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A scientific session of the Division of General Physics and Astronomy of the U.S.S.R. Academy of Sciences was held on 27 May 1970 in the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. U. Kh. Kopvillem, V. A. Golenishchev-Kutuzov, and N. A. Shamukov, Acoustomagnetic Double Resonances.
2. M. P. Petrov and G. A. Smolenskiĭ, Distribution of Spin Density and Nuclear Echo in Magnetic Crystals.
3. V. A. Alekseev and A. A. Vedenov, Electric Conductivity of Dense Cesium Vapor.

We publish below a brief content of the papers.

U. Kh. Kopvillem, V. A. Golenishchev-Kutuzov, and N. A. Shamukov. Acoustomagnetic Double Resonances.

Double magnetic resonances are extensively used at present in magnetic spectroscopy to increase the sensitivity of measurements of the polarization of nuclei, to obtain maser effects, and to study fine details of interactions between spins. It is shown in the paper that the use of the double-resonance technique in quantum acoustics makes it possible to solve a number of similar problems, which cannot be solved by the methods of ordinary acoustic magnetic resonances.

The idea of the existence of a phonon maser effect on the levels of the electronic and nuclear spins was advanced in [1]. The theory of the phonon maser effect has shown that this phenomenon can be observed experimentally.

Analogous assumptions were advanced also in [2, 3]. A hypersound generator and amplifier was realized using corundum doped with Cr^{3+}.[4] The two-quantum phonon maser effect was theoretically predicted in [5, 6] and observed in [7]. The existence of coherent spontaneous phonon radiation was predicted in [8] and observed experimentally in [9].

The main difficulty encountered in the detection of nuclear acoustic magnetic resonance[10] is that modern techniques of quantum acoustics make it possible to observe sound absorption coefficients satisfying the condition $\sigma \geq 10^{-8}\ \text{cm}^{-1}$.[11] Therefore this effect was observed directly only in few single crystals. On the other hand, the use of the double-resonance technique in ruby has shown[12, 13] that $\sigma \sim 10^{-10}-10^{-12}\ \text{cm}^{-1}$ can be readily measured. For example, acoustic NMR on nuclei of paramagnetic ions (^{53}Cr in Cr^{3+}) was first detected in the form of a dip against the background of the NMR line on ^{27}Al. The atomic concentrations of the Cr^{3+} ions and of the ^{53}Cr nuclei were 5×10^{-4} and 5×10^{-5}, respectively. Thus, the technique of double-electron-nuclear and nuclear-nuclear magnetoacoustic resonances greatly broadens the circle of substances that can be investigated by acoustic resonance methods. An investigation of the line shift of acoustic NMR of ^{53}Cr nuclei against the background of the NMR line of ^{27}Al has shown that if the sound pumping has sufficient intensity, a fraction of the spin system of ^{27}Al acquires a negative spin temperature. We note that two-quantum and forbidden transitions of the ^{53}Cr induced by acoustic and alternating magnetic fields were also observed.

Polarization of the atomic nuclei ^{29}Si in silicon doped with phosphorus by hypersound was realized in [14]. Generation of hypersound at 1.6°K was realized with the aid of CdS films. These results show that hypersound can apparently also be used to polarize nuclei in metals.

Finally, observation of double electron-nuclear acoustomagnetic resonance $U^{4+} \leftrightarrow {}^{19}F$ in CaF_2 single crystals is reported in [15]. This result is of interest because the ordinary electron-nuclear double resonance cannot be effectively observed in this substance, because the U^{4+} ion is not of the Kramers type and magnetic transitions with change of the quantum number $\Delta m = \pm 2$ are weak. On the other hand, the corresponding acoustic transitions have high intensity.

Among the new possible double resonances in which phonons take part we note the following effects, which so far have been considered only theoretically, viz., observation of acoustic resonances on excited nuclei with the aid of the Mossbauer effect and $\gamma\gamma$-angular correlation.[16] In particular, interest attaches to the possibility of detecting EPR on Cr^{3+} and NMR on ^{27}Al in corundum with the aid of the Mossbauer effect and $\gamma\gamma$-angular correlation in chromium nuclei. Optical methods can be used to observe acoustic resonances in excited states of atoms and molecules. In particular, laser radiation generated by a crystal can be used to detect acoustic resonances in the same crystal. Since the population differences of the spin levels are strongly altered during the time of action of the laser, the generating lasers apparently can also simultaneously generate hypersound. It is easily seen that the development of double resonances with participation of phonons is only in the initial stage of its development, and undoubtedly can lead to interesting scientific results.

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M. P. Petrov and G. A. Smolenskiĭ. Distribution of Spin Density and Nuclear Echo in Magnetic Crystals.

The magnetic moments of nuclei are natural magnetic probes in solids, and make it possible to investigate the spatial distribution of magnetic fields and of the spin density in objects of interest to us.

In magnetic crystals there is a so-called spin-density transport effect,[1, 2] i.e., the appearance of spin decompensation of electron shells of non-magnetic ions. At those points where the nuclei of nonmagnetic ions are located, a magnetic field appears. The intensities of such fields may be low, but nonetheless it can be readily measured by MNR, owing to the high resolution of this method. The paper contains results of experimental investigations of the spin density at nuclei of non-magnetic ions (Rb^+, F^-, etc.) in the paramagnetic region of the antiferromagnets $RbMnF_3$, $RbCoF_3$, $RbFeF_3$, and $TlMnF_3$. The NMR method has made it possible to observe the spin density both at nuclei of fluorine as well as at nuclei of thallium and rubidium, i.e., to demonstrate experimentally that the electrons with unpaired spins are not localized completely in the shell of the magnetic ions (Mn^{2+}, Co^{2+}, Fe^{2+}), but are distributed over the entire crystal. It turned out that the spin densities at the fluorine and rubidium nuclei have different signs, i.e., there are spatial oscillations of the spin density. The investigated delocalization of the spin density is a direct manifestation of the effects of covalence of the chemical bond and of indirect exchange interaction in nonmetallic solids. It was possible to demonstrate theoretically and experimentally how the character of the crystal symmetry and the electronic structure of the shells of the magnetic ions influence the concrete type of spin-density distribution.[3, 5]

The measurement of the fields at the fluorine level in $RbNiF_3$ has also made it possible to trace the temperature behavior of the magnetizations of the sublattices in this ferrimagnet.[6] A new phenomenon was observed, the so-called induced ferrimagnetism, wherein a complicated magnetic structure is produced in the ferrimagnet at temperatures greatly exceeding the Curie point (by a factor 1.5–2), if the sample is placed in an external magnetic field. It was observed in $RbNiF_3$ by the NMR method that at $T_0 > T > T_C$ there exist two oppositely-directed magnetic sublattices, if the sample is situated in an external field ($T_0 \approx 2T_C$). This effect can be easily explained within the framework of the molecular-field theory in the following manner: each sublattice is acted upon by a resultant magnetic field consisting of the external field and the internal effective exchange field. Since the interaction between the sublattices is antiferromagnetic, it follows that at $T > T_0$ the effective field is directed opposite to the external field; with decreasing temperature towards T_0, the resultant field on one of the sublattices vanishes, and the magnetization of this sublattice reverses sign. We note that owing to the nonequivalence of the sublattices (this is the necessary condition) the resultant field of the other sublattice does not reverse sign.

A detailed comparison of the experimental data with calculations within the framework of the constant-coupling method has made it also possible to determine the temperature region where an important role is played by short-range magnetic order.[6, 7]

Significantly different values of the field are realized at nuclei under conditions of observation of nuclear resonance in ferrimagnets at temperatures above T_C. In magnetically-ordered crystals the field at the nuclei reaches values of hundreds and thousands kOe, and the intensity of the nuclear resonance increases by several orders of magnitude. Under these conditions, an effective method of investigation is the method of nuclear spin echo in internal fields. Observation of nuclear echo makes it possible to investigate nuclear-relaxation processes, which in magnetic crystals are due to the interaction of the nuclear moment with the ordered electron system, with essentially new relaxation processes taking place here, for example the spin-spin nuclear relaxation due to the interaction of nuclei via emission and absorption of virtual spin waves (the Suhl-Nakamara interaction), are spin-lattice relaxation due to the scattering of spin waves by nuclear moments. An important role is played here by many-magnon processes and by spin-wave damping. The paper presents results of investigations of spin-spin and spin-lattice relaxations of ^{57}Fe nuclei in the ferrimagnet $Y_3Fe_5O_{12}$.

The results of the investigations are contained in the attached bibliography.

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