Investigation of carbon screening on TEXTOR with Dynamic Ergodic Divertor in 6/2 mode.

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1. Introduction.

One of the main purposes of the Dynamic Ergodic Divertor, DED, on TEXTOR [1] is the increase of particle transport at the plasma boundary, without deteriorating the global confinement. This action is expected to lead to enhanced impurity screening and/or to enhanced edge radiation [2]. In this paper, we present few observations related to the influence of DED, operating in m / n = 6/2 static mode, on intrinsic carbon, which is the main impurity in TEXTOR. Our analysis is based on the evaluation of the ratio of two spectral lines measured in the UV The intensity of CIII line at 229.6 nm (emitted by C^{2+} ions only in the vicinity of the carbon source) can be associated both with the carbon fluxes and with the total carbon radiation [3], while the CV line at 227.1 nm (emitted by C^{4+} ions far from the source) can be associated with the carbon content in the confined plasma. The lines are measured both on the High Field Side, HFS, where the graphite tiles which cover the DED coils are located and on the Low Field Side, LFS, at the poloidal belt limiter ALT-II (also graphite). On the HFS, CIII is measured only on the bottom part of area of the divertor plate, so that we have to assume symmetry in the emission top-bottom, when computing the total CIII emission on the HFS. Considering the basically 2 dimensional character of DED, this may lead to significant errors. For that reason the observed increase of the ratio CIII/CV with DED can not be considered as a quantitative measure of the increase in screening/radiation of carbon, but rather as a qualitative trend.

2.Experiments.

At a certain level of the current of DED, I_{DED}, (i.e. at a certain strength of the perturbing field) the 2/1 tearing mode is triggered, with correlated loss of plasma energy. For a given distance between the plasma edge and the divertor coils the threshold depends on the value of the safety factor, q(a): decreasing q(a), I_{DED} must decrease too. On the other hand, for a given q(a), decreasing the distance plasma-coils, I_{DED} must be reduced. Therefore, we are severely limited in the possibility of decreasing q(a) at high I_{DED} (I_{DED} max = 7.5 kA, for 6/2 mode operation), if the plasma minor radius remains constant, *a* = 0.46 m. Henceforth, the horizontal position of the plasma column is given by the position of the geometrical centre of its poloidal cross- section, i.e. by the plasma major radius R. At R = 1.73 m the interaction plasma-wall occurs at the HFS at the divertor tiles, while at R = 1.76 m the plasma is limited on the LFS by the toroidal limiter ALT-II.

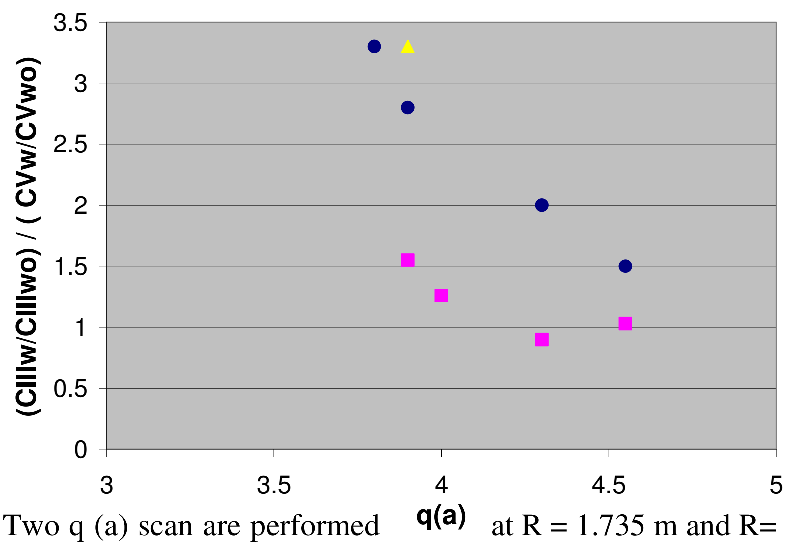
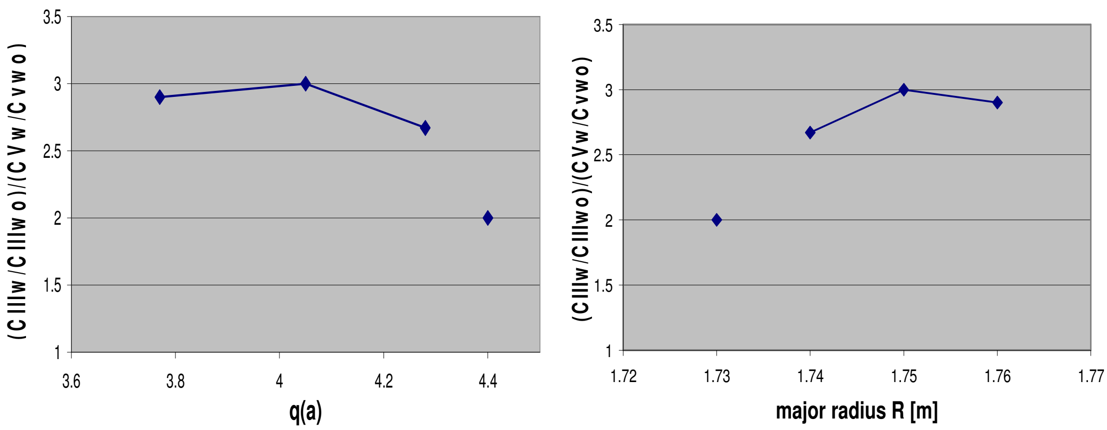


Figure 1. CIII/CV as function of q(a) at R= 1.735m (pink squares) and R=1.755 m (blue circles) at Ided = 5.5 kA. The yellow triangle is Ided=6.5 kA at R= 1.755

Two q (a) scan are performed at R = 1.735 m and R= 1.755 m with I_{DED} =5.5 kA (see fig.1). Taking the ratio of CIII to CV line intensity as a figure of merit for the changes caused by DED, we note that, in general, the effects of DED on carbon transport increase with decreasing q(a) -see also ref. [4]- but they are much stronger at higher R, even though the strength of the perturbing field is significantly reduced with increasing R, since $B_r \sim (r/r_{coil})^9$. (Note that the triangle in fig. 1 refers to a single pulse with I_{DED} = 6.5 kA). In these two series, the increase of the ratio CIII/CV with DED is determined by the strong increase of the CIII line intensity while the CV line tends to increase. Measurements in the visible are in agreement with measurements in the UV showing a robust increase of CI and CIII lines in the whole HFS during DED at low q(a). The C^{6+} ion density from CXRS is generally seen to increase slightly in the DED phase, basically in agreement with UV measurements. Both the edge temperature and density, measured at the LFS, decrease significantly with DED, in qualitative agreement with bremsstrahlung signals which remain unchanged or decrease slightly at the LFS during DED. However, at the HFS and also in the central plasma, bremsstrahlung radiation increases with DED, as a consequence of the 2- dimensional character of DED in static mode. The central Zeff, reconstructed by inversion of line integrated signals, increases during DED operation at low q(a) as does the total radiated power, Prad, leading to the constancy of $[Prad/(Zeff- 1)]/n_e^2$. However, it must be noted that the reconstructed central Zeff tends to be overestimated with DED, especially in the case of significant changes at the plasma edge [5]. Fig.2 shows the effects on the ratio CIII/CV induced by DED at I_{DED} = 5.5 kA for a series of four discharges in which both q(a) and the horizontal displacement R are changed simultaneously. The plasma current is increased with increasing the distance R in such a way that the q = 2 surface remains at the same distance from the divertor coils. In spite of the relatively large range of variability of q(a), only minor differences are seen among



Figures 2- 3. CIII/CV as function of q(a) and of R

the three data points connected with a line, while a clear decrease is seen for the point at q(a) = 4.4. In fig 3, where the same four data points are plotted against R, one can notice that the drop in CIII/CV seen at q(a) = 4.4 in fig.2 is, in fact, related to the plasma horizontal position R = 1.73 m, for which the plasma-wall interaction occurs predominantly at the divertor tiles. In contrast with the data reported in fig. 1, for these discharges the increase of CIII/CV depends on the simultaneous increase of the CIII line and decrease of the CV line. Also CXRS shows a decrease of the CVI line, in agreement with UV data. On the other hand, the edge Zeff increases significantly while the central one remains constant. The absence of the expected decrease of the central Zeff with DED can again be explained by the difficulty of resolving small differences in the reconstructed central Zeff profile in presence of large increase of bremsstrahlung at the plasma edge. Measurements of CII line in the visible show an increase of the signals on the whole HFS, thus confirming the enhanced radiation level due to low ionized carbon.

3. Discussion and conclusion.

Although the data of fig. 1 indicate the major relevance of the q profile, as seen also in ref. [4], the three data of figs 2-.3 connected with a line, suggest that, in fact, q(a) is not the leading parameter responsible for the change in carbon screening/radiation. The CIII/CV ratio seems, more likely, to be affected by the strength of the perturbing field at surface q = 2 (and q=3). Indeed, decreasing q(a) the distance between q = 2 surface (and q= 3) and the divertor coils decreases, leading to higher B_r at q = 2 surface. The observed dependence of CIII/CV on the level of B_r more than on q(a) may be related to the poor poloidal spectrum of the DED field in 6/2 mode [6]. On the other hand, comparison of the data at R= 1.735 m in fig.1 with those at R = 1.755 m and comparison of the point at R = 1.73 m with the other three of fig. 3 may indicate that the effects induced by DED are reduced when plasma-wall interaction occurs on the high field side, in close proximity with the divertor coils. This would be consistent with numerical simulations made with the multi-fluid code TECXY [7].

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