diameter and 140-μm cladding diameter). The cascaded transmission star coupler is formed by fusion splicing the output ports of one star coupler to the input ports of the other. The coupling coefficients and excess losses of the star couplers were measured before and after cascading. Table I lists the results for an 8×8 cascaded transmission star coupler. The coupler has an average excess loss of 1.6 dB and a coupler dynamic range of 2.9 dB. The cascaded star coupler has a uniformity comparable with that of a mixing rod star coupler, yet the excess loss is significantly lower.

The effect of putting mode scramblers between the two star couplers and the fabrication and performance of cascaded star couplers with more than eight output ports will also be discussed. **(13 min)**

1. B. S. Kawasaki and K. O. Hill, Appl. Opt. **16,** 1794 (1977).
2. E. G. Rawson and M. D. Bailey, Electron. Lett. **15,** 432 (1979).

Wednesday **AFTERNOON**
10 June 1981 **WN**
JEFFERSON ROOM

1:30 PM **Fusion Physics: 1**

Martin C. Richardson, Presider

WN1 Wavelength scaling of laser plasma interactions and factors influencing the choice of a laser-fusion driver

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The use of lasers to drive inertial confinement fusion (ICF) has been under investigation since the advent of *Q*-switching with major program efforts over the past eight years. Critical factors which have emerged concerning the choice of a laser to drive a fusion power plant include the coupling of the laser light of the target, the cost, complexity, and reliability of the driver, and the driver efficiency. Within the current ICF program, target coupling physics and laser development are pursued as parallel lines of investigation. Through harmonic generation and frequency mixing, glass laser facilities provide the necessary flexibility to supply wavelength scaling information.

The interaction of intense laser light with a plasma target is a complex process. Incident light can be scattered via various nonlinear processes, absorbed to produce thermal electrons, or excite plasma oscillations which in turn produce highly energetic superthermal electrons. Which processes prevail depend on the intensity, wavelength, and pulse duration of the incident light as well as the target material. Recent experimental results obtained in several laboratories using glass lasers with harmonic conversion indicate an increase in absorption and a decrease in superthermal electron production at shorter wavelengths. However, most of these experiments have been carried out with subnanosecond pulses. With longer pulses, stimulated Brillouin scattering, filamentation, and self-focusing can occur in the long scale-length plasma, increasing either backscattering or superthermal electron generation. Current experiments are probing long scale-length plasmas but are limited by the energy requirements of long-pulse high-intensity irradiation over target areas large enough to suppress transverse effects.

Although short wavelength lasers are favored from the viewpoint of plasma physics, they may be less attractive in providing uniform target compression. At a short wavelength, the laser energy is deposited closer to the ablative surface of the target, reducing the effective smoothing of beam inhomogeneities provided by thermal transport in the plasma. Several means of reducing the laser beam uniformity requirements are under investigation, including converting the laser energy to soft x rays to drive the target, using low-intensity long-wavelength light to provide a plasma atmosphere outside the target, and varying the frequency of the driving laser.

Currently the ICF program emphasizes the KrF excimer laser as a candidate short-wavelength driver. Since excimers are not energy-storage media, some form of optical pulse compression is required. Two approaches are under investigation: pulse stacking, with optical delay lines, and the backward traveling Raman amplifier, which is geometrically simpler but involves less well-known physics. For any short-wavelength system, performance is ultimately limited by optical materials considerations. As the operating frequency approaches the UV, there are fewer materials available either for windows or thin film coatings. Preliminary evidence indicates that damage thresholds are lower at shorter wavelength, and the index nonlinearity n_2 is expected to increase markedly in the vicinity of two-photon excitation across the band gap. Furthermore, to maintain a relatively smooth beam, free of modulation, the passive optical requirements of the system may also be more severe than at longer wavelengths.

The ultimate choice of driver technology for ICF must be made in the context of the full system requirements. Considerations include driver efficiency, target coupling and cost, and the driver energy needed to achieve the required target gain. There is ample room for innovation in the ICF program, in new laser development, new optical materials, and better pulse compression schemes, as well as improved pulse power technology. However, new ideas should offer promise of significant improvement over current performance.

(Invited paper, 25 min)

WN2 0.35-μm laser–matter interaction experiments at the University of Rochester

W. SEKA, L. M. GOLDMAN, MARTIN C. RICHARDSON, J. M. SOURES, B. YAAKOBI, T. BOEHLY, R. KECK, K. TANAKA, L. FORSLEY, R. BONI, R. S. CRAXTON, J. A. DELETTREZ, and R. L. McCRORY, University of Rochester, Laboratory for Laser Energetics, Rochester, N.Y. 14623.

Recently there has been renewed strong interest in short-wavelength laser fusion experiments as a means of possibly reaching break even at moderate laser energies of ≤ 100 kJ. In an effort to broaden the data base for short-wavelength laser–matter interaction experiments we have recently conducted a series of 0.35-μm laser plasma experiments. Our goals were to examine the absorption, electron transport, and light-scattering measurements at irradiation intensities of 10^{13}–10^{15} W/cm^2 and for 100–500-psec pulses. The target materials ranged from CH to Ni and Au. Detailed results of various aspects of these experiments will be reported in companion papers at this conference.

The absorption experiments were carried out using a box calorimeter capable of measuring ion and scattered light energies separately. For all intensities the short-pulse (100-psec) absorption fraction was always lower than the corresponding long pulse data, independent of target *Z*. Typical low-*Z* absorption measurements ranged between 60 and 90% for short pulses and intensities between 10^{13} and 10^{15} W/cm^2. For 500-psec pulses, 80–95% absorption was found for Ni over the same intensity range. Comparison of the experimental data with calculations on the basis of inverse bremsstrahlung absorption and a flux limit of $f = 0.03$ for the free-streaming electrons showed quite good agreement for the longer pulses, while some as yet unresolved differences remain in the short-pulse (100-psec) comparison.

The angular dependence of absorption has frequently been used to demonstrate the presence of resonance absorption by observing a peak in the absorption at an angle of incidence of 20–30°.[1] Similar measurements carried out at 0.35 μm in this series of experiments were inconclusive. There was no detectable polarization dependence of the angular absorption or did the absorption drop off significantly up to 60°. These experiments showed no evidence for resonance absorption; the high absorption at very large incident angles was most likely related to spatial nonuniformities in the plasma production and/or blow-off.

Electron transport measurements have been carried out chiefly using x-ray spectroscopy combined with multilayer targets at intensities of 10^{14}–2×10^{15} W/cm^2. Three x-ray burn-through experiments have been simulated with 1-D and 2-D hydrocode (LILAC, SAGE) to give corresponding spectral line intensities. From comparison of the experimental and computed spectral data we infer a free-streaming electron flux limit of $f = 0.03$–0.06.

Extensive plasma blow-off and x-ray temperature measurements have been made using a Thomson parabola (ion spectrometer), charge collectors, and x-ray PIN diodes. Temperatures inferred from the ion velocity distributions differ from those deduced from the x-ray spectra reflecting the different plasma regions being sampled. The plasma blow-off analysis as well as the x-ray spectra showed no indication of fast-ion blow-off or the presence of hot electrons. **(13 min)**

1. R. A. Hass *et al.*, Phys. Fluids **20,** 322 (1977).

WN3 Absorption of 0.35-μm radiation in laser–matter interaction experiments

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Theoretical predictions indicate that 0.35-μm laser light should be efficiently absorbed by dense plasmas. In this paper we present the results of recent experimental measurements of absorption at $\lambda = 0.35$ μm for intensities between 10^{13} and 10^{15} W/cm^2 incident on solid targets and 100- and 500-psec pulse duration.

The measurements were made using a box calorimeter surrounding the target. The principal characteristics of the box calorimeter have been described elsewhere.[1] The signals from this calorimeter can be analyzed in terms of contributions arising from the scattered light and from the blow-off plasma and x rays. The former has a short-time response, while the latter has a delayed response of several minutes after the shot. The plasma and x-ray signal is due to the purely radiative coupling between the ion shield and the sensors of the box calorimeter. By analyzing both signals, a redundant measurement of the absorption has been made. We avoided linear and nonlinear laser light absorption in the ion shield through the use of a quartz (Suprasil) ion shield whose transmission at 0.35 μm was periodically remeasured.

The absorption measurements were done on flat targets. The incident intensity was varied by changing the laser spot size. Cross checks using variable laser energies but constant spot size were