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Plasma relaxations induced by gas-puffing and plasma biasing in the CASTOR tokamak

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A puffing of neutral gas (acetylene) using a very fast valve coupled on the capillary of 5 mm in diameter placed close to LCFS , and an edge plasma biasing by means of a carbon electrode immersed deep in a plasma are used separately and even simultaneously to study the relaxation processes in a small-size plasma of the CASTOR tokamak (R=0.4m, a=0.1m).

Diagnostics set-up

At the edge plasma, the ion saturated current, Isat (≈local density), and floating potential, Ufloat, are measured by a rake of Langmuir probes (sampling frequency 50 kHz, spatial resolution = 5 mm), which is positioned in an upper diagnostic port and can be moved into the confined plasma region, i.e. z = 65÷95 mm.

A radiated power profile is detected by AXUV-based fast bolometric arrays looking to the plasma perpendicularly from the top and LFS side.

A new insight on transport processes taking place in a poloidal cross-section is offered by 2D tomographic-reconstructions with a spatial resolution about 1cm and a temporal resolution of 1μsec.

Plasma relaxations in gas puffing regime

Randomly distributed small-scale and short living structures of frequencies ≈ 40÷80 kHz exist in a standard discharge regime in CASTOR. In considered gas-puffing regime the typical relaxation frequency is five-eight time lower and can be well identified by bolometric system using Fast Furrier Transformation (FFT) or Singular Value Decomposition (SVD) methods. The time-behaviour of both plasma emission detected by the bolometers and Halpha line intensity is shown in **Fig.1**. An appearance of plasma relaxations is caused by pulse injected neutral gas. The gas injection starts at 5 ms after the discharge beginning, the pulse duration is Δt=5ms. The bolometric signal namely reflects the ultrasoft x-ray emission from the central part of the column, however at the periphery corresponds rather to the VUV emission range.

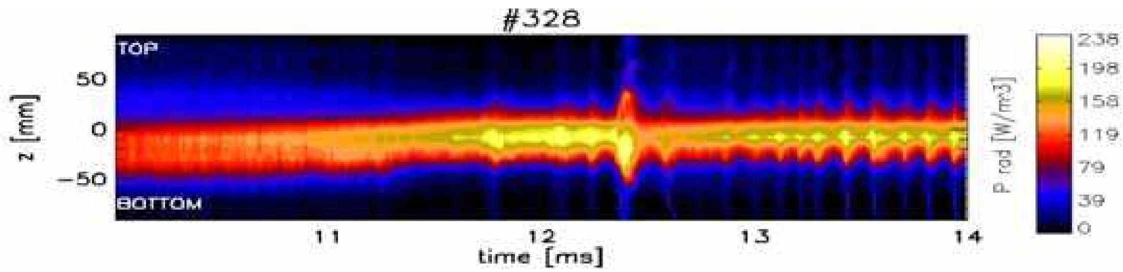

Fig.1a Radiated power detected by AXUV-based fast bolometric array

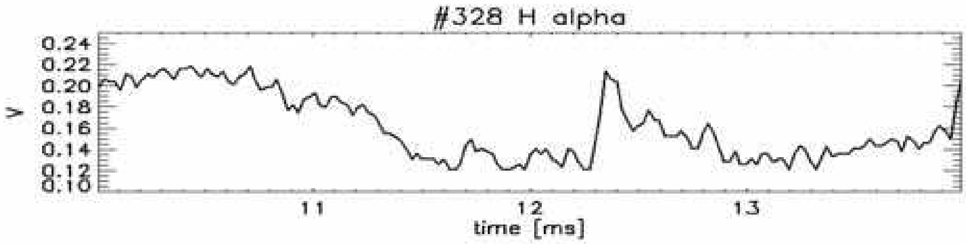

Fig.1b Halpha line intensity

It is conventionally accepted, that a reduction of the particle transport towards the wall and consequently the reduction of recycling can be deduced from simultaneous increase of plasma density and by Halpha line intensity decrease. In a gas puffing regime in CASTOR, the remarkable 1 – 2 ms period of such Halpha line intensity and density behaviour is clearly observed roughly 5 ms after the gas pulse injection start. A radiated power profile shows its peaking and a decrease of the edge plasma activity. This quiet period is followed by a big relaxation visualised as a expansion of radiation profile and the Halpha peak. A next slow Halpha intensity decrease is accompanied by smaller but more frequent relaxations of ≈ 10 kHz with similar evolution as the big one.

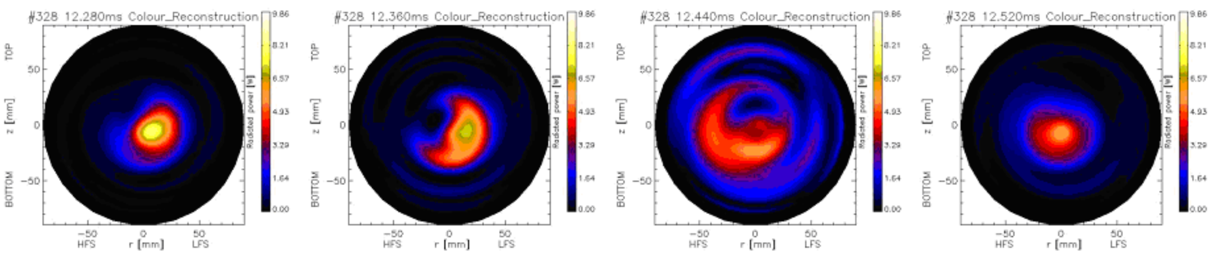

Fig.2 Time development of the relaxation by tomography reconstruction

A more complex description of plasma radiation in a poloidal cross-section is given by the 2D bolometric tomography. A peaked smooth radiation profile at quit phase changes into moon-like shaped profile. A wave-like radial structures then moves from the moon arm to the upper part of the chamber, see **Fig.2**. Such edge structures are observed by a processing of Isat and Ufloat measured by the rake of Langmuir probes [**2**].

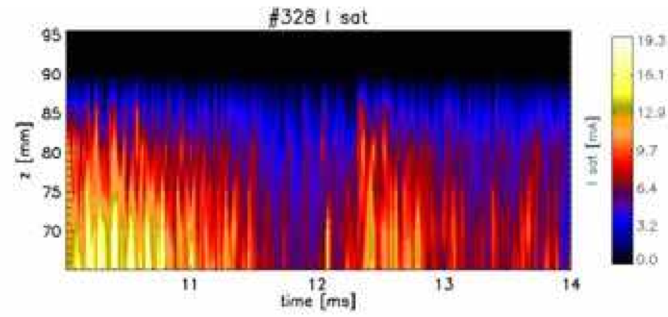

Fig 3 Isat during the action of injected gas

A burst like behaviour of the saturation current, Isat (~ local plasma density) measured by the rake probe is displayed in **Fig.3**. The plasma column is pinching to the central part. Comparing the time behaviour of measured radiation profile in **Fig.2** and Isat (≈local density) in **Fig.3** we can conclude, that the density gradient becomes evidently steeper during the period, if Halpha intensity reaches the minimum.

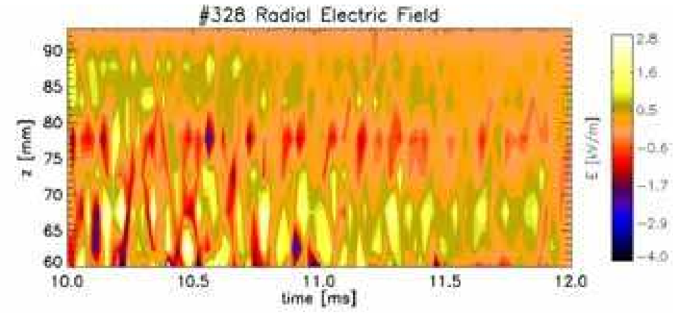

Fig 4 Locale values of the radial electric field, Erad deduced from the measurements of floating potential, Ufloat

Let we see now **Fig.4**, where the local values of the radial electric field, Erad = ΔUfloat / ΔrPin, deduced from the local measurements of the floating potential by the Langmuir rake probe are shown. The most frequent localization of Erad higher values seems to move from the outer positions (z ~ 85 mm) to the inner positions (z ~ 65 ÷ 70 mm) during the Halpha intensity decrease and emission profile peaking. The localization of the radial electric field maximum should determine the position of the transport barrier at plasma edge. Evidently, the appearance of the strongly sheared radial electric field is unstable. Its crashing is probably caused by induced relaxations during the action of driven injection of the neutral gas in the tokamak CASTOR experimental conditions [**3**].

Plasma relaxations in plasma biasing regime

In the biasing regime, the bias voltage +200 V at 10 ms after the discharge start is applied to the relatively large carbon electrode immersed deep in the plasma, $R_{bias} < R_{LCS}$ [**3**]. The plasma relaxations induced in this regime have almost the same character as the relaxations in gas-puffing regime. They are started immediately after the potential is applied. There is a dominating relaxation frequency, which is well correlated with the Halpha line intensity modulation. This regime, thanks to a higher regularity of the events, is more suitable for a transport barrier investigation then previously discussed the gas-puffing regime.

Summary

One of typical feature of biased or gas-puffed discharges in the CASTOR tokamak is the presence of almost regular plasma density relaxations of 10 kHz frequency. An intensive plasma transport across the magnetic field is observed during the relaxation. The detailed 2D observation of plasma emission in poloidal cross-section shows, that the density relaxation is triggered by some instability in the gradient part of the central hot plasma. A "plasma jet " fills the moon-like cloud, which quickly diffuses at the distance much larger than the Larmor radii and strikes the chamber wall. In our experiment, the plasma relaxations become an object of anomal plasma transport investigation with effective use of 1D and 2D high spatial and temporal resolved diagnostics.

A common feature of both regimes is a regularization of relaxation events close to 10 kHz frequencies. In a gas puff regime, an improved confinement phase of a low-level edge activity is followed by a big relaxation event and a sequence of relatively smaller relaxations. In a biasing regime, a long time improved confinement phase of a high-magnitude edge activity is followed by a slow relaxation to pre-biasing state.

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