35th EPS Conference on Plasma Phys. Hersonissos, 9 - 13 June 2008 ECA Vol.**32D**, P-2.027 (2008)

PLASMA BLOB MOTION IN THE SIMPLE MAGNETIZED TOROIDAL PLASMA OF THE THORELLO DEVICE

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The formation, the motion and the decay of large-scale fluctuation structures is an important research topic in studies of the turbulence in magnetised plasmas [1,2,3]. Such structures play a relevant role also in the turbulence induced anomalous transport, whose control and understanding is yet a major stumbling block degrading confinement and performances of fusion aimed devices. Experimental investigation of structures in turbulent regime of magnetised plasmas is actively pursued not only in fusion but also in low temperature plasma toroidal and linear devices. Here we presents results concerning the formation and the motion across the magnetic field of plasma density blobs observed in the toroidal plasma device Thorello, recently upgraded and operated at the University of Milano-Bicocca.

The device consists of a toroidal vessel, major and minor radius respectively 40 and 8 cm. A simple toroidal magnetic field (up to 0.2 T) is provided by a current supply feeding 59 closely packed coils. Plasma in Thorello is produced in low pressure hydrogen (about 10^{-2} Pa) by a steady hot cathode discharge. Electrons are thermo-ionically emitted by a tungsten filament, wrapped in a spiral, 2 cm in diameter and located in correspondence of the center of the poloidal cross-section. Discharge is ignited by imposing a negative bias to the filament respect to the vacuum chamber. A quite stable and steady discharge current can be maintained almost indefinitely in the device.

Electrostatic probes have been employed to characterise the plasma filling the device. A movable probe, with a tungsten tip (5 mm long, 0.3 mm diameter) scans the 2-D poloidal section of the device, allowing the reconstruction of the average profiles of plasma parameters. Here we report about plasma produced in discharges at 4×10^{-2} Pa, with a filament current of 70 A and a bias of -100 V. The magnetic field was 250 Gauss. Plasma profiles of the ion saturation current and of the floating potential are shown in Fig.1. A quite dense plasma column is formed, approximately centered on the magnetic shadow of the filament. A diffuse plasma is observed in the whole poloidal section too. A deep potential well corresponds to the plasma column, inducing an overall clockwise rotation about its axis. In the upper outer edge, the potential has a maximum, which coresponds to a ExB velocity inversion and then to a shear.

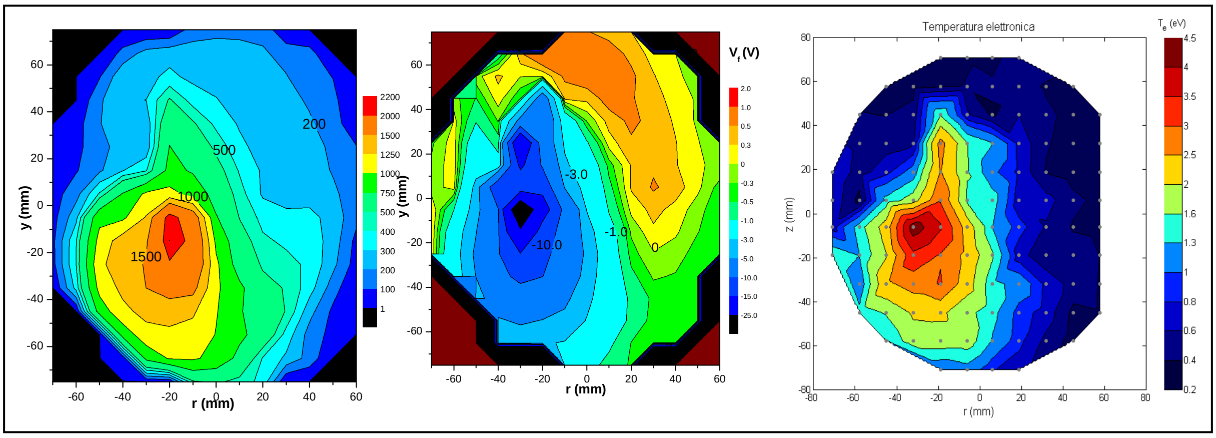

Fig.1 – Poloidal section profiles of the ion saturation current, the floating potential and the electron temperature.

Using probes, we have measured time series of fluctuating plasma parameters simultaneously in two positions of the poloidal section (10^5 points sampling every 0.5 μs). The first (reference) was fixed at the edge of the plasma column (see Fig.1), while the second was moved throughout the whole poloidal section. Ion saturation current fluctuations measured by the reference probe show a probability distribution, skewed towards plasma density enhancement, with quite strong excess over Gaussian for amplitudes larger than 3 standard deviations, as shown in Fig.2. Then a conditional sampling analysis has been performed in order to detect and study the spatiotemporal evolution of structures associated with such large amplitude fluctuations in the poloidal section of the device in the turbulent state [4]. As a trigger we have considered a positive density fluctuation with an amplitude between 2.5 and 3.5 standard deviations (see Fig.2). About fifty 200 μs time windows opened around the trigger time was detected and averaged for each location of the poloidal section. The corresponding spatiotemporal evolution of the fluctuations was then reconstructed. Results show the presence of blobs of plasma, spatially small density fluctuations, propagating mainly under the overall ExB drift. Structures originate at the inner edge of the plasma column, on

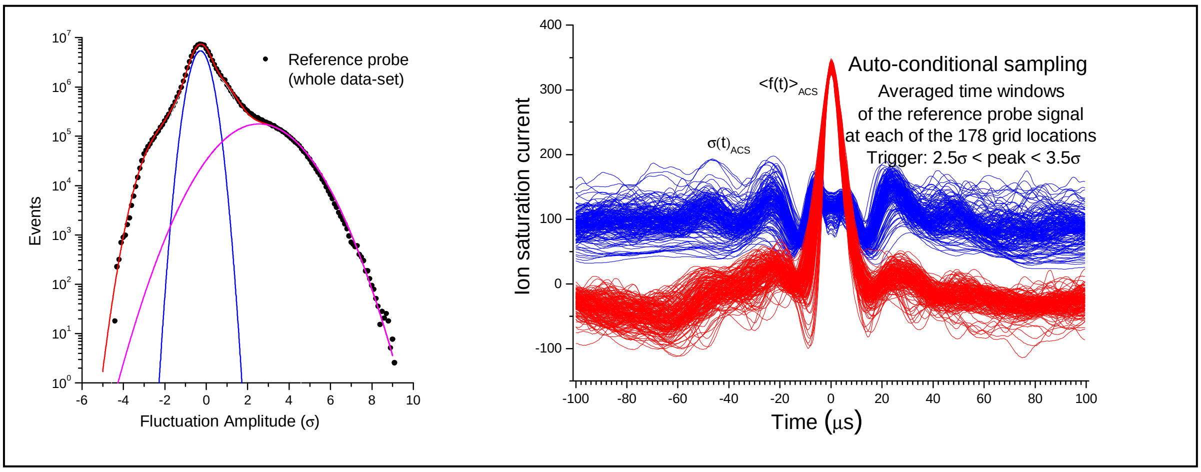

Fig.2 – Left: PDF of the ion saturation current fluctuations measured at the reference probe location. Right: Autoconditional sampling of the reference probe time series when triggered with the peak condition.

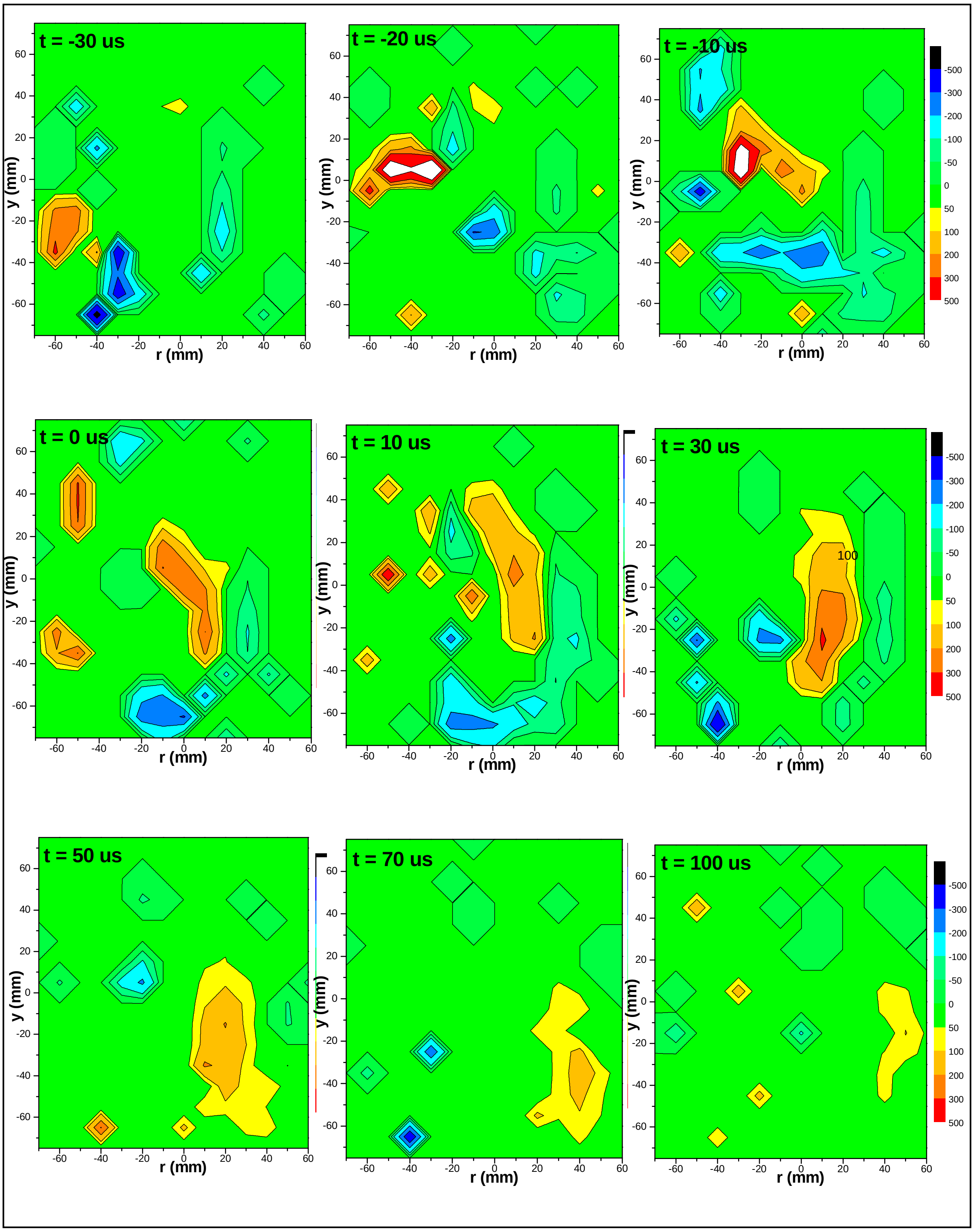

Fig.3 – Temporal evolution of density fluctuations extracted from conditional sampling analysis. The trigger condition was a peak in the reference probe time series with an amplitude around 3σ.

the high field side. After a quite fast rotation along the border of the potential well they arrive on the opposite side, where the average plasma potential lines open. Then the structures moves slowly mainly radially outwards and fade after more than 100 μs. Such structures are associated to a local modification of the electric field, in the form of a shallow dip in the potential, centered on the plasma blob and surrounding it. This corresponds to a vortex in the ExB velocity field providing slow rotation of the plasma blobs, at least in the edge region, where the overall electric field is small [5], as displayed in fig. 4. It is interesting to observe that blobs do not appear to propagate upwards into the region where an ExB shear is present. Some enhancement in the plasma density, correlated with this class of fluctuatiions is observed there only at late times, as a diffusion from the edge of plasma column.

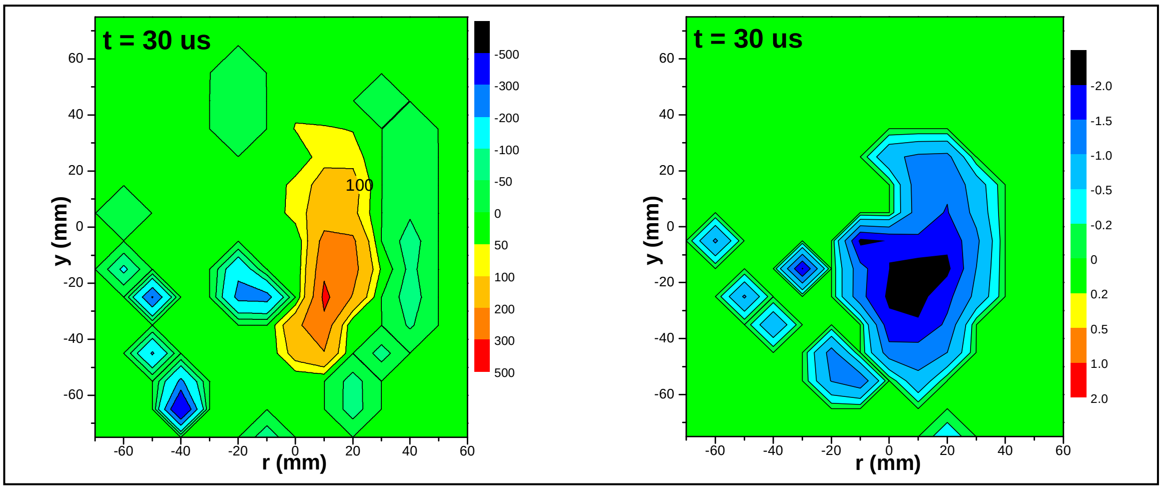

Fig.4 – Electrical potential (right) associated with density structures (left) as revealed from the same conditional analysis applied to the floating potential time series.

In conclusions, we have observed the spatio-temporal evolution of a magnetised plasma in turbulent state associated with the happening of large amplitude density fluctuations at the edge of the plasma column. The formation, transport and subsequent decay of plasma density blobs have been observed. An electric field modification associated with the blobs was observed too. The overall effects is a net radial transport of plasma across the magnetic field outwards toward the limiter. This advection mechanism could then contribute substantially to the anomalous transport associated with turbulence besides the diffusive one [6].

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