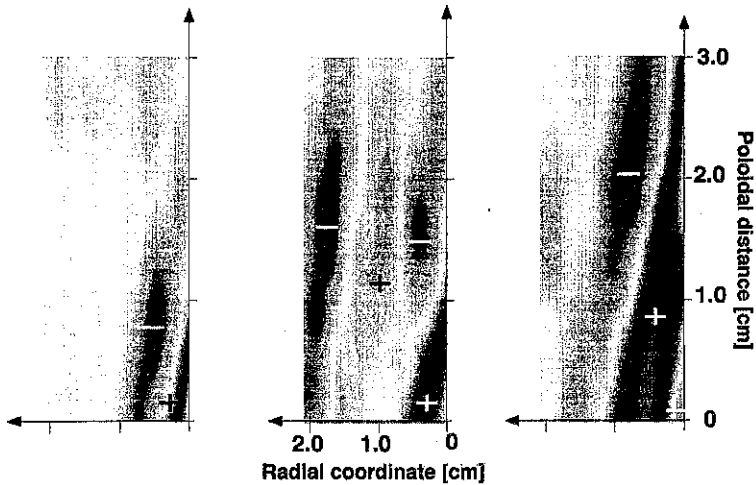


Figure 2: 2d-correlation functions ($\tau = 0$) obtained by an angled probe array for floating-potential (left) and ion-saturation-current (middle). The cross-correlation between floating-potential and ion-saturation-current is shown right.

3. Correlation along field lines passing the torus inside. The experimental setup at W7-AS allows connection of two toroidally separated probes by a magnetic field line that passes the inside of the torus and has a connection length of 32 m. Due to the suppression of fluctuations in the regions of good magnetic curvature and due to the long connection length the correlation observed is only around 40% for both floating-potential and ion-saturation-current. In these experiments the connection between both probes is

only possible within the confinement zone of W7-AS.

In this case the correlation is no longer along the computed magnetic field line but there is a shift in the poloidal direction observed. This shift can be explained by a nonzero k_{\parallel} since the correlation is observed along the wavefront which is no longer along the magnetic field, if k_{\parallel} is different from zero.

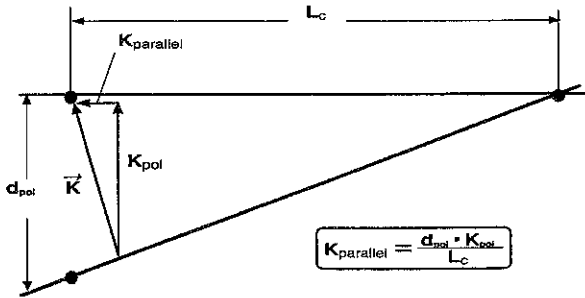


Figure 3: Schematic view of the experimental setup for the measurement of k_{\parallel} .

The experimental results give $k_{\parallel} = 0.0098 \frac{1}{m}$, which corresponds to a parallel wavelength of $\lambda_{\parallel} \approx 320 m$.

4. Conclusion. Analysing the structure of edge fluctuations in the W7-AS stellarator we found that in the radial-poloidal plane these fluctuations look like deformed convective cells with a longer half width in the poloidal than in the radial direction. As mentioned earlier [1], these fluctuations are oblique in the radial-poloidal plane. The potential-density cross-correlation showed in addition that the fluctuation-induced particle flux is not purely in the radial direction but that it has a significant poloidal component. Along the magnetic field we observed very long wavelengths of the fluctuations in the order of some 300 meters. Good curvature does not suppress fluctuations completely.

5. References

- [1] J. Bleuel et. al., Proc. 23rd EPS Conference on Controlled Fusion and Plasma Physics, Kiev 1996, volume 20C, part II, pp. 727-730