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Direct evidence of coupling between density tails and turbulent transport in the scrape-off layer region in the TJ-II stellarator

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I. Introduction

Comparative studies of the structure of plasma turbulence carried out in different magnetic confinement devices have led to insights furthering the understanding of turbulent transport in fusion plasmas. The overall similarity in the structure in the statistical properties of fluctuations has led to conclude that plasma turbulence in magnetically confined plasmas as many other dynamical systems, display universal characteristics [1]. Recently the importance of intermittent plasma turbulence have been investigated in tokamaks plasmas to explain non-exponential decays in the scrape-off layer (SOL) plasma profiles region of fusion devices [2]. Experimental evidence of intermittent events propagating radially with velocities in the range of 1000 m/s has been reported [3-5]. This radial velocity suggests the importance of the competition between both parallel and radial transport to explain particle losses onto the divertor plates in fusion devices [5]. The present work shows a direct link between the statistical properties of turbulent transport and non-exponential density profiles in the SOL region in the plasma boundary region of the TJ-II stellarator.

II. Experimental set-up

Experiments were carried out in the TJ-II stellarator (P_{ECRH}= 200 - 400 kW, $P_{NBI} \le 200$ kW, $B_T = 1$ T, R=1.5 m, $<a> \le 0.22$ m, $\iota(a)/2\pi \approx 1.7 - 1.8$). Edge radial profiles of different edge quantities have been simultaneously measured in the plasma edge region using a multi array of Langmuir/Mach probes [5]. Probes are inserted into the plasma edge from the top of TJ-II. The influence of limiter biasing on plasma confinement, turbulence and plasma flows is under investigation in the TJ-II [8]. Experimental results show that it is possible to modify global confinement and edge plasma parameters with both limiter and electrode biasing.

III. Edge turbulence and profiles in ECRH and NBI plasmas

NBI heated plasmas have been recently performed in TJ-II. Flattened core electron temperatures in the range 200 to 300 eV and bell-shaped density profiles with $n_0 \le 5\text{x}10^{19}\ m^{-3}$ are achieved in NBI plasmas whereas ECRH plasmas show hollow density profiles with steep temperature gradients. Combined ECRH and NBI experiments reveal that, once ECRH heating power is turned-off, a confinement regime characterized by a strong reduction in ExB turbulent transport and fluctuations and a significant increase in plasma density is achieved. Edge plasma turbulence and profiles have been compared in ECRH and NBI regimes. Figure 1 (left) shows radial profiles of ion saturation current and level of fluctuations in ECRH and NBI plasmas. Tails in the ion saturation current profiles currently observed in ECRH plasmas in the far SOL region disappear in NBI regime.

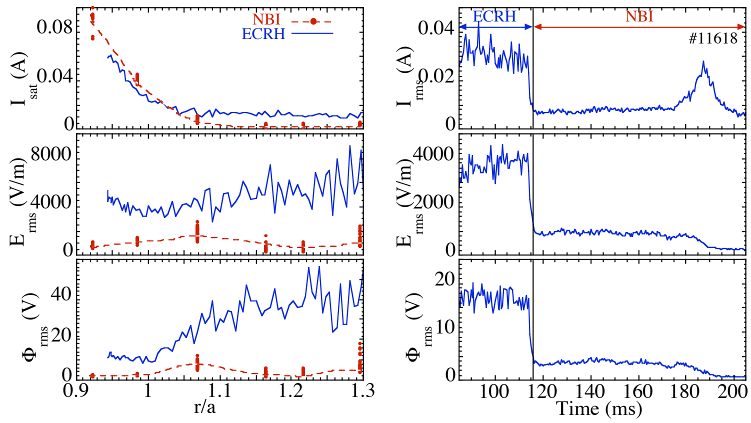

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Figure 1. LEFT: Radial profiles measured in the ECRH and NBI plasmas. Measurements in NBI plasmas were taken shot to shot at a plasma density of about $3\text{x}10^{19} m^{-3}$, RIGHT: the time evolution of the edge level of the fluctuations during the transition from ECRH to NBI.

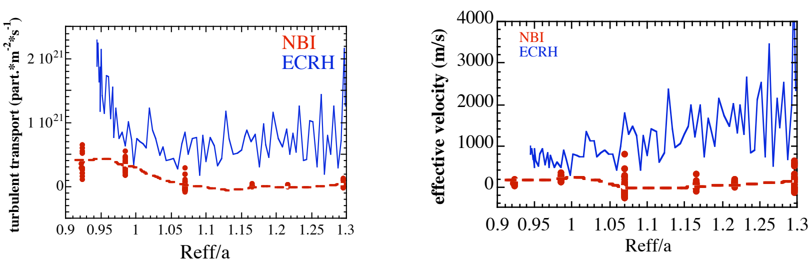

Figure 2. Scanning of NBI plasma shots showing the ExB turbulent driven flux and radial effective velocity of events spreading radially outward.

Simultaneously, there is a drastic reduction in the ExB turbulent driven flux (given by $\Gamma_{ExB} = <\tilde{n}(t)\,\tilde{E}_\theta(t)> / B$), $\tilde{E}_\theta$ being the fluctuating poloidal electric field and B the toroidal magnetic field) when the ECRH heating is turned off. This reduction in the level of turbulent driven transport is due to a decrease in electric field and density fluctuations. The level of fluctuations *rms* for the ion saturation current "I_{sat}", the electric field "E_{rms}" and the floating potential Φ_{rms} drastically decreases both in edge and SOL for NBI regime as is shown in Figure 1 (right) for probe located close to the last close flux surface (LCFS) (r/a≈0.95). The time evolution of frequency spectra reveals that the reduction of fluctuations is due to the decreasing of all frequency components (Fig. 4). Linked to the reduction of the current tails, we also observed the same behavior of reduction for the effective radial velocity of events propagating radially outward, i.e. tails in velocity are getting smaller while plasma reach the NBI regime (Fig. 2, left). The behavior of plasma edge magnitudes has been investigated as density was changed in the range (0.35–1) x 10^{19} m^{-3} from shot to shot (Fig. 3). Experimental results have shown that the development of the naturally occurring edge velocity shear layer requires a minimum plasma density (or gradient) in the TJ-II stellarator; above this critical density value the naturally occurring velocity shear layer appears in the proximity of the LCFS [6, 7]. During the development of the shear layer for plasma mean density around the critical value ≈ 0.5 - 0.6 x 10^{19} m^{-3}, a sharp change can be observed in the different parameters measured at the plasma periphery. As the plasma density increases up to the critical value, ion saturation current measured in the SOL at a fixed position increases, and for density values above the critical one the ion saturation current remains almost constant, whereas it increases at the plasma edge as sheared flows are developed.

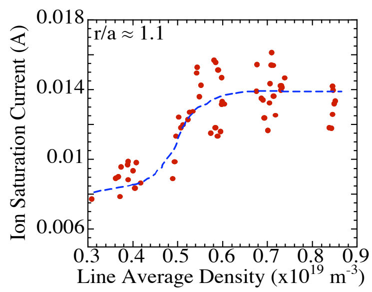

Figure 3. Ion saturation current as a function of the plasma density measured in the scrape-off layer.

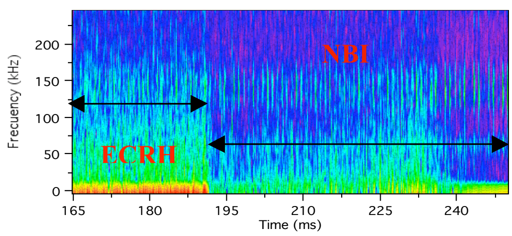

Figure 4. Power spectrum of ion saturation current fluctuations for ECRH and NBI plasma phases in the scrape-off layer region.

IV. Electrode biasing

The time evolution of the plasma parameters during electrode biasing is shown in figure 5. In agreement with previous experiments, the level of edge fluctuations and turbulent transport is significantly reduced after electrode biasing is turned on. In addition, tails measured in the region during ECRH plasmas are remarkably reduced.

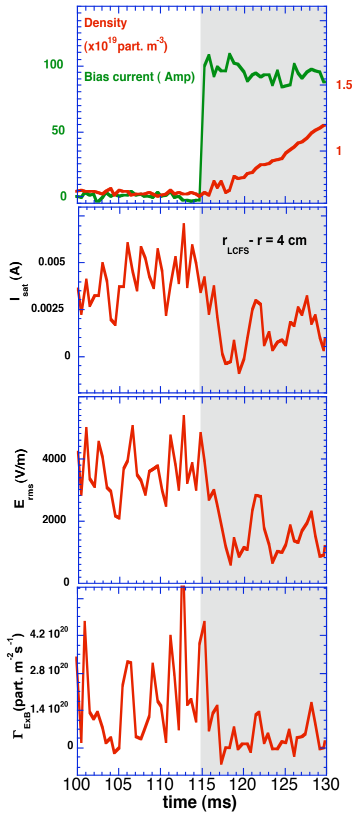

Figure 5. Time evolution of the main parameters for a discharge with DC electrode biasing (V_{bias}=-300V).The shadowed area indicates the time when the bias is applied

V. Conclusions

Comparative studies of the structure of turbulence both in ECRH and NBI plasmas in the TJ-II stellarator have shown a drastic decrease in the level of turbulence in the transition from ECRH to NBI plasmas. As a consequence the radial effective velocity of transport decreases and tails usually observed in ECRH plasmas disappear in the NBI regime. Furthermore, tails in the SOL are also reduced during biasing induced improved confinement regimes. These findings provide direct evidence of coupling between density tails and turbulent transport in the scrape-off layer region in the TJ-II stellarator.

[1] C. Hidalgo et al.: New Journal of Physics **4** (2002) 51.1.
[2] J.A. Boedo et al.: Phys. of Plasmas **10** (2003) 1670.
[3] G.J. Antar et al.: Phys. Rev. Lett **87** (2001) 065001.
[4] M.V.A. Heller et al.: Phys. Plasmas **6** (1999) 846.
[5] M.A. Pedrosa. et al.: Rev. Sci. Instrum. **70** (1999) 415.
[6] R. Balbín et al.: Rev. Sci. Instruments **63** (1992) 4605.
[7] J. Herranz et al.: Fusion Eng. Des. **65** (2003) 525.
[8] C. Silva et al., EPS-2005.