

OBSERVATION OF TOROIDALLY SYMMETRIC OSCILLATIONS IN THE SOFT X-RAY SPECTRAL REGION ON THE EXTRAP-T2 RFP

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1. Introduction

The intensity of radiation emitted by a magnetically confined plasma in the soft X-ray spectral region is a strong function of the electron temperature and density. Soft X-ray detector arrays are commonly used to study the spatial and temporal dependence of soft X-ray emission. The results can be related to magnetohydrodynamics and other plasma phenomena in the high temperature central region of the plasma. At the EXTRAP-T2 reversed field pinch (RFP) filtered surface barrier diodes (SBD) measure the intensity of the emitted radiation above 1 keV from the plasma at different toroidal and poloidal locations with a time resolution of 1 μ s. The SBD signals have a very high degree of toroidal and poloidal symmetry. In some discharges the SBD signals exhibit fluctuations with frequencies of around 15 kHz and amplitude variations of up to 40%, which are correlated with toroidally localized toroidal flux oscillations with amplitude variations of about 1%, and toroidally localized fluctuations of the H_α emission. The toroidally localized $m = 0$ dynamo magnetic fluctuation is strongly correlated both with fluctuations at the edge and in central regions of the plasma on the fast time scale corresponding to 15 kHz oscillations, which suggests that the dynamo activity is a mechanism that affects interaction between the core of the plasma and the edge.

2. Experimental

The SBD array consists of three lines-of-sight toroidally placed at 157.5°, 304° and 337.5° and at the same poloidal location. The signal from the SBDs is amplified and digitized on the same board with a sampling frequency of 1 MHz and a 12 bit resolution. Data has been analyzed by applying the fast Fourier-transform algorithm 50 μ s consecutive to ensembles of 1 ms and computing the one-sided power spectrum. These power spectra are compared with those obtained from other diagnostics.

3. Results and Discussion

The experiment has been performed at standard EXTRAP-T2 parameters [1] with plasma currents in the range 120–210 kA and with a line averaged electron density in the range $1\text{--}10 \times 10^{19} \text{ m}^{-3}$. The time traces of discharge #6775 (Fig. 1) show the time evolution for the SBD signals measured at the toroidal location of 157.5° and 337.5° and the same poloidal position. Also shown are the time traces for H_α at 203°, H_β at 155°, poloidal loop voltage at 208°, plasma current and electron density. At about 6 ms into the discharge a 13 kHz oscillation is seen in the SBD signals. This oscillation also shows up in the poloidal loop voltage and in the H_α

emission at 203° . Furthermore at that time the H_α emission increases dramatically and the C III emission at 229.69 nm at 203° , not shown in the timetraces, is greatly enhanced. This event is very toroidally localized, there is no corresponding event in the H_β emission at 155° .

3.1. High degree of toroidal and poloidal symmetry

A remarkable feature of the SBD signals on all the discharges is their temporal correlation as seen in timetraces of the SBD signals shown in Figure 1. This correlation is even more evident looking at the one-sided power spectrum (Fig. 2) of the signals. The contour plot of the power as a function of time and frequency shows that power is mainly going into the frequencies 13 kHz, 17 kHz, 12 kHz and 14 kHz. This happens simultaneously at two toroidal positions separated by 180° . Further temporal correlations of the SBD signals measured at various poloidal and toroidal positions show a high degree of toroidal and poloidal symmetry of the emission. This might be indicative of global toroidally and poloidally symmetric fluctuations in the plasma core.

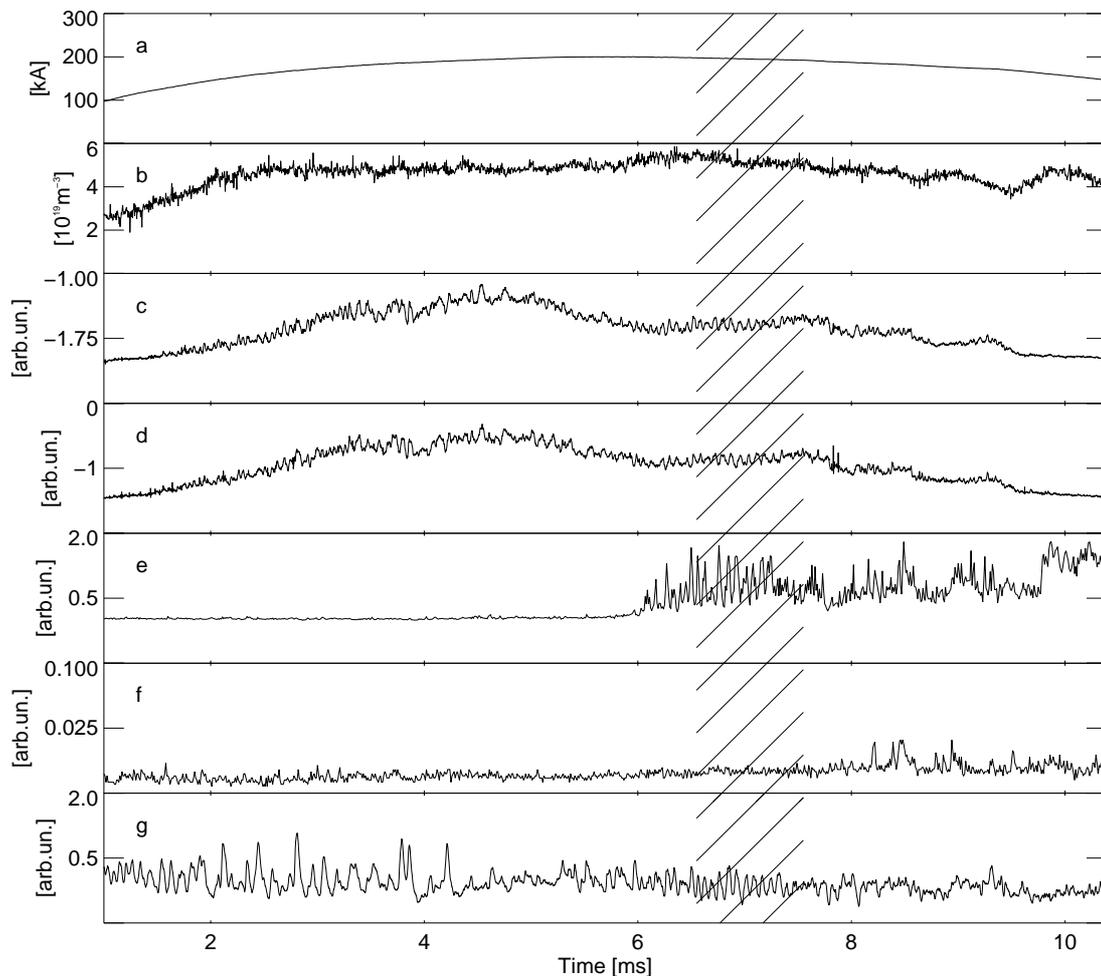


Figure 1. Time traces for discharge #6775 for plasma current (a), electron density (b), SBD signals measured at the toroidal location of 337.5° (c) and 157.5° (d), H_α emission at 203° (e) and H_β emission at 155° (f) and poloidal loop voltage at 208° (g). At about 6 ms into the discharge a 13 kHz oscillation is seen on some of the signals.

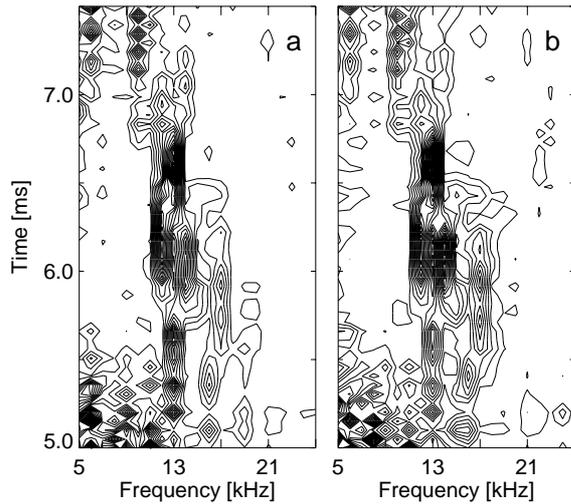


Figure 2. A clear resemblance is seen comparing the one-sided power spectrum of SBD signals measured at the toroidal location of 157.5° (a) and 337.5° (b).

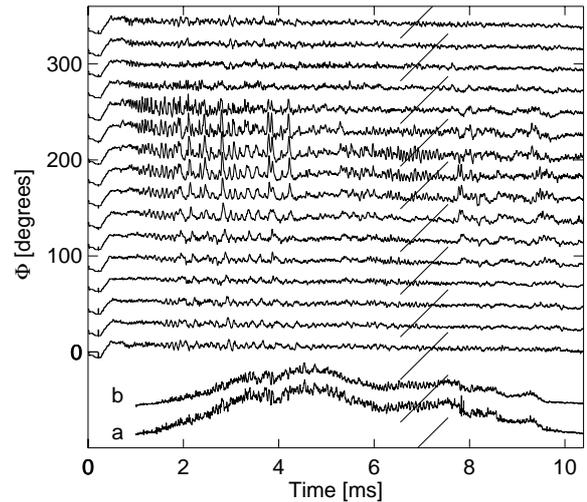


Figure 3. Poloidal loop voltage measured toroidally at sixteen locations plotted together with the SBD signals measured at the toroidal location of 157.5° (a) and 337.5° (b). The oscillations seen on the SBD signals can be correlated to a local toroidal flux perturbation.

3.2. Correlations with other diagnostics

Amplitude fluctuations observed in the SBD signals are correlated to oscillations in the poloidal loop voltage. Time traces for the poloidal loop voltage measured at sixteen toroidal positions uniformly spaced around the torus are plotted for the same discharge (#6775) in Figure 3 together with the signals measured by the SBDs. At about 6 ms a toroidally localized fluctuation is seen on the poloidal loop voltage. The oscillations observed in the SBD signals seem to be strongly correlated to this local toroidal flux perturbation. Figure 4 demonstrates the resemblance of the power spectrum of the SBD signal at 337.5° with that of the poloidal loop voltage at 208° which differs from that at 230° . The toroidal flux perturbations have been interpreted as a local dynamo event in the vicinity of the wall locked mode [2]. The observation suggests dynamics in the high temperature central region of the plasma to be correlated with toroidally localized dynamo events. We next consider the behaviour of the plasma at the edge during those oscillations. As seen in Figure 1 at about 6 ms there is a well localized increase of H_α emission at 203° . Comparing the power spectrum of the SBD signal at 337.5° and the H_α emission at 203° in Figure 4 one notices their clear resemblance. It appears that the H_α edge signal also might be correlated to the oscillating local dynamo event.

4. Conclusions

Toroidal and poloidal symmetric oscillations have been observed in signals of the SBDs at the Extrap-T2. In these first studies we found a close correlation of the power spectrum of these oscillations to that of the local flux oscillations. This observation indicates the possibility that dynamics in the high temperature central region of the plasma are correlated with localized dynamo events. Furthermore, the oscillations are correlated with plasma wall interaction.

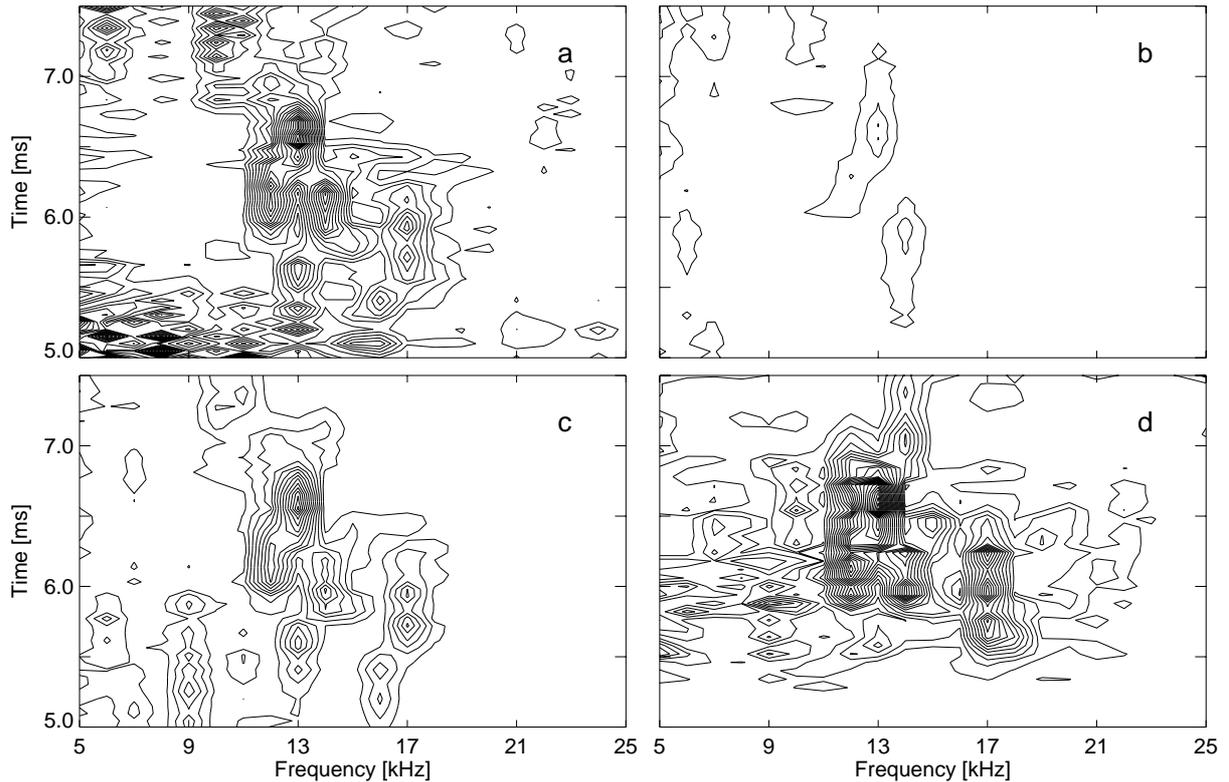


Figure 4. Comparison of the one-sided power spectrum of SBD signals measured at 337.5° (a), the poloidal loop voltage at 230° (b), and 208° (c), and H_α emission at 203° (d). A clear correlation of the toroidally localized flux perturbation with diagnostics sensitive to the central core temperature and a diagnostic sensitive to (localized plasma wall interaction) wall recycling can be seen.

Two possible explanations are being considered. First, the localized dynamo activity can cause displacements of flux surfaces which independently affect plasma wall interaction (H_α oscillations) and the core region (SBD oscillations). An alternative is that the dynamo activity reflects transport related temperature decreases which result in correlated plasma wall interaction. These alternatives as well as other possible effects, will be subject of further study.

Acknowledgement

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References

- [1] J.R. Drake et. al.: IAEA, Montreal, IAEA-CN-64/CP-11 (1997)
- [2] G. Hedin: *to appear in Plasma Phys. Contr. Fusion* (1998)