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ABSORPTION OF ALUMINUM X-RAY LINES IN A LASER CREATED GOLD PLASMA

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We have studied the absorption of aluminum X-ray lines through a gold plasma by focusing a high intensity laser-beam onto a specific target. Absorption in the wavelength range of 5 to 7 Å has been evidenced and measured for Aluminum resonance lines.

La focalisation d'un faisceau laser intense sur une cible adaptée nous a permis de mettre en évidence et de mesurer l'absorption des raies de résonance de l'aluminium par un plasma d'or dans la gamme de longueur d'onde 5-7 Å.

Interpretation of experimental data obtained from laser produced plasmas needs a good knowledge of radiation absorption processes in order to determine the plasma parameters.

In previous papers [1,2] we have studied the self-absorption of H-like and He-like X-ray lines in an aluminum plasma. In this paper we report an experiment where aluminum lines are absorbed by a gold plasma.

Experiments have been performed with a high intensity laser delivering 80 J in 800 ps at the wavelength λ_L = 1,06 μm. The beam was focused onto planar silica targets, on which small dots of aluminum and gold were deposited. The gold dot was shaped as a 300 μm diameter disc and the aluminum dot as 100 μm x 100 μm square, 100 μm apart (Fig.1).

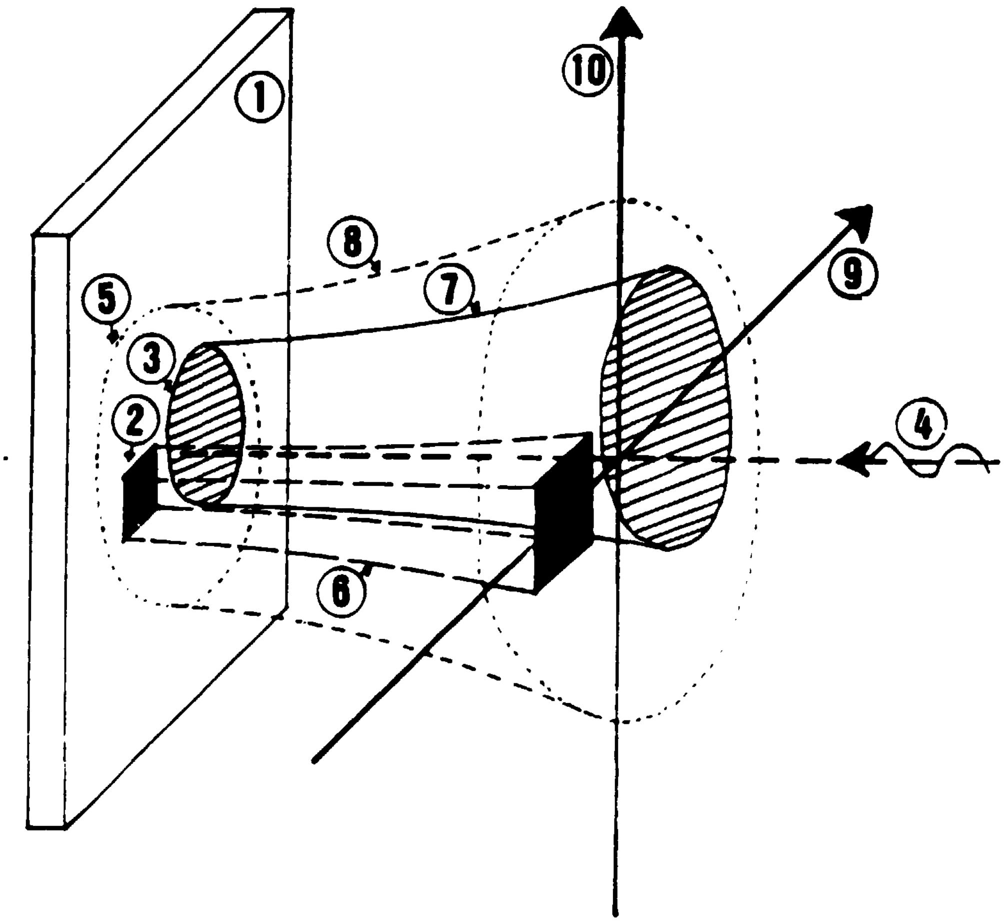

Figure 1 : Target and plasma structures.

1 - Silica substrate.
2 - Aluminum dot.
3 - Gold dot.
4 - Laser beam.
5 - Focal spot.
6 - Aluminum plasma.
7 - Gold plasma.
8 - Silica plasma.
9 - Towards longitudinal spectrograph.
10 - Towards transverse spectrograph.

The metal dots were made thick enough (> 1 μm) to prevent the ablation of the substrate material. The set of the disc and the square dots was fully covered by the laser focal spot whose diameter was chosen to be of 600 μm providing a mean irradiance of $3\ 10^{13}$ W. cm^{-2}. The aluminum square dot acted as a X-ray source and the absorption of its radiation could be observed through the gold disc in the longer direction.

Absorption of the source radiation was analyzed by means of two identical spectrographs viewing in the two main directions of the square-disc set, transverse (T) and longitudinal (L), (Fig.2).

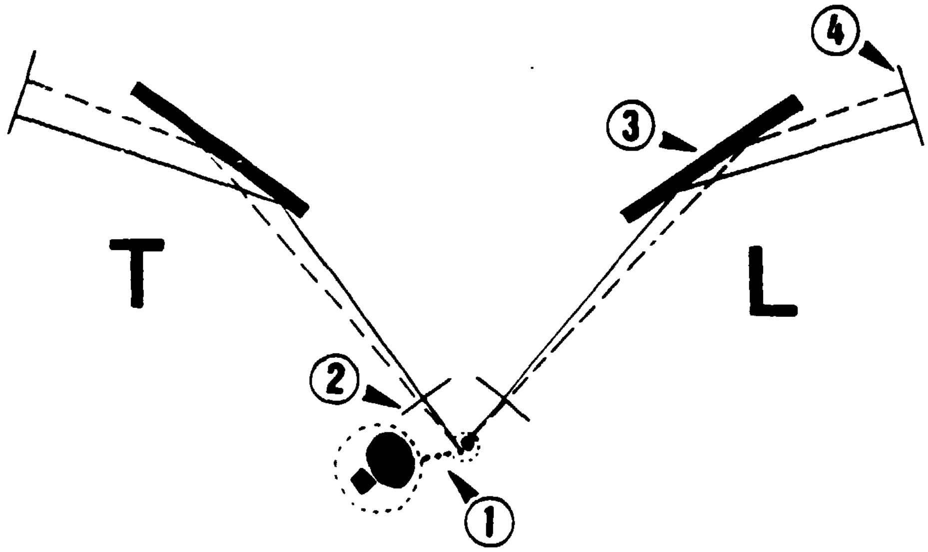

Figure 2 : Experimental Set-up.

1 - Front view of the target.
2 - Spatial resolution slit.
3 - Flat TlAP crystal.
4 - SB2 Kodak Film.

Spectral dispersion was achieved through the use of flat TlAP crystals, and each spectrograph was equipped with a 10 μm-width slit providing the spatial resolution along the direction of the plasma expansion.

Figure 3 shows the spatial variation of the H-like and He-like resonance lines intensities (integrated over the whole line profile) of aluminum versus the distance from the initial target position for the two directions of observation (L) and (T). Strong absorption by the gold plasma is clearly seen for these the lines even far in the plume, though gold emission is not important enough to be detectable at distances from the target surface larger than 50 μm, at least in the observed wavelength range.

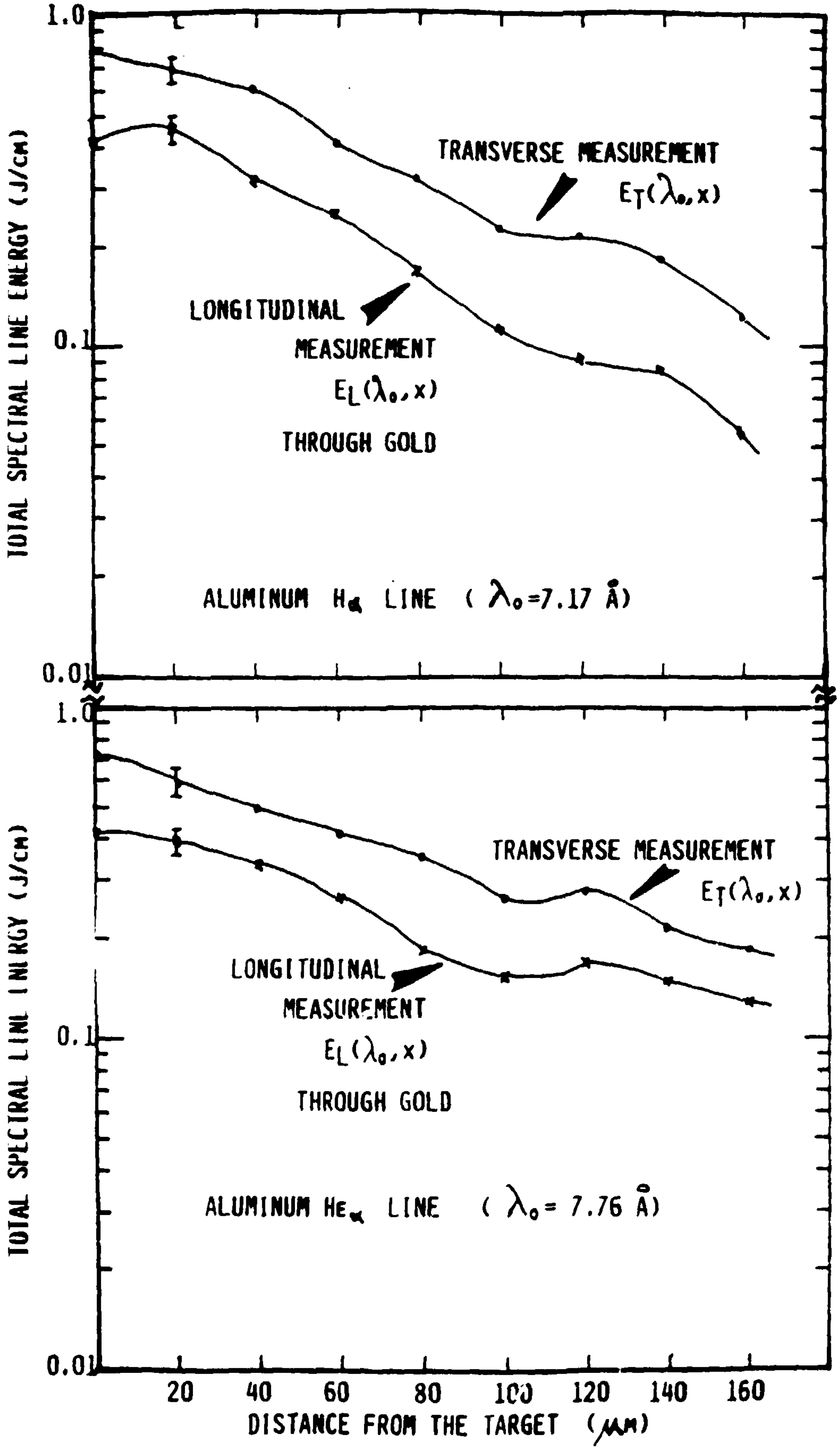

Figure 3 : Line integrated energy of aluminum lines versus the distance from the target.

Interpretation of the results is done through few simple assumptions. Slabs of gold plasma located at a given distance from the target surface are supposed to have homogeneous density and temperature. Temporal variations of the absorption coefficient are considered to be very small as the time duration of aluminum emission is shorter than the evolution time of the gradients (this has been checked in previous experiments with both temporal and spatial resolution [3]). Then the ratio of the total energy for a given line (at wavelength λ) emitted at a distance X, by the source and absorbed by the gold plasma and measured in the L and T directions is :

$$\frac{E_{L}(\lambda,X)}{E_{T}(\lambda,X)} = \exp\left(-K_{\lambda}(X).L\right)$$

where $K_{\lambda}(X)$ is the gold spectral absorption coefficient at the distance X, of an aluminum line of wavelength λ ; L is the longitudinal dimension of the gold plasma, which is supposed to have no variation with X, as a result of the confinement by the surrouding silica plasma.

The inferred K_{λ} values for the Heα ($1s^2 - 1s2p$, $\lambda = 7.76$ Å)and Hα ($1s - 2p$, $\lambda = 7.17$ Å) aluminum lines are reported in Fig.4.

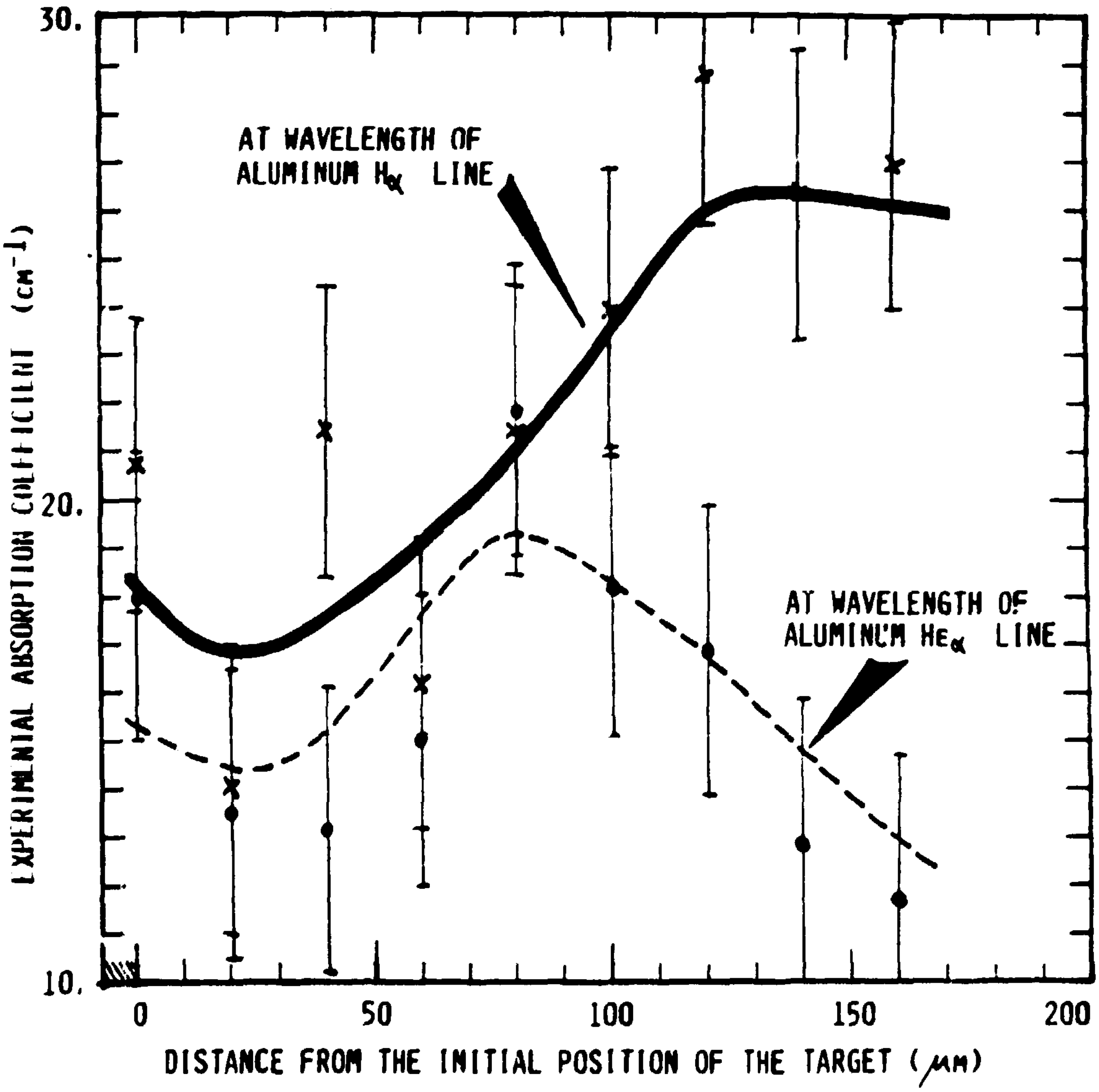

Figure 4 : Absorption coefficient of Aluminum H-like and He-like lines in a gold plasma deduced from experimental measurements.

In conclusion, we have shown that, with a specific target geometry, the X-ray spectral absorption can be evidenced and measured in a high-Z laser created plasma by means of a close X-ray source created in the same laser shot.

REFERENCES

[1] Louis-jacquet M., Combis P. (1983) C.R. Acad. Sci. 296, 1019
[2] Combis M., Louis-jacquet M. (1984) Phys. Rev. A 29, 1606
[3] Combis M., Louis-jacquet M. (1984) C.R. Acad. Sci. 299, 275