Edge Plasma Physics and Relevant Diagnostics on the CASTOR Tokamak

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ABSTRACT

We describe results of two sets of measurements performed with a full poloidal array of Langmuir probes located in the scrape-off layer (SOL) of the CASTOR tokamak. At first, a biased electrode is inserted into the SOL. The resulting poloidally localized electric field structures are identified by means of the ring of probes and a consequent modification of the convective transport is demonstrated. In the second experiment, the turbulent fluctuations are measured in standard ohmic discharges. The analysis of the probe signals reveals a spatially periodic mode with the poloidal mode number equal to the edge safety factor q, which propagates poloidally in the direction of the E_rxB drift. This observation is interpreted as a signature of a single turbulent structure, which snakes around the torus several times following the local helicity of the magnetic field.

Keywords: tokamak, edge plasma, probe diagnostics, biasing

INTRODUCTION

It is widely recognized that the Langmuir probes are a primary tool for studying edge plasma physics in tokamaks because of their temporal and spatial resolution. Single probes are used to measure the local plasma parameters. In large-scale tokamaks with a long pulse length, the probe's tip is fixed to a reciprocating head to avoid its overheating followed by destruction. One such excursion of the probe head inside and outside the plasma takes typically ~ 200 ms. During this time interval, the radial profiles of the plasma density, electron temperature and floating potential can be determined from the IV characteristics of the probe several times during a discharge.

In small-scale experiments, however, the overheating is avoided automatically because the pulse length is relatively short, typically of the order of several tens of milliseconds. Therefore, the Langmuir probe can survive at a fixed position during the whole discharge. The radial profiles are measured by changing the probe position on a shot-to-shot basis. However, this approach requires sufficiently reproducible discharges and measurements become slightly cumbersome. The above-mentioned complication can be partially overcome by using a row of tips oriented either in the radial or poloidal direction. Such probe arrays appeared to be extremely useful for the analysis of plasma fluctuations. For this purpose, a temporal resolution ~1 μs is required and the spatial resolution must be in the range of 2-3 mm.

Pioneering experiments with the probe arrays were performed by Zweben(1) in the 80s. These measurements have identified turbulent structures with a typical lifetime 5-40 μs and a poloidal and radial correlation length of ~ 1 cm. Systematic measurements of the edge turbulence by probe arrays in large scale experiments were carried out in the ASDEX tokamak(2) and the W7-AS stellarator(3). There, an array of 16 tips, oriented in the poloidal direction, was fixed to a reciprocating head. In spite of a spatially limited picture, the poloidal periodicity of the turbulent events in the SOL (with a typical poloidal wavelength of about 5-15 cm) has been also observed. Comparable measurements performed in the CASTOR tokamak(4) with a similar array have demonstrated that the SOL turbulence in small tokamaks is basically of the same nature as in larger machines. Later on, a two-dimensional array of 64 tips (8x8 tips) was used on CASTOR to analyze the properties of the edge turbulence

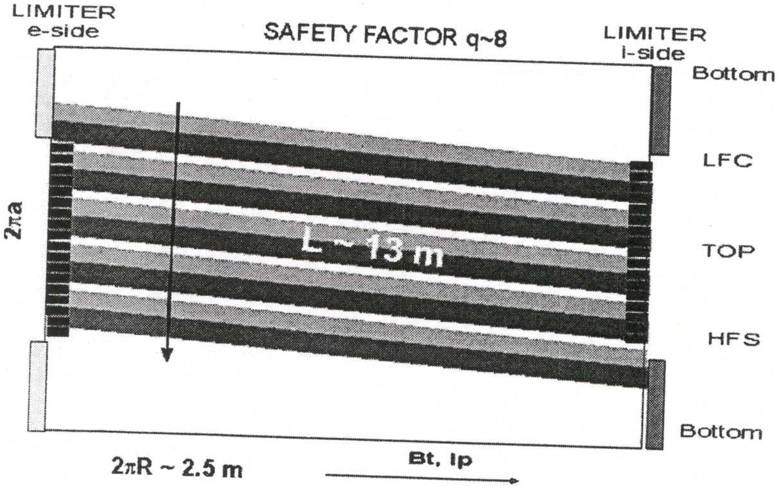

Fig. 5: *Unfolded magnetic surface in the SOL of the CASTOR tokamak for the edge safety factor q~8. The red/blue colors denote regions of the magnetic surface with a higher/lower potential then its time-average value. The dipole structure of a length ~13 m, which follows helical magnetic field lines from one to the other side of the poloidal limiter, is depicted. The poloidal mode number is m=q. It propagates poloidally because of* $E_r x B_T$ *drift. The lifetime of the structure is probably determined by duration of its contact with the limiter surface. When the contact is lost, the structure dies, but a new structure is formed.*

CONCLUSIONS

It is evident that full understanding of the edge plasma physics in tokamaks requires experimental information with a high spatial and temporal resolution. A good representative of the diagnostic, providing such kind of experimental data are the arrays of Langmuir probes, which are relatively non-expensive and easy to build. Major investments are a multichannel and fast data acquisition system and sophisticated software for data processing.

We try to demonstrate in this contribution that the probe arrays can be efficiently employed in small tokamaks because of their flexibility. The most important point is to find whether the obtained results do not reflect only particular features of the given experiment, but that they are relevant also for large-scale devices.

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