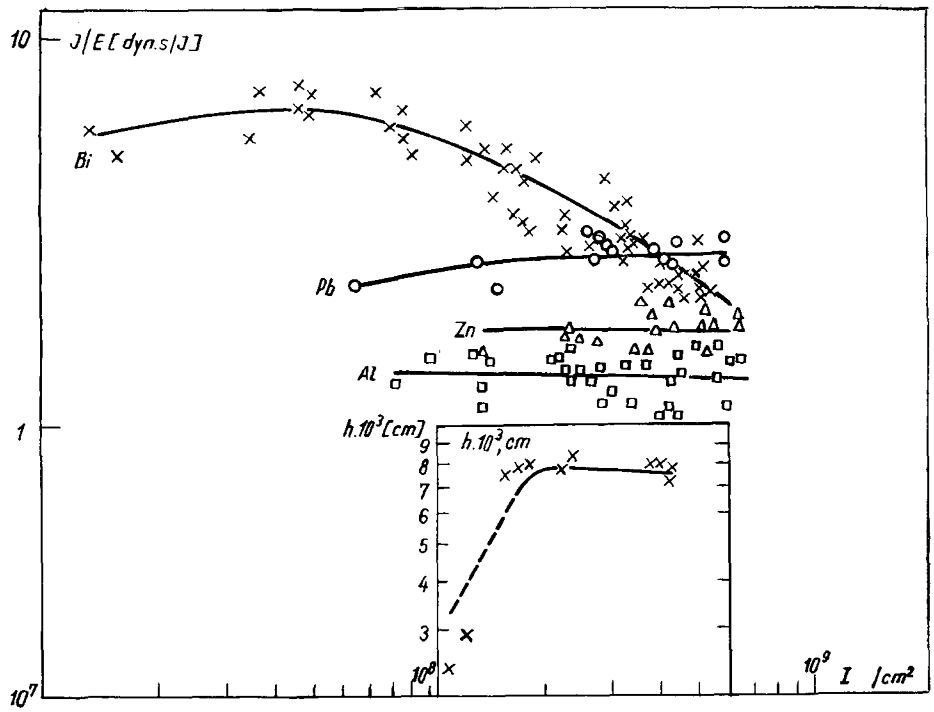

Fig. 2. Specific recoil impulse, J/E, for Bi, Pb, Zn and Al and crater depth, h, for Bi, versus incident intensity on target, I.

front. In this layer the energy conservation can be written as $I \simeq j\Delta$, where j is the mass flux removed from the target and Δ is the energy characterising the interaction (damage). For small intensities the absorbed power is spent in atom ionization, $\Delta(I) \simeq$ const. and the velocity of the removed substance is small and almost independent of intensity. Then $J \sim jv \sim I$, $J/E \sim$ const.(I) and $h \sim j \sim I$. For high intensities the absorbed power appears as a plasma kinetic energy, $\Delta \sim (kT/m) \sim I$ (where m is the atom mass), $j(I) \sim$ const. and $h(I) \sim$ const.

Concerning this model the data for Pb, Zn and Al correspond to the low-intensity regime. For Bi both regimes were put into evidence. The relative disposal of the curves in fig. 2 also agrees with the ionization potentials per gram for these metals.

The data permit also the calculation of plasma parameters. Thus, in the case of Bi, on the damage front the plasma density considerably exceeds the critical density, $n^* = 10^{19}\,\mathrm{cm}^{-1}$. The radiation is absorbed in a layer where the density decreases by diffusion under the critical value. The inverse Bremsstrahlung absorbtion coefficient in this layer which is higher than $10^3\,\mathrm{cm}^{-1}$, ensures on the spot dimension $d \simeq 5\times10^{-2}$ cm a considerable adsorbtion. The recombination radiation in this layer delivers a radiation which can penetrate through and heat effectively a plasma of such parameters.

Further experimental evidences could be also interpreted with this model.

Finally we want to point out that the pulsed CO_2 laser interaction in the aforementioned intensity range with highly absorbing targets, creates the possibility to study postcritical density plasmas.

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K9 OPTICAL BREAKDOWN PLASMAS: X-RAY EMISSION AND PICOSECOND CO_2 LASER PULSES

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We have been studying the physics of laser-produced plasmas in gaseous targets, using a 0.1 J, 500 psec CO_2 laser pulse. The oscillator–amplifier system [1] is based on the plasma shutter [2] and the optical-free-induction-decay technique [3] of producing short pulses.

In laser–plasma interaction, it is generally agreed that the energy absorption occurs in that region where the plasma frequency equals the laser frequency. For the CO_2 laser frequency, the critical density is 10^{19} el/cm^3.

Gaseous targets offer us the opportunity of controlling the plasma density. The reason for this is interesting: in a gas target the plasma is formed by avalanche ionization. The ionization front (or breakdown wave, as it is sometimes referred to) travels

[4] through the gas at a speed $>10^8$ cm/sec at laser intensities of $\approx 10^{13}$ W/cm^2. This is much faster than the ion-sound speed in the plasma. Therefore, the plasma density behind the ionization front is equal to the neutral density of the original gas. For example, hydrogen gas at 150 torr pressure produces a plasma density of 10^{19} el/cm^3 when fully ionized. Thus, by varying the gas pressure in the neighborhood of 150 torr, we studied the underdense regime, the resonant regime and the overdense regime.

We observed the sudden onset of X-ray and fast electron emission at precisely 150 torr. It rose to a resonant peak at ≈ 180 torr and fell off again at higher pressures. The electron energy spectrum extended out to 20 keV, as measured by the range-energy relations. Pinhole X-ray photographs gave spatial resolution of the zones near the focal volume where the X-rays were being produced. Strong anisotropy of the fast electron emission has also been observed. This is an important clue in distinguishing between different theories of the laser absorption mechanism, such as the nonlinear parametric interaction [5] or the linear resonance model [5].

In addition to the experiment reported above, we have measured CO_2 laser pulses of 30 psec duration. The short pulses were produced by the plasma shutter optical-free-induction-decay technique [3]. The duration was determined by two-photon correlation using second harmonic generation in GaAs. The peak power of the pulses was ≈ 1 MW. The plasma shutter was triggered externally by a transistorized Marx bank, generating the picosecond optical pulse with < 1 nanosecond jitter [6]. The pulse-to-pulse amplitude stability was better than 10%. The duration could be independently controlled by adjusting the gas pressure in the free-induction-decay cell.

It is felt that we have not yet reached the lower limit of optical pulse duration with this technique.

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K10 ANOMALOUS EFFECTS OF A LASER PRODUCED PLASMA – SELF-PHASE MODULATION AND ION JET STREAM

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The mechanisms responsible for absorption of laser light and compression of a plasma are very important problems in laser-fusion research. The kinetic behavior of laser plasmas has been investigated by the backscattered laser light and the generated ion jet stream from a target. When a solid hydrogen target is irradiated by a glass beam with intensity of 10^{14} W/cm^2 the corona plasma is removed from the region of the laser beam due to the ponderomotive force. This phenomenon produces an increase of the refractive index to cause the self-phase modulation of backscattered light. Simulation results for a laser intensity of 9×10^{14} W/cm^2 are shown in fig. 1. When the

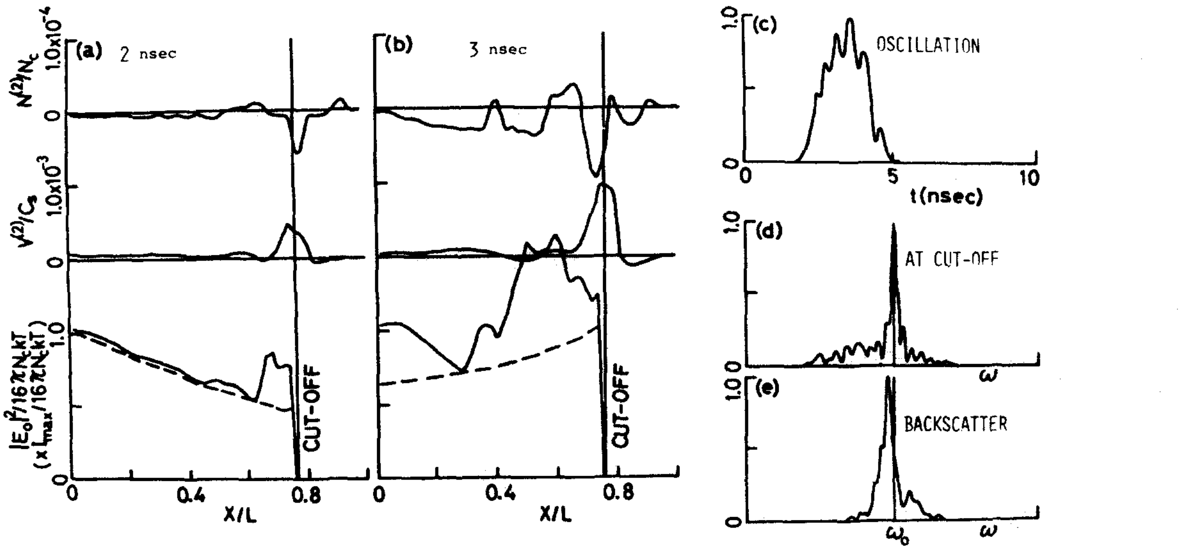

Fig. 1. Spatial profile of density $N^{(2)}$, velocity $V^{(2)}$ and amplitude of laser light, (a), (b); pulse oscillation (c) and spectral broadening of laser light (d), (e).