LIQUID-METAL MIRRORS FOR LASERS

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Multilayer dielectric mirrors on optically worked transparent supports are widely used in lasers. These mirrors have almost completely displaced metal mirrors, for the latter are of lower reflectivity and give considerable absorption, so they do not withstand prolonged use even at medium output energies. Giant pulses readily destroy even carefully made
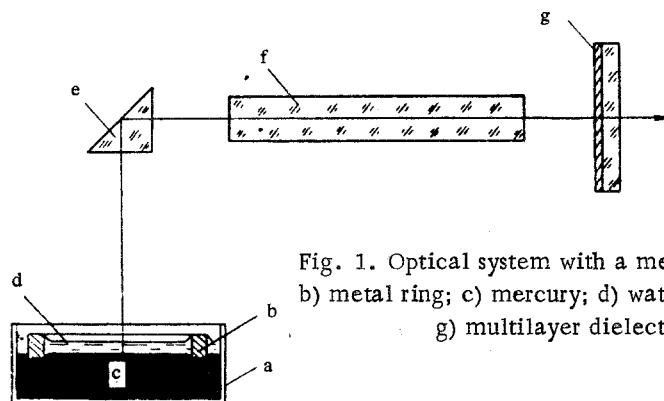

Fig. 1. Optical system with a mercury reflector: a) cell;
b) metal ring; c) mercury; d) water; e) prism; f) ruby;
g) multilayer dielectric mirror.

metal mirrors. Dielectric mirrors have better stability, but even these are damaged by megawatt pulses. Only single-layer dielectric coatings are comparable in stability with the supports (glass and quartz) [1].

Here we discuss the use of massive mirrors of liquid metal. The easiest and simplest is mercury, whose surface recovers after damage; it can be used with an exposed surface or in a special cell. Both methods have given good results.

In the first case the mercury is placed in a Petri dish mounted on the optical bench. Evaporation of the mercury is suppressed by covering the surface with water. A freely floating metal ring suppresses surface oscillations of the mercury, which usually increase the threshold pumping energy considerably. Figure 1 shows a system with an open mercury surface
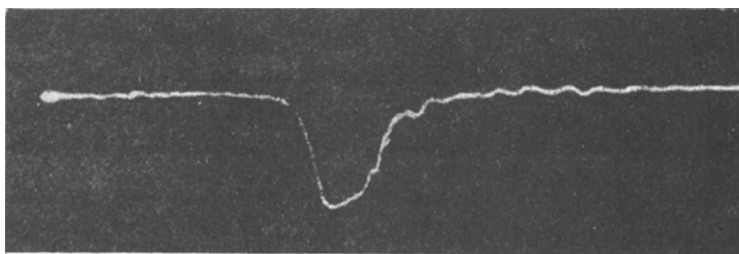

Fig. 2. Oscillogram of a single pulse from a ruby laser employing a
prism Q-switch and a mercury reflector; speed 0.1 μsec/cm.

used as one reflector. In these tests the second reflector usually was a multilayer dielectric mirror employing lead oxide and cryolite. The second mirror may also be made of mercury, in which case the laser works without specially prepared surfaces or coatings. The threshold energy was increased by a factor 1.1 when one such coated mirror (the denser one) was replaced by mercury. There was no appreciable reduction in output energy.

At present a difficulty arises over the choice of the second reflector in a prism Q-switch. We have produced giant pulses by using a mercury mirror in this way. In this case the mercury was in contact with the plane-parallel window of the cell in a Rayleigh interferometer. The radiation was extracted to the detector with a plane-parallel plate placed in the cavity at ~45° to the optical axis. This also increased the threshold pumping energy slightly. The duration of the giant pulse was virtually unaltered, and the mercury mirror was unaffected by prolonged use. Figure 2 shows a pulse recorded in this way; the length and shape are almost as when a dielectric mirror is used.

Thus, although mercury has a reflection coefficient of only about 70% for ruby radiation and high absorption, a mercury mirror can be used. The mercury could be replaced by alkali metals, whose reflection coefficients in the visible region approach 100%. Liquid metals should be especially valuable for mirrors for producing megawatt and gigawatt

pulses; they may also prove of value in the laboratory in studies of the action of laser radiation on open surfaces.

REFERENCES

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SPECTRAL DEPENDENCE OF THE POLARIZATION OF THE LUMINESCENCE
OF ANTHRACENE CRYSTALS CONTAINING NAPHTHACENE AT 4.2° K

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We used anthracene purified by zone melting and also anthracene containing naphthacene. The polarization was measured with the sensitive spectropolarimetric apparatus of [1] to 1%. The crystals were cooled to helium temperature in a cryostat providing cooling either in the liquid or in the gas. The 365 and 313 nm lines from a PRK-4 lamp were used to illuminate the crystals from the back side; reabsorption had no appreciable effect, since the thickness of the crystals was about 1 μ.
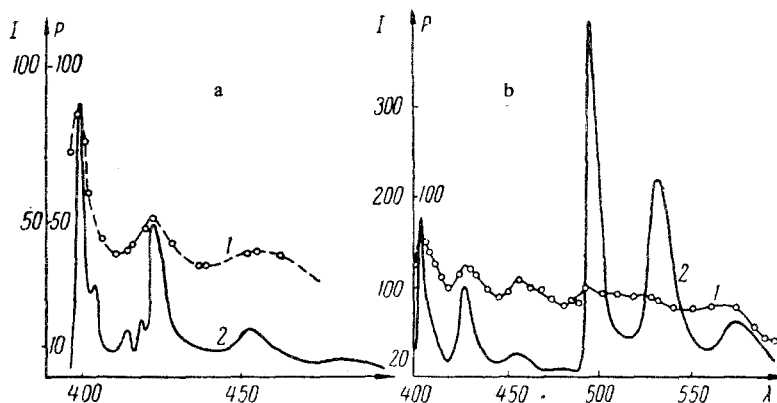
1) Degree of polarization as a function of wavelength; 2) fluorescence spectrum, for: a) pure anthracene; b) anthracene containing 8×10^{-4} g/g of naphthacene. P in %, λ in nm.

Pure anthracene at helium temperature gave a degree of polarization (part a of figure) that may be compared with the results [1] for 77 and 290° K. The maximum polarization at room temperature is 75%, falling to zero, whereas at 77 and 4.2° K it falls to 30–60% from 90–95%, and the maximum is displaced towards the short-wave side. Radiation by free excitons is [2] responsible for the sharp changes in polarization at the short-wave end of the spectrum. There are two exciton bands for anthracene, which correspond to the Davydov splitting and which are polarized along the crystallographic a and b axes. These bands largely overlap at room temperature, so the polarization at the maximum is not 100%, and that at the short-wave side falls to zero. The intensity distribution in these bands is dependent on the temperature; the intensity of the band polarized along the b axis (transition to the lower exciton band) increases as the temperature is reduced, whereas that of the band polarized along the a axis (transition to the upper exciton band) is reduced. This explains why the maximal polarization increases on going from 77 to 4.2° K, while the polarization does not fall to zero on the short-wave side [1, 3]. The short-wave shift as the temperature is reduced may be explained via the potential curves for the ground and excited states [4]. Some conclusions on the structure of the exciton band can be drawn from this. Marked changes in polarization shown by stilbene are eliminated by cooling to 77° K which is due to impaired exciton emission as the temperature is reduced. This occurs when the point K = 0 in the exciton band does not correspond to the bottom of the band. No such effect occurs for anthracene, so the point K = 0 must lie near the bottom of the exciton band.

Part b of the figure shows analogous results for anthracene containing naphthacene; this indicates that the polarization for naphthacene has the values corresponding to those calculated for the oriented-gas model. The polarization in the long-wave region is roughly as for anthracene, but the spectrum has a certain structure absent from the polarization spec-