

NONRESONANT PARAMAGNETIC ABSORPTION OF SOUND IN CHROME ALUM

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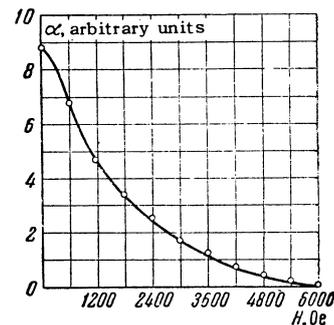
Nonresonant paramagnetic absorption of sound has been detected experimentally as a function of an applied steady magnetic field at a frequency of 30 Mc. The absorption coefficient was determined. The absorption is due mainly to spin-spin interaction.

THE resonant absorption of sound waves by paramagnetic substances, analogous to paramagnetic resonance, was first considered by Al'tshuler.^[1] The first experimental investigations of resonant acoustic absorption were carried out by Proctor and Tanttila by means of observing the change in population of the spin levels of nuclei in NaClO₃.^[2]

Besides acoustic paramagnetic absorption, there is also nonresonant absorption of sound, analogous to paramagnetic absorption when the constant and alternating magnetic fields are parallel. This question was considered theoretically by Koloskova, Kopvillem, and Kochelaev,^[3] who estimated the absorption coefficient and the experimental possibility of observing the effect.

The present paper gives the results of the experimental detection of nonresonant absorption of sound in chrome alum at a frequency of 3×10^7 cps. The sound absorption in the sample was measured as a function of applied constant magnetic field by the change in Q of the tuned circuit of a generator connected through a matching circuit to a quartz converter. At mechanical resonance of the sample, its acoustic impedance, and consequently the electrical impedance of the converter are functions of the acoustic attenuation in the sample. Thus, the tuned circuit of the generator becomes sensitive to changes in the attenuation in the paramagnetic sample. The acoustic field was directed along the trigonal axis of symmetry of the crystalline field of one of the non-equivalent Cr³⁺ ions.

The figure shows the shape of the sound absorption curve at 295°K. The absorption coefficient for $H = 0$ was determined from an equation given by Bolef and Menes^[4] and was found to be 10^{-6} cm⁻¹. The line width $\Delta\nu \sim 0.4 \times 10^{10}$ cps, which exceeds $\Delta\nu = 0.6 \times 10^9$ cps for absorption in an alternating magnetic field.^[5] This can be attributed to two causes: first, unlike paramagnetic absorption, iso-



tropic exchange broadens an acoustic absorption line; second, the presence of dislocations strongly broadens an acoustic absorption line.

The sound absorption coefficient can be written in the following form^[3]:

$$\alpha(\nu) = \frac{G^2 N g(\nu) \nu^3}{kT \nu v^3} \frac{s(s+1)[4s(s+1)-3]}{2s+1},$$

where G is a spin-lattice interaction parameter,^[5] N is the number of paramagnetic spins per unit volume, $g(\nu)$ is the shape function of the absorption line, ν is the frequency of the sound vibrations, and v is the speed of sound. Using the values $g(\nu) \approx 1/\Delta\nu = 0.25 \times 10^{-9}$ and $s = 3/2$, we obtain $G = 10^{-15}$ erg, which agrees in order of magnitude with earlier values.^[6]

From the shape of the absorption line it follows that the magnetic moment fluctuations responsible for the absorption are produced, in the main, by magnetic spin-spin interaction. To clarify the contribution of spin-lattice interaction in nonresonant acoustic absorption^[7] it is necessary to study this effect at other frequencies and with changing temperature.

Experiments on nonresonant sound absorption carried out at lower frequencies and with simpler means than paramagnetic resonance absorption can yield new information about the spin-phonon interaction and the structure of the spin-system.

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