

The observed dynamics of the laser-initiated reaction is analogous to the processes of propagation of combustion waves in laminar flows in closed vessels [2]. In our case, apparently, chain reactions involving formation and decomposition of higher boranes (boron hydrides) and chlorination of hydrogen are initiated on the combustion-wave front by the appearance in the laser-beam zone of atomic chlorine and of the active radicals BCl and BCl₂.

Knowledge of the dynamics of the explosion makes it possible to find the flame velocity and to calculate the combustion velocity in the first wave of the reaction; the latter turns out to range from 0.5 to 2 m/sec. It can also be assumed that the secondary glow contains reaction waves having large combustion velocities at the cell walls, leading to the appearance of pressure waves, which are clearly seen in Fig. 1c.

Thus, irradiation with a powerful laser beam at 10.6 μ wavelength has made it possible to observe initiation of chain reaction in a mixture of the gases BCl₃ and H₂. Experiments of this type point to the possibility of controlling chemical reactions with lasers.

- [1] N.V. Karlov, Yu.N. Petrov, A.M. Prokhorov, and O.M. Stel'makh, ZhETF Pis. Red. 11, 220 (1970) [JETP Lett. 11, 135 (1970)].
 [2] B. Lewis and G. von Elbe, Combustion, Flames, and Explosions of Gases, Academic, 1961.

LAYERED COMPOUNDS OF NiCl₂ AND CoCl₂ WITH GRAPHITE AS TWO-DIMENSIONAL HEISENBERG FERROMAGNETS

Yu.S. Karimov, M.E. Vol'pin, and Yu.N. Novikov
 Institute of Chemical Physics, USSR Academy of Sciences
 Submitted 5 July 1971
 ZhETF Pis. Red. 14, No. 4, 217 - 220 (20 August 1971)

NiCl₂ and CoCl₂ have a layered structure with layers of metallic ions alternating with layers of chlorine. There is ferromagnetic interaction between metallic ions of the same layers, and a weaker antiferromagnetic interaction between neighboring layers [1]. In compounds of NiCl₂ and CoCl₂ with graphite, the chloride layers are separated by one or two layers of graphite, which weaken greatly the interaction between the magnetic layers, so that these compounds can be regarded, with good approximation, as two-dimensional paramagnets.

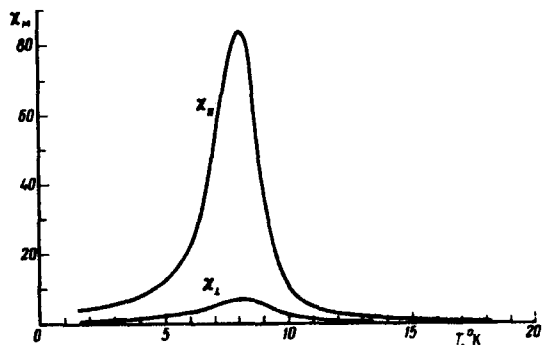


Fig. 1. Temperature dependence of the molar magnetic susceptibility of the compound of CoCl₂ with graphite (per g-mole of CoCl₂) in the zero external field.

The investigated compounds were obtained by heating pyrolytic oriented graphite with the metal in a chlorine stream. The reaction temperature was 650°C for both compounds, and the reaction time was 9 hours. After the termination of the reaction, the samples were washed with hydrochloric acid, the chloride content was ascertained, and the distances between the layers of the metallic ions and the graphite were determined by x-ray diffraction. The NiCl₂ and CoCl₂ layers in the investigated compounds were separated by two layers of graphite, and the interaction between the metallic-ion layers was negligibly small [2]. The chloride content was 14.5% for the sample with NiCl₂ and 8.5% for CoCl₂. The structure

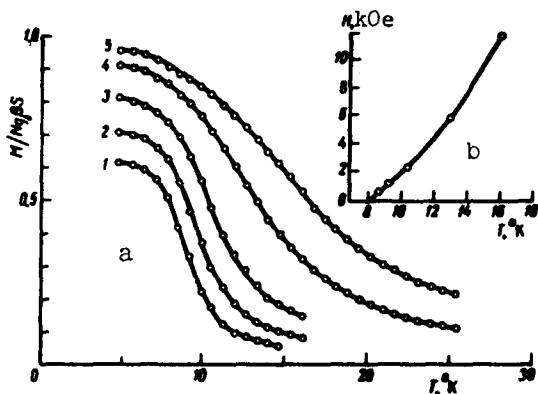


Fig. 2

Fig. 2. Temperature dependences of the relative magnetic moment of the compound of CoCl_2 with graphite in various magnetic fields: 1 - $H = 0.59$ kOe, 2 - $H = 1.19$ kOe, 3 - $H = 2.37$ kOe, 4 - $H = 5.92$ kOe, 5 - $H = 11.85$ kOe.

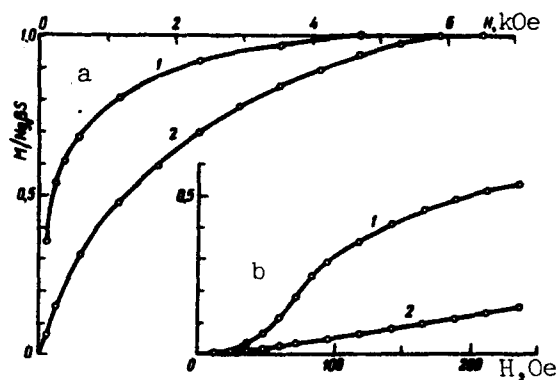


Fig. 3

Fig. 3. Magnetization curves of the compound NiCl_2 with graphite: in strong (a) and weak (b) fields; the external field is parallel (1) and perpendicular (2) to the graphite layers, $T = 1.8^\circ\text{K}$.

of the chloride layers in these compounds is unknown, although it can be assumed by analogy with investigated compounds [3] that the structure of the layers in the compounds with the graphite does not differ from pure chlorides. We used spherical samples of 3 mm diameter. The magnetic properties were measured by a ballistic method. The susceptibility in a zero external field was measured by a bridge circuit at 175 Hz, and the amplitude of the alternating magnetic field at the sample did not exceed 1 Oe.

Figure 1 shows the temperature dependence of the magnetic susceptibility for a compound of graphite with CoCl_2 . With decreasing temperature, the susceptibility goes through a maximum, after which it decreases several-fold. Such a behavior of the susceptibility may indicate that the paramagnet undergoes a phase transition. Attention is called to the anisotropy of the susceptibility. At the critical temperature T_c corresponding to the susceptibility maximum, the anisotropy is maximal and χ_{\parallel} and χ_{\perp} differ by more than one order of magnitude. The compound of NiCl_2 with graphite behaves similarly, with the maximum susceptibility observed at 18.1°K .

Evidencing the presence of a phase transition in the investigated paramagnets is also the temperature dependence of the magnetic moment (Fig. 2). To determine T_c , in analogy with ferromagnets, one finds for each value of the field the temperature at which the $M(T)$ curve has an inflection (minimum of $\partial M/\partial T$). The critical temperature is determined as the limiting temperature as $H \rightarrow 0$ (Fig. 2b). The values of T_c determined in this manner for both substances agree, within the limits of errors, with the temperatures at which the susceptibility maximum is observed. Thus, a phase transition is observed in the compounds of NiCl_2 and CoCl_2 with graphite. One might assume that the investigated samples become ferromagnetic. They are not, however, ordinary ferromagnets below the transition point. This is evidenced by the magnetization curves of Fig. 3. The direction perpendicular to the layers is that of the difficult-magnetization axis. It can be assumed that in the absence of a magnetic field the spins lie in the plane of the layer. The distinguishing feature of these compounds is the absence of hysteresis when the samples are magnetized along the easy-magnetization direction, which lies in the plane of the layer. The residual magnetization is thus equal to zero. This is apparently a consequence of the two-dimensionality of the investigated paramagnets.

Stanley and Kaplan [4] have shown that a phase transition should be observed in two-dimensional paramagnets. On the other hand, Mermin and Wagner [5] have proven that in such paramagnets there is no spontaneous magnetization at any nonzero temperature. Therefore the phase transition in the two-dimensional Heisenberg model does not lead to establishment of long-range order. At the same time, the presence of even weak anisotropy, which makes any one direction favored, transforms the two-dimensional system into a ferromagnetic state [6]. In real paramagnets, one of the sources of the anisotropy fields is the dipole-dipole interaction of the magnetic ions. In the two-dimensional case such an interaction has axial anisotropy and causes the spin to be located in the plane of the layer. However, the ferromagnetic spin arrangement does not correspond to the minimum of the dipole energy. The formation of a ferromagnetic spiral is more favored energywise. The pitch of the spiral will be determined by the competing influence of the exchange and dipole interactions. The properties of the investigated compounds can apparently be described by means of the two-dimensional Heisenberg model with allowance for the dipole interaction.

- [1] A.S. Borovik-Romanov, Itogi nauki (Science Summaries), Phys.-Math. Sciences, No. 4, AN SSSR, 1962.
- [2] A.V. Zvarykina, Yu.S. Karimov, M.E. Vol'pin, and Yu.N. Novikov, Fiz. Tverd. Tela 13, 28 (1971) [Sov. Phys.-Solid State 13, 21 (1971)].
- [3] A.W.S. Jonson, Acta Cryst. 23, 770 (1967).
- [4] H.E. Stanley and T.A. Kaplan, Phys. Rev. Lett. 17, 913 (1966).
- [5] N.D. Mermin and H. Wagner, Phys. Rev. Lett. 17, 1133 (1966).
- [6] M.E. Lines, Phys. Rev. B, Solid State 3, 1749 (1971).

USE OF LIQUID CRYSTALS TO MAKE INFRARED RADIATION VISIBLE

A.V. Tolmachev and V.M. Kuz'michev
Khar'kov State University

Submitted 5 July 1971

ZhETF Pis. Red. 14, No. 4, 220 - 223 (20 August 1971)

The use of cholesteric liquid crystals to make electromagnetic radiation visible is based in the property of these substances that they reflect white light selectively, reproducing the entire visible spectrum from red to violet in a definite temperature interval [1 - 3]. Owing to the internal ordering, the cholesteric liquid crystal has a screw-like structure. With changing temperature, the pitch of the structure changes, leading to selective scattering of the light by the substance, in analogy to a multilayered interference mirror. This property is the basis for the operating principle of image receivers reproducing the thermal picture of an absorbed electromagnetic signal [4, 5].

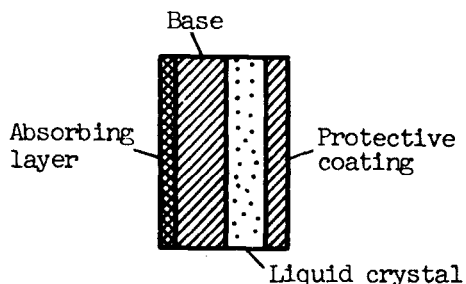


Fig. 1. Diagram of liquid-crystal detector (LCD)

To make near-infrared radiation visible, we constructed a liquid-crystal detector (Fig. 1). The base was a lavsan polyester film having sufficient strength, rigidity, and temperature and chemical stability. The thickness of the base coating was $\sim 30 \mu$. A layer of finely-dispersed gas lampblack, intended for absorption of the received signal, was deposited on the base. The liquid-crystal material was a mixture of 30% cholesteryl-pelargonate and 70% cholesteryl-oleate, with a working temperature range 32 - 36.5°C. The working medium was deposited on the back side of the film base. The thickness of the liquid-crystal layer converting the thermal picture of the received signal into a visible