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Inner shell photoabsorption spectra of C ions

ABSTRACT

The absorption spectra of ionized and neutral carbon have been obtain in the soft X-ray range by using two laser produced plasmas. They correspond to the transitions of the 1s inner electron. The CIV and CIII spectra, in addition with the CV one already studied, are reported. Furthermore the absorption spectra of neutral carbon have been observed for the states: solid, vapour (clusters) and CI atoms.

THE EXPERIMENT AND THE RESULTS

Absorption spectra of moderately charged ions can be obtained with two laser produced plasmas, one acting as the background continuum source, the other as the absorbing medium. This technique has been widely used both in the normal and in the grazing incidence spectral regions (Jannitti, 1987 and references).

Here we report on the absorption measurements of the spectra of carbon ions (CI, III, IV) in the grazing incidence. In the same spectral region the spectra of graphite vapours and for comparison of an amorphous graphite film have been observed. The experimental technique has been described in detail in a previous paper (Jannitti, 1987). In fig. 1 the absorption of the CV, IV and III ions between 25 and 45 Å is reported. The CV spectrum is due almost to the optical electron and is shown here for comparison with the other spectra. It was obtained by focusing about 1.3 J of laser energy in a 1 mm diameter focal spot size on a graphite target and delaying the continuum irradiation of the absorbing plasma about 4.5 ns. Furthermore the absorbing plasma has been probed at y=0.5 mm from the target surface. The photoionization cross-section measurement

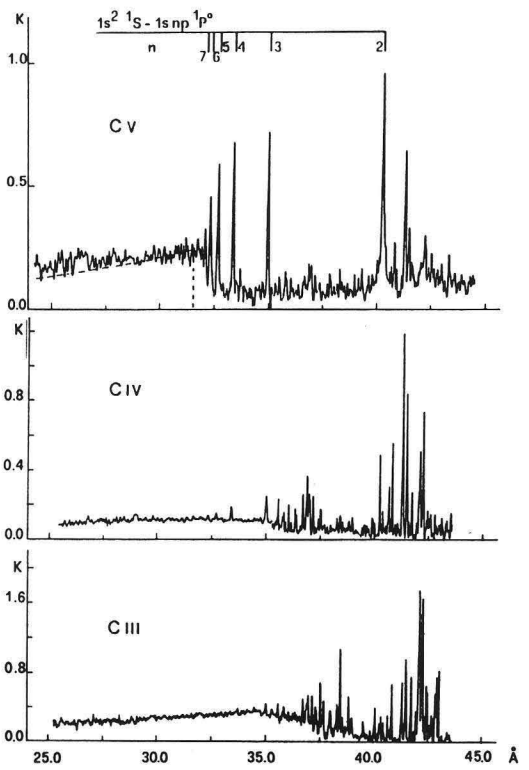

Fig. 1. Experimental absorption coefficient of the C III, IV, V ions.

has been already reported (Jannitti, 1988). The CIV spectrum has been produced with 0.7 J focused in a spot of 1.2 mm diameter and the absorbing plasma has been irradiated at y=1.1 mm with a delay of 30 ns. On the other hand the CIII spectrum has been produced by focusing 1.4 J in 0.3x16 mm^2 and the plasma has been probed at y=0.7 mm with a delay of 18 ns. The long wavelength portion of the two spectra showing the discrete transitions has been deconvoluted by applying a constrained deconvolution procedure to the absorptance (Jannitti, 1989). With respect to the CV spectrum there is apparent an increased mixing between the ionization stages. The main reasons can be: the range of the abundance ratio of the Li- and Be-like ions in an ionization balanced plasma, the duration of the background continuum emission (~ 20 ns) compared to the life time of the Li- and Be-like ions, the poor uniformity of the laser power density distribution in the focal spot on the graphite target. The CIII and CIV spectra are due to inner shell transitions of the 1s electron to np (and ϵp)

levels. A complete analysis of these spectra is in progress while a preliminary identification of the observed transitions has been already reported (Jannitti, 1989). The CIV transitions can be mostly attributed to the $1s^2 2s$-$1s2snp$ and $1s^2 2p$-$1s2pnp$ configurations.

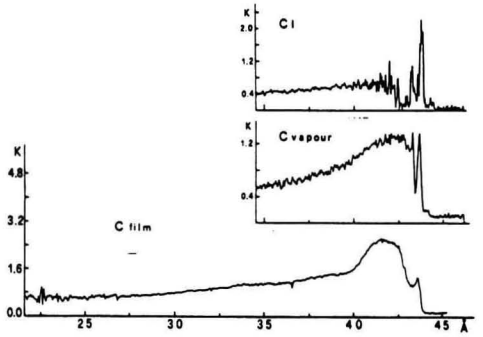

Fig. 2. Experimental absorption coefficient of neutral carbon.

The absorption spectra of neutral carbon are shown in fig. 2. Also the long wavelength portions of the CI and C vapour spectra have been deconvoluted. The experimental parameters were respectively for the CI case: 0.45 J laser energy, focal spot size 0.7x7 mm^2, y=1.5 mm and delay ~ 100 ns; for the C vapour: 0.07 J, 4.2x10mm^2, y=0.25 mm and delay ~ 100 ns.Finally the spectrum of amorphous graphite has been obtained by positioning a 30 $\mu g/cm^2$ graphite film in front of the spectrograph entrance slit and by using the laser produced plasma continuum. It is evident that by decreasing the laser power density on the graphite target the spectrum changes deeply. The CI photoionization spectrum extends down up to about 35 Å with the threshold at about 41.5 Å. It corresponds to the 1s photoionization from the $1s^2 2s^2 2p^2\ ^3P, ^1D, ^1S$ states. Some preliminary wavelength measurements and the corresponding tentative assignments have been already reported (Jannitti, 1989). Work is in progress also on this spectrum. The C vapour spectrum looks like those corresponding to core level-valence state transitions of solid or clusters compounds. The graphite film spectrum has been recorded for comparison. It shows clearly a bulk absorption starting at about 43 Å. The shape at shorter wavelengths appears different from the clusters and CI cases while an absorption peak is present at wavelengths longer than the absorption edge in a perfect agreement with the high resolution spectra obtained with synchrotron radiation (Del Grande, 1988) It appears a true structure of carbon absorption and corresponds in wavelength to the peak observed in the cluster vapours spectrum. On the other hand there is not an immediate correspondence with the discrete lines of the CI spectrum. In conclusion these spectra show a smooth transition from the solid state to the atomic behaviour and once again confirm that in absorption spectroscopy LPP's compare favourably, as continuum source, with synchrotron radiation.

REFERENCES

Del Grande, N.K. and K.G. Tirsell, 1988 - A program to obtain reliable photoabsorption cross sections. In SPIE Conf. Proc., 911, 6-10.

Jannitti, E., P. Nicolosi and G. Tondello, 1988 - Photoionization Cross-section Measurement of the CV Ion. In Phys. Lett. A, 131, 186-189.

Jannitti, E., P. Nicolosi and G. Tondello, 1989 - Absorption spectra from the 1s inner shell electron of ionized and neutral carbon. To be published in Physica Scripta.

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