

at a pump power somewhat higher than the instability threshold. This is due to the difficulty of constructing a loop ensuring optimal coupling with the radiation field of a definite mode of oscillations of the ferrite sample [4].

An investigation of the influence of the crystallographic anisotropy (Fig. 2) on the instability of the MSW has shown that a change of the crystallographic orientation does not affect significantly the location of the generation bands of the volume MSW relative to the magnetization field. The radiation band of the surface MSW broadens greatly and is chopped up to a greater degree. This is obviously connected with the broadening of the region in which surface MSW exist [3] ( $\gamma\sqrt{H_1 B_1} \leq \omega \leq \gamma(H_1 + B_1)/2$ ); since  $H_1$  increases as a result at the expense of the anisotropy field, the different oscillation modes are better separated.

An anomalous change is observed in the gap between the threshold of the additional absorption and the threshold of occurrence of auto-modulation oscillations when the anisotropy field is increased. This change cannot be explained by the existing theory [2].

An analysis of the dependence of the radiation power on the pump power (see Fig. 3) leads to certain conclusions concerning the character of the steady state of the MSW. It must be noted first that the amplitude dependences of the volume MSW (curves 1 and 4) have no sharp anomalies when the instability of nonlinear ferromagnetic resonance sets in (when auto-modulation oscillations appear, Figs. 1 and 2). This indicates that the establishment of the MSW amplitude is not connected with excitation of auto-modulation oscillations, as is the case for short spin waves [2]. The smooth curves of the radiation power of volume MSW in Fig. 3 confirm that the MSW radiation is produced "directly," and not as a result of scattering by inhomogeneities (natural defects or elastic oscillations excited by the auto-modulation ones). The step seen on the power curves of the surface MSW (curves 2 and 3) is likewise not connected with excitation of auto-modulation oscillations (see Fig. 1), although the physical mechanism producing it is not quite clear. It is possible that this involves two-magnon processes (scattering of spin waves by defects) or processes of higher order (for example, 4-magnon processes (5)).

The authors are grateful to Ya. A. Monosov for a useful discussion.

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#### DISSOCIATION OF BORON TRICHLORIDE MOLECULES BY CO<sub>2</sub> LASER RADIATION

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Submitted 21 January 1970  
ZhETF Pis. Red. 11, No. 4, 220 - 222 (20 February 1970)

It is known that gaseous BCl<sub>3</sub> is used in quantum electronics [1-4]. We have observed exposure of this gas to CO<sub>2</sub>-laser radiation leads to dissociation of the BCl<sub>3</sub> molecules, accompanied by recombination radiation. This radiation was observed following both pulsed and

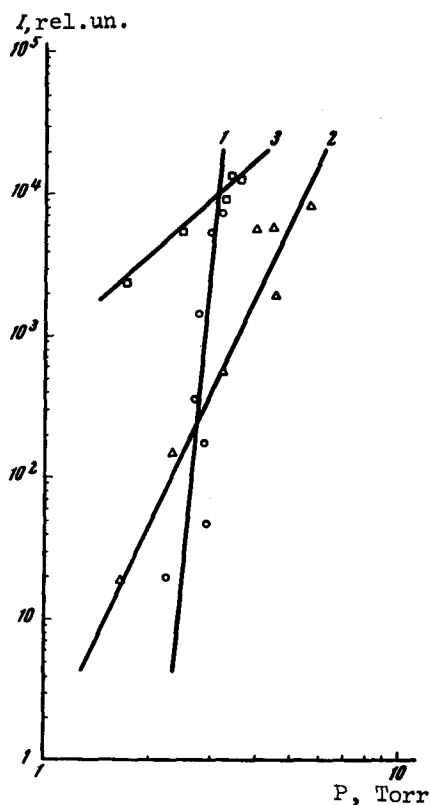
continuous irradiation of the gas-containing cell by a  $\text{CO}_2$  laser of power up to 100 W. The cell length was 10 cm and the diameter 2 cm. The laser radiation frequency coincided with the oscillation frequency  $\nu_3$  of the  $\text{BCl}_3$  molecule.

The glow has a continuous spectrum with a maximum in the yellow-green region. Its intensity increases with increasing pressure. At high pressures, the glow brightness is very high. The laser emission is then completely absorbed by the cell, and its heating is negligible. When the glow appears, the pressure in the cell increases. The pressure increment is proportional to the glow intensity. The glow disappears when the  $\text{BCl}_3$  is diluted with helium in a 1:1 ratio.

The glow intensity  $I$  had a power-law dependence on the laser-irradiation power  $P$ . This dependence is plotted logarithmically in the figure.  $I \sim P^{2.5}$  at 150 Torr,  $I \sim P^5$  at 375 Torr, and  $I \sim P^2$  at 675 Torr.

In the case of pulsed irradiation, the glow occurs after a delay whose length does not depend on the irradiation intensity and decreases with increasing pressure. At 150 Torr, the delay was 1.5 msec.

The visible glow of boron trichloride is accompanied by infrared luminescence. The



Glow intensity  $I$  (relative units) vs. irradiation power  $P$ : 1 - pressure 150 Torr, 2 - 375 Torr, 3 - 675 Torr.

luminescence was observed in the wavelength range 5 - 12  $\mu$ . Its spectrum was registered with an IKS-21 spectrometer. The luminescence was most intense in the 9.5 - 12  $\mu$  region, where series of bands of different types of oscillations were observed up to the dissociation threshold. The bands were identified on the basis of the knowledge of the frequency of the normal oscillations, by searching for serial regularities. With increasing pressure, luminescence was observed from successively higher vibrational levels  $n\nu_3$  and (to a lesser degree)  $n(\nu_1 + \nu_2)$ . Identification of the bands has made it possible to determine for the normal modes of the  $\text{B}^{11}\text{Cl}_3$  molecule, using a Morse-type potential, the zero-point frequencies  $\omega_0$ , the anharmonicity constants  $\chi$ , and the dissociation limits  $D$ , all of which are listed in the table.

Oscillations	$\omega_0, \text{cm}^{-1}$	$-\chi, \text{cm}^{-1}$	$D, 10^3 \text{cm}^{-1}$
$\nu_1$	472.05	0.570	97.7
$\nu_2$	466.69	1.405	38.8
$\nu_3$	957.67	1.648	139.5
$\nu_4$	242.23	6.213	69.0

The experiments were performed with  $\text{BCL}_3$  having a natural isotope content. We were unable to identify the luminescence spectrum of the  $\text{B}^{10}\text{Cl}_3$  molecule.

As seen from the table, the oscillation  $\nu_2$  has the lowest dissociation limit and consequently this oscillation determines the dissociation threshold. We note that in the  $\nu_2$  oscillation the boron atom goes outside the plane of the molecule. Consequently, the dissociation of the  $\text{BCL}_3$  molecule begins with detachment of the boron atom.

At pressures exceeding 20 Torr one can clearly see in the spectrum the low-frequency limit of the  $n\nu_3$  series, corresponding to the transitions  $43\nu_3 \rightarrow 42\nu_3$  and  $42\nu_3 \rightarrow 41\nu_3$ . The energies of the  $43\nu_3$  and  $42\nu_3$  levels are  $38.1 \times 10^3 \text{ cm}^{-1}$  and  $37.3 \times 10^3 \text{ cm}^{-1}$ , respectively, in agreement with the dissociation limit of the  $\nu_2$  oscillation, which is the dissociation threshold. It follows therefore that the dissociation of the  $\text{BCL}_3$  molecule under the influence of the  $\text{CO}_2$  laser emission constitutes pre-dissociation during oscillation, i.e., a nonradiative transition from the high vibrational levels of  $\text{BCL}_3$  to the continuous spectrum adjacent to the dissociation limit of the  $\nu_2$  oscillation.

Excitation of high pre-dissociation vibrational levels, the strong power-law dependence of the intensity of the visible glow on the laser-emission power, and the very slight heating of the cell, all demonstrate that an important role is played by the cascade process of excitation propagation.

We assume that the cascade excitation proceeds via collisional transfer of excitation with a relaxation time  $\tau$  from the  $k\nu_3$  level to the group of levels adjacent in energy of other oscillation modes. A radiative transition occurs from these levels to the higher level  $(k+1)\nu_3$ . The process then repeats. The population of each succeeding level is realized at a time  $\tau$  after the population of the preceding level. The  $n$ -th level thus becomes populated in such a cascade excitation in a time  $n\tau$  after the start of the process. This precisely is the reason for the delay in the production of the glow when the irradiation is turned on rapidly. It is also clear that in the cascade process the population of the  $n$ -th level is proportional to the  $n$ -th power of the laser emission.

If the rate of relaxation increases with increasing pressure more slowly than the rate of transfer of the excitation to the neighboring energy levels, then the power-law dependence of the cascade process weakens, as is indeed observed in the experiment. However, the observed weakening of the power-law dependence can be due also to an increase of the role of the direct processes.

Thus, the use of a  $\text{CO}_2$  laser has made it possible to obtain and to observe directly the excitation of high vibrational levels, leading to dissociation of the molecule, up to the pre-dissociation levels. Experiments of this type offer a new method of determining the parameters of molecules.

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