Spectroscopic Characterisation and Plasma Surface Interaction Experiments with the linear Plasma Simulator PSI-2

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Application Note

Introduction

PSI-2 produces a plasma column of 2.5 m length and about 6 cm diameter in an axial magnetic field of 0.1 T. In the target region, the temperature and density reach values of about 1-20 eV and 10^{17}-10^{19} m^{-3}. Spectroscopy is a favourable method to measure plasma parameters as it has big advantages compared to movable mechanical systems such as Langmuir probes. First measurements will be reported to determine the radial plasma parameters in PSI-2 with the use of a 2D-detector coupled to a spectrometer. Moreover, the interaction of Argon ions with a tungsten target plate could be studied in detail.

Expertimental Setup

In figure 1 the plasma simulator and the observational line of sight to an Acton Spectrograph (SP750) with the Newton EMCCD detector (DU971P-UVB) is shown.

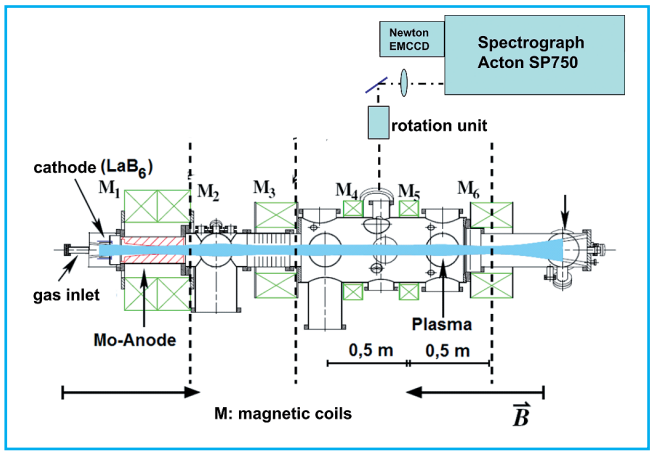

Fig.1: The linear plasma simulator PSI-2 (to scale) with the optical observation system (not to scale)

The rotation unit allows to turn the entrance slit by 900 so that an easy change in the spatial direction from the radial to the axial direction can be accomplished. Figure 2 displays these arrangements together with a running deuterium plasma.

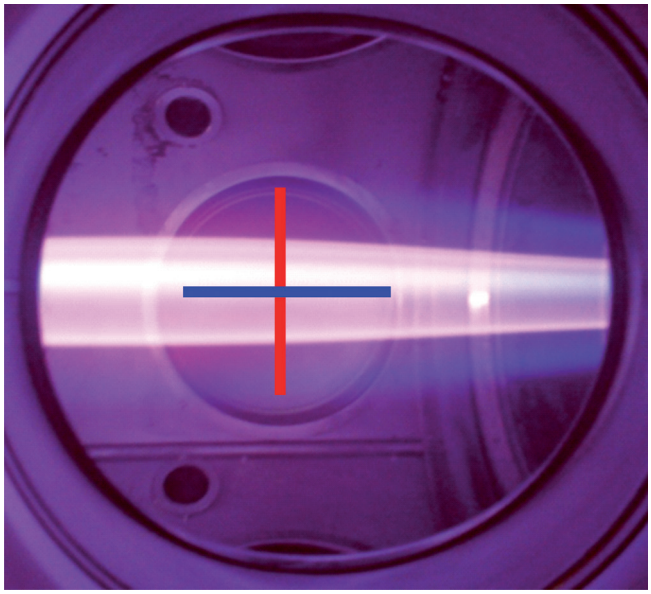

Fig.2: A view through the optical observation window during a running deuterium discharge with the possible orientations of spectrometer slits indicated

Results

A radially resolved spectrum around 610 nm of such a discharge with the slit in vertical position is shown in figure 3.

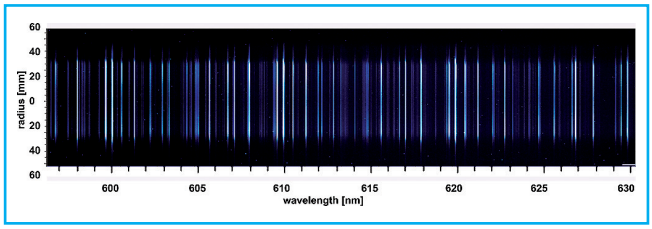

Fig.3: Radially resolved deuterium molecular spectrum in the range of the Fulcher-α band

One can already detect intensity variations along most of the spectral lines of the molecular Fulcher-α band, which dominate this part of the spectrum. For a more quantitative analysis the intensity profiles have been Abel inverted and the rotational temperature deduced. The results are seen in figure 4, where the development of Trot in the bottom half of the plasma column is plotted.

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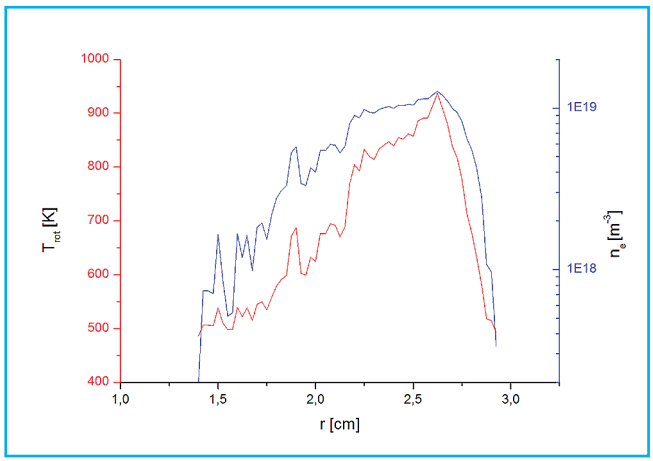

Fig.4: Rotational temperature and derived electron temperature as a function of the plasma radius

Using the dependence of the electron density ne as a function of Trot the radial dependence of ne can be derived [1]. A similar dependence can also be derived by the use of Langmuir probes, however, the spectroscopic method is much less interfering and non destructive.

An example for experiments with the slit turned into the horizontal position is displayed in figure 5.

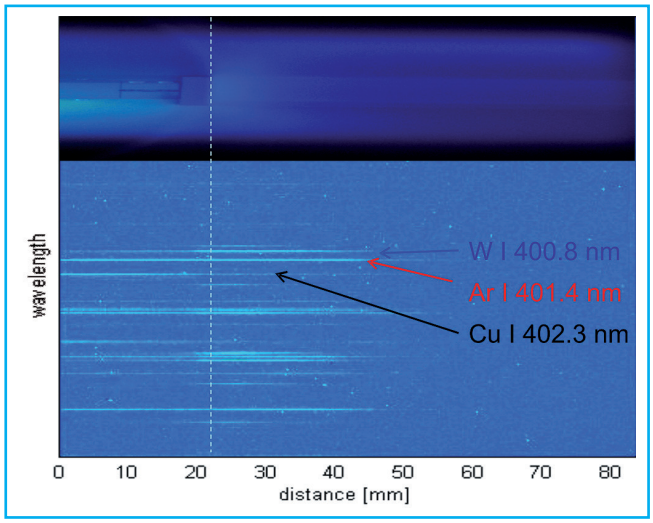

Fig.5: Axial distributions of different elements near a tungsten target plate in an Argon plasma

The analysis of the sputtering process of Ar-ions from a tungsten target plate is strongly supported by the axial appearance of the different spectral lines: the Ar I line represents the discharge over the whole length of the axis observed, the tungsten W I line starts at the target and falls off rapidly after 15mm, and the copper source shows right at the rear side of the (copper) holder.

References

[1] S.Brezinsek, Publications of the Research Centre Jülich, Jülich Germany, Report No 3962 (2002)

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