

## Electrostatic turbulence driven by positive biasing in Texas Helimak

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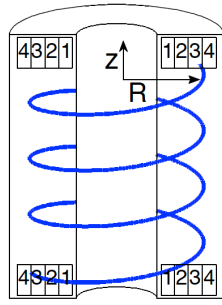
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Plasma edge turbulence have been investigated in several fusion and simpler magnetic plasma devices [1]. Generally, such observed turbulence in the density fluctuations consists of two components: a broadband background fluctuation and a sequence of large intermittent bursts [2].

Experiments have been performed to study electrostatic turbulence in plasmas with flow and magnetic shear in helimaks [3 - 6]. The helimak is one of a class of basic plasma experiments with characteristics of edge fusion plasmas in a simple geometry. This basic plasma toroidal device has a sheared cylindrical slab that simplifies the turbulence description and provides results that can be used to understand plasma edge and the scrape-off layer characteristics in major fusion machines. As the plasma of helimak is colder and less dense when compared with tokamaks, it is possible to use a large set of diagnostic probes. These characteristics make the helimak an interesting device to study the plasma flow shear influence on wave turbulence.

In Texas Helimak, turbulence biasing control has been investigated and, in the biased region, states of greatly reduced turbulence have been achieved [4]. Furthermore, it was found evidence that induced transport turbulence in this device is much affected by wave particle resonances and, eventually, by a shearless transport barrier [7]. Overall, for positive biasing, turbulence shows enhanced broadband spectra and non Gaussian PDF with extreme events [8].

In this article we analyze fluctuation changes due to alterations on the radial electric field profile, in a plasma region of Texas Helimak with roughly uniform equilibrium gradients, compelled by external positive voltage bias applied to a set of border plates. We analyze the ion saturation current fluctuations, in the perturbed discharges, collected in a large set of Langmuir probes.



*Fig. 1 Schematic of the Texas Helimak with a sample magnetic field line.*

In Texas-Helimak most of the magnetic field lines start and terminate into sets of four plates located at the top and the bottom of the machine (Fig. 1). These plates are used as a support to the Langmuir probes and to apply external electric potentials (bias) to change the radial electric field profile. The helimak geometry is well described by the sheared cylindrical slab since the connection lengths are long enough to neglect the end effects.

In the analyzed experiments, the dominant toroidal field is about 0.1 T, the shot duration is up to 20 s and the plasma is in a steady state with stationary conditions during 10 s, the time interval considered for fluctuation analyzes described in this work. The mean floating potential radial profile presents a positive gradient in the analyzed radial region,  $1.10 \text{ m} < R < 1.25 \text{ m}$ . In this region, the density gradient is practically uniform and the electric field is much affected by the external bias imposed in the four bias plates positioned from  $R = 0.86 \text{ m}$  to  $R = 1.07 \text{ m}$ . We verify that the observed turbulent signals possess two components: a random nearly Gaussian fluctuations plus intermittent bursts, similar to what has been observed in many experimental investigations of turbulence in several magnetic confinement devices [9].

Figure 2a shows an example of the fluctuation, part of the time series for fluctuating ion saturation current perturbed by a bias potential of 15 V, measured in a probe located at  $R = 1.13 \text{ m}$  and  $z = 0.233 \text{ m}$  ( $z = 0$  on the bottom). High intensity spikes can be easily distinguished; the presented signal has a high frequency background component and an intermittent burst sequence. The PDF of the whole turbulence signal observed for positive biasing, showed in Fig. 2b, have a long tail, an indication of intermittent bursts. Thus, our observations confirm that the analyzed signals possess the two usual components: a random nearly Gaussian fluctuations plus intermittent bursts.

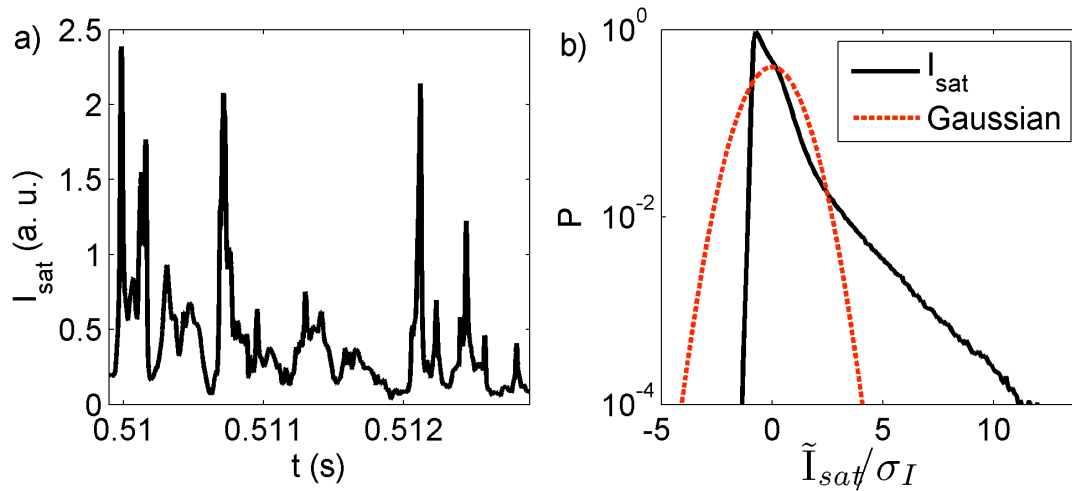


Fig. 2 a) Small time interval of the fluctuating ion saturation current in a probe positioned at  $R = 1.13$  m,  $z = 0.233$  m, for an applied voltage bias = 15 V. b) PDF of the complete ion saturation current fluctuation signal.

An example of the  $S(k, f)$  spectrum, for the signal of Fig. 2 is shown in Fig. 3. The frequency spectrum is broad but shows an average linear dependence  $k(f)$  so the phase velocity can be estimated through this spectrum, indicating that the dominant waves propagate in the vertical direction with similar phase velocities. Next, we identify the intermittent bursts and determine their propagation velocity and frequency of appearance. Thus, we identify bursts propagating along the plasma flow with velocities comparable to those obtained for the turbulence average phase wave velocity.

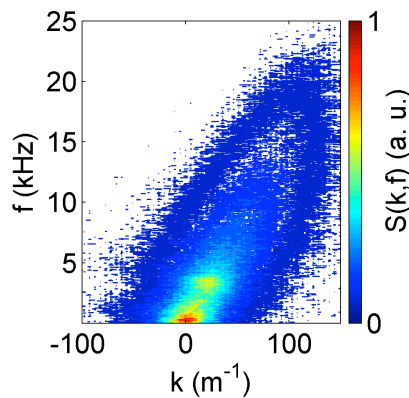


Fig. 3  $S(k, f)$  spectrum between signals of probes positioned in  $z = 0.213$  m and  $0.233$  m,  $R = 1.13$  m and bias = 15 V.

Figure 4(a) shows that the average vertical phase velocity changes with the applied bias. Fig. 4(b) shows that the burst rate also increases with the bias voltage. The time interval between successive bursts follows an exponential distribution with a characteristic time scale  $\tau_0$  that decreases with the bias voltage.

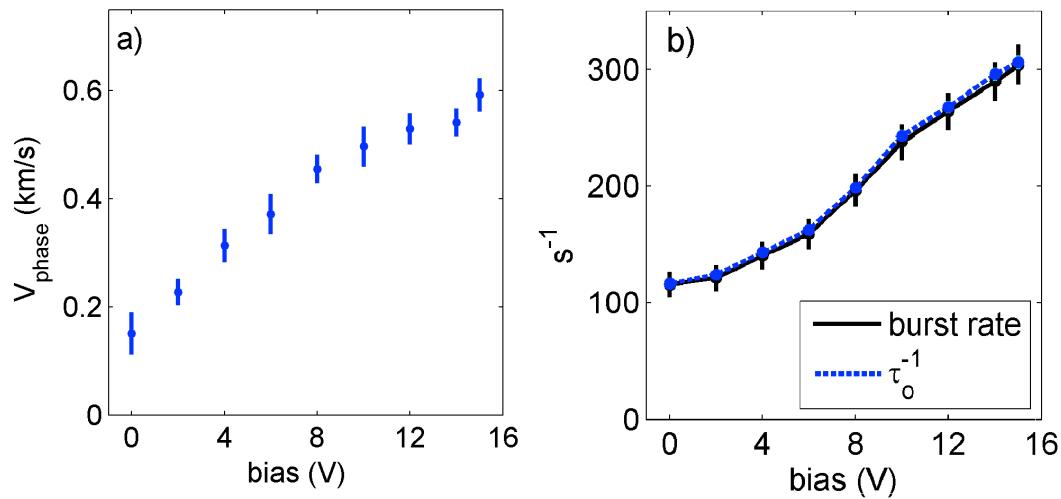


Fig. 4: Average vertical phase velocity (a) and burst rate (b) according to the applied bias voltage.

In conclusion, the plasma turbulence is modified by altering the radial electric field component through application of positive biasing, presenting an intermittent sequence of bursts embedded in the turbulent background. The performed statistical analysis shows a monotonic increase in the strength of the intermittent bursts in the plasma turbulence with increasing of the applied bias voltage. Furthermore, the average time between bursts decreases with the bias voltage.

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