| Substance | $10^{50}$ cm$^4$sec |
|-----------|----------|
| Anthracene, crystal | 25 |
| Anthracene, solution | 3.5 |
| Acridine, solution | 2 |
| 3-aminophtalimide, solution | 2 |

The table lists the obtained values of δ (cm$^4$sec/photon-molecule), equal to the ratio of the effective cross sections σ (cm$^2$) to the flux F (photons/cm$^2$sec), i.e., quantities no longer dependent on the power.

As seen from the table, the effective cross sections of two-photon absorption are very close for the three investigated molecules. This indicates that the symmetry of a complex molecule does not influence the probability of two-photon absorption. The values of δ for the anthracene crystal exceeded by several times those for the solution. We assumed that this was due to the influence of the crystal surface on the luminescence yield in the case of single-photon excitation. The reduced yield of single-photon excitation obtained in our method of measurement yielded too high a value of the two-photon absorption. However, a control experiment with a cleaned surface did not confirm this assumption. The value obtained for δ for an anthracene solution was higher than indicated earlier [1], even with allowance for the possible error (by a factor ∼2) in the determination of the laser energy density.

An estimate of the two-photon absorption coefficient for allowed transitions can be obtained, following Kleinman's paper [2], using the formula

$$\delta = \frac{\sigma}{F} = (e^2/mc^2)^2 \frac{f_1 f_2 \overline{\cos^2 \vartheta_1 \cos^2 \vartheta_2}}{cn^2 \overline{\nu}^2 \overline{\Delta \nu}^2},$$

where $f_1$ and $f_2$ are the oscillator strengths for transitions in the intermediate state, $\vartheta_1$ and $\vartheta_2$ are the angles between the light-wave vector and the dipole moment of these transitions, and $\overline{\Delta \nu}$ (in cm$^{-1}$) is the half-width of the absorption band. Putting $f_1 = f_2 = 1$ and $\overline{\Delta \nu} \sim 5000$ cm$^{-1}$, we obtain $\delta \sim 10^{-49}$ cm$^4$sec. The values of δ measured by us agree with this estimate in order of magnitude.

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CAUSES OF FORMATION OF A RADIATION PEAK BEHIND A SHOCK WAVE IN A NONEQUILIBRIUM GAS

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A number of recent papers [1,2] report experimental observation of a radiation peak behind a shock wave. Radiation from a nonequilibrium relaxing gas greatly exceeds the radiation level after equilibrium is reached. Attempts to explain this phenomenon were not successful. We show here that the causes of the radiation peak are: (i) nonequilibrium state

distribution of the radiating atoms, and (ii) heating of the electron gas by inelastic collisions with molecules. The results of the calculations are compared with experiment.

To describe the state of a nonequilibrium plasma produced behind a shock wave it is necessary to use, besides the three conservation equations, also the equations for the ionization kinetics and the electron energy balance [3,7]:

$$\frac{d}{dx}(n_e v) = S_e, \tag{1}$$

$$\frac{d}{dx}(\frac{3}{2}n_e T_e v) + n_e T_e \frac{dv}{dx} = S_{ee}. \tag{2}$$

Here $T_e$ is the electron temperature, $n_e$ their density, $v$ the gas-stream velocity, $x$ the distance of the front, and $S_e$ the electron source. During the first relaxation state, associative ionization predominates, followed by ionization by electrons. We take into account in the electron energy source $S_{ee}$, as usual, elastic collisions with ions, associative ionization, and ionization by electrons. An important role is also played by inelastic collisions with vibrationally-excited molecules [6], in spite of the fact that behind strong waves ($v_1 \geq 10$ km/sec) the molecules dissociate rapidly and their number is small [7].
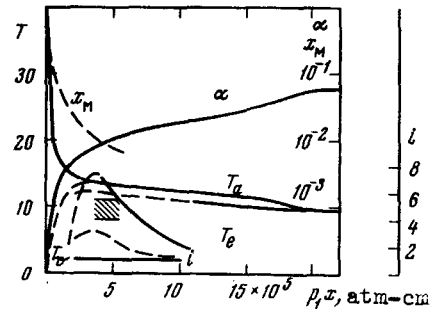
The distribution of the atoms over the states can be investigated with the aid of the Fokker-Planck equations in energy space [4,5]. Using the previously-obtained expression for the atom concentration $n_k$ at the level k:

$$n_k = \left( n_1 \sum_{i>k} S_i + n_e^2 \sum_{i<k} S_i \right) \left( \sum_i S_i \right)^{-1} \tag{3}$$

where $S_i = (n_i^0 D_i)^{-1}$ ($n_i^0$ is the local equilibrium value of $n_i$, and $D_i$ is the coefficient of diffusion, caused by atom-electron collisions, in the discrete energy space [5]).

The results of the solution for a wave in air are shown in the figure, together with the profile of i (average curve) - the ratio of the intensity of the radiation in the 3s - 3p lines of nitrogen to their value at equilibrium, and the experimental results [2]. Here T is the temperature in $10^3$ °K, $\alpha$ the degree of ionization, and $x_M$ the fraction of $N_2$ molecules. The less reliable sections of the curves are shown dashed. The shaded area corresponds to the magnitude and position of the experimental maximum of i [2].



Profiles of the parameters of nonequilibrium air behind a 10-km/sec shock wave; the pressure ahead of the front is $p_1 = 0.1$ mm Hg.

To take into account the role of the possible uncertainty connected with the calculation of the oscillation temperature $T_v$ and the number of molecules, we have estimated the largest and smallest values of i. The lower (almost-horizontal) line corresponds to calculation with no account of the contribution of molecules from $S_{ee}$, and is a rigid lower bound. It turns out that in this case the intensity of radiation is not small,

and is practically equal to the equilibrium value. The upper curve (solid section), plotted under the assumption that $T_e = T_a$ (the highest temperature), is a rigid upper bound. At small values of x this estimate is not valid, since the oscillation temperature is low in this case, and the molecules can heat the electrons only to $T_e = T_v$, corresponding to the dashed upper curve of i.

It is also possible to attribute the radiation peak in a band spectrum behind strong shock waves to excitation of the molecules by electrons. Thus, for example, the populations of the first excited states of $N_2^+$ arising in the case of associative iionization soon reach the local-equilibrium values. The calculated radiation intensities are in good agreement with the earlier measurements [2].

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POSSIBILITY OF EXCITING CYCLOTRON INSTABILITY IN SEMICONDUCTORS

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Increased interest has been recently evinced in the excitation of microwave oscillations in solid-state plasma [1,2]. It is not without interest to consider in this connection the possibility of exciting cyclotron instability in a solid-state plasma by means of a current. It is known that ion-cyclotron instability can be excited in this manner in a gas-discharge plasma [3] and that these results can be carried over to the case of a solid-state plasma. The dispersion equation describing cyclotron instability in a solid-state plasma is [3][1)]

$$\sum_i \alpha_i \exp(-s_i) \sum_{n=-\infty}^{\infty} I_n(s_i)[1 + i\sqrt{\pi}(z_{ni} + nh_i)W(z_{ni})] = 0, \tag{1}$$

where