4) When the multiplicity increases to 6 and more charged particles, all the foregoing singularities of the process are gradually lost.

Comparison with accelerator data on π^-p interactions at 8 and 16 GeV/c[3] and with data on cosmic rays (for interactions of pions with light nuclei) at an average energy 200 GeV [4] offers evidence that the indicated effects increase with increasing energy of the primary pion.

However, to obtain more definite information on the "leading" particle and on the energy characteristics of the remaining secondary particles, and to permit comparison with the theoretical interaction models, it is necessary to know the signs of the charges and also the exact values of the momenta of at least the charged mesons. Such data can be obtained with emulsions irradiated in pulsed magnetic fields of 200 - 300 kOe intensity.

In conclusion, the authors are deeply grateful to the staff members of the Institute of High-energy Physics L. A. Kuzin and V. N. Bolotov for help with irradiating the emulsions, the staff members of the development center of the High-energy Laboratory of JINR for developing the films, laboratory assistants A. S. Kolyadina, E. A. Krupetskova, A. I. Sirotkina, and M. V. Tyurina for much work done in searching and measuring the events, and also E. L. Feinberg, N. A. Dobrotin, V. S. Murzin, A. A. Komar, and V. N. Akimov for a discussion of the results.

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ANTIFERROMAGNETIC RESONANCE IN $NiCl_2$

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Layered halides of transition metals of the iron group are characterized by the prescence of a strong ferromagnetic interaction in the layers of the magnetic ions and relatively weak antiferromagnetic interaction between the layers; their magnetic properties were first predicted by Landau [1].

In anhydrous nickel chloride ($NiCl_2$), the Ni ions are arranged in layers that alternate with the halide layers; the symmetry axis C_3 is perpendicular to the layers, and three twofold axes lie in the plane of the layer (the crystal structure of $NiCl_2$ is of the type D_{3d}^5).

$NiCl_2$ becomes antiferromagnetic at $T_N \sim 52°$ K, and is fully isotropic below T_N [2]. It can therefore be assumed that the spins lie in the basal plane of the crystal, where the anisotropy is small and the magnetizations of the sublattice are perpendicular to the field in a relatively weak field.

As shown by the theory [3], in layered antiferromagnets with anisotropy of the "easy plane" axis, as well as in ordinary antiferromagnets with a sublattice magnetization lying in

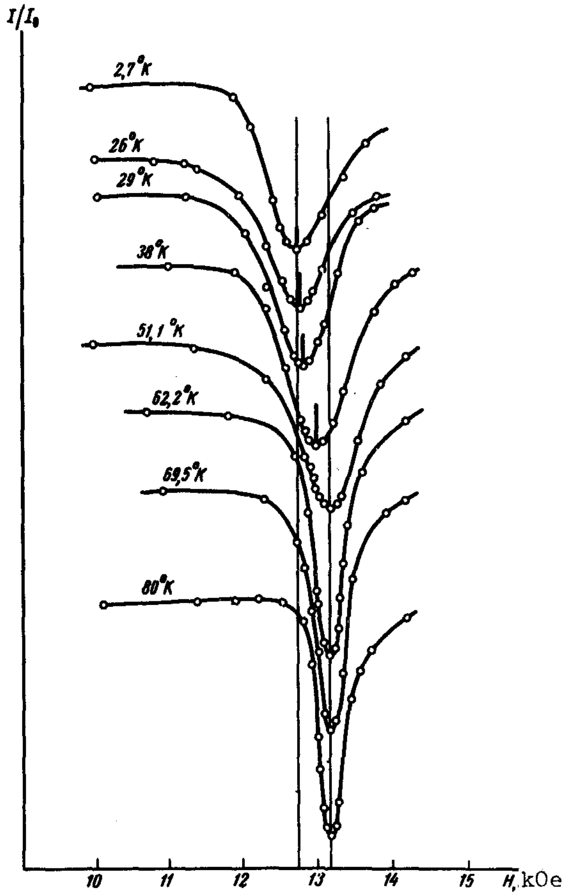

Fig. 1

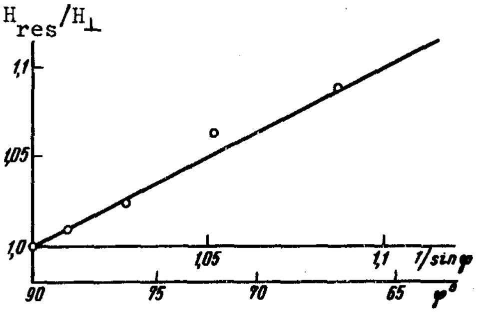

Fig. 2

the plane [4, 5], the antiferromagnetic resonance (AFMR) spectrum contains a low-frequency branch whose frequency is determined by the external field.

In this study, we investigated resonant absorption by single-crystal $NiCl_2$ in the temperature range from 2 to 78° K at a frequency 41.2 GHz.

In the measurements we used the usual short-circuited waveguide section immersed in a Dewar. The part of the waveguide, under the cover of the instrument, was made of stainless steel to reduce heat transfer to the bath; the entire waveguide was surrounded by a jacket containing heat-exchange helium. The sample was mounted directly on the insert short-circuiting the waveguide. The resonance was revealed by the change of the reflected microwave power when an external field was applied by means of an electromagnet. In the measurements, the static field H and the microwave fields were mutually perpendicular.

A method proposed in [6] was used to obtain temperatures from 4.2 to 52° K; a nitrogen bath was used, from 52 to 78° K a liquid-helium bath was used below 4.2° K.

Figure 1 shows the resonance absorption lines obtained at 41.2 GHz for different temperatures between 2 and 78° K, i.e., in both the paramagentic and antiferromagnetic regions, for single-crystal $NiCl_2$ (T_N = 52° K). The figure shows also the ratio of the signal from the detector in various fields H oriented in the basal plane, to the signal in a zero magnetic field.

The position of the paramagnetic line at 78° K corresponds to a g-factor 2.23, and the line width amounts to ∿ 450 Oe. The paramagnetic line hardly shifts when the temperature drops to T_N, but broadens near the Curie point. In the antiferromagnetic region, the line intensity does not change noticeably with temperature, down to 2° K, and its width amounts to approximately 950 Oe.

In the antiferromagnetic region, a shift of the resonant field is observed when the temperature drops below T_N. When the temperature changes from T = 52 to 2° K, the resonant

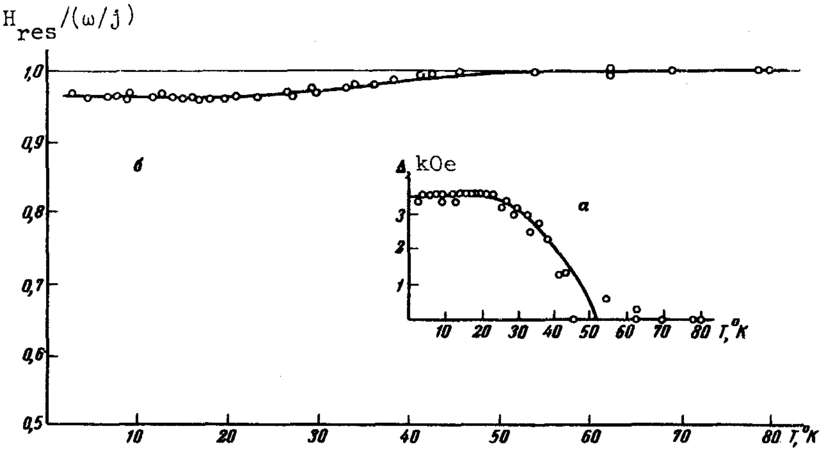

Fig. 3

field decreases by approximately 450 Oe.

Figure 2 shows the dependence of the resonant field H_{res} on the orientation of the field relative to the principal axis C_3 of the crystal, obtained at T = 4.2° K. The results are given in coordinates $H_{res}/H_{\perp}$ is the value of the resonant field in the basal plane and ϕ angle between the C_3 axis and the field direction; in these coordinates, the dependence is close to linear. We see that the field component lying in the basal plane is effective in the excitation of the resonant absorption.

The temperature dependence of the resonant field at ω = 41.2 GHz, when the field is oriented in the basal plane, is shown in Fig. 3 in coordinates $H_{res}/(\omega/j)$ and T.

It follows from the theory [7] that any anisotropy in the basal plane of ordinary antiferromagnet with "easy plane" anisotropy leads to the appearance of a gap Δ in the low-frequency AFMR branch $(\omega/j)^2 = H^2 + \Delta^2$, where $\Delta^2 = 2H_AH_E$ (H_E - exchange field and H_A - anisotropy field). Using this formula for layered antiferromagnetic $NiCl_2$, we calculated the gap as a function of T from the values of H_{res} measured at 41.2 GHz. These data are shown in Fig. 3a; at low temperatures, Δ amounts to approximately 3.5 kOe.

The presence of the gap in the low-frequency branch of the AFMR may be the cause of the vanishing of the resonance at 9.2 GHz, previously observed in $NiCl_2$ [8]. At 9.2 GHz and at hydrogen temperatures, the value of H_{res} decreases and a strong absorption in a zero field is observed when the gap reaches $\sim$ 3 kOe. With further decrease of the temperature, the intensity of the resonant absorption decreases greatly and only slight residual absorption is retained at low temperatures, due possibly to defects of the sample. A small periodic dependence of H_{res} on the orientation of the external field in the basal plane is also observed. The value of Δ changes in this case by $\sim$ 15%, with a period of $\sim$ 60°.

In conclusion, the authors are grateful to A. S. Borovik-Romanov and L. A. Prozorova for useful discussions and A. I. Shal'nikov for interest in the work.

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RADIATION PRESSURE ON AN OBJECT WITH VARYING POLARIZABILITY CHANGES. DEFORMATION ABSORPTION OF A WAVE BY VARIABLE INHOMOGENEITIES

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In the calculation of the absorption of a wave and its pressure on a small piece of matter (plasmoid, macroparticle, etc.) it is usually assumed that its volume, shape, or properties remain unchanged, and that the pressure is connected with scattering or ordinary absorption of the radiation inside the medium.

We shall consider absorption of radiation and the radiation-pressure force of a wave incident on an object whose polarizability changes as a result of changes in its volume, shape, orientation, or properties. These processes, which change the dipole energy in an external field, lead to a change in the wave energy as the result of the work performed by the object on the field or by the field on the object, and can greatly change (increase or decrease) the radiation pressure on the object.

1. Pressure of Electromagnetic Wave on a Particle of Varying Polarizability

The average pressure force on a particle that is small compared with the wavelength

$$f_{av} = \frac{1}{c} < [\dot{\mathbf{P}}\mathbf{H}]>_{av} \simeq \frac{1}{c} w_{diss}\, n$$

is determined by the dissipation of the wave energy in scattering ($w_{scat} \approx \ddot{P}^2/c^3$) and internal absorption ($w_{abs} \approx <\dot{P}E>_{av} \approx P\omega E_0 \sin\phi$, where ϕ is the loss angle). If the dipole moment is $P \approx \alpha E_0 \sin\omega t$, then the corresponding radiation reaction forces are $f_{scat} \approx \alpha E_0^2/\lambda\!\!\!^{-}$ and $f_{abs} \approx \alpha E_0^2 \sin\phi/\lambda\!\!\!^{-}$.

Let us estimate the force connected with the change of the polarizability $\alpha(t)$ (for a simplicity, we assume that its characteristic variation time is $T >> 1/\omega$). Assuming $\alpha \approx \alpha_0 + \alpha t$, we obtain the force

$$f_\alpha \approx \frac{1}{c} \dot{\alpha} E_0^2,$$

which can be obtained also from the expression for the average energy of a dipole in an external field

$$\mathcal{E} \approx \frac{1}{2} \alpha E_0^2; \quad (f \approx \frac{1}{c} \dot{\mathcal{E}}).$$

We note that the deformation force f_α can have different directions, depending on the sign of $\dot{\alpha}$. For example, when the polarizability increases the direction of the force coincides with the direction of the ordinary light pressure, and when α decreases the force is directed