A. S. Borovik-Romanov, N. M. Kreĭnes, and V. G. Zhotikov. *Scattering of light by thermal and UHF excited magnons in antiferromagnetic substances.* Recent years have seen the beginning of an intensive study of the scattering of light by low-energy magnons, thanks to the development and design of high-contrast multipass Fabry-Perot interferometer.[1] These experiments should accordingly be referred to as experiments on single-magnon Mandel'shtam-Brillouin scattering (SMBS). In this report we review the experimental studies on the scattering of light by low-frequency magnons in two antiferromagnetic substances with weak ferromagnetism: $FeBO_3$[2] and $CoCO_3$.[3-5] The scattering in $FeBO_3$ is due to the strong Faraday effect, and in $CoCO_3$, to the equally strong magnetic birefringence.

The SMBS method has a number of advantages over the inelastic neutron scattering method in studying the spectrum of thermal magnons. In the SMBS method the magnons constitute the object of study, and the energy of the magnons comes in roughly equal parts from the interaction of the spin system with the external magnetic field, the exchange interaction, and the dipole-dipole interaction of the spin waves. The first experimental data on the dipole-dipole energy of spin waves in an antiferromagnetic substance with weak ferromagnetism (27 GHz for $CoCO_3$), obtained by us, turned out to be in good agreement with the prediction of Bar'yakhtar *et al.*[6] The velocity of the spin waves was determined for propagation along the C_3 axis (13.5 km/sec for $FeBO_3$ and 3.3 km/sec for $CoCO_3$) and perpendicular to that axis (11.3 km/sec for $FeBO_3$ and 4.3 km/sec for $CoCO_3$).

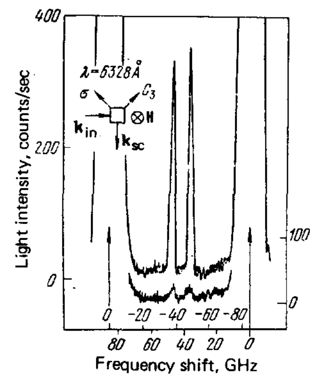

FIG. 1. Spectrum of light scattered at 90° in $CoCO_3$ from thermal magnons propagating along the $z(C_3)$ axis (lower curve) and from magnons excited by an AFMR at ≈36 GHz (upper curve). The geometry of the experiment is indicated on the figure.

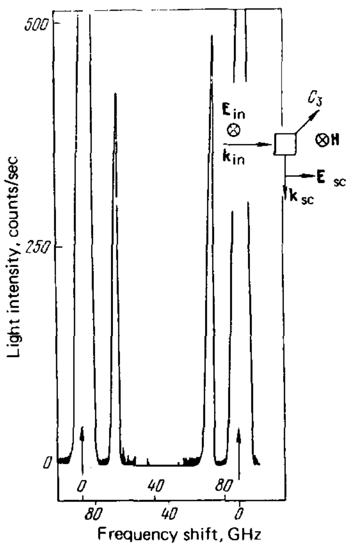

FIG. 2. Spectrum of light scattered in $CoCO_3$ by parametrically excited magnons ($\nu = 17.7$ GHz) propagating along the $z(C_3)$ axis under the application of ~500 MW of UHF power at $\nu = 35.4$ GHz. The geometry of the experiment is indicated on the figure.

We examine the results of optical studies of the relaxation processes of spin waves in $CoCO_3$.[3,4,7] In the excitation of the antiferromagnetic resonance (AFMR) the energy of the uniform spin vibrations (magnons with $k = 0$) is transformed in a very short time ($\approx 10^{-9}$ sec) by elastic scattering from nonuniformities into magnons with wave vectors of $\sim 10^4 - 10^6$ cm^{-1}. The lifetime of magnons with $k \neq 0$ turned out to be three orders of magnitude longer ($\approx 10^{-6}$ sec). Thus, the magnon system is subject to the so-called "bottleneck effect," as a result of which, when an AFMR is excited in the specimen, the number of magnons with $k \neq 0$ and frequency equal to the frequency of the incident UHF waves is several tens of times larger (at an absorbed UHF power of ~5 MW) than it should be for a fully thermalized magnon system. This conclusion is confirmed by the results presented in Fig. 1.

Finally, we describe experiments in which scattering from parametrically excited magnons was observed.[5] It is known that when the power level is high enough a single UHF photon may produce two magnons with opposite wave vectors and frequency equal to half the photon frequency.[8] Up to now parametric excitation has been observed in antiferromagnetic substances only with parallel pumping and in compounds containing manganese ions (see Ref. 9). In Ref. 5 it was found that strong peaks (Fig. 2) corresponding to parametrically produced magnons with $\mathbf{k} \| k_z$ and a frequency of 17.7 GHz appear when high UHF power (>100 MW) at 35.4 GHz is applied to the specimen. Such a strong peak is observed only in a narrow (±10 Oe) range of field strengths. Peaks at half the UHF frequency were also found in studying the scattering from quasiparticles propagating in the basal plane in the direction of the magnetic field. In this case, however, the positions of the peaks were virtually independent of the magnetic field strength. Their frequency and the polarization conditions of the observations provide grounds for assuming that in this case it was parametric buildup of phonons via the magnetoelastic interaction with the spin system that was observed.

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