Section 4
NATIONAL LASER USERS FACILITY NEWS

This report covers the activities of the National Laser Users Facility (NLUF) during the quarter July to September 1982. During this period one user experiment was conducted on the GDL facility. This issue of the *LLE Review* highlights some of the results of this experiment conducted as a collaborative, UCLA/Yale University program. Participants in this experiment were Francis Chen, Chan Joshi, and Humberto Figueroa from UCLA; and Nizarali Ebrahim and Hiroshi Azechi from Yale University. During this quarter, the UCLA/Yale experiment accumulated 11 system shots (in previous quarters, 95 experimental shots plus 25 diagnostic check-out shots were dedicated to this experiment).

The objective of the UCLA/Yale experiment was to study the effects of parametric instabilities in producing energetic electrons and scattering of the incident laser light. In the underdense corona of a laser fusion pellet, two processes may occur which are of potential interest: the two-plasmon decay ($2\omega_p$) instability and stimulated Raman scattering (SRS). Both of these processes can produce energetic electrons which can preheat the fuel before the pellet compresses. In the $2\omega_p$ decay instability, the incident laser light is converted into two plasma waves with a frequency matching condition of $\omega_o \approx 2\omega_p$, where ω_o is the incident laser frequency and ω_p the plasma wave frequency. The $2\omega_p$ instability can thus occur only at a point where the electron density is one-fourth of the critical density (n_c). SRS involves the conversion of the incident laser light wave into one plasma wave and scattered light wave. This process can occur for plasma densities $n < n_c/4$.

The experiments were conducted by first forming a sub-critical density plasma to eliminate the effects occurring at the critical density. A prepulse, with an energy of approximately 7 joules at 1.054 μm, was used to form the sub-critical density plasma. A second pulse, of approximately 35 joules at 0.35 μm, was then used to study the instabilities occurring in the underdense region. The critical density for 0.35 μm light is 9×10^{21} cm^{-3}. The spot size of the 1.054-μm beam was approximately 2 mm, producing an irradiance of 5×10^{11} W/cm^2. The 0.35-μm beam was tightly focused to a diameter of approximately 70 μm, yielding an irradiance of 10^{15} W/cm^2. The maximum plasma density was controlled by an appropriate choice of foil thickness. Carbon foils of 800 Å, 2000 Å, and 4000 Å were used as targets. Figure 36 shows a schematic of the experimental focusing conditions.

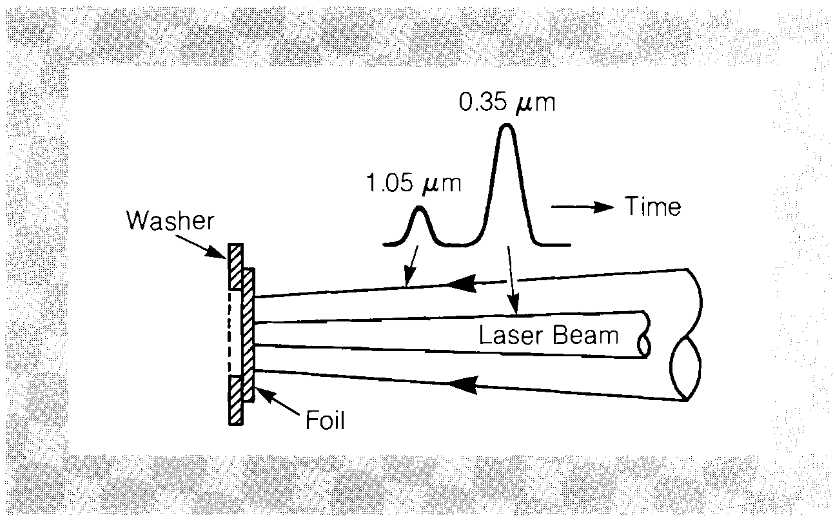

Fig. 36
Schematic of the experimental target setup.

The diagnostics used in the experiments included two electron spectrometers to obtain the angular distribution of hot electrons between 35 and 350 keV. In addition, two visible spectrographs were used to obtain the Raman spectra backscattered through the focusing lens and at 45° to the lens. The backscattered spectrum was also temporally resolved using a subnanosecond-resolution streak camera. The data was then used to estimate the maximum density as a function of time. The side-scattered spectrum was spatially resolved to provide an estimate of the plasma density profile. Additional diagnostics, supplied by LLE, included six calibrated photodiodes to monitor the angular distribution of the $\omega_0/2$ light, an array of x-ray detectors to record the continuum spectrum, and a transmission calorimeter to obtain the transmitted 0.35-μm beam energy.

A summary of the observations from this experiment is shown in the following figures. Figure 37 shows an example of the time-integrated Raman backscatter. The spectrum is shown for three separate experiments with carbon foils of 800 Å, 2000 Å, and 4000 Å. In the long-wavelength region, the Raman spectrum extends up to 0.06 n_c for the thinnest foil. This density is observable because a specific wavelength of Raman scattering occurs at a specific density. Also, the data for the thinnest foil shows no half-harmonic emission at 0.7 μm. These observations imply that the thin-foil plasma density is less than $n_c/4$, at the time of the 0.35-μm laser pulse. When the target foil is increased in thickness, the Raman spectrum extends to longer wavelengths and associated higher densities. The 2000 Å foil shows a cutoff corresponding to 0.09 n_c, while the 4000 Å foil shows a cutoff corresponding to 0.16 n_c. The harmonic emission at 0.7 μm is observed in both of the thicker foils, which is a unique signature that there is a $n_c/4$ density layer to interact with the 0.35-μm laser pulse. The results also show that the long-wavelength cutoff shifts as a function of foil thickness.

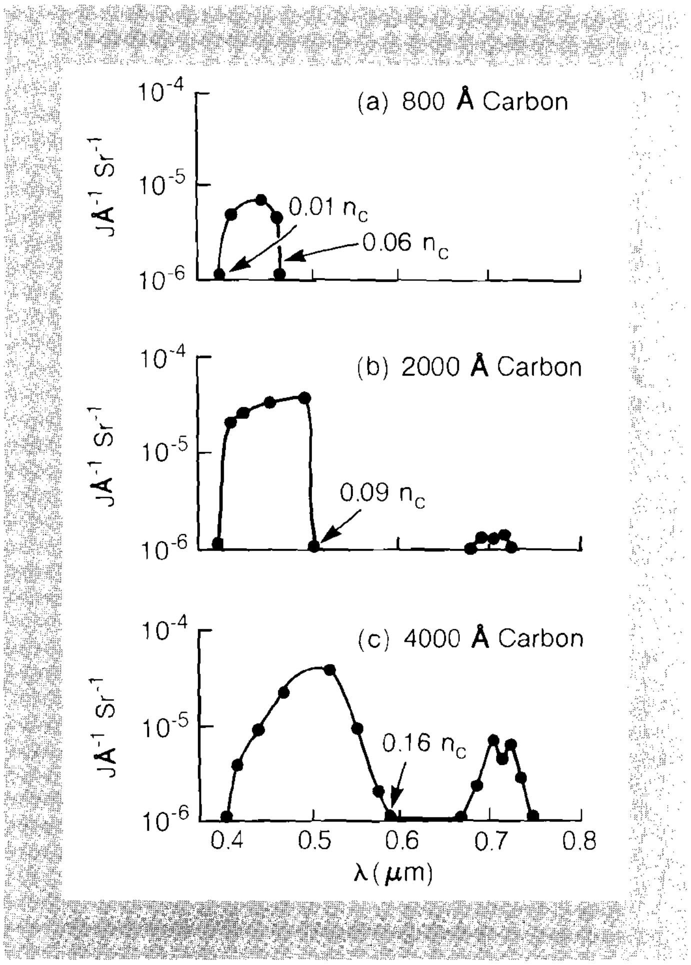

Fig. 37
Time-integrated Raman-backscatter spectra from carbon foils of various thicknesses.

An estimate of the temporally averaged density profile of the plasma was obtained by spatially resolving the 45°, Raman-sidescattered light. This density profile measurement is possible, because the Raman scattering from a specific density produces a specific wavelength. Raman-sidescattered light at 45°, with respect to the 0.35-μm beam, was imaged, using an achromatic lens, onto the slit of a 0.25-meter, space-resolving spectrograph. Information about the plasma was obtained between 0.075 n_c and 0.095 n_c for a 2000 Å carbon target. The plasma region between these densities was approximately 50 μm long.

An additional measurement of the time-resolved, Raman backscatter shows a shift of the long-wavelength cutoff to shorter wavelength as a function of time. An example of this effect for Raman-backscattered light from a 4000 Å carbon foil is shown in Fig. 38. Time is plotted on the vertical axis of Fig. 38 while wavelength (and its equivalent density) is plotted on the horizontal axis. The observed wavelength shift versus

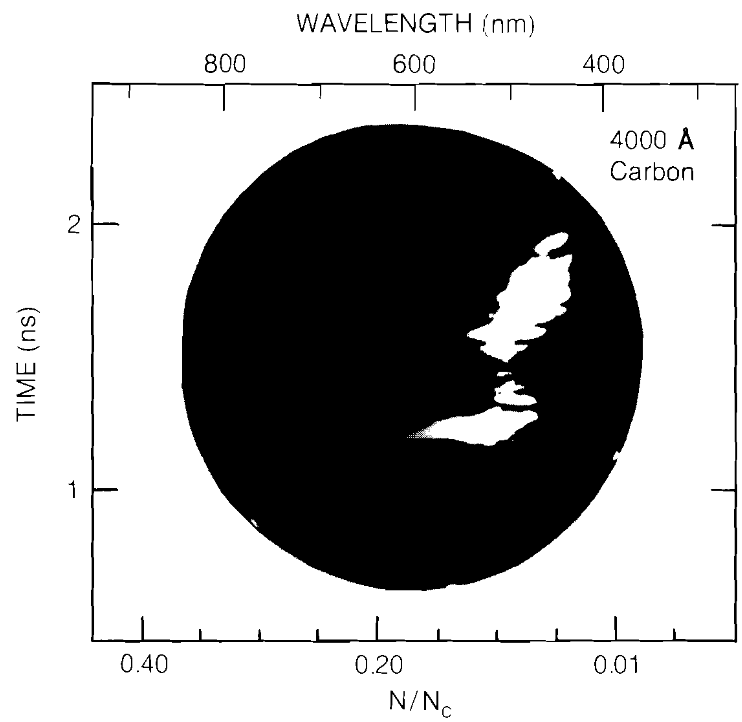

Fig. 38
A typical streak record of Raman-backscattered light from a 4000-Å-thick carbon foil plasma.

time is indicative of the peak foil density (plateau region) decreasing with time. Still another measurement made use of the high-energy, electron emission associated with SRS and $2\omega_p$ instabilities. No significant electron emission was observed from the 800 Å foil plasma. The thicker foils produced readily observable high-energy electron emission. These measurements are consistent with high-energy electron generation at the $n_c/4$ density layer.

Additional information on these results can be obtained from the scientists associated with the experiment. The information on the UCLA/Yale experiment is an excerpt from a UCLA report. This experiment was supported by a contract with the U.S. Department of Energy.

Future issues of the *LLE Review* will highlight other experiments by users.

Further information on the NLUF is available by writing to:

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REFERENCES

1. H. Figueroa, C. Joshi, C. E. Clayton, H. Azechi, N. A. Ebrahim, and K. Estabrook, *UCLA Report* PPG-674 (1982).