Section 4
NATIONAL LASER USERS FACILITY NEWS

This report covers the activities of the National Laser Users Facility (NLUF) during the quarter January to March 1983. During this period, eight users conducted experiments on LLE facilities. The visiting scientists associated with these experiments represented UCLA, Yale University, the Naval Research Laboratory, the University of Maryland, the University of Illinois, the University of Rochester, the University of Pennsylvania, and the University of Connecticut.

Eight user experiments were conducted in this quarter compiling a total of 118 shots on the Glass Development Laser (GDL) and the OMEGA laser system. Table 1 gives a summary of the number of shots for each user experiment.

Research scientists from the following institutions participated in the experiments:

1. Francis Chen, Chan Joshi, and Humberto Figueroa (UCLA), and Nizarali Ebrahim (Yale University).
2. J. Kent Blaise, D. Pierce, Donatella Pascolini, and A. Scarpa (University of Pennsylvania).
3. Leo Herbette and Robert McDaniel (University of Connecticut).
4. James Forsyth and Robert Frankel (University of Rochester).

5. Uri Feldman and George Doschek (Naval Research Laboratory), Samuel Goldsmith (University of Maryland), and W. E. Behring (Goddard Space Flight Center).
6. Hans Griem and Samuel Goldsmith (University of Maryland).
7. George Miley, Chan Choi, Aaron Bennish, and David Harris (University of Illinois).
8. Barukh Yaakobi (University of Rochester), and H. W. Schnopper and P. O. Taylor (Smithsonian Institution).

User System Shot Distribution
January 1 to March 31, 1983

USER (Principal Investigator)	FACILITY	NUMBER OF SHOTS
UCLA/Yale University (F. Chen)	GDL	26
University of Pennsylvania (J.K. Blaise)	GDL	28
University of Connecticut (L. Herbette)*	GDL	--
University of Rochester (J. Forsyth)	GDL	24
Naval Research Laboratory (U. Feldman)	OMEGA	18
University of Maryland (H. Griem)	OMEGA	15
University of Illinois (G. Miley)	OMEGA	5
University of Rochester (B. Yaakobi)**	OMEGA	2
	TOTAL	118

*Shared shots with the University of Pennsylvania
**Shared shots with other Users

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Table 1
User system shot distribution from January 1 to March 31, 1983

This issue of the LLE Review highlights results from the University of Maryland experiment entitled "Shifts and Widths of Hydrogenic Ion Lines" (principal investigator, Hans Griem).

The experimental observation of shifts and widths of hydrogenic ion lines emitted by very dense plasmas is an essential step in the general study of the properties of bound states of multiply charged ions in dense plasmas. This research is of importance in a number of areas, notably equilibrium statistical mechanics (equation of state), plasma radiation physics (energy transport and diagnostics), and calibration of wavelengths in the extreme-vacuum-UV region (10 Å $< \lambda <$ 200 Å). In the latter case, the wavelengths of lines from one-electron ions are generally considered to be well known theoretically and are regarded as standards for plate calibration. The question nevertheless arises as to whether or not significant changes in wavelength can occur, for example in low-inductance sparks[1] or laser-produced plasmas[2] which are often used as line sources.

The existing theoretical treatments of the corresponding many-body problem include several proposed models, although no exact solutions are available. According to these models, the line width is due to plasma perturbation of the internal atomic electric field and depends on fluctuations in the local electric field. The line shift also depends on these fluctuations, but additionally depends on the value of the local plasma electron density. It should be noted that in the domain of high-density (compressed) laser-produced plasmas, the dominant parameter determining the line-shifts may be the mean value of the electron density, rather than the fluctuations. The opposite situation pertains to the more conventional domain of plasma spectroscopy, i.e., $N_e \sim 10^{17}\ cm^{-3}$ and $kT_e \lesssim 5$ eV where N_e is the electron density and T_e is the electron temperature.

The study of spectral line shifts and widths of hydrogenic ions reported here included the Lyman lines of CVI(C^{5+}), NVII(N^{6+}) and OVIII(O^{7+}) emitted by plasmas produced from microballoon targets by the 24 beams of the OMEGA laser system. Low-Z elements were chosen for this study because the wavelength shift scales as N_e/Z^6 (see Ref. 3). CVI and CV lines were produced either from solid polystyrene spheres or from shells of parylene-N coated on polystyrene supports. The sources of OVIII and OVII ions were either the oxygen component of the glass from the microballoons or oxygen gas inside the microballoons. Nitrogen was also used as a filling gas to obtain the lines of NVII.

The 24 laser beams were focused nearly tangential to the target spheres with the total energy $\approx$2.5 kJ, the pulse width in the range of 0.7 – 0.9 ns, and the radiation intensity $\approx 5 \times 10^{14}\ W/cm^2$. The spectrum was recorded with a 3-m grazing-incidence spectrograph[4] at an angle of incidence of 88°. The image of the point-like plasma source was focused onto the spectrograph slit using a cylindrical mirror fabricated from a Be strip (coated by high-Z elements) and bent to obtain a grazing-incidence reflection of the XUV radiation.[5]

In addition to the conventional photographic spectra, two runs were made with an additional 50-μm slit, placed perpendicular to the spectrograph slit, obtaining spatial resolution parallel to the direction of the main slit. This arrangement allowed us to record relative line shifts as functions of the distance from the center of the compressed plasma.

The spectra were calibrated using known lines of Si, Al, Ni, and Cu, which were introduced into the original target as metallic coatings. In Figs. 36 and 37 we present microdensitometer

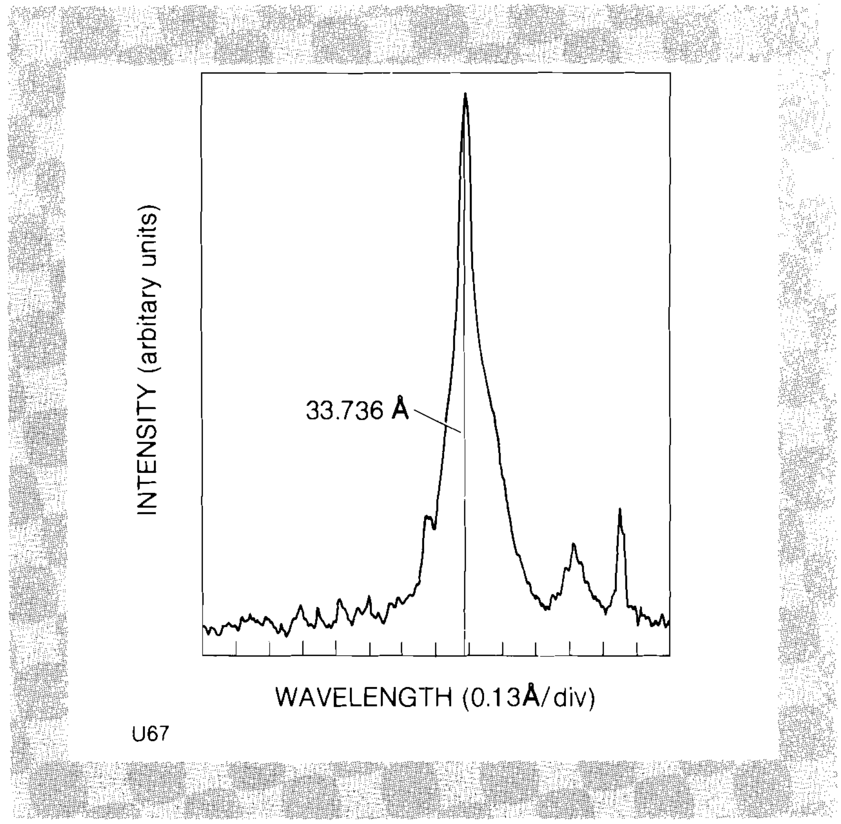

Fig. 36
The Lyman-α (L_α) line of CVI at 33.736 Å.

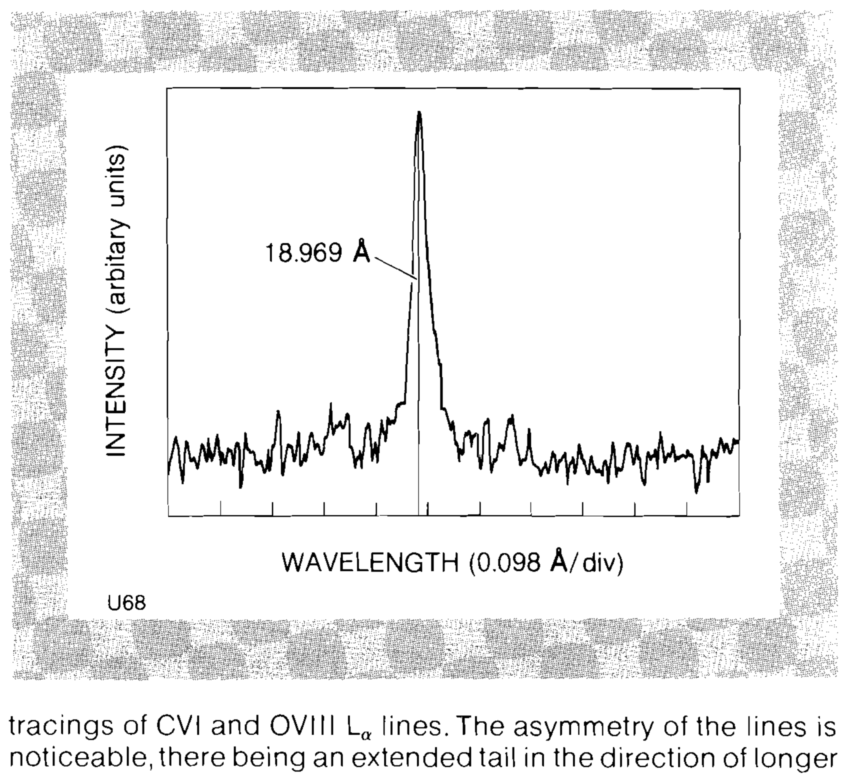

Fig. 37
The Lyman-α (L_α) line of OVIII at 18.969 Å

tracings of CVI and OVIII L_α lines. The asymmetry of the lines is noticeable, there being an extended tail in the direction of longer wavelength. This L_α shape can be explained, in part, as the effect of He-like lines of CV and OVII, arising from the simultaneous excitation of the two electrons in the He-like ions. However, it may also be explained as the superposition of shifted and unshifted L_α lines.

A new and interesting result was obtained when a spatially resolved spectrum of the CVI L_α line was photographed. A two-dimensional microdensitometer tracing of this line is presented in Fig. 38. The horizontal direction corresponds to the wavelength λ, and the vertical direction gives spatial resolution. The arrow in Fig. 38 points toward a filament-like structure, protruding from the center of the line and indicating a change of wavelength with distance from the center. The maximum relative shift between the center of the broadened line and the extreme edge of the filament is about 80 mÅ. The dimension of the extended plasma is about 0.6 mm.

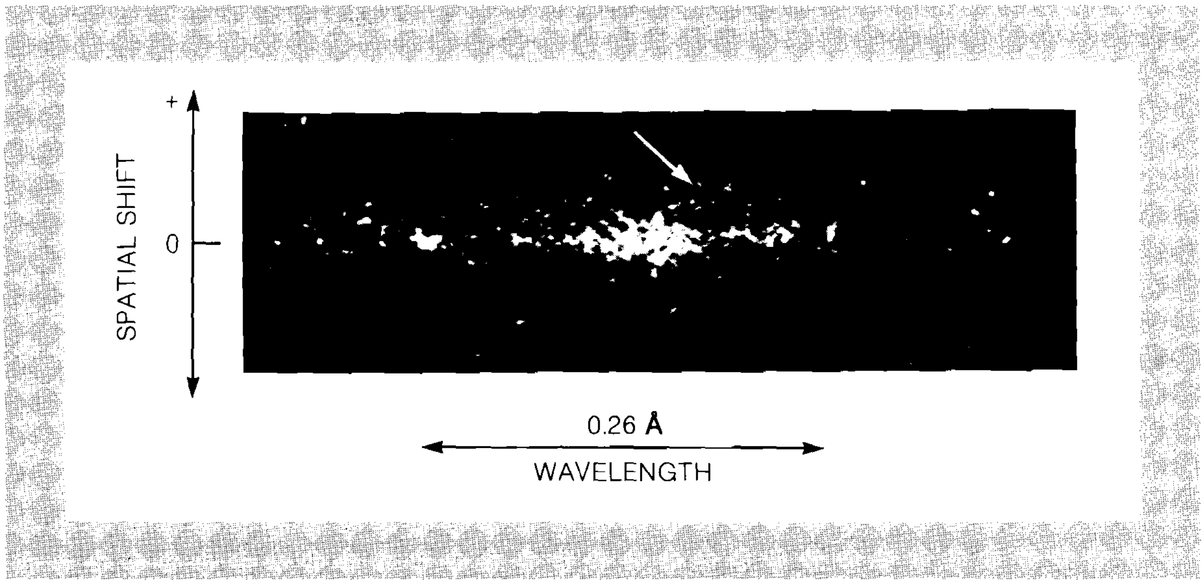

Fig. 38
Two-dimensional microdensitometer trace of the spatially resolved CVI L_α line. The horizontal axis corresponds to wavelength (λ increases to the right), and the vertical axis corresponds to spatial shifts from the line center (at zero).

It is too early to assess whether the plasma is so opaque and/or so highly ionized that the observed lines come mostly from a cool and not-so-dense region surrounding a hot plasma core. Furthermore, two additional effects, plasma motion and spectral satellites, should be considered; both of these may cause broadening and obscure shifts. The ratios of CV to CVI lines will also be studied with the data obtained here. From these ratios and from the broadening of the lines, the average values of N_e and T_e may be extracted. The next series of experiments will incorporate a second mirror for the spectrograph which will enhance the collecting power of the spectrograph and provide spatial resolution of the XUV emission.

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