*31st EPS Conference on Plasma Phys. London, 28 June - 2 July 2004 ECA Vol.**28G**, P-1.118 (2004)*

# Overview of Recent Impurity Transport Experiments on TEXTOR

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## Introduction

The investigation of particle transport and confinement has been a challenging task in fusion experiments in the past years. Recent experiments on TEXTOR applying Dynamic Ergodic Divertor fields (DED) in 3/1-configuration (c.f Finken et al [1]) have provided an intriguing test-bed for transport studies. Of particular interest is the possible change of core transport coefficients in the presence of an island structure close to the q=2 surface (cf. Koslowski et al [2]).

Several spectroscopic diagnostics were used to investigate the behaviour of intrinsic and fuelled low-Z impurities ($C^{+6}$ and $Ne^{+10}$) as well as that of argon. Steady-state behaviour and characteristic profile changes were explored by a radially resolved CXRS diagnostic, and the time dynamics of several ionisation states following a short blip of argon gas during the DED flat top phase was studied by a fast VUV spectrometer.

## 1. Argon transport experiments during DED operation

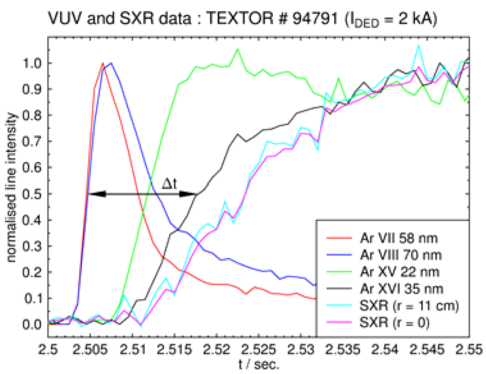


*Fig.1 Time evolution of ionised argon emission lines during the presence of 2/1 mode. The mode appears at a threshold of $I_{DED}$=0.7kA. The merging of the two SXR signals inside r=11cm indicate enhanced core transport.*

Radial transport of impurities has been studied in TEXTOR discharges with and without the static DED field in 3/1 mode configuration. In these experiments short argon puffs were injected into the discharges and the time evolution of spectroscopic signals from different ionisation stages was recorded with high time resolution. Using the new VUV spectrometers, spectral lines from the ionisation stages Ar VII (58 nm), Ar VIII

(70 nm), Ar XV (22 nm) and Ar XVI (35 nm) are measured simultaneously. In the plasma centre, the Ar XVI and Ar XVII signals at $\lambda = 0.4$ nm are collected for different sightlines by means of SXR cameras equipped with 100 µm Be foils. At plasma parameters: $\overline{n}_e = 2.0\cdot10^{13}\ cm^{-3}$, $I_p = 300$ kA, B = 2.25 T and low NBI heating power $P_{NBI} = 300$ kW, one frequently observes the onset of a locked 2/1 tearing mode in case of DED currents above $I_{DED} \geq 0.75$ kA. In Fig. 1 and Fig 2 the normalised line intensities of argon puffing experiments are displayed for the case with and without DED, respectively. All measured line intensities show a fast increase, followed by a slower decay phase, where the signals from the higher ionisation stages are delayed with respect to the lower stages by only 5 to 20 ms. The time delay Δt between the different argon signals is displayed in figure 3 as function of the DED current. Increasing the DED current, we observe that the radial inwards motion of the argon particles is significantly delayed as soon as the locked 2/1 tearing mode is formed. However, within the plasma centre (r ≤ 11 cm) the time delay vanishes as soon as the mode is formed, showing that the radial transport in the plasma core is significantly enhanced in the presence of the 2/1 mode.

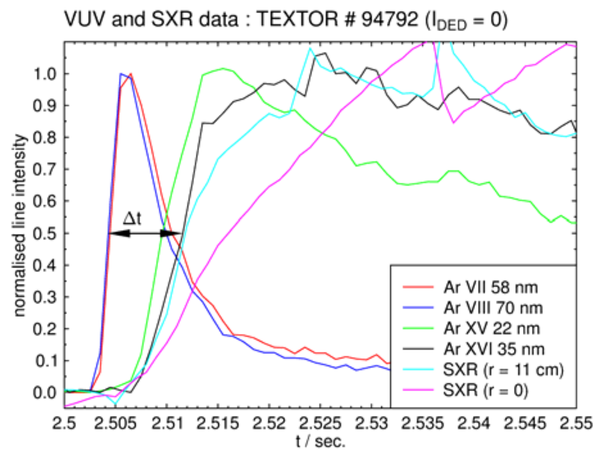


***Fig.2*** *Comparison with zero DED current. The time delay of particle propagation is much shorter and the different temporal responses of the 2 SXR signals indicate a variation of transport in the very core region.*

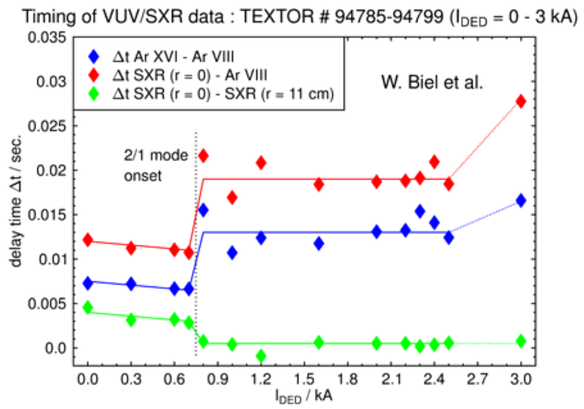


***Fig.3*** *A scan of the dc DED current shows the onset of the 2/1 mode at 0.7kA. A second transition is possibly indicated close to 3kA where a 3/1 mode is triggered.*

## 2. Steady-State Low-Z impurity density studies during 2/1 mode

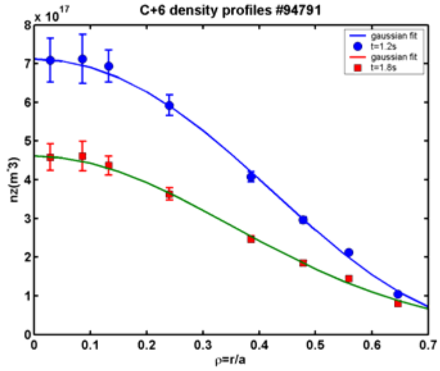


***Fig.4*** *Radial profile of $C^{+6}$ density before (t=1.2s) and after mode (t=1.8s) onset. A parametrised Gaussian profile is fitted to the experimental data.*

The deduction of transport coefficients from experimental profiles is usually based on the measurement of the dynamic response of impurity density profiles following the inlet of a short gas puff at the plasma edge. Diffusion coefficient D and pinch velocity v can be derived from data on particle flow and profile gradients In the present paper we address primarily characteristic changes of low-Z impurity density profiles in steady-state conditions: In this case only the ratio v/D can then be derived from local gradients ($\frac{v}{D} = \frac{1}{n_z} \cdot \frac{\partial n_z}{\partial r}$). Radial profiles in two representative time windows are shown in Fig.4. Time traces of v/D shown in Fig.5 clearly indicate the transition during the DED phase. The reduction of v/D suggests an enhancement of D in the region r/a>0.5.

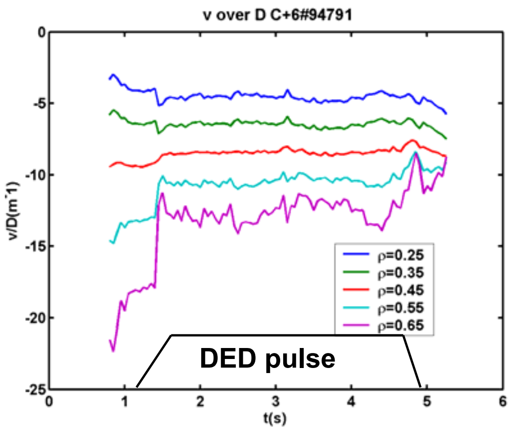


***Fig.5*** *Ratio of transport coefficients v/D as derived from parametrised density profile gradients. A clear change can be seen at the onset of the 2/1 mode for r/a>0.45.*

## 3. Impurity screening effects

A comparison with simultaneously measured particle influx data is used to assess impurity screening effects induced by the onset of a m=2/n=1 mode during the DED phase above a critical threshold of the DED coil current. Two examples are shown, without (#94251, Fig.6, right column) and with additional $C_3H_4$ gas puffing (#95237, Fig.6, left column). The common feature of both pulses, is that the core impurity level does not respond noticeably to changes of particle inflow. In the first case, at constant inflow, the core concentration even drops, and in the second case, it is only marginally increased during a distinctive increase of the edge carbon flow. The behaviour of the particle influx is represented in the two examples by the CII line intensity as measured by the equatorial fan of lines-of-sight of the CX diagnostic which views the outer TEXTOR wall.

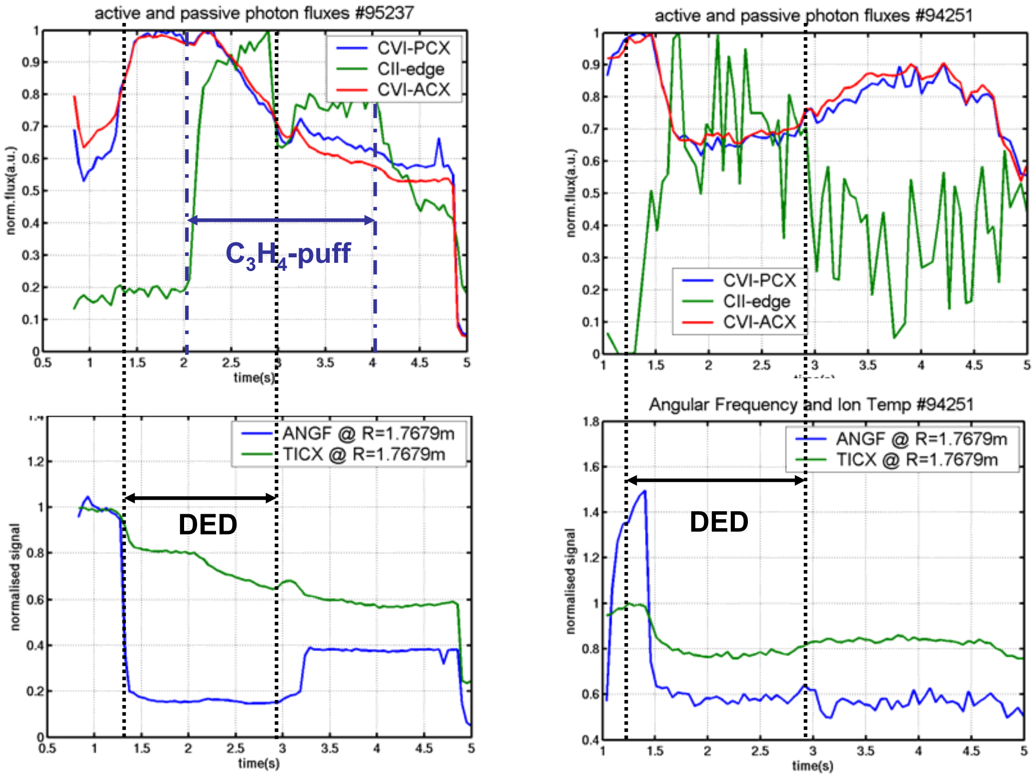


***Fig.6** Impurity screening effects. Left column, example with added gas-puff of C3H4. The CII signal reflects the gas inlet from 2 to 4s. Right column, example with no additionally puffed gas inlet.*
*In each case is the response of the core signals representing the active and passive CVI line in the CX spectrum respectively, only weakly correlated with the particle inflow at the plasma edge.The effects of the 2/1 mode on toroidal angular frequency and ion temperature (bottom row) are used as time markers.*

## 4. Conclusions

A first evaluation of low-Z and medium-Z spectroscopic data shows distinctive changes in core and edge transport during the onset of a m=2/n=1 mode triggered by a DC-DED field. Further comprehensive transport modelling is required for a full interpretation. Moreover, experimental data in the outer confined plasma region (0.7<r/a<1) need to be obtained, in order to investigate local gradient changes.

**Acknowledgement**
This work, supported by the European Communities under the contract of the Association EURATOM/FOM, was carried out within the framework of the European Fusion Programme with financial support from NWO. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

**References**

[1] K.H. Finken et al.and TEC team, this conference, I2-06

[2] H.R.Koslowski et al., this conference, P1-124