

Temporally and spatially resolved measurements of VUV lines intensity profile in the tokamak CASTOR

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Abstract

The time and spatial evolution of the light impurities emission is investigated by the VUV imaging spectrometer coupled with fast, 1 kHz, detection imaging system in plasma periphery in the CASTOR tokamak.

Temporal measurements of the time behaviour of radial profile of the chord integrated line intensity are mostly performed in the spectral range of 90-130 nm. In a fixed tilting position of the spectrometer, the imaging of N V (123.8 nm), Ly α H I (121.6 nm) and O VI (103.2 nm, 103.7 nm) emission is created and analysed.

The radial intensity profile indicates the sensitivity to the transport parameters, like diffusion coefficient $D_{\text{perp}}(r)$ and inward velocity $V_{\text{inw}}(r)$. It offers the experimental data for quantifying the influence of the transport phenomena on ionisation equilibrium of the light impurities in tokamak experimental conditions [1].

Temporally and spatially resolved measurements

The advanced diagnostic methods of the plasma vacuum ultraviolet (VUV) imaging spectroscopy provides a possible way of light impurity transport investigation [2,3]. The study of the character of the intrinsic impurities transport in the tokamak plasma periphery is one of the important topic for design of the future thermonuclear reactor. The transport coefficients could be evaluated by measuring and modelling of the spatial and temporal behavior of the emission line profiles.

In IPP Prague, recently successfully developed the VUV Imaging Seya-Namioka Spectrometer & 2D Fast Detection System [3] offers a new possibilities in the investigation of the line intensity radial profiles. Spectrometer monitors the radial profiles of

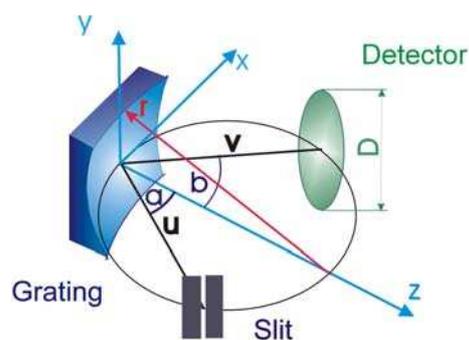


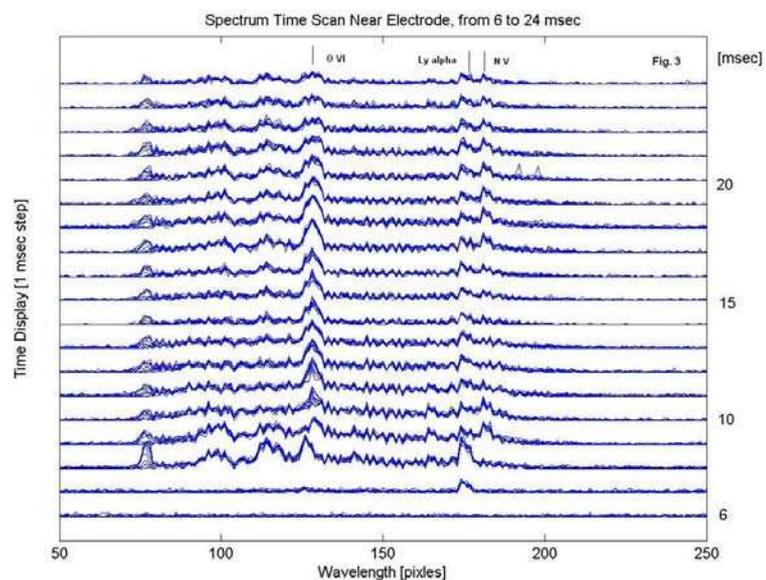
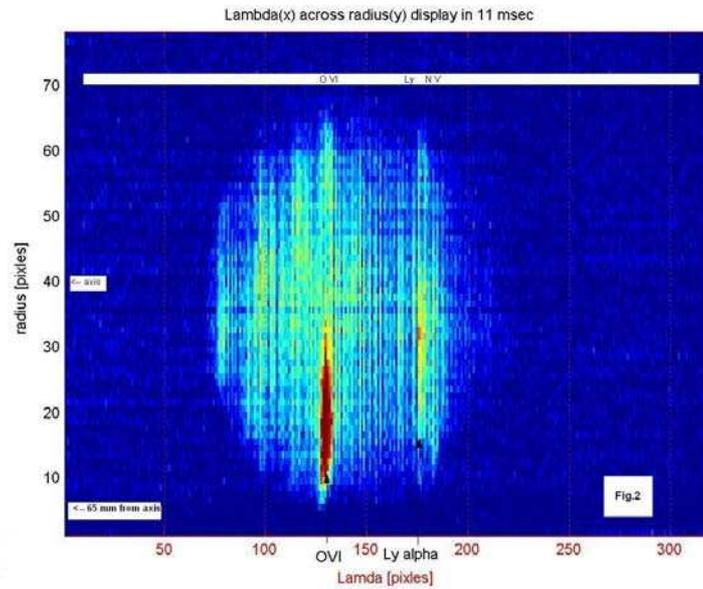
Fig. 1. Scheme of Seya-Namioka VUV spectrograph

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 spatial resolution is found

to be about 3mm. Optical enlargement of the system is 2.93, so the view part of the plasma is 70 mm in high.

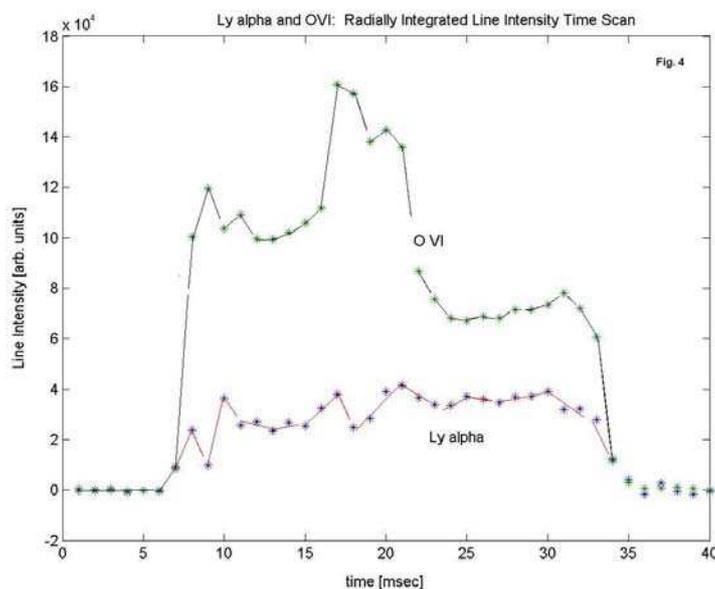
The design of the spectrometer was based on use of spherical dispersion grating [1,2]. In Fig.1, the optical scheme of reconstructed Seya-Namioka spectrometer is shown. The two-dimensional detection system consists of two channel-plates set of the working area $\phi=38$ mm. The output electrons are accelerated 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 1 ms exposition time. The Fast CCD camera, 320 x 156 pixels, 1 kHz frames rate is optically coupled to the lightguide output of the detection system.

The VUV spectroscopy results we present here were created during the so called “polarized discharge” in tokamak CASTOR. A biasing tungsten or carbon electrode is movable in radial direction to the plasma column and is positioned in the VUV



spectrometer field of view. The biasing pulse duration is 5-10 ms long and can be triggered from 0 to 15 ms after the beginning of the discharge. Depending on electrode radial position and applied biasing potential the influence on plasma confinement is expected.

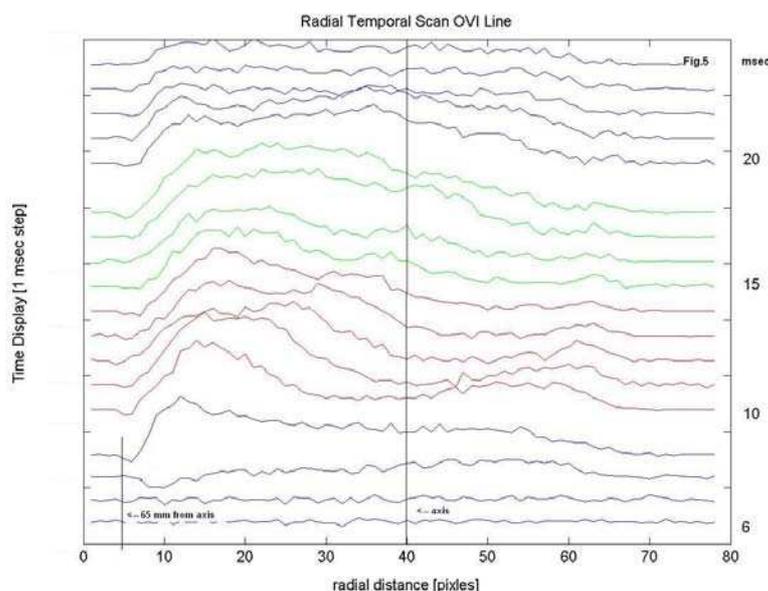
Chord integrated line intensity measurements were performed mostly in the spectral range from 90 to 130 nm. In a fixed tilting position of the spectrometer, the imaging of N V (123.8 nm), Ly α H I (121.6 nm) and O VI (103.2 nm, 103.7 nm) was created, Fig 2.



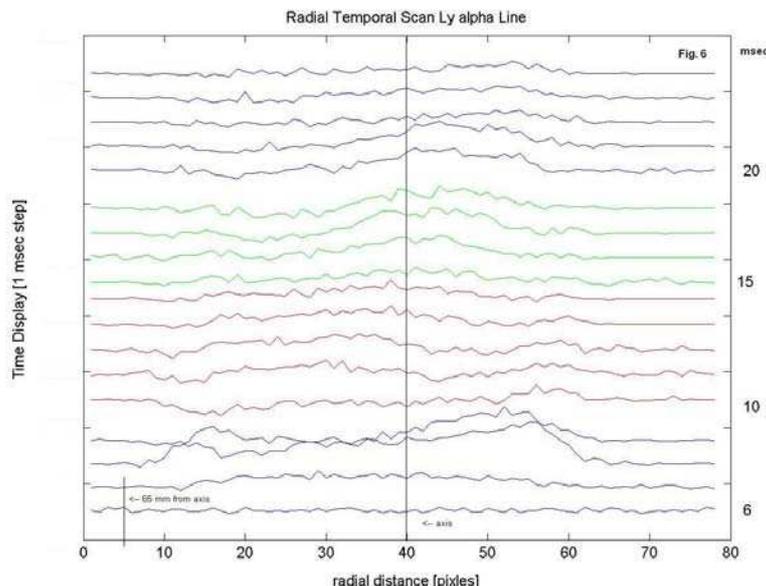
During the plasma build up, the electron density as well as the temperature grows. The content of high ionised stages of light impurities, especially at the plasma edge, is matched to local ionisation equilibrium influenced by the transport process.

In the Fig.3, we present the time evolution of the wavelength spectrum in narrow plasma layer near the electrode. Ly α H I appears as first followed by relatively strong Oxygen radiation.

In Fig.4, the time scan of lines power of Ly α H I and O VI is shown. In this case, the line intensity is integrated over the whole radial plasma cross-section. The biasing potential, + 200 V, was applied in a period from 10 to 15 msec, and the electrode was located 65 mm from the chamber axis.



Another interesting feature of the radial intensity profile behaviour during the plasma discharge could be seen in Fig.5 (O VI line) and in Fig.6 (Ly alpha line). The average line power, integrated over the line width, is expanded in radial direction. The curves



time order is from 6 msec to 24 msec. We can see a flat maximum, which moves from the left to the right side at the picture. For the line emission power is dominantly influenced by “local” electron density perturbation the plasma bulk velocity is lower than 10 m/sec.

Conclusion

Recently, new data have been obtained, which illustrate the real possibility to analyse the spatial (radial) image of line emission spectrum created by VUV Imaging Spectrometer & 2D Fast Detection System in tokamak CASTOR discharges. The shape of the radial profile of the chord-integrated intensity of the OVI (103.2 nm) and Ly α H I (121.6 nm) lines was obtained. The obtained experimental data are used for quantifying the influence of the transport phenomena on ionisation equilibrium of the light impurities in tokamak experimental conditions.

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