27th EPS Conference on Contr. Fusion and Plasma Phys. Budapest, 12-16 June 2000 ECA Vol. **24B** (2000) 1461 -1464

Change in rotational velocity shear caused by the effect of ECH on transport barriers

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1 Introduction

At the RTP-tokamak the existence of electron temperature transport barriers was shown some time ago [1]. During the experiments concerning the behaviour of these barriers under different circumstances we also monitored the Doppler shift of selected spectral lines. This showed that changes in the rotational velocity (shear) were related to these barriers. A more systematic search of this phenomenon was undertaken and some first results will be presented here.

2 Experimental Setup

The toroidal rotation was measured using lines of He II and C III at 468.6 and 464.7 nm resp. The spectrometer used was a 1 m Czerny-Turner spectrometer, equipped with a 2400 lines/mm grating. Poloidal rotation was measured using the resonance lines of C IV at 154.8 nm and of N V at 123.9 nm. The required extreme high resolution for the latter measurements was provided by a 6.65 m spectrometer with a 1200 l/mm grating [2], allowing detection of a velocity change of 100 ms^{-1}. Apart from these instruments a soft x-ray five channel multi-layer mirror polychromator [3] was measuring the time evolution of the intensity of the C VI resonance lines at 3.4 nm. We studied in particular the effect of Electron Cyclotron Heating (ECH) on the rotational velocity.

3 Results

In RTP, a radial scan of the deposition of ECH, with steps $< 1\%$ of the minor radius of 180 mm revealed a discretised response of the electron temperature. The central electron temperature, T_e, showed sharp transitions between plateaux (see fig. 1) as a function of the ECH deposition radius, ρ_{dep} [1]. Also the line broadening during ECH showed this remarkable stepwise behaviour (see figs. 2 and 3), even while we were measuring at a radius which was at least 1.5 times as large as the largest deposition radius (ρ_{dep}). The measurements in fig. 2 show the effect on the poloidal rotation, those in fig. 3 on the

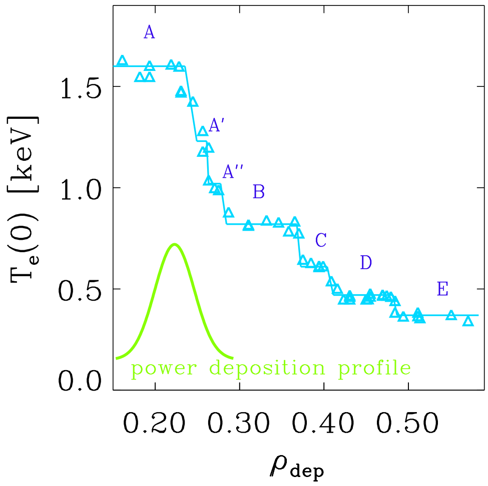

Figure 1: *Central electron temperature, T_e, vs. the deposition radius, ρ_{dep}; the latter is given as a fraction of the minor radius ($\rho_{dep} = r/a$).*

toroidal rotation. An interesting aspect is that the change in line width can become even negative for poloidal rotation when the deposition occurs more off-axis.

Commonly a change in spectral line width is attributed to a change in ion temperature. In this case this should imply in some cases a decrease in ion temperature while we are heating the plasma. Careful study of the lineprofiles of He II showed however that while these are asymmetric to one side before ECH, they change to the other side during ECH. This shows the existence of two velocity groups of this ion, which indicates the appearance of rotational velocity shear. During ECH the relative speed and intensity of these two groups of ions are changed, which can lead both to line broadening as well as line sharpening. The existence of different velocity groups was also seen in the C IV line during other experiments, where this line was clearly splitted in two, three and often four components, each with the same line width, during and after ECH. Apparently different velocity groups of this ion were created, but all with the same temperature.

During another session the results seemed to be more unclear and there were at a first look no steps to be seen (see fig. 4). However, when we correlated the central electron temperature and the electron temperature profile with the line broadening, we could classify the different discharges into four groups, each with about the same central T_e and profile. The change in line broadening in each of these groups changed gradually with ρ_{dep}. The overlap in ρ_{dep} beween the groups might be caused by the fact that the different groups were, except for a few shots, widely separated in time during the session. Electron density (development) and ECH-power were almost the same for all discharges. However those in the uppermost left and right groups contained more carbon before ECH.

Also the time evolution of the intensity signals from the soft x-ray polychromator could be correlated to the different groups identified above. It was the same for almost every discharge in each group but clearly different for discharges in different groups. The

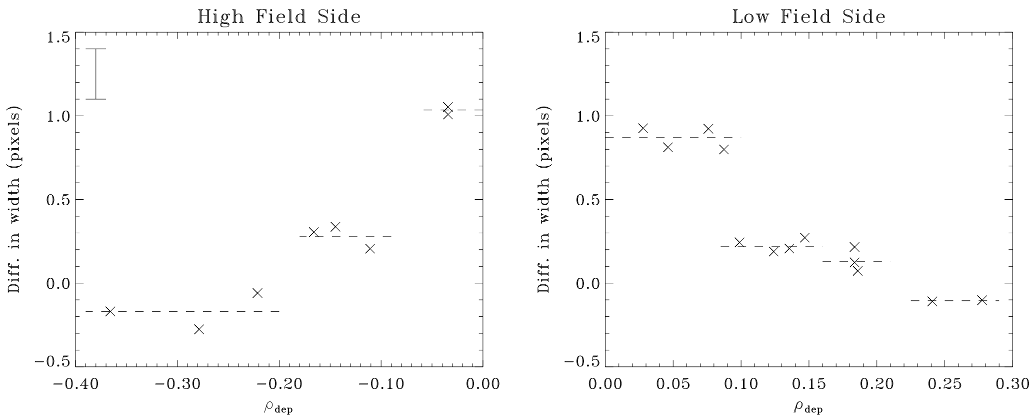

Figure 2: *The effect on the poloidal rotation due to ECH. The change in line width of the C IV line at 154.8 nm is plotted as a function of* ρ_{dep}*, showing a steplike structure as in fig. 1. A direct comparison can not be made due to different conditions during these series of discharges. 1 pixel corresponds to 1.6 pm.*

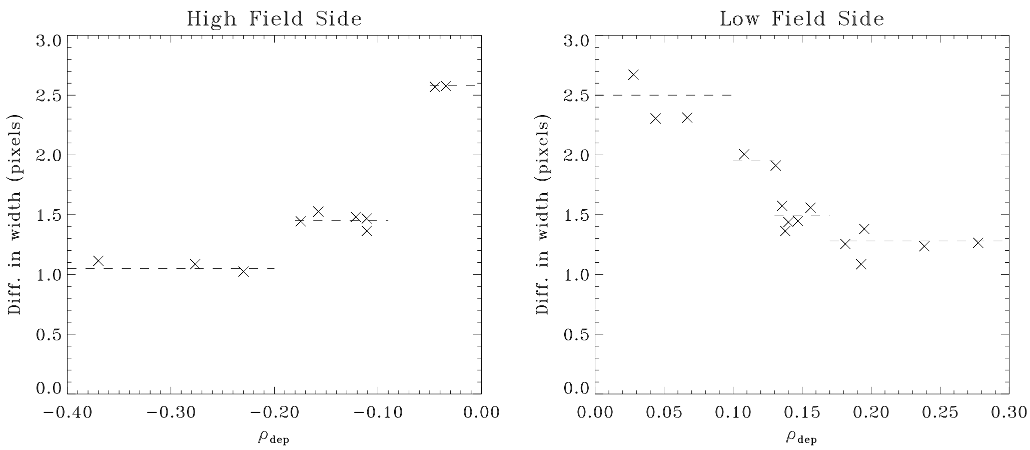

Figure 3: *The effect on toroidal rotation for the same discharges as in fig. 2, as shown by the change in line width of the C III line at 464.7 nm vs.* ρ_{dep}*. 1 pixel corresponds here to 3 pm.*

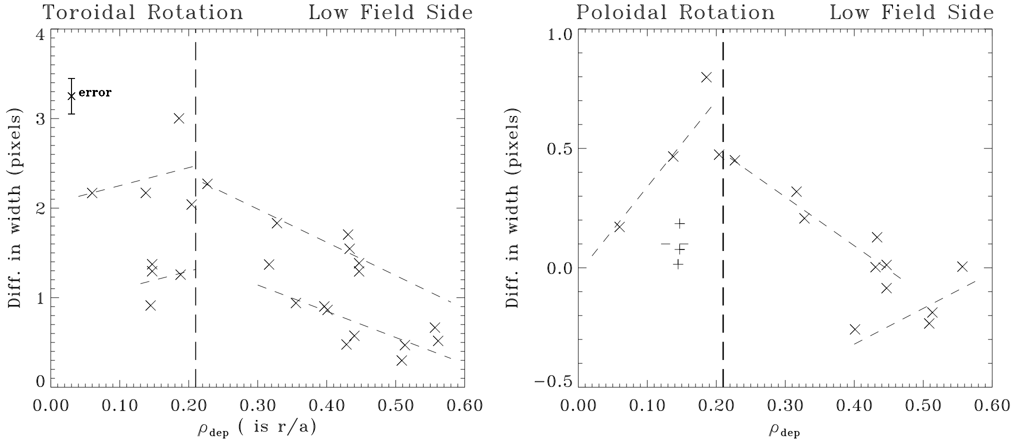

Figure 4: *At the left the change in line width of the He II line at 468.6 nm vs.* ρ_{dep}*; at the right for the C IV line at 154.8 nm (×) and the N V line at 123.9 nm (+); the different shots are grouped according to the central* T_e *during ECH. The dashed vertical line represents the q=1 surface.*

plasma is thus not only changed in a static way during ECH, but also the time development of the plasma during and after ECH is influenced.

The C IV radiation, emitted at a radius of 140 mm, showed an intensity increase during ECH which was higher at lower central electron temperature. This could provide information about cooling mechanisms for discharges with off-axis ECH and could help explain the appearance of hollow temperature profiles under certain circumstances.

4 Conclusions

Electron thermal transport barriers are clearly evident in spectroscopic measurements, as demonstrated by the effect on rotational velocity shear of ions. This shows that velocity shear is related to confinement. The effect of ECH deposition does not only change the plasma in a static way during heating, but the time development of the plasma depends also on the role of the barriers.

Acknowledgements

The first author gratefully acknowledges support by a grant from the Royal Swedish Academy of Sciences.

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