THE E×B VELOCITY SHEAR AND TURBULENT TRANSPORT IN THE EDGE OF TOKAMAK TF-2

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1. Introduction

Poloidal shear flow [1,2] and radial gradients in the turbulent Reynolds stress [3] remain the best explanations of the fluctuation suppression at the naturally occurring velocity shear layer and at L-H transition. In-out asymmetry of fluctuation reduction behavior may occur [4]. The aim of the presented experiments was to investigate the effect of sheared E×B flow on turbulent transport and in-out asymmetry in biasing and ergodic magnetic limiter discharges. The profiles of the Reynolds stress has been measured.

The turbulence (fluctuation level, turbulence driven flux, cross coherence) at the shear layer in the TF-2 tokamak (R=0.23 m, r=0.04 m, $B_{(r=0)}$=1T, q=3.6, I_{pl}=5-6 kA, n_e=2-3×10^{19} m^{-3}, T_{e0}=0.2-0.3 keV) have been studied using movable Langmuir probe array. Standard techniques are used to calculate various plasma characteristics.

2. Turbulent transport and sheared poloidal flow

Negative biasing of electrode (-500 V with respect to the vessel) was performed in steady state of tokamak discharge. Electrode (normally floating) has got 0.12 cm^2 surface perpendicular to the magnetic field and positioned 1 cm inside to the Last Closed Flux Surface (LCFS) at the outer side of tokamak vessel. Biasing experiment shows the changes in the edge plasma parameters confirming the importance of the shearing (Fig. 1). Biasing suppresses the turbulence in the shear region near LCFS resulting in the reduction of transport. In-out asymmetry of the fluctuation reduction behavior was observed at biasing. The reduction is significantly higher at the large major radius side. The reduction in turbulent transport is localized to the velocity shear layer r/a=0.95. Coherence between density and potential fluctuations (Fig. 2) changes with biasing. The poloidal dependence of poloidal velocity was detected with maximum at outboard and minimum at the inboard both in float and biased phase as predicted by model [4]. Radial correlation length has been reduced by rotational shearing at biasing.

To quantify long range coupling of turbulent cells nonlinear correlation technique [6] was used for radial correlation profile near the shear layer (Fig. 3). E×B shear leads to nonlinear decorrelation of turbulent cells.

Experiment with ergodic magnetic limiter shows the change in the edge and in the SOL profiles. Fluctuation level n_{rms}/n is reduced by 30% with the EML in the SOL and shear region (Fig. 4). Radial correlation length has not been reduced by rotational shearing at EML. Growth in the radial electric field value measured in the shear region (r/a=0.95) was ~0.3 msec earlier than the changes in the turbulence and edge density profile steeping. Fractal dimensionality decreases from 7-8 down to ~5 in the shear region after ergodization leading to growth in the turbulent transport.

Comparing the probe measurements with theory [5], we find that the ratio of the turbulent decorrelation rate to hybrid shear decorrelation rate is $\Delta\omega_t /(2\omega_s\Delta\omega_t)^{1/3}$ ~ 2-2.5 in float phase of discharge. At biasing, we find $\Delta\omega_t /(2\omega_s\Delta\omega_t)^{1/3}$ ~0.8-1. In EML discharges, $\Delta\omega_t /(2\omega_s\Delta\omega_t)^{1/3}$ ~2.5-3.5.

3. Poloidal profile of Reynolds stress

The radial profiles of the cross-correlation between fluctuating E_θ and E_r have been investigated at inboard, outboard, top and bottom of the edge to analyze the importance of poloidal flow driven by electrostatic Reynolds stress. Fig. 5 shows the radial profiles $\langle E_\theta E_r \rangle$ obtained from measurements of tips placed 2 mm apart in the poloidal and radial direction. Radial derivative of $\langle E_\theta E_r \rangle$ evolves in the proximity of the naturally occurring velocity shear layer all over the edge.

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References

[1] T. Chiuen, P.W. Terry and P.H. Diamond: Phys. Fluids-B **29**, 231 (1986).
[2] K.H. Burrell et al.: Phys. Plasmas **1**, 1536 (1994).
[3] P. Terry et al.: *Proc. 16th IAEA* (IAEA -CN-64/DP-20), (1996).
[4] T.S. Hahm and K.H. Burrell: Phys. Plasmas **2**, 1648 (1995).
[5] H. Biglary, P.H. Diamond and P. Terry: Phys. Fluids-B **2**, 1 (1990).
[6] W.X. Ding et al.: Phys. Rev. Letters, **79**(13), 2458 (1997).

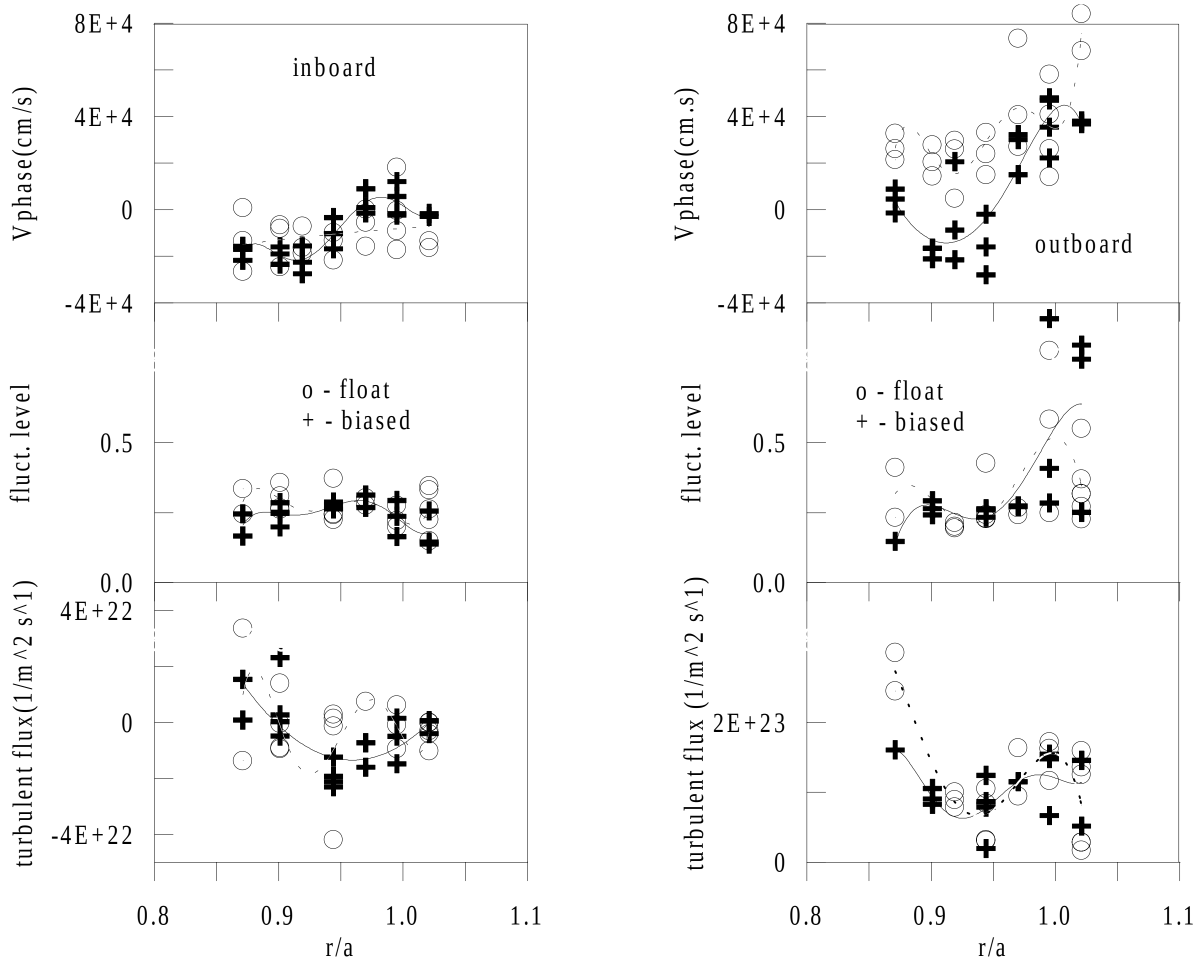

Fig. 1. Radial profiles of poloidal phase velocity of fluctuations, density fluctuation level n_{rms}/n and turbulence induced flux $\Gamma_t = \langle n \upsilon_{E\times B} \rangle$ at inboard and outboard of discharge in biasing experiment.

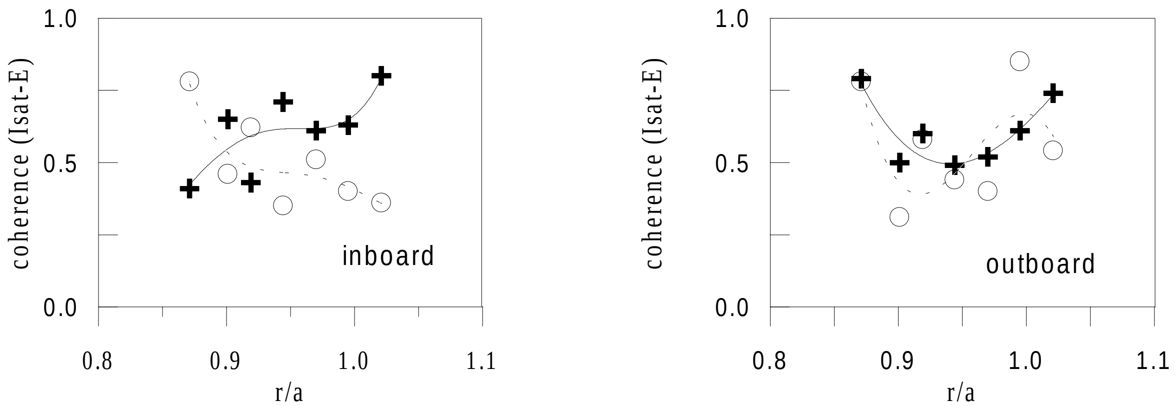

Fig. 2. Coherence $(I_{sat} - E_p)$ at float (circles) and biasing (crosses) phases of discharge at inboard and outboard of tokamak.

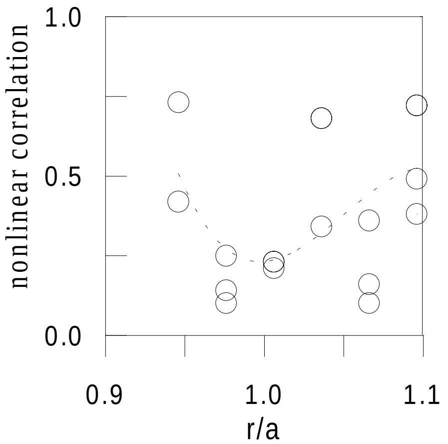

Fig. 3. Radial profile of nonlinear correlation of probe I_{sat} signals. Probes are separated radially by 2 mm. Outboard.

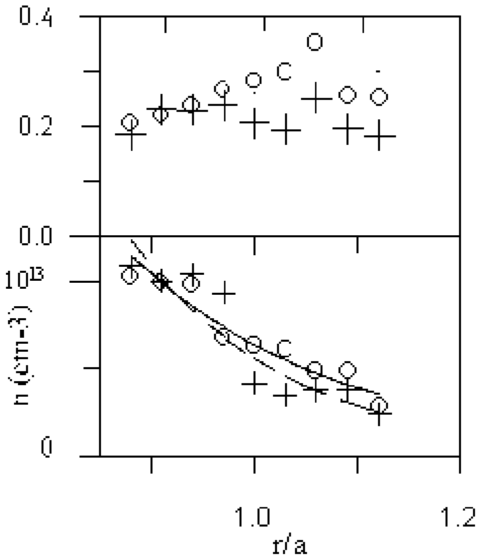

Fig. 4. Profiles of density and density fluctuation level with (circles) and without (crosses) ergodic magnetic limiter.

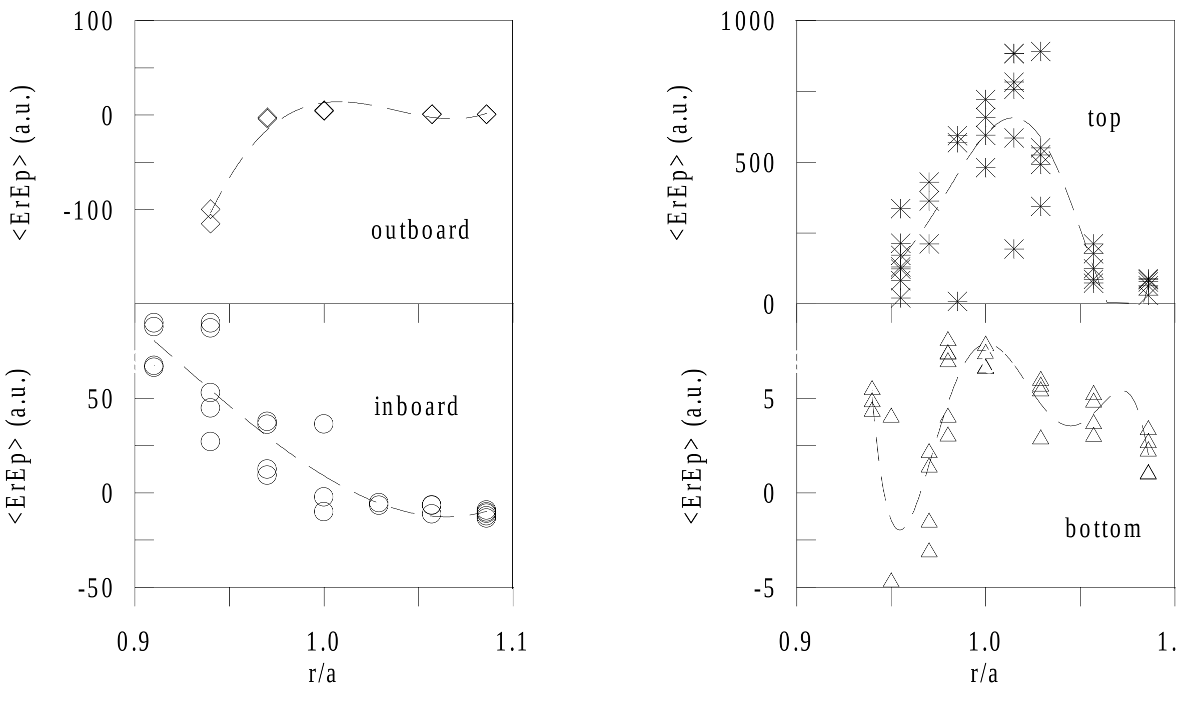

Fig. 5. Radial profiles of Reynolds stress at different poloidal positions.