concentrations (~50% $H_8$) at which it is practically impossible for them to be isolated.

It should also be noted that when impurity exciton states are analyzed by the coherent-potential method [5, 9, 10], the possibility of formation of discrete aggregates such as groups of two, groups of three, etc. is excluded, and a statistical averaging of the configuration is proposed. Therefore, the absorption curves obtained in this manner for the exciton states can apparently be set in correspondence only with the envelope of the experimental spectrum.

Finally, the independence of the fine structure and of its quantitative characteristics of the heat treatment of the samples is evidence that there is no macroscopic lamination in the mixed $H_8$-$D_8$ crystals, which has in general a rather low probability in such isotopic systems.

In conclusion, the authors are grateful to E.I. Rashba and T.G. Tratas for taking part in a discussion of the results.

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## OBSERVATION OF MAGNON-PHONON INTERACTION IN ANTIFERROMAGNETIC $MnCO_3$

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Parametric excitation of spin waves was recently observed experimentally in the antiferromagnetic crystals $CsMnF_3$ [1 - 3] and $CuCl_2 \cdot 2H_2O$ [4]. It is important that the nonlinear interaction responsible for the parametric excitation of the spin waves in an antiferromagnet couples the oscillations of the variables belonging to different branches of the spin-wave spectrum, and, in contrast to ferrites, is of exchange origin [5].

We have observed parametric excitation of spin waves in antiferromagnetic $MnCO_3$, and thereby observed resonant interaction of excited spin waves with phonons.

The excitation of the spin waves was revealed also, just as in [3], by the additional microwave-power absorption occurring in the sample[1] placed in a high-Q resonator in such a way that the static and high-frequency fields were parallel to each other and lay in the basal plane of the crystal. The detected

[1]) We used $MnCO_3$ single crystals grown by the hydrothermal method by N.Yu. Ikornikova and V.R. Gakel' of the Crystallography Institute.

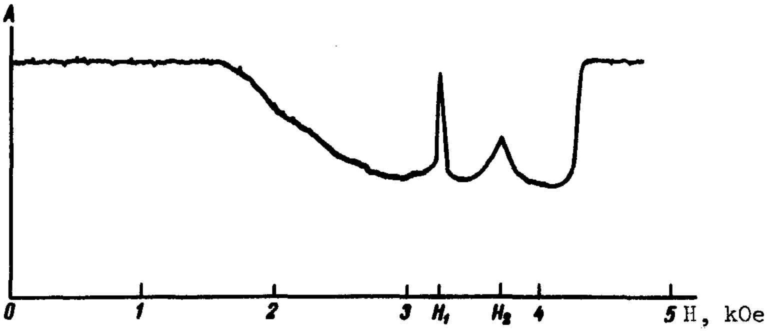


Fig. 1

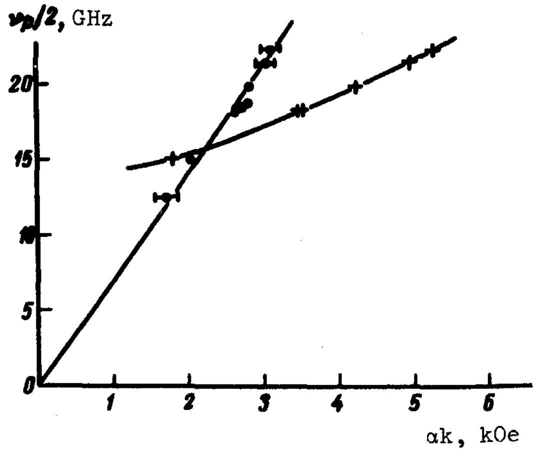


Fig. 2

signal, proportional to the power passing through the resonator, was registered with a two-coordinate automatic potentiometer as a function of the static field H. Additional absorption occurred if the microwave field H exceeded a certain threshold value, given in accordance with Ozhogin's calculations [5] by the formula

$$h_c = \frac{\Delta \nu_k \nu_p}{\gamma^2 (H + 2H_D)} . \tag{1}$$

Here $\nu_p$ is the pump frequency, $\Delta\nu_k$ is the reciprocal lifetime of the spin waves with wave vector k, $H_D$ is the Dzyaloshinskii field, and $\gamma$ is the gyromagnetic ratio. The magnitude of the wave vector of the excited spin waves depends on the applied field H and is determined from the dispersion law, which for rhombohedral crystals such as $MnCO_3$ is given by

$$(\nu_k/\gamma)^2 = H(H + H_D) + H_\Delta^2 + \alpha_z^2 k_z^2 + \alpha_\perp^2 k_\perp^2 , \tag{2}$$

where $\nu_k = \nu_p/2$ is the frequency of the excited spin waves, $H_\Delta$ is the gap determined by the hyperfine interaction, and $\alpha_z$ and $\alpha_\perp$ are exchange constants.

In accordance with formula (2), the additional absorption corresponding to parametric excitation of spin waves is observed only in fields H smaller than $H_0$ determined from (2) for k = 0. By way of an example, Fig. 1 shows a plot of the signal passing through the resonator at T = 1.45°K and ν = 36.3 GHz. We see from the figure that in fields $H_1$ and $H_2$ the absorption amplitude has minima corresponding to an increase of the threshold field $h_c$ in these fields. To ascertain the nature of these peaks, we have performed a series of experiments for different pump frequencies $\nu_p$ (23 - 47 GHz). It was established that $H_1$ and $H_2$ vary with the frequency, but do not depend on the orientation of the static field in the basal plane. Figure 2 shows the results of these experiments in coordinates $\nu_k$ and αk, the latter being calculated for each peak by means of formula (2), with the constants $H_D$ and $H_\Delta$ taken from [6].

The $\nu_k$ (αk) dependence for the peak determined by the field $H_1$ is described by the parabola

$$\nu_k^2[\mathrm{GHz}^2] = 195[\mathrm{GHz}^2] + 11.2\,[\mathrm{GHz}^2/\mathrm{kOe}^2](\alpha k)^2[\mathrm{kOe}^2], \tag{3}$$

and for the other peak by a straight line passing through the origin

$$\nu_k[\mathrm{GHz}] = 7.1[\mathrm{GHz/kOe}](\alpha k)[\mathrm{kOe}]. \tag{4}$$

The linear character of the $\nu_k(\alpha k)$ dependence for the peak in the field $H_2$ allows us to assume that an intersection of the spin-wave and the phonon spectra takes place at the point $H_2$. Owing to the magnetoelastic interaction existing in the antiferromagnet, magnetoelastic waves are produced in the vicinity of this point; the threshold for these waves is somewhat higher than for the spin waves [7]. An analogous phenomenon was observed in $CsMnF_3$ by Seavey [2]. The correctness of this assumption can be verified by calculating the velocity of sound from the data of our experiment. An examination of the Hamiltonian of the magnetoelastic interaction and the absence of a dependence of the field $H_2$ on the direction of H in the basal plane, which was established by us, give grounds for assuming that the observed peak is due to the interaction between spin and transverse sound waves propagating along the z axis. According to data obtained by Holden (private communication) on inelastic scattering of neutrons in $MnCO_3$, $\alpha_z = 5.31 \times 10^{-5}$ kOe-cm. Using this value and the result of our experiments, we calculated the velocity of the transverse acoustic oscillations propagating along z, $C_{tz} = 3.8 \times 10^5$ cm/sec. This is 10% larger than $C_{tz}$ for $CaCO_3$, which should have acoustic properties close to those of $MnCO_3$ (there are no published data on the velocity of sound in $MnCO_3$).

It can thus be assumed that the increase of the threshold field (damping) in the field $H_2$ is due to magnon-phonon interaction.

The nonlinear dependence of the frequency on the wave vector for the second peak (in the field $H_1$) indicates that this peak is not connected with the acoustic phonons. We cannot explain its origin at present.

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## FREQUENCY DEPENDENCE OF THE THRESHOLD OF OPTICAL BREAKDOWN IN AIR IN THE ULTRAVIOLET BAND

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Optical breakdown of a gas in the focus of an intense light wave has by now been thoroughly investigated in the infrared and visible bands, at wavelengths 1.06, 0.69, and 0.53 μ. It is known that the breakdown phenomenon is