Fig. 3 that for the first series of measurements the dependence of D on $I/I_{min}$ has the same character within the angle range 67 - 90°, whereas at smaller angles the change in the brightness, due to the change in the limiting angle, is superimposed on the dependence of the track brightness on the ionization.

In conclusion, the authors consider it their pleasant duty to thank A. I. Alikhanyan for interest and collaboration, A. A. Tyapkin for proposing the measurement of the angles, and E. M. Matevosyan for help with the data reduction.

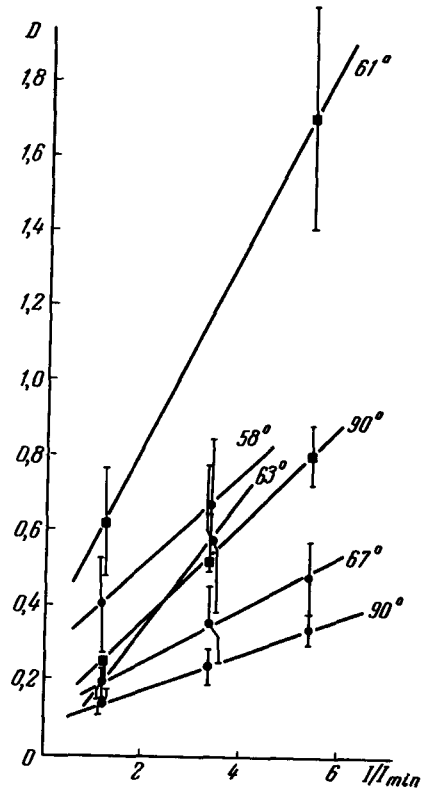


Fig. 3. Calibration curves of density D vs. $I/I_{min}$ for different angles α. • - $\tau_1$; ■ - $\tau_2$.

[1] T. L. Asatiani, K. A. Gazaryan, V. N. Zhmyrov, et al., Izv. AN ArmSSR 1, 127 (1966).
[2] S. Fukui and S. Miyamoto, The Discharge Chamber and Its Characteristics, Phys. Instit., Nagoua University.
[3] S. Fukui, CERN Preprint 63-37, 1963.
[4] B. A. Dolgoshein, in: Voprosy fiziki elementarnykh chastits (Problems of Elementary Particle Physics), AN ArmSSR, Erevan, 1964. p. 503.
[5] I. S. Rudenko, Abstract of Dissertation, Tomsk University.

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## INVESTIGATION OF THE KINETICS OF SELF-FOCUSING IN LIQUIDS

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Self-focusing of light, predicted by Askar'yan in [1], has lately attracted much attention. In particular, very interesting results were obtained by the authors of [2,3], who observed filaments with transverse dimension up to 2 μ and with a lifetime $\sim 10^{-9}$ sec. It was also noted [4] that in nonlinear reflection of light from a liquid, the lifetime of the Stokes component of Raman scattering is $\sim 3 \times 10^{-11}$ sec, which apparently is also connected with self-focusing. So far, however, the kinetics of the self-focusing process and its cor-

relation with the laser pulse remain unclear. The latter is important also for an understanding of the role of different self-focusing mechanisms.

We have investigated the kinetics of self-focusing with the aid of an electron-optical converter (EOC), and observed instability of the self-focusing channel. The results of this note were first reported in April 1967 at the All-union Seminar on Self-focusing in Gor'kii.

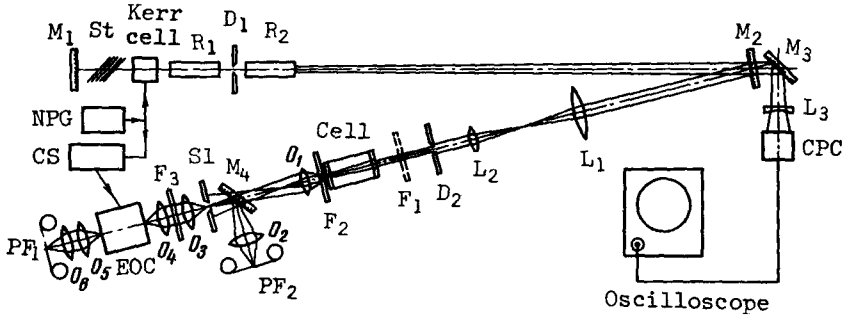


Fig. 1. Diagram of experimental setup. St - Stoletov stack, NPG - nanosecond pulse generator, CS - control system, EOC - electron-optical converter, CPC - coaxial photocell

The experimental setup is shown in Fig. 1. A Q-switched ruby laser was used. Diaphragm $D_1$ (1.5 mm diam.) placed between ruby crystals $R_1$ and $R_2$, separated the $TEM_{00}$ mode. The laser beam passed through a telescope system ($L_1$ and $L_2$) and through diaphragm $D_2$ (0.5 mm diam.) to a liquid-filled cell. Micro-objective $O_1$ projected the output end of the cell unto the slit Sl of the EOC, which operated in the linear-sweep mode. The cell was placed at a distance ~12 cm from the diaphragm, i.e., beyond the Fresnel focus, and the distance between the laser and the cell (4.5 m) was chosen such as to eliminate feedback due to nonlinear reflection. Mirror $M_4$ and objective $O_2$ monitored the accuracy with which the image of the self-focused filament was aligned with the EOC slit. The laser-pulse power was measured with a calibrated coaxial photocell. Neutral filters $F_1$, $F_2$, and $F_3$ were used to attenuate the radiation.

The maximum power entering the cell was 500 kW. The threshold powers obtained by us for a cell 10 cm long were 30 ± 5 kW for nitrobenzene and 60 ± 10 kW for toluene, in good agreement with the results by others [5]. The streak photographs have shown that at threshold power the self-focusing filament is produced at the instant of maximum lasing (Fig. 2a). With increasing power, the instant of filament formation shifts towards the start of lasing, and the lifetime of such a filament is $\lesssim 0.5$ nsec for nitrobenzene and 2 - 3 nsec for toluene (Figs. 2b, c). The streak photographs show the disintegration of the filament, its transverse expansion velocity being $(1.9 \pm 0.5) \times 10^5$ and $(2.4 \pm 0.5) \times 10^5$ cm/sec for nitrobenzene and toluene, respectively, or approximately 1.5 times the speed of sound. The minimal transverse filament dimensions were 10 ± 7 μ for nitrobenzene and 30 ± 7 μ for toluene.

The fact that the transverse spreading is faster than sound indicates the presence of a large excess pressure in the filaments.

The buildup of such a pressure can be realized as follows. When the input beam dia-

meter satisfies the condition $2v\tau < a$ (a - diameter, v - speed of sound, $\tau$ - laser pulse duration), the principal role in the self-focusing is played by the optical Kerr effect.

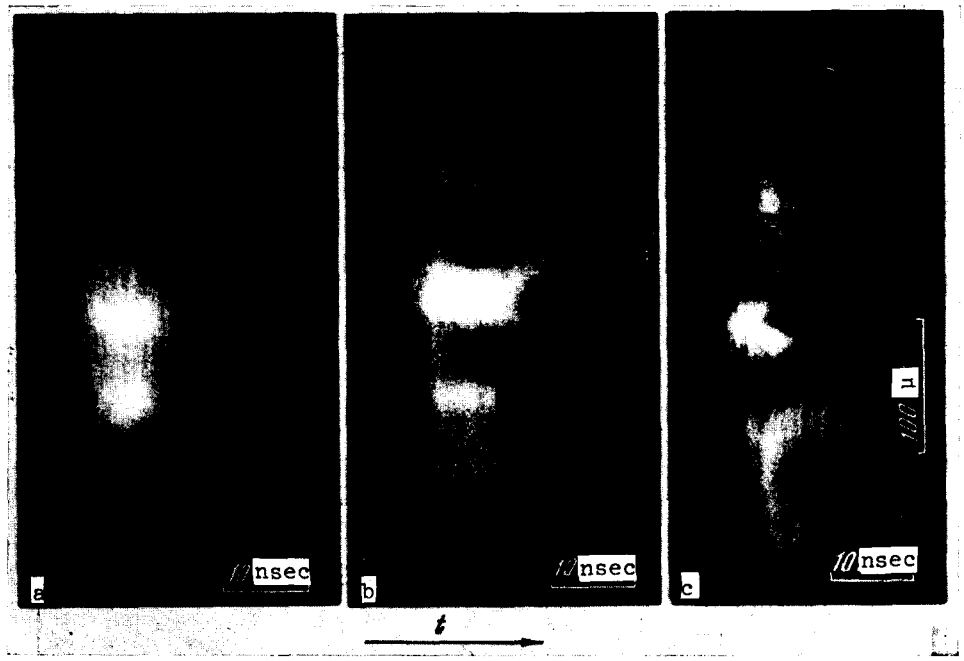


Fig. 2. Streak photographs. a - toluene, peak power 100 kW; b - toluene, peak power 250 kW; c - toluene, peak power 300 kW.

However, as the beam collapses, the foregoing inequality is violated and at diameters ~50 $\mu$ striction already assumes an important role (at a diameter ~2 $\mu$, the time of establishment of striction is $\sim 10^{-9}$ sec). The equilibrium striction pressure is $P_{str} = (E^2/8\pi)\rho(\partial\epsilon/\partial\rho) = 5 \times 10^{-2}$ atm at the intensity prevailing in the channel, $E \sim 10^5$ cgs esu [3]. When the input radiation is strongly attenuated by nonlinear reflection or absorption, the excess pressure in the filament, which is connected with the change in density of the medium, will not be balanced by the pressure of the field, and the filament begins to disintegrate. Further increase in pressure is connected with the temperature rise due to nonlinear absorption. The importance of this mechanism is seen from the fact that the spreading is faster than sound. The pressure in the channel can be calculated from the formula

$$P = P_0 + \rho_0 u^2 (1 - \frac{\rho_0}{\rho}),$$

where u is the wave velocity and $\rho_0/\rho$ the relative compression.

It is possible to use for this purpose the shock adiabats given in [6]. Estimates show that in our case the pressure is ~5 - 10 x $10^3$ atm. Such a pressure rise can apparently not be attributed to striction alone.

In conclusion, the authors thank G. A. Askar'yan for a useful discussion.

[1] G. A. Askar'yan, Zh. Eksp. Teor. Fiz. 42, 1567 (1962) [Sov. Phys.-JETP 15, 1088 (1962)].

[2] R. G. Brewer and J. R. Lifsitz, Phys. Lett. 23, 79 (1966).
[3] R. G. Brewer and C. H. Townes, Phys. Rev. Lett. 18, 196 (1967).
[4] M. Maier, W. Kaiser, and J. A. Giordmaine, Phys. Rev. Lett. 17, 1275 (1966).
[5] E. Garmire, R. Y. Chiao, and C. H. Townes, Phys. Rev. Lett. 16, 347 (1966).
[6] J. M. Walsh and M. H. Rice, J. Chem. Phys. 26, 815 (1957).

# E R R A T A

In article by A. I. Golovashkin et al., Vol. 6 No. 5, p. 143, in the first formula read "$\sigma = \frac{1}{12}$ ..." in lieu of "$\sigma = \frac{1}{h}$ ..."

In article by I. A. Fomin, Vol. 6 No. 6, p. 198, line 2, read "... $12^{-2}$ 1/cm..." in lieu of "... 1%..."

In article by A. V. Butenin et al., Vol. 6 No. 6, p. 175 line 6, read "5 x $10^{2}$ atm..." in lieu of "5 x $10^{-2}$ atm..."