with the obtained diffusion length of the triplet molecular excitons, which, according to [9, 10], equals 10^{-3} cm, much less than the crystal dimensions employed by us.

Thus, the results of the present investigation show that in anthracene there exist long-lived highly mobile excited states, which are produced by recombination of electrons and holes (by annihilation of triplet molecular excitons), and which apparently are triplet excitons with charge transfer and are characterized by the following parameters: lifetime 4 msec, diffusion length ≈0.03 cm, and energy E > 2.35 eV.

[1] R. Knox, Exciton Theory (Russ. Transl.), Mir, 1966.
[2] L. E. Lyons, J. Chem. Soc., 5001 (1957).
[3] E. L. Frankevich and E. I. Balabanov, ZhETF Pis. Red. 1, No. 6, 33 (1965) [JETP Lett. 1, 169 (1965)].
[4] E. L. Frankevich and I. A. Sokolik, Fiz. Tverd. Tela 9, 1945 (1967) [Sov. Phys.-Solid State 9, 1532 (1968)].
[5] E. L. Frankevich and B. M. Rumyantsev, ZhETF Pis. Red. 6, 553 (1967) [JETP Lett. 6, 70 (1967)].
[6] E. L. Frankevich and B. M. Rumyantsev, Zh. Eksp. Teor. Fiz. 53, 1942 (1967) [Sov. Phys.-JETP 26, 1102 (1968)].
[7] J. Ferguson, Austr. J. Chem. 9, 160 (1956).
[8] E. L. Frankevich and B. M. Rumyantsev, Phys. Stat. Sol. 30, 329 (1968).
[9] V. Ern, P. Avakian, and R. E. Merrifield, Phys. Rev. 148, 862 (1966).
[10] M. Levin, J. Jortner, and A. Szoke, J. Chem. Phys. 45, 1591 (1966).

FLUCTUATION STRUCTURE OF A GIANT LIGHT PULSE AND ITS VARIATION WHEN PASSING THROUGH A NONLINEAR ABSORBER

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1. Great interest attaches to an investigation of the process of formation of ultrashort pulses of light in a laser with a nonlinear absorber [1]. In [2], attention was called to the important role which may be played by intensity fluctuations of multimode radiation in the formation and development of ultrashort pulses in such a laser. Such fluctuations are the result of interference of radiation with random phases in a very large number of modes.

In the present investigation we used apparatus with high temporal resolution (10^{-11} sec) to observe fluctuations of multimode radiation of a ruby laser, and the process of separation of the most intense fluctuation peaks in multiple passes through a nonlinear absorber (cryptocyanine).

2. The experimental setup is shown in Fig. 1. The source of the multimode radiation was a ruby laser (1) Q-switched by a Kerr cell (pulse duration 15 - 20 nsec, resonator length 60 cm, width of emission spectrum 1 - 2 cm^{-1}). An amplifier using a ruby crystal (2) made it possible to regulate the pulsed radiation power.

A system of two diaphragms (3) of 1 mm diameter, spaced 1.5 meters apart, produced a wave that was plane within the diffraction limitations. With the aid of two parallel mirrors (4) (R = 64%, distance 1.5 meters) the light pulse was made to pass several times through two cells with cryptocyanine solution (5). To compensate for the loss in the mirror and in the

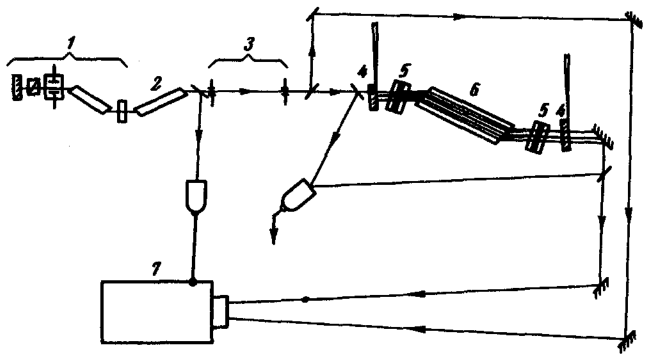

Fig. 1. Experimental setup: 1 - ruby laser with Kerr-cell Q-switch, 2 - ruby amplifier, 3 - diaphragm, 4 - parallel mirrors, 5 - cell with cryptocyanine, 6 - ruby crystal, 7 - photoelectronic recorder.

absorber, a ruby crystal (6) with a maximum gain per pass ∿ 10 was placed between the cells (240 mm, 18 mm diameter). The pulse energy was insufficient to change the gain of the ruby.

The initial transmission of each cell was 24%, and therefore on the whole the system was in a stable absorbing state in the case of weak signals. Such a two-component medium has the ability to shorten the pulse duration when the intensity is close to the threshold, at which the total loss in the medium becomes comparable with the gain. This property of the two-component medium was investigated in [3]. The threshold power in the experiment was several MW/cm^2.

The input radiation and also the radiation passing several times through the two-component medium were registered, at a high time resolution, by means of a special photoelectronic recorder (7) developed at VNIIOFI [4]. The time resolution of this instrument was measured with the aid of ultra-short laser pulses and reached approximately 10 psec. In our experiments we used long sweeps, in which the resolution was somewhat poorer. The experimental setup made it possible to register the input and output radiation.

Figure 2 shows time sweeps of the intensity of the input radiation (below) and output radiation (above). A sine wave with period 3 nsec served as the time scale. We see that the input radiation fluctuates. The average duration of the fluctuations is 50 - 100 psec, which agrees with the width of the input-radiation spectrum. After passing through the two-component medium, only the most intense fluctuation peaks remain. Their repetition period is determined by the time required to pass twice through the two-component medium (9.3 nsec). Effective separation of the individual fluctuations is possible only when the average intensity of the input radiation is close to threshold.

3. The two-component medium is a pulse-height discriminator. Figure 3a shows the transmission characteristic of a non-inertial two-component medium at different lengths L, i.e., for different numbers of passes; the characteristic was obtained by solving the equation

Fig. 2. Time sweep of input and output radiation intensities (lower and upper traces, respectively), obtained with the photoelectronic recorder. Period of sinusoid - 3 nsec.

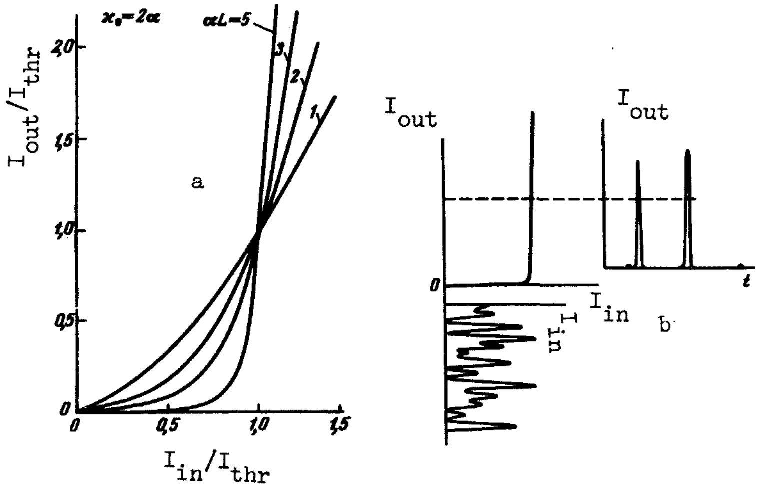

Fig. 3. Two-component medium: a - transmission characteristic for the case $\kappa_0 = 2\alpha$ and $I_{thr} = I_{sat}$ at different lengths L; b - change of fluctuation structure on passing through the two-component medium.

where α is the coefficient of the linear gain per unit length with allowance for all the linear losses, including the losses in the mirrors of the setup of Fig. 1; κ_0 is the initial coefficient of the saturable absorption per unit length; I_{sat} is the saturation power. The threshold intensity $I_{thr} = (\kappa_0 - \alpha)/\alpha$. With increasing optical density of the medium αL, the characteristic acquires a threshold character. Figure 3b shows the change of the fluctuating structure on going through such a medium. If the average intensity of the fluctuations is chosen to be somewhat lower than I_{thr}, then only rare fluctuation peaks pass through the medium. The described qualitative picture explains fully the results of the experiment.

4. A similar separation and reduction of the most intense fluctuation peaks of multimode radiation by passage through a nonlinear absorber occurs apparently in ultrashort-pulse lasers [1]. Multiple passage through a nonlinear absorber with a short saturated-state relaxation time causes the most intense peaks to become amplified, and the less intense ones to attenuate. In a laser, this is equivalent to establishment of definite phase relations between the modes (self-synchronization or self-locking of the modes). The shortening of the duration of the fluctuation peaks is equivalent to an increase of the number of generated modes.

5. The experiment demonstrates that a two-component medium is actually capable of shaping ultrashort pulses of light out of the fluctuation noise of multimode radiation. In principle, such a method can yield single ultrashort pulses from intense incoherent radiation such as superluminescence.

[1] A. J. De Maria, P. A. Stetser, and H. A. Heynau, Appl. Phys. Lett. 8, 174 (1966).
[2] V. S. Letokhov, Zh. Eksp. Teor. Fiz. 55, 1077 (1968) [Sov. Phys.-JETP 28 (1969)].
[3] N. G. Basov, P. G. Kryukov, V. S. Letokhov, and Yu. A. Matveets, ibid. 56 (1969) [29 (1969)].
[4] N. G. Basov, Yu. A. Drozhbin, V. V. Nikitin, A. S. Semenov, B. M. Stepanov, and V. A. Yakovlev, High-speed Photography, Stockholm, 1968.