The authors are grateful to A. P. Aleksandrov for interest in the work, to Yu. M. Kogan and A. M. Afanas'ev for a discussion and useful advice, and also to R. S. Silakov, A. A. Sirotkin, P. F. Samarin, I. A. Semin, and Yu. N. Pshonkin for taking part in the experiments.

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SELF-FOCUSING FILAMENTS AS A RESULT OF THE MOTION OF FOCAL POINTS

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Submitted 18 December 1969
ZhETF Pis. Red. 11, No. 3, 153 - 157 (5 February 1970)

The question whether the filaments produced in self-focusing [1, 2] are the results of motion of individual focal points, as proposed in [3, 4], or whether these filaments exist as stationary formations, as proposed in [5 - 7], has been the subject of lively discussion in the recent literature.

An experimental verification of the correctness of either of these two points of view is far from a simple matter. It was first shown in [8 - 9] that the self-focusing filaments exist in liquids a very short time, $\sim 10^{-9} - 10^{-10}$ sec. In [10 - 12], self-focusing filaments were observed as a result of the motion of individual points. However, the results of [10 - 12] cannot be interpreted unequivocally in favor of the theory of focal points. The difficulty lies here in the fact that even in the case when the stationary theory is valid, the large radiation density inside the self-focusing filament can lead to a strong heating [9] and even to destruction [11] of the medium, owing to various nonlinear effects, plasma formation [13], etc. These phenomena alter radically the properties of the medium and lead to a rapid disintegration of the filament, as a result of which its length at some particular instant of time may be very small. When the laser power is varied, the starting point of such a short self-focusing filament will shift in the medium, thus creating the illusion of a moving focus. Moreover, the entering laser beam may break up into individual transverse regions with subsequent self-focusing of each of these regions [8, 13, 14]. In this case, even in the framework of the theory of stationary filaments, it is possible to explain the simultaneous existence of several moving foci. These foci will move in the medium, however, along different trajectories, separated by distances on the order of the dimension of the transverse-breakdown region ($\sim 50 - 100$ μ [13]).

To check on the validity of the two self-focusing theories, the authors used an electron-optical converter (EOC) to investigate to kinetics of self-focusing in liquids. The experimental setup is shown in Fig. 1.

The radiation from a single-mode (one angular and one axial mode) laser passed through a cell of length $\ell = 10$ cm, filled with nitrobenzene or carbon disulfide. The radiation entering the cell had a plane phase front with an approximately Gaussian transverse distribu-

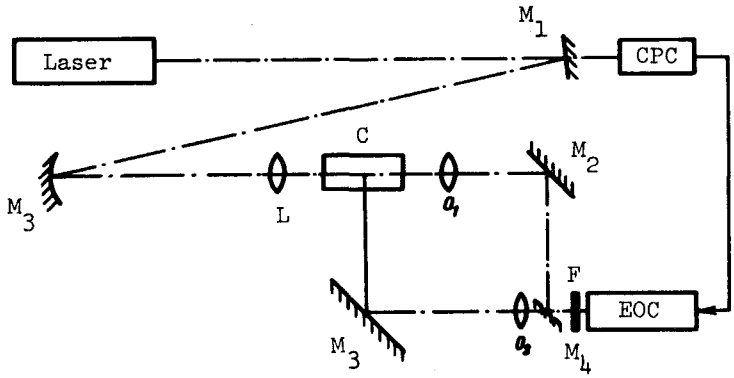

Fig. 1. Experimental setup: EOC - electron-optical converter, CPC - coaxial photocell to trigger the EOC, C - cell with investigated substance, M_1 - light-delay mirror, M_2 and L - telescopic system, O_1 and O_2 - objectives, M_3 - flat mirror, M_4 - removable flat mirror used when the cell is photographed from the rear. F - light filter for λ = 6943 Å.

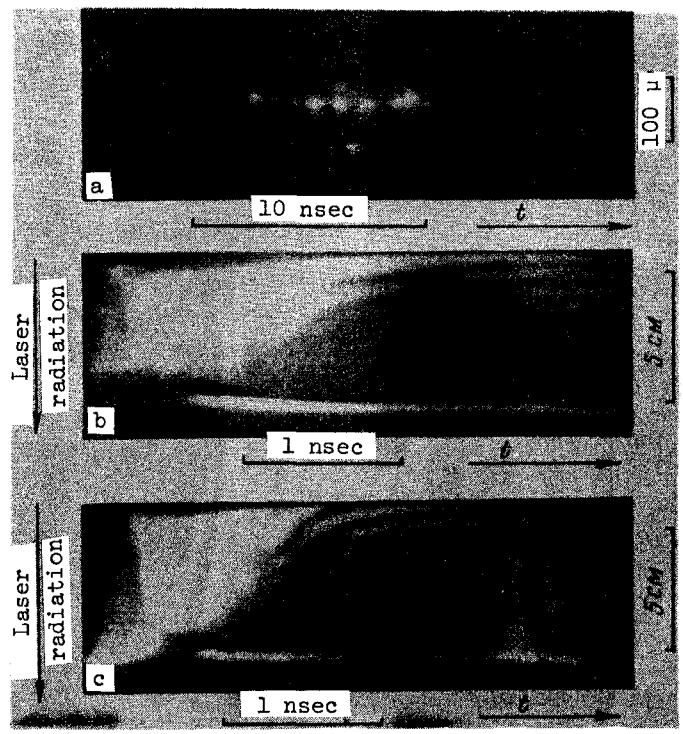

Fig. 2. a - Sweep of self-focusing picture in carbon disulfide at the output end of the cell; b, c - sweep of self-focusing picture in carbon disulfide from the side of the cell.

tion. The diameter of the input beam was ∿0.25 mm, and the power reached 1.5 MW at a pulse duration ∿15 nsec. The EOC was triggered by a coaxial photocell. A filter passing only the laser radiation was located in front of the EOC. A typical photograph of the time sweep of the end of the cell is shown in Fig. 2a. We see that the diameter of the self-focusing spot at the exit from the cell is ∿5 μ, corresponding approximately to the resolving power of the registration system. The self-focusing spot lasts less than 0.5 nsec, after which it vanishes and the next spot appears in the same place (within 5 μ) after 1 - 2 nsec. Sometimes, as seen in Fig. 2a, a second self-focusing spot is produced at a distance ∿50 μ, but this is observed very rarely.

Self-focusing sweep photographs taken from the side of the cell are shown in Figs. 2b and 2c. It is seen from the photographs that intense glow, apparently connected with some stimulated scattering, is observed at the very start of the laser pulse. The termination of the stimulated scattering is followed clearly by the motion of individual points in the di-

rection of the entrance end of the cell. The maximum velocity of this motion is $\sim 3 \times 10^9$ cm/sec. As the points move to the interior of the cell, their velocity decreases to approximately zero at the maximum of the laser pulse. The number of moving points is approximately equal to the number of self-focusing spots observed on the sweep of the exit end of the cell.

The photographs 2b and 2c show practically no backward motion of the self-focusing spots when the input-beam power is decreased. This can be attributed to violation of the self-focusing as a result of various energy-dissipation processes (for example, linear absorption), which are most appreciable precisely at the instant of reversal.

Under our experimental conditions, the maximum value is $N = E/E_{cr} \approx 7$, where E is the intensity of the input field, $E_{cr} = [n_2(ka)^2]^{-1/2}$ (k - wave number, a - radius of entering beam, n_2 - nonlinear refractive index). The theory developed in [3, 4, 15] predicts for N = 7 and $\zeta = \ell/ka^2 \approx 0.5$ the existence of about 7 focal points, which is quite close to the experimental data obtained in our paper. The velocity of the focal points is also in satisfactory agreement with that calculated in [4].

The authors believe that the obtained experimental results confirm the validity of the self-focusing theory developed in [3, 4, 15].

In conclusion, the authors thank V. N. Lugovoi for fruitful discussions.

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TWO-QUANTUM ANTI-STOKES PROCESSES IN THE EXCITATION OF DYES

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Submitted 19 December 1969
ZhETF Pis. Red. 11, 157 - 162 (5 February 1970)

We report here an experimental observation of anti-Stokes Raman scattering by the electronic state of molecules and luminescence from the second excited electronic states in organic dyes.

In dyes used for saturable filters, luminescence in transitions from the second excited state to the ground state is quite easily observed, and its investigation is reported for example, in [1]. However, a more careful investigation of the spectra reveals, besides the