1f shows the structure of an individual radiation pulse swept with a resolution 5×10^{-12} sec. Figure 1g shows that when the dc component of the injection current is doubled only the first pulse in the group is synchronized, and the succeeding pulses have a self-modulation character. The pauses between the groups decrease with increasing dc component of the current, and gradually free self-modulation sets in when the dc component greatly exceeds the sinusoidal injection current. A convenient method of eliminating the dc component and at the same time protecting the diode against breakdown at large inverse sinusoidal injection currents is to connect two diodes in antiparallel.

It should be noted in conclusion that the regular sequences of light pulses obtained by synchronizing semiconductor-laser emission by sinusoidal injection current have the following useful properties, which are not possessed by the self-modulation regime: The repetition frequency ω of the pulses and their phase are rigidly controlled by the external signal and are independent to a considerable degree of the diode properties, which vary from sample to sample with time (aging), and also of the external parameters. The repetition frequency ω and the pulse duration T are not interrelated, making it possible to vary independently the ratio $T/(2\pi/\omega)$ down to very low values.

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ANTHRACENE LUMINESCENCE QUENCHING BY A MAGNETIC FIELD

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Investigations [1-4] of the photoconductivity of anthracene single crystals and of its variation in a magnetic field have led to the conclusion [2] that there exist in anthracene excitons (Π) of large radius (with charge transport or of the Wannier type), whose lifetimes depend on the magnetic field (as a result of the mixing of the Ψ-functions of the singlet Π_1 and triplet Π_3 states of the excitons). The excitons Π_1 and Π_2 are produced in the anthracene, according to [2-4], when the holes and electrons generated by the light recombine. It is also known that the recombination of the holes and electrons within the volume of single-crystal anthracene is accompanied by luminescence due to radiation by singlet molecular excitons M_S^*[5].

The aforementioned results of [2-4] and [5] differ from each other. Their comparison leads to the conclusion that differences should exist in the conditions of exciton production as well as a definite connection between the large-radius Π excitons and the molecular M* excitons. To elucidate these distinguishing features of these two types of exciton, we investigated the behavior of the recombination luminescence of single-crystal anthracene in a magnetic field.

The holes and electrons whose recombination produced the luminescence were simultaneously injected in the single-crystal anthracene by an electric field from two opposite sides of the sample, using liquid contacts (from a solution of anthracene and $AlCl_3$ in nitromethane for hole injection and from a solution of anthracene and Na in tetrahydrofuran for electron injection). In this respect, the procedure was similar to that used by Helfrich and Schneider[5,6]. The hole and electron currents were determined by the space charge in the sample and by the injection properties of the contacts. At an average electric field intensity in the crystal up to 10^4 V/cm, the current through the sample reached 2×10^{-5} A. The sample was in a light-tight chamber placed in the gap of an electromagnet. The anthracene luminescence was registered with an FEU-11B photomultiplier located 1 meter away from the sample and dependably screened against the stray magnetic field. (When a magnetic field H = 3000 Oe was turned on and light from a control source located at the place of the sample was registered, the sensitivity of the photomultiplier did not change by more than 0.2%.) Figure 1 shows the current i through the sample and the luminescence intensity L as functions of the voltage V applied to the sample.

Application of the magnetic field to the sample caused L to decrease. The change ΔL for H = 3000 Oe is shown in Fig. 1 (the ΔL/L plot). ΔL increases in absolute magnitude with increasing H (Fig. 2) and is practically independent of the relative orientation of the sample and of the current in the magnetic field.

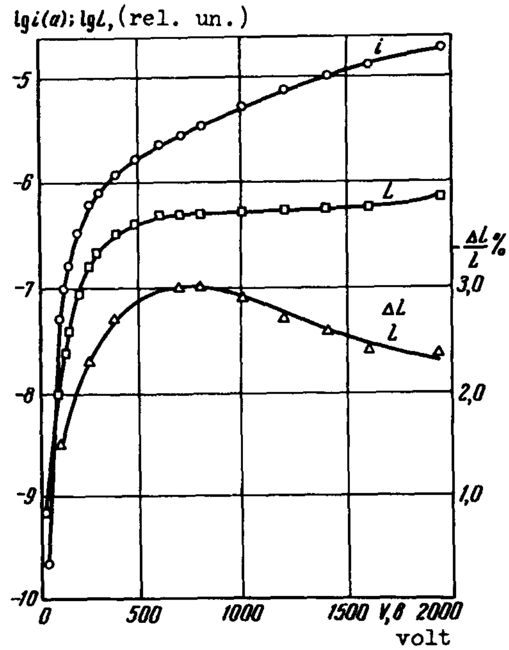

Fig. 1. Current i through sample, luminescence intensity L, and relative change of luminescence ΔL/L as functions of the voltage V applied to the sample.

The results give grounds for assuming that the observed effect of luminescence quenching in a magnetic field is connected with excitons with charge transport.

The most linear scheme that includes excitons with charge transport in the light-generation process is

$$e + h \rightarrow \frac{1}{4}\Pi_1 + \frac{3}{4}\Pi_3, \qquad (1)$$

$$\Pi_1 \rightarrow M_S^* \xrightarrow{h\nu} M_0, \qquad (2)$$

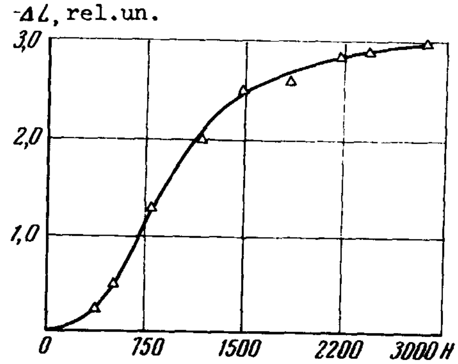

Fig. 2. L vs. magnetic field H for constant V.

where M_0 is the ground state of the anthracene.

However, according to [2], the magnetic field, by mixing the states Π_1 and Π_3, should lead to an increase of the fraction of the short-lived excitons (Π_1) and consequently, in accord with this scheme, it should lead to an increase of the luminescence intensity, in contradiction to the experiment. The quenching effect of the magnetic field and the small magnitude of the effect can be understood by assuming that the recombination of the electrons and holes (e_i and h_i) injected into the crystal results essentially in the production of molecular excitons, which are not affected by the magnetic field:

$$e_i + h_i \rightarrow \frac{1}{4} M_S^* + \frac{3}{4} M_T^* . \qquad (3)$$

On the other hand, for Π excitons with charge transport to be produced in accordance with scheme (1) it is necessary to have electrons that are at a higher energy level, the number of which is small under dark injection conditions. Such electrons, however, are produced when generated by light, especially in the process of annihilation of triplet molecular excitons M_T^* [3,4]. The injected electrons e_i may possibly be those in the narrow conduction band (and localized on the anthracene molecules), while the e electrons are those in the broad conduction band [6]. The injected holes h_i are apparently equivalent to h in all cases. Simultaneous occurrence of the processes (1) and (3), under the condition that only a small fraction of the e_i electrons go over into e, makes it possible to explain the observed luminescence quenching.

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QUARTZ RESONATOR WITH Q CLOSE TO 120 × 10^6 AT TEMPERATURE 2°K *

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We investigated the absorption mechanisms brought about by inelastic processes in quartz crystals by measuring the internal friction in resonators at low and infralow temperatures. The resonators were quartz elements in the form of doubly-convex lenses of AT-cuts, secured in a special manner to a quasineutral plane, and placed in a vacuum bulb. They were excited in a crystal holder with slots, at a fundamental frequency 1000 kHz.

The internal friction of the piezoelectric quartz was measured by a method in which the time of the free damped oscillations was automatically recorded [1]. The Q factor was calculated from the determined time of decrease of the amplitude in free damping of the oscillations; the measure of the internal friction was taken to be the quantity Q^{-1}. The instrument makes it possible to measure Q with an error not exceeding several per cent.

The temperature was measured with a platinum resistance thermometer accurate to ±0.01% in the temperature interval 12 - 300°K, and with a germanium thermometer accurate to ±0.1% in