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The Fine Structure of the Spectrum of the Paramagnetic Resonance of the Ion Cr^{3+} in Chromium Corundum

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THE paramagnetic resonance of chromium slats has been studied mostly in alums. The crystalline electric field, acting on a chromium ion in these combinations, has trigonal symmetry, and creates the splitting of two Kramers spin doublets (in the absence of an external magnetic field) in the interval from 0.12 to 0.18 cm^{-1}, depending on the type of alum [1].

We have investigated the spectrum of the paramagnetic resonance in a strong solution Al_2O_3-Cr_2O_3 (chromium corundum), at a chromium concentration of 0.05%. Earlier, this combination was investigated by Kashaev [2]; however, the author failed to explain the spectrum observed by him. We investigated the above-named combination at two frequencies, ν_1= 11970 mc/sec and ν_2=8960 mc/sec, at room temperature.

Chromium corundum represents a uniaxial crystal. When the axis of symmetry of the crystal is parallel to the direction of the applied external magnetic field, a fine structure of the spectrum of paramagnetic resonance is observed, consisting of three lines, which correspond to an electronic spin of Cr^{3+} equal to 3/2. At the frequency ν_2 =8960mc/sec. two of the observed lines are due to the magnetic dipole transitions $M = 3/2 \leftrightarrow 1/2$, and one of the lines is due to the transition $M = 1/2 \leftrightarrow -1/2$. The transition $M = -3/2 \leftrightarrow -1/2$ is not observed at this frequency, since the initial splitting of the levels $M = \pm 1/2$ and $M = \pm 3/2$, created by the internal crystalline electric field, is greater than $h\nu_2$. At the frequency ν_1 = 11970 mc/sec the observed lines of the fine structure are due to the transitions

$$M = 3/2 \leftrightarrow 1/2, \quad M = 1/2 \leftrightarrow -1/2,$$

$$M = -3/2 \leftrightarrow -1/2.$$

When the axis of symmetry is perpendicular to the direction of the external magnetic field, two lines are observed at the frequency ν_2 =8960mc/sec, and four lines at the frequency ν_1 =11970mc/sec. Here in agreement with theory, the relative intensity of the lines depend on the angle between the axis of symmetry of the crystal and the direction of the radiofrequency field.

Assuming that the chromium ion is acted on by an electric field with trigonal symmetry, the observed spectrum may be described with the aid of the following Hamiltonian [1].

$$\hat{H} = D[\hat{S}_z^2 - 1/3\, S(S+1)] + g_{\parallel}\beta H_z \hat{S}_z + g_{\perp}\beta(H_x\hat{S}_x + H_y\hat{S}_y),$$

where D is a constant characterizing the splitting of the levels in the crystalline electric field, S is the electron spin, $\hat{S}_x$, $\hat{S}_y$, $\hat{S}_z$ are the components of the spin operator, g_{11} and $g_{\perp}$ are spectroscopic splitting factors corresponding to parallel and perpendicular orientation of the crystal with respect to the external magnetic field, β is the Bohr magneton, and H_x, H_y, H_z are the components of the magnetic field intensity.

The initial splitting of the spin levels in the absence of the magnetic field $|2D|$, was found to be 0.3824 cm^{-1}, which exceeds the splitting in alum by more than a factor of two. The g-factors are, $g_{\parallel} = 1.984 \pm 0.0006$; $g_{\perp} = 1.9867 \pm 0.0006$.

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The Radiation of CO_2 in the Region of 15μ in an Electric Discharge

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THE investigation of radiation from electric discharge through CO_2 in the region of 15

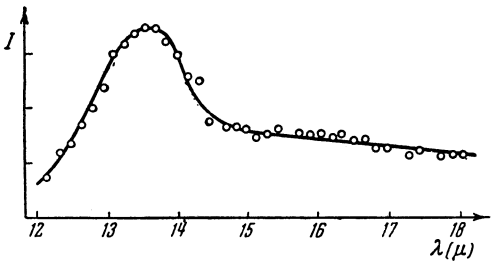

FIG. 1. The emission spectrum of CO_2 in discharge in the region 12-18μ.

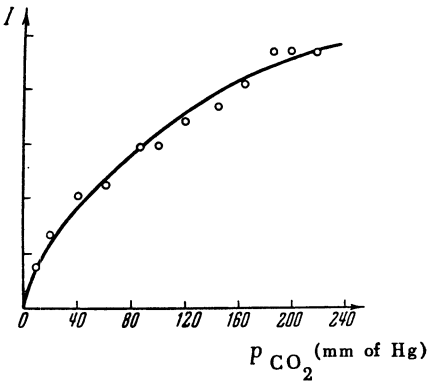

FIG. 2. The dependence of the intensity of the CO_2 emission band at 13.7 μ on the pressure of CO_2 in the discharge tube.

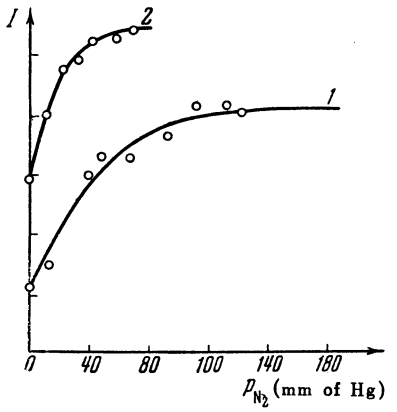

FIG. 3. The dependence of the intensity of the CO_2 emission band at 13.7 μ on the pressure of N_2. Curve 1: p_{CO_2} = 8 mm Hg, Curve 2: p_{CO_2} = 20 mm Hg;

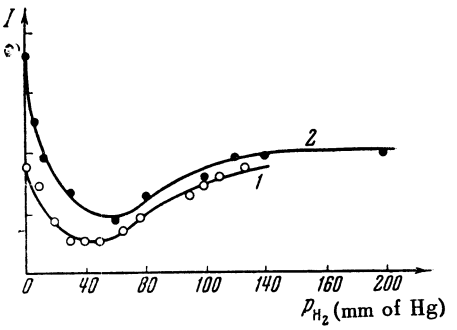

FIG. 4. The dependence of the intensity of the CO_2 emission band at 13.7 μ on the pressure of H_2. Curve 1: p_{CO_2} = 20 mm Hg; Curve 2: p_{CO_2} = 40 mm Hg.

microns is of interest because it would enlarge our knowledge of excitation, dissipation and transfer of vibration of energy of molecules.

Terenin and Neuimin[1] have discovered in the emission spectrum of CO_2, produced by an electric discharge, bands at 4.65 and 2.8 microns. These bands correspond to the unsymmetric vibration of the molecule and the combination band with simultaneous change of the quantum numbers of unsymmetric and symmetric vibrations. As is well known the absorption band due to deformed vibration of CO_2 is at 14.7μ. The corresponding emission band was found in the emission spectrum of hot gas at 14.1μ and in the Bunsen flame at 13.1μ[2]. In references 3 and 4 the emission spectrum of CO_2 was studied in the region of 15μ, but no emission bands were found. The authors of that work have shown that their apparatus was sensitive to detect bands 50 times weaker than bands at 4.4μ that were observed in the flame spectrum. Silverman, Hornbeck and Herman[5] discovered two bands with maxima at 15 and 13.85μ in the emission spectrum of CO_2 heated to 1400° K and flame spectrum generated by combustion of CO in oxygen. The authors point out that the intensity of these bands is very low.

Both the discharge tube and the source of low frequency voltage used in the present work have been described previously[6]. The measurements were made at pressures between 10 and 200 mm Hg, and with discharge current 280 ma. The discharge current was maintained constant as pressure of the gas changed. The spectrum was observed through a

hermetically sealed spectrometer with KCL prism. To absorb moisture and CO_2 found in the air, $CaCl_2$ and KOH were placed inside. The spectrometer was placed closely to a window in the discharge tube made of sodium chloride. The widths of the inlet and outlet slits of the spectrometer were 1mm. As a detector a bolometer was placed directly at the outlet slit of the spectrometer. The sensitive area of the bolometer was 1×8 mm^2 and the sensitivity was 0.57 V/W. The bolometer voltage was amplified using a photo-electrooptical FEOU-15[7] with additional cascade photo-electrooptical amplification. The galvanometer deflection at the output of the FEOU-15 was amplified by a photo-electrooptical amplifier, constructed in our laboratory. The sensitivity of the FEOU-15 was 1.5×10^{-9} V/mm at 2 meters. The application of the additional cascade amplifier increased the sensitivity approximately 90 times.

Emission band was maximum at about 13.7 microns (Fig. 1) was observed in the emission spectrum of CO_2. The band was about 350 times weaker than the band at 4.65μ. Within the limits of accuracy of the measurements the maximum of the observed band coincides with the maximum of one of the two bands in the flame emission spectrum of $CO + O_2$ and of hot CO_2 [5] at 13.85μ.

It should be noted that while the maximum of the emission band at 4.65 μ corresponding to the unsymmetric vibration of the molecule is displaced in the direction of longer wavelength in comparison with the absorption band at 4.25μ, the maximum of the emission band at 13.7μ corresponding to deformed vibration of the molecule is displaced in the direction of the shorter wavelengths as compared with the absorption band at 14.7μ. The band with maximum at 15μ which is observed in the flame spectrum of $CO + O_2$ and hot CO_2 discharge was not observed by us in the excited emission spectrum of CO_2. The absence of the band in the spectrum may be explained by strong absorption of radiation in that region by CO_2 gas that filled the discharge tube. The emitted radiation passes through a distance 1.5 and 8 cm in the discharge tube, depending on the experimental conditions. It is evident that even with a thickness of the absorbing layer as small as 1.5 cm the absorption is so strong that radiation at 15μ is fully absorbed.

The observed dependence of the emission band at 13.7μ on pressure of CO_2 in the discharge tube is shown if Fig. 2. This curve has the same character as the one for the band at 4.65μ [1]. The addition of nitrogen or hydrogen which have no emission spectra in the infrared region, respectively increase and decrease the intensity of the band at 13.7μ(Fig. 3 and 4). In the case of unsymmetric vibration of the molecule CO_2 (the emission band at 4.65μ) the increase of intensity of the emitted radiation also took place on addition of nitrogen. This increase was explained by Terenin and Neuimin by greater efficiency of molecular transfer of the vibrational quanta between molecules of CO_2 and N_2. A similar point of view cannot be taken to explain the increase of the intensity of the band at 13.7 μ on addition of nitrogen, since in that case the vibrational quanta of CO ($\nu \sim 700$ cm^{-1}) and nitrogen ($\nu \sim 2000$cm^{-1}) are very different.

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The Yield and Angular Distribution of Photoneutrons of High Energy

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A NUMBER of investigations has been carried out in recent years of photonuclear reactions occurring under the action of γ – quanta with energies of the order of tens and hundreds of mev. However, there still does not exist a satisfactory model describing such reactions at photon energies higher than 50 mev. For the construction of a model, studies are required of the emission by the nuclei of protons, as well as of neutrons, under the action of high energy photons. Although there exists a large number of investigations on the