*33rd EPS Conference on Plasma Phys. Rome, 19 - 23 June 2006 ECA Vol.**30I**, P-5.103 (2006)*

Bursty radial transport events and their influence on scrape-off layer width in the Tore Supra tokamak

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Abstract

The connection between bursty radial transport and the scrape-off layer (SOL) width in the Tore Supra tokamak is investigated. We changed the radial position of poloidal limiters on the outboard midplane and found that, when the limiters are in contact with plasma, the SOL is very thin and we do not detect bursty transport deep in the SOL. However, when the poloidal limiters are retracted, the SOL expands dramatically and we detect bursty behaviour deep in the SOL. The existence of bursty behaviour deep in the SOL is correlated with the existence of a wide SOL. Since the reciprocating Langmuir probe, used for these measurements, is inserted into the machine from top, the observed changes in radial profiles with plasma position can only be explained if the radial turbulent flux of particles is mainly poloidally localized near the outboard midplane. We also conclude that bursty radial transport events play the decisive role in establishing the width of the SOL in tokamaks.

Introduction

Understanding the physical nature of anomalous cross-field transport in the scrape-off layer (SOL) of tokamaks is one of the key issues of magnetic fusion research. In particular, for the next generation fusion devices, such as ITER, a wider SOL would be beneficial because the power load on divertor target plates will be reduced. On the other hand an excessively wide SOL would not be good because this will cause the strong erosion of plasma facing components and vacuum chamber walls, together with the unwanted losses of tritium. In this context, we need better understanding of the role of bursty radial transport events in establishing the width of the SOL.

Main consideration

In order to study the influence of bursty radial transport events on the SOL width, we have produced special discharges in the Tore Supra tokamak. The plasma minor radius was a=0.66m, which is 6 cm less than usual; it always had a contact point on bottom toroidal pumped limiter (TPL); and we changed the radial position of antenna protection limiter (APL) on the outboard midplane shot-to-shot. During first shot (#35234) the APL was in contact with plasma and in the next four shots (#35235 - # 35238) it was gradually retracted (see figure 1). The radial distance between the last closed flux surface (LCFS) and inner surface of APL in those shots was 1, 2, 4 and 8 centimeters respectively.

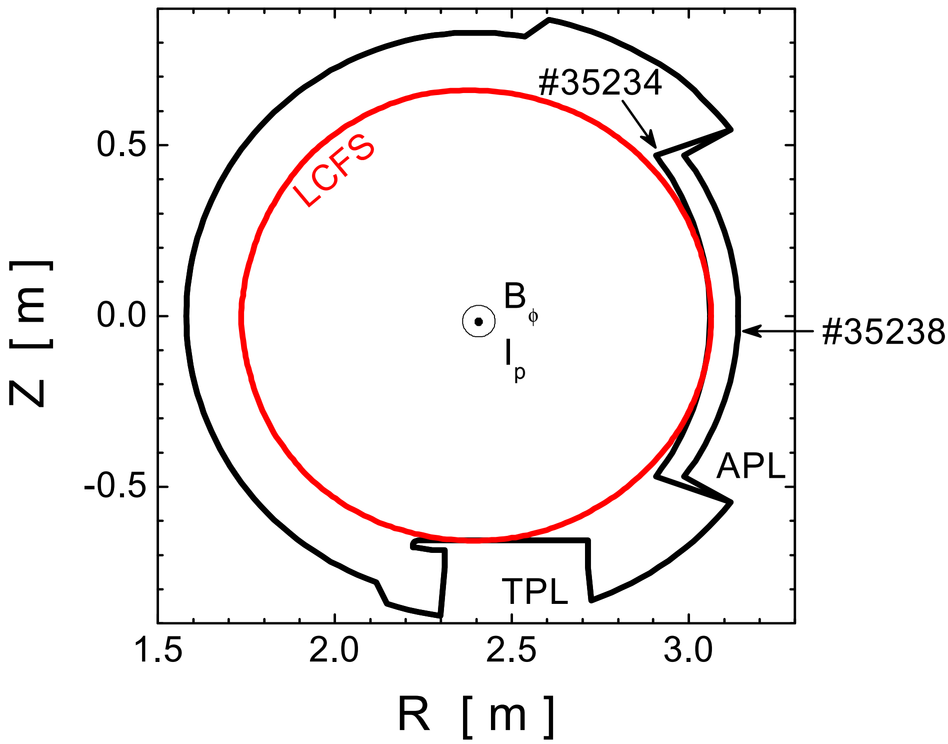

Figure 1 Cross-section of the Tore Supra tokamak

We measured ion saturation current (I_{sat}) by means of reciprocating Langmuir probe. The probe makes several plunges in plasma per discharge. The data is acquired continuously at 1 kHz. At the same time, during each plunge close to the deepest position of the probe, fast data is acquired with a sampling frequency 1 MHz for 16 ms. It is possible to program independently the depth of each plunge with respect to the LCFS. Thus, we have continuous mean radial profile of I_{sat} together with the discrete radial scan of its turbulent characteristics in the SOL.

In the first discharge (#35234), when APL is in contact with plasma on the outboard midplane, the SOL at the probe location is very thin - exponential decay length of I_{sat} is only 18 mm only (see figure 2). At the same time we do not detect bursty fluctuations of I_{sat} deep in the SOL. I_{sat} skewness, which directly characterizes the intensity of bursty behaviour is relatively low and almost constant radially in the SOL (see figure 3). When the APL is retracted gradually the SOL width increases dramatically. In the last discharge (#35238) exponential decay length of I_{sat} is 62 mm. At the same time, while the APL is retracted, we start to detect bursty behaviour deep in the SOL. Close to the LCFS I_{sat} skewness is lower than in the previous discharges and it reaches very high values - around 1 - deep in the SOL (see figure 3).

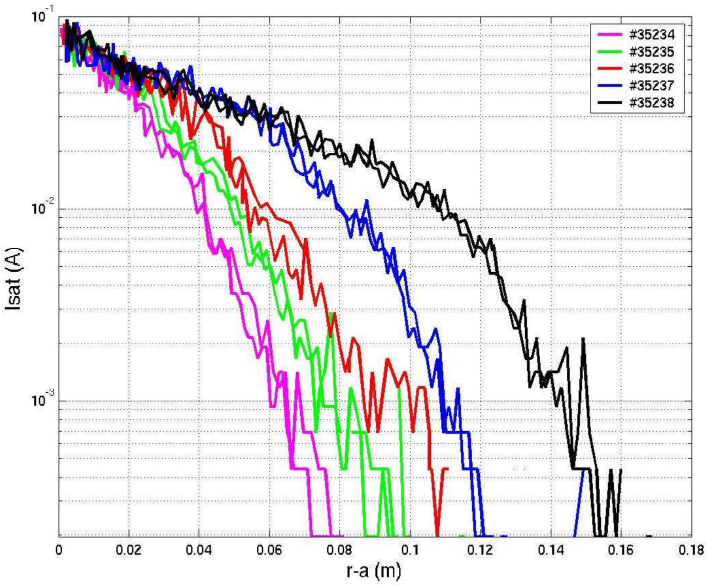

Figure 1 The radial profile of Isat in the SOL

Remembering that the Langmuir probe is inserted into the machine from top, the observed changes in radial profiles can only be explained if the radial turbulent flux of particles is mainly poloidally localized near the outboard midplane. When the APL is in contact with plasma on the outboard midplane the particle radial flux neutralizes on the sides of the limiters. In this case, the probe is not magnetically connected with the region of outboard midplane and the particle flux can not flow to the top of the machine, where the probe is located. The SOL is very narrow and we do not detect the bursty behaviour because most of the coherent turbulent structures, which are responsible for bursty behaviour [1-5], are born near the outboard midplane. When the APL is retracted, the radial turbulent flux of particles is no longer obstructed by the limiters and can freely flow to the probe along the magnetic field lines. In such conditions, the probe is magnetically connected to the region of outboard midplane. The SOL width increases dramatically and we start to detect bursty behaviour deep in the SOL.

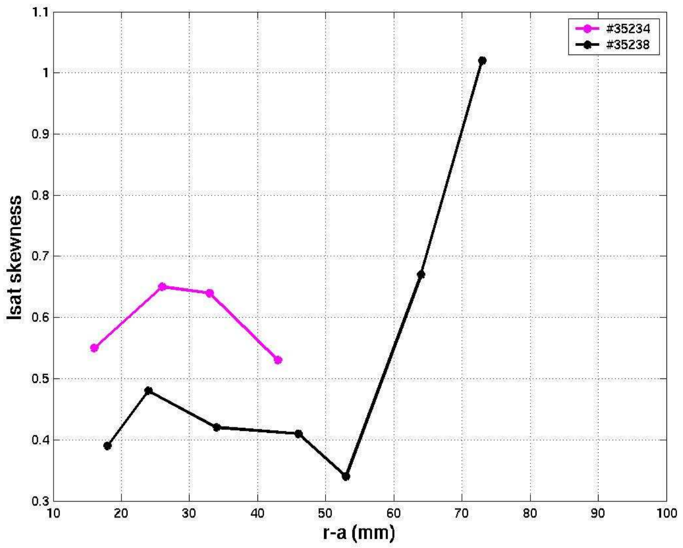

Figure 3 The radial profile of I_{sat} skewness in the SOL

Conlusions

Finally, we can conclude the following. First of all the radial turbulent flux of particles in the SOL of the Tore Supra tokamak is mainly poloidally localized near the outboard midplane. At the same time the coherent turbulent structures, which are responsible for bursty behaviour, should play the decisive role in establishing the width of the SOL in fusion devices because the existence of a wide SOL and bursty behaviour deep in the SOL are highly correlated.

References

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