Title
LASER-INDUCED FLUORESCENCE OF METAL-ATOM IMPURITIES IN A NEUTRAL BEAM



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## Accelerator & Fusion Research Division

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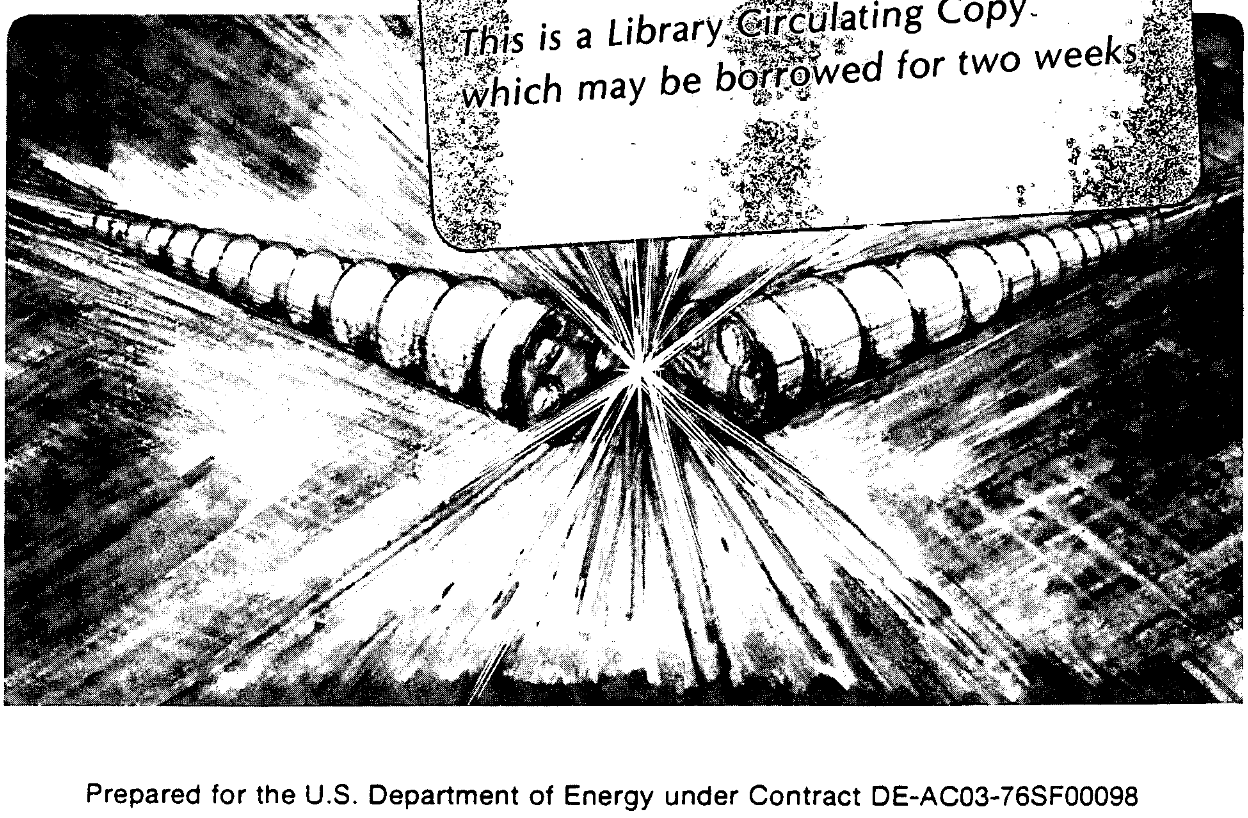



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## DISCLAIMER

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# Laser-Induced Fluorescence of Metal-Atom Impurities in a Neutral Beam*

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# Laser-Induced Fluorescence of Metal-Atom Impurities in a Neutral Beam*

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The need to limit impurities in fusion devices to low levels is well known. We have investigated, by the techique of laser-induced fluorescence, the concentration of heavy-metal atoms in a neutral beam caused by their evaporation from the hot filaments in a conventional high-current multifilament hydrogen-ion source.

Tunable radiation in the range 340 nm to 950 mn is provided by a pulsed dye laser (Lambda Physik 2002 E) pumped by an excimer laser (Lambda Physik EMG 201). A KDP frequency-doubling crystal extended the range down to 260 nm in the ultraviolet. The configuration of the experiment is shown in Fig. 1. The experimental chamber is located at the end of a 2-meter-long neutralizer. The laser beam, which was expanded to a 3.8-cm diameter, intersects the neutral-beam axis at an angle of $75^{o}$, so that the Doppler shift permits one to distinguish between fast atoms in the beam and slow atoms sputtered off walls or in the ambient gas. The scattering system has 90-cm-long entrance baffles and a laser beam dump based on Brewster-angle placement of black absorbing glass. The collection optics and photomultiplier are positioned to view the excited volume (113 $cm^3$) in a direction perpendicular to the plane of the laser and neutral beams. The stray-light level was reduced to approximately one photoelectron per laser shot.

The ion source in this experiments utilized an accelerator designed for the JET experiment (MARK III-I) coupled with a conventional field-free multifilament plasma generator. In this plasma source the electron emission by the arc current is produced by hot tungsten filaments of 0.5 mm diameter.

L.I.F. data was also taken when the plasma source was operated with hot molybdenum filaments of 0.5 mm diameter. Long filaments of 0.5 mm diameter tungsten and molybdenum were also placed in the experimental chamber on alternate sides of the laser beam to produce, by evaporation, a controllable vapor of W or Mo atoms, for calibrating the laser wavelength scale and to check the laser scattering system. The absolute density of impurity atoms in the beam was calibrated by Rayleigh scattering in air.[1,2] The vapor density of molybdenum and tungsten produced by the Mo and W filaments placed in the experimental chamber were measured by the L.I.F. technique. The measured densities agreed to within a factor of 3 to the calculated densities which were based on filament current, temperature and evaporation rates.

A search was made for tungsten atoms in a 30-keV neutral beam by increasing the filament heater current. Fast tungsten atoms in the beam were detected just before the filament reached its current limit and ruptured as shown in Fig. 2. The final trace at the top, after the resonance is observed, is flat due to the rupture of the filament and absence of background light caused by the neutral beam. The density of tungsten in the ground state is $10^5$ $cm^{-3}$, and, if we assume all the fine-structure sub-levels of the ground level are equally populated, the total density of tungsten is $2.5 \times 10^6$ $cm^{-3}$ at the point of observation. For the 1-ampere 30-keV beam this corresponds to a relative impurity current of $7 \times 10^{-4}$.

In order to obtain comparison data we replaced the tungsten filaments with identical molybdenum filaments. With these filaments we reproducibly observed Mo atoms in the beam at 20 keV. At a filament heater current of 15.8 A the molybdenum density was $5 \times 10^4$ $cm^{-3}$ and the relative impurity current level was $2 \times 10^{-5}$.

* Work supported by U.S. DOE under Contract Number DE-AC03-76SF00098.

1. Makoto Hamamoto and Mitsuo Akogaki, Jpn. J. Appl. Phys. 20, 1709 (1981).

2. C. F. Burrell, A. S. Schlachter, R. V. Pyle, and C. E. Searle, J. Vac. Sci. Technol. A2, 708 (1984).

## Figure Caption

Fig. 1 Schematic of experiment.

Fig. 2 Laser wavelength scan of 260.6 nm resonance line of W atoms in the beam.

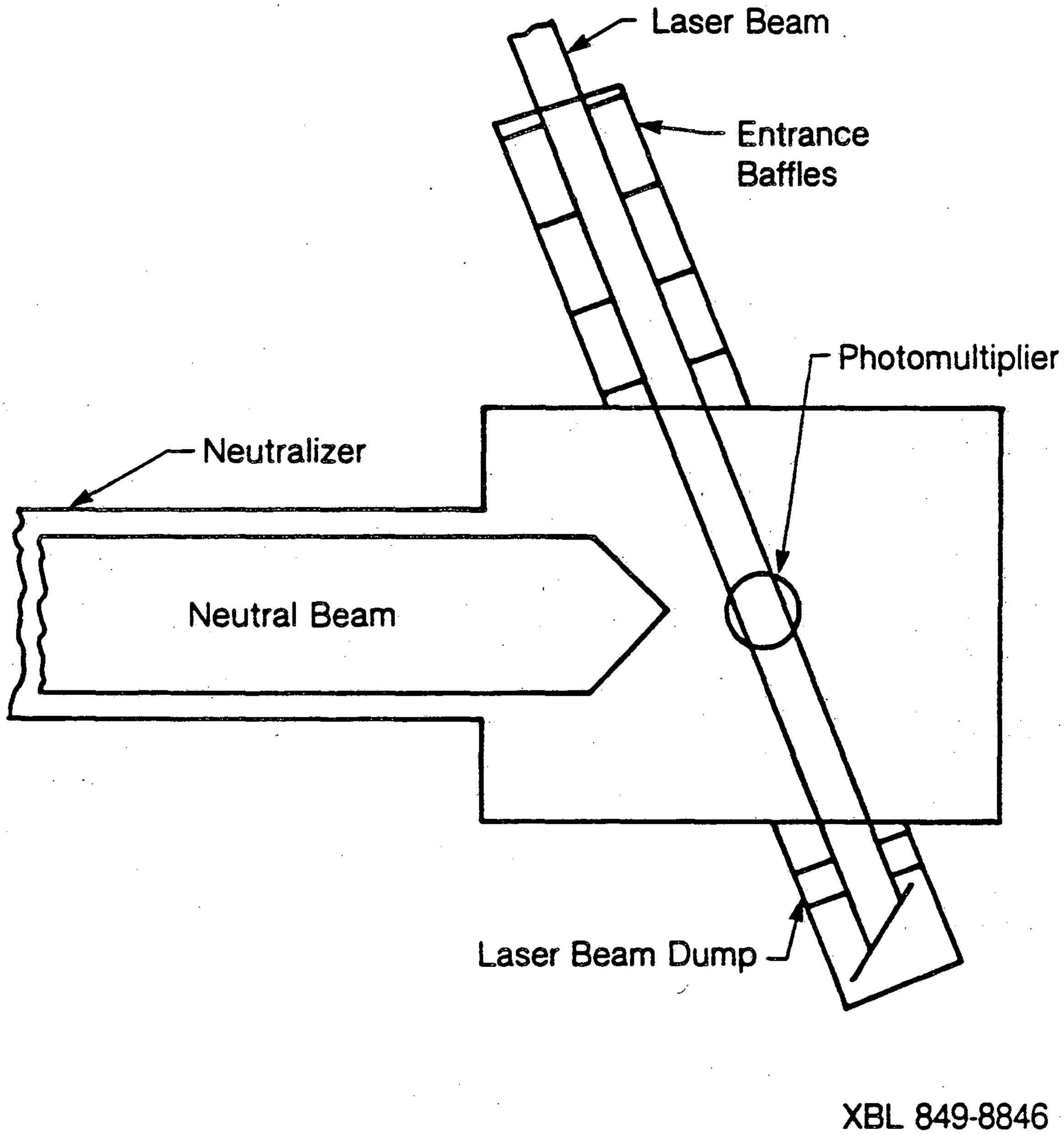
Laser Beam
Entrance
Baffles
Photomultiplier
Neutralizer
Neutral Beam
Laser Beam Dump
XBL 849-8846

Fig. 1

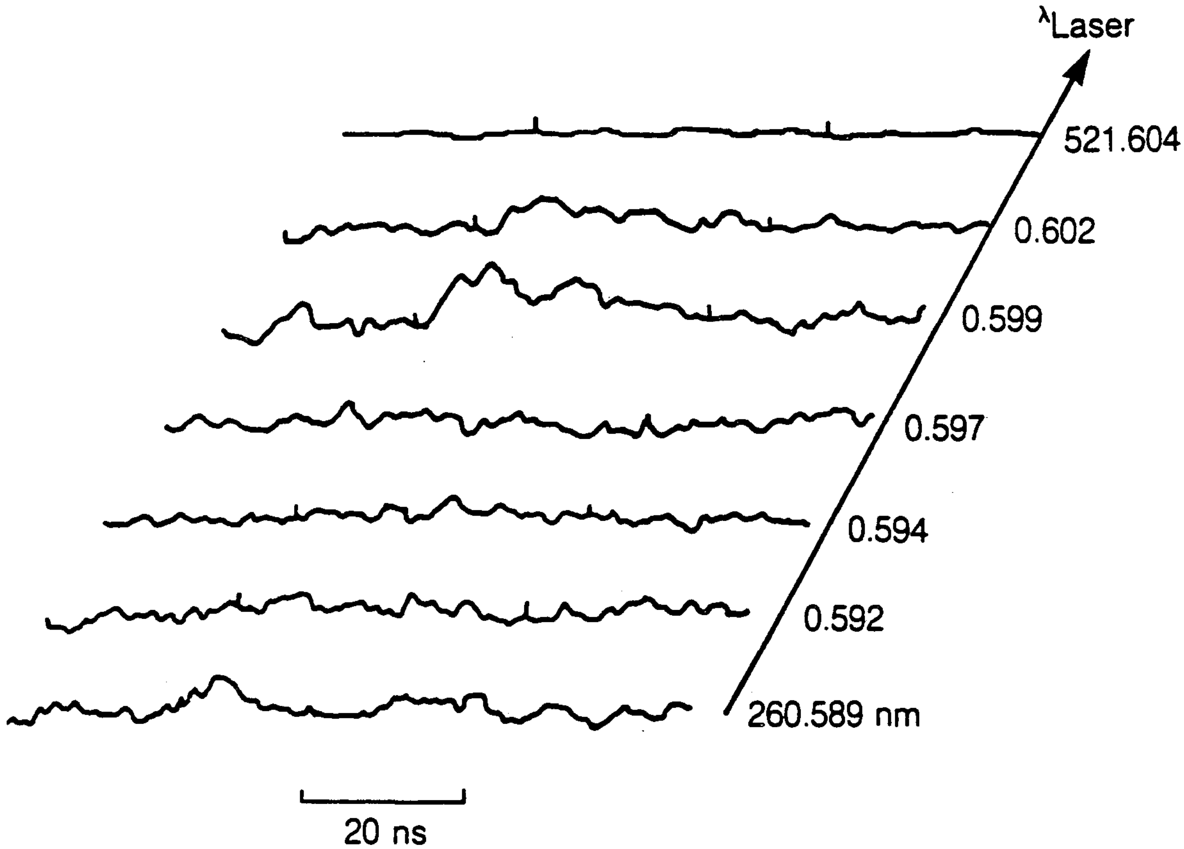


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Fig. 2

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