

THERMAL SELF-FOCUSING IN A LIGHT BEAM WITH LOW INTENSITY NEAR THE AXIS

G. A. ASKAR'YAN and I. L. CHISTYĬ

P. N. Lebedev Physics Institute, USSR Academy of Sciences

Submitted August 29, 1969

Zh. Eksp. Teor. Fiz. 58, 133-134 (January, 1970)

Thermal self-focusing in a strong light beam with reduced intensity near the axis is investigated. A blue light beam from a 0.3 W continuous argon laser was employed. Self-focusing was particularly pronounced in methylene iodide, in an alcohol solution of iodine, and in other liquids. It is shown that self-focusing of the inner part of the beam occurs under stationary conditions at different convection regimes (vertical and horizontal rays were investigated). Movement of the liquid destroys self-focusing. Black-white and color stills and motion pictures of the process were taken.

It was shown in^[1] that a decrease of the intensity $I(r)$ near the axis of a powerful light beam can cause self-focusing of the internal region of the beam (where $\partial I(r)/\partial r > 0$) in ordinary media, in which the refractive index decreases upon heating (where ordinary beams with a monotonic decrease of intensity become defocused); this process was demonstrated under conditions of external self-focusing in the beam of a pulsed laser without Q switching. In the present paper we investigate this process in a continuous gas-laser beam. We show that self-focusing is produced in the stationary regime under different convection regimes.

The experimental setup is shown in Fig. 1. The beam of the cw argon laser (1) of 0.3 W power was focused by a lens, to eliminate divergence (with focal distance 2 m), and passed through a glass plate with a small screen (2), causing the beam to become attenuated near the axis. A diaphragm (3) sharpened the outer boundary of the beam. A cell (4) with the investigated liquid was placed in the path of the beam, at a distance ~ 1 m from the screen. The cell could be readily moved perpendicular to the beam, making it possible to study the nonstationary processes, restoration of the unperturbed medium, and the influence of motion of the beam on the self-focusing. At a distance ~ 1 m from the cell there was placed a screen (5), from which the image was recorded by a still or by a motion-picture camera (6) on black and white or colored films, or else was observed visually. To reduce the convection, the beam entered the liquid vertically, using for this purpose a beam-splitting mirror and a prism (7). Such a splitting of the beam ensured simultaneous registration, from the screen, of the traces of the beam going past the cell and through the cell. Images of the beams were also produced directly on photographic film, by using a camera with a lens removed.

The most distinct and strongest self-focusing processes, at the available values of the power, were obtained in methylene iodide (CH_2I_2) and in a solution of iodine in alcohol. Figure 2 shows photographs of the cross section of a vertical beam going past the cell (a) and through the cell (b) with methylene iodide (thickness of liquid layer 4 mm at a laser-radiation transmission coefficient $\sim 10\%$). The picture was established within a fraction of a second and subsequently remained constant.

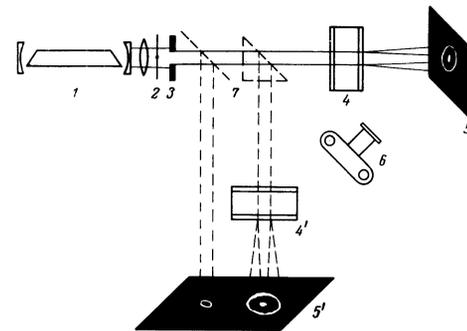


FIG. 1



FIG. 2



FIG. 3

Figure 3 shows a photograph of the steady-state glow of the beam in the case of horizontal passage through the liquid. Distortion due to the convection is observed; this convection does not prevent formation of a focused spot, but only deforms the outer boundaries of the beam, which become defocused, since

$\partial I / \partial r < 0$ for these boundaries. The radial lines in Fig. 2 and 3 are due to the azimuth inhomogeneity of the intensity of the initial beam. The caustic of the focal region was quite extended (≈ 2 m) and moved rapidly, following heating, from infinity to a finite distance (the existence of such a gap in self-focusing was first pointed out in^[2].)

When the cell is moved perpendicular to the beam at a rate of several centimeters per second (unidirectional or reciprocating motion), self-focusing disappears and the profile of the beam is unchanged by passage through the cell.

The described experiments illustrate the possibility of controlling nonlinear optical effects by choosing the profile of the distribution of the beam intensity. These effects can appear spontaneously in the presence of intensity dips in the laser beam, and also in the shadow zone behind absorbing and scattering centers in the

media. By choosing the profile it is possible to vary the distribution of the light inside a medium and to increase the intensity on the axis when light is infinite on a semi-infinite medium, etc.

The authors are grateful to V. F. Kitaeva and Professor N. N. Sobolev, in whose laboratory this work was performed, for interest in the work and for useful discussions, and to I. R. Gekker for taking part in taking the colored self-focusing photographs.

¹G. A. Askar'yan and V. B. Studenov, ZhETF Pis. Red. 10, 113 (1969) [JETP Lett. 10, 71 (1969)].

²V. N. Lugovoi and A. M. Prokhorov, *ibid.* 7, 153 (1968) [7, 117 (1968)].

Translated by J. G. Adashko
20