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Intensity radial profiles of VUV lines near the carbon target in the CASTOR tokamak

V.Piffl[1], Vl.Weinzettl[1], A.Burdakov[2], S.Polosatkin[2]

[1]Institute of Plasma Physics, Association EUROATOM-IPP.CR, Za Slovankou 3, P.O.Box 17, 182 21 Prague 8, Czech Republic
[2]Budker Institute of Nuclear Physics, Novosibirsk, Russia

I. Introduction

An investigation on interaction of hot plasma with carbon and tungsten targets is carried out in CASTOR tokamak (IPP Prague) and multi-mirror magnetic trap facility GOL-3 (Budker Institute, Novosibirsk). In both experiments, the imaging Seya-Namioka Spectrometer has been upgraded to monitor the radial profiles of the line intensities in VUV spectral range. Such spatial resolved intensity monitoring along the plasma radius together with the radiation code simulation allows to clear a radial distribution of ions of different ionisation stages near the target immersed in an hot plasma, if the energy release from plasma to the target is of order of 100 J/m^2 (CASTOR) and 30 MJ/m^2 (GOL-3). We note here the characteristic parameters in CASTOR: R=0.4 m, a=8.5 cm, $B_T \sim 1.3$ T, $n_e \sim 4\text{-}20{*}10^{18}$ m^{-3}, $I_p \sim 10$ kA, $T_e \sim 200$ eV, $\tau_p \sim 1$ ms.

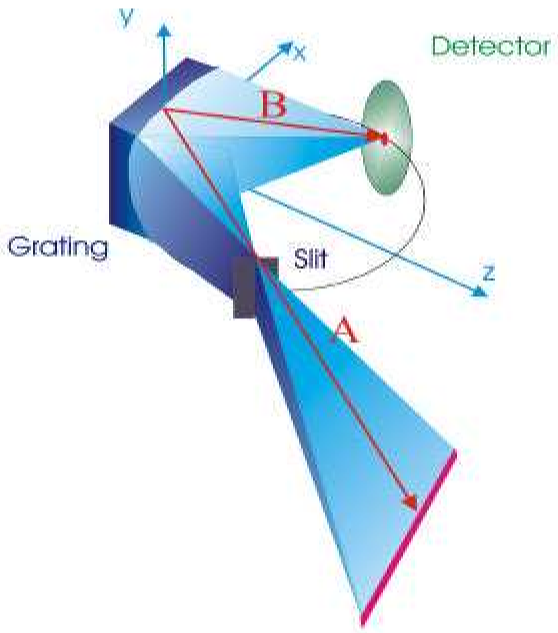

Fig.1 Image creation by spherical grating based spectrograph. The thin layer of emission source, which is located in vertical focus of the device, is imagined as a point in a detection plane.

II. VUV Imaging Seya-Namioka Spectrometer

The present Seya-Namioka Spectrometer has been upgraded to monitor the radial profiles of the chord-integrated line emission of the dominating low-Z plasma impurities in 50 - 200 nm wavelength range**.** The first order of line emission is indicated up to the wavelength 110 nm, while the lines of second and third order are seen in the range up to 200 nm.

The design of the spectrometer was based on use of spherical dispersion grating [1,2]. In Fig.1, the optical scheme of reconstructed Seya-Namioka spectrometer is shown. The two-dimensional detection system consists of two channel-plates set of the working area ϕ=38 mm. The output electrons are accelerated onto the scintillator of the fiberoptic lightguide, which is consequently used as a vacuum throughput. The image of the radial intensity distribution of the chosen lines sequence could be taken during the whole period of the plasma discharge with 2-10 ms exposition time. A CCD camera (165 x 192 pixels) is optically coupled to the lightguide output.

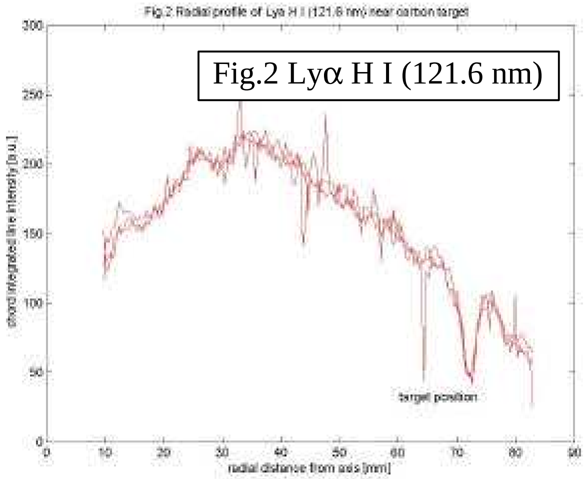

Fig.2 Lyα H I (121.6 nm)

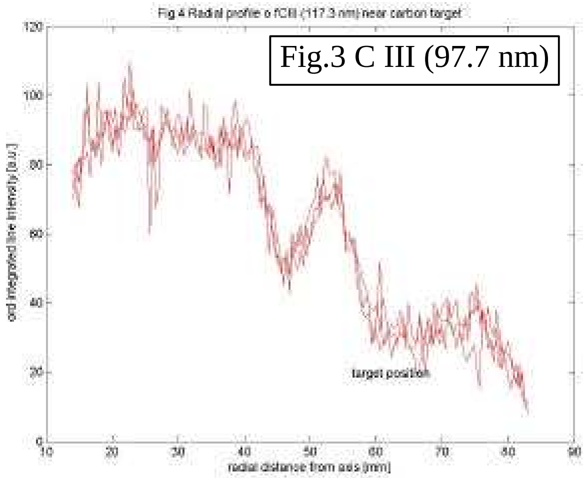

Fig.3 C III (97.7 nm)

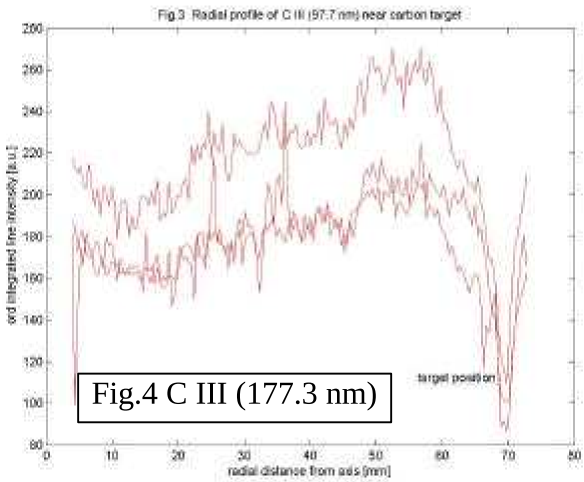

Fig.4 C III (177.3 nm)

III. Intensity radial profiles of VUV line radiation near the solid targets in CASTOR

Two different targets are used in tokamak CASTOR experiment. The biasing carbon-electrode, which can induces the electric field shear in SOL for a suppressing the plasma turbulences in edge plasma. The other one: the tungsten bulk target is used for material transport studies [3].

Biasing carbon-electrode can be moved in radial direction and is positioned in the VUV spectrometer field of view. The biasing pulse duration is 5-10 ms and can be triggered from

0 to 15 ms after the begining of discharge. Depending on electrode radial position and applied biasing potential the different influence on plasma confinement is expected.

Chord integrated line intensity measurements were performed in the spectral range of 90-130 nm. In a fixed tilting position of the spectrometer, the imaging of Lyα H I (121.6 nm), C III (97.7 nm and 117.3 nm), N V (123.8 nm), and O VI (103.2 nm, 103.7 nm) was created and analysed. The radial chord intensity profiles of Lyα H I (121.6 nm) in Fig.2, C III (97.7 nm) in Fig.3 and CIII (117.3 nm) in Fig.4 in OH regime are presented.

The maximum of Lyα HI (121.6 nm) line chord intensity is located near to the target, which is positioned at radial distance 60 mm from the chamber axis. Like as in Lyα HI case, the chord integrated line intensity of C III (97.7 nm) and CIII (117.3 nm) grows near to the target location, as we can see in Fig.3 and Fig.4. The radial intensity profile of Lyα H I as well as of both CIII lines culminate close to the target surface, where the temperature of plasma cloud is in the range of 5 – 10 eV.

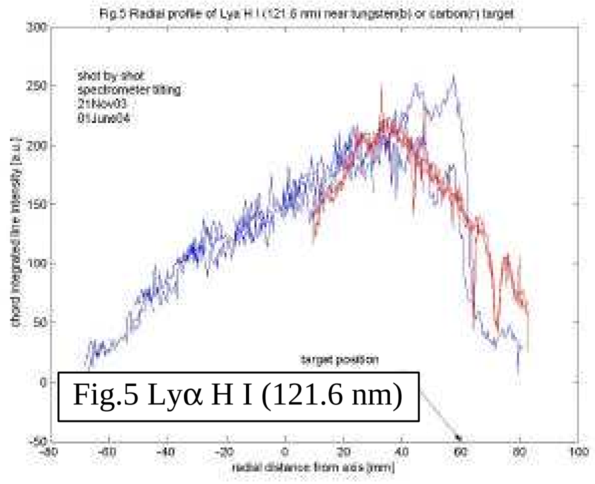

Fig.5 Lyα H I (121.6 nm)

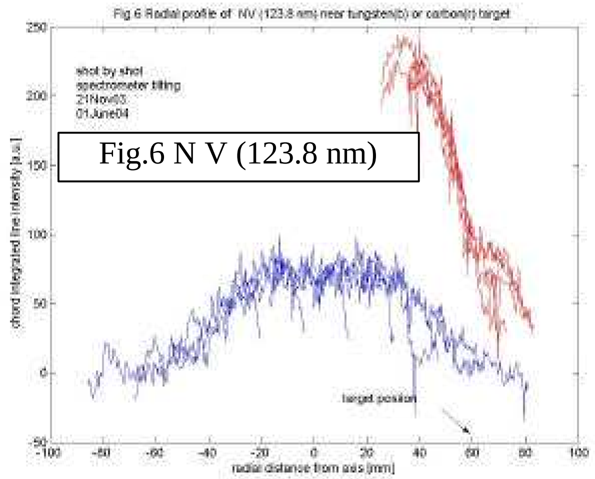

Fig.6 N V (123.8 nm)

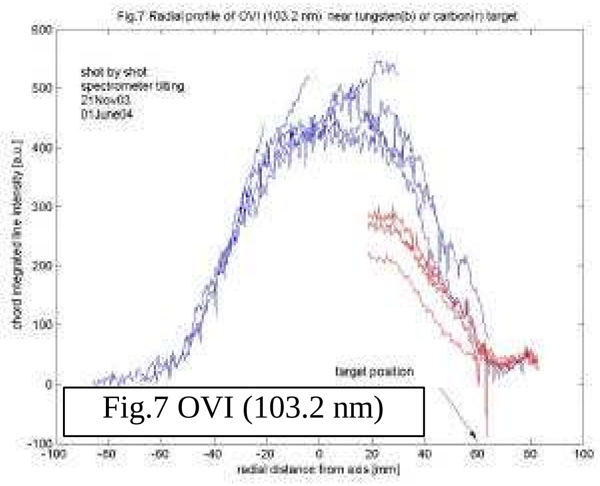

Fig.7 OVI (103.2 nm)

In other experiments, the carbon target was replaced by the tungsten bulk target for comparison of the line intensities behaviour near to the surface of low- and high-Z material. The tungsten target can be moved in radial direction deeply inside the last closed flux surface (LCFS). In Fig.5, Fig.6 and Fig.7 the radial intensity profiles of Lyα H I (121.6 nm), NV (123.8 nm) and OVI (103.2 nm) are shown in the vicinity of the carbon (red) and tungsten (blue) target surface. Due to the temperature growth in the plasma core, the higher ionisation stages appear at larger distance (>10 mm) from the target and the chord integrated intensity profiles of NV and OVI remain more or less axially symmetric.

IV. Conclusion

In the CASTOR tokamak, the total energy load on the wall is relatively small, in order of 100 J/m^2, while in the multi-mirror magnetic trap facility GOL-3 the energy load on the wall can reaches 30 MJ/m^2. As reported in [4], the behaviour of the radial profiles of line radiation of lower and higher ionisation stages of the same light impurities is similar in the vicinity of the solid target in both experiments. Thought, the target surface becomes a source of the hydrogen and light-Z atoms, due to the recombination of the plasma ions.

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