considered, for example, in [2], in which the real part of the conductivity can be negative already at a small signal. To this end, however, it is necessary to have at least two suitably chosen characteristic times, whereas in the case considered by us only one such time is necessary.

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MAGNETIC STRUCTURE OF THE ANTIFERROMAGNETIC GARNET $NaCa_2Co_2V_3O_{12}$

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"Single-sublattice" garnets (i.e., garnets in which the magnetic ions are situated in voids of only one kind, either tetrahedral or octahedral) are of great interest from the point of view of the study of the nature of intra-sublattice exchange interactions. The synthesis and investigation of such compounds with garnet structure and with magnetic 3d-ions in octahedral voids only are described in [1]. Several articles are devoted to the results of neutron-diffraction studies of the magnetic structures of the analogous compounds $Ca_3Mn_2Ge_3O_{12}$ [2], $Ca_3Fe_2Ge_3O_{12}$ [3, 4], and $Ca_3Fe_2Se_3O_{12}$ [5].

We have undertaken a neutron-diffraction study of the garnet $NaCa_2Co_2V_3O_{12}$ for the purpose of determining its atomic and magnetic structures, and also the spin state of the Co^{2+} ion.

The neutron-diffraction pattern of polycrystalline $NaCa_2Co_2V_3O_{12}$ powder was obtained at room and helium temperatures (T_N = 8.1°K according to the data of [1]). The general form of the neutron diffraction patterns is shown in Fig. 1 (the reflections 200 and 222 were obtained with larger statistics). We have assumed that the investigated compound belongs to the space group O_h^{10} - Ja3d with the sodium and calcium ions statistically distributed in the position 24 (c), the cobalt ions in the position 16 (a), the vanadium ions in position 24 (d), and the oxygen in the common position 96 (h).

The coordinates of the oxygen atoms characterize the geometry of the bonds in the structure, and therefore one of our tasks was to determine the oxygen parameters. The calculation was performed with the M-220M computer of our institute, using a least-squares refinement procedure in accordance with the program "Rentgen-69" [8]. The results of the calculation are listed in Table 1, which shows for comparison the parameters of the oxygen atoms in the analogous "single-sublattice" garnet $Ca_3Fe_2Ge_3O_{12}$, obtained by various workers, including ourselves.

The observed magnetic reflections are indexed in the same unit cell, and their indices satisfy the condition $h + k + \ell = 4n + 2$. The magnetic structure corresponding to this extinction law is shown in Fig. 2a. It can be described by two primitive cubic ferromagnetic sublattices ("sub-sublattices" would be more correct) imbedded antiferromagnetically one in the other.

It should be noted that the observed magnetic structure is the third in the series of "single-sublattice" garnets. Two other types of antiferromagnetic ordering are observed in $Ca_3Mn_2Ge_3O_{12}$ [2] (Fig. 2b), $Ca_3Fe_2Ge_3O_{12}$ ([3, 4] and our unpublished data), and in $Ca_3Fe_2Se_3O_{12}$ [5] (Fig. 2c). We can conclude

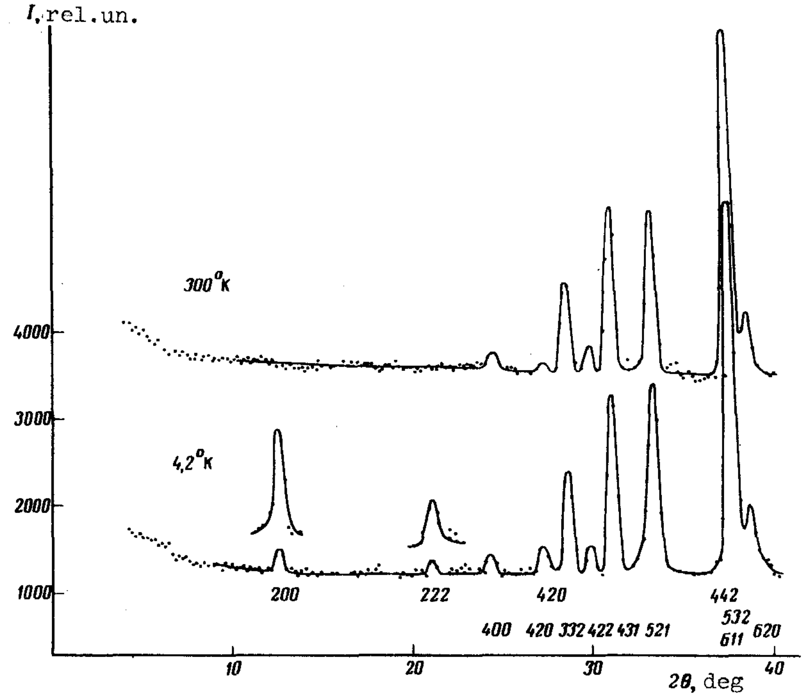

Fig. 1. Neutron diffraction patterns of $NaCa_2Co_2V_3O_{12}$ at room temperature (upper curve) and at 4.2°K (lower curve). The magnetic maxima 200 and 222 were obtained with larger statistics (and are shown separately).

TABLE I

Oxygen atom parameters	$NaCa_2Co_2V_3O_{12}$		$Ca_3Fe_2Ge_3O_{12}$			
	Our results	Data of [9]	Our results	Data of [3]	Data of [4]	Data of [6]
x	-0.039_9	-0.0382 ± 0.0004	-0.034_3	-0.0355	-0.03424 ± 0.00022	-0.032_1
y	0.049_6	0.0514 ± 0.0006	0.052_1	0.0528	0.05096 ± 0.00021	0.054_7
z	0.1551	0.1551 ± 0.0007	0.150_6	0.1510	0.15169 ± 0.00024	0.154_2
R	1.3%	–	3.6%	–	6%	5.5%

therefore that replacement of a magnetic ion in an octahedral position gives rise to different types of magnetic ordering, apparently as a result of the change of the interaction in different coordination spheres.

Using the intensities of the magnetic reflections and the form factor of the Co^{2+} ion [7], we obtained the amplitude of the magnetic scattering, p = 0.43×10^{-12} cm (for a zero scattering angle), corresponding to an effective spin number S = 0.8. This is somewhat higher than the S = 0.5 corresponding

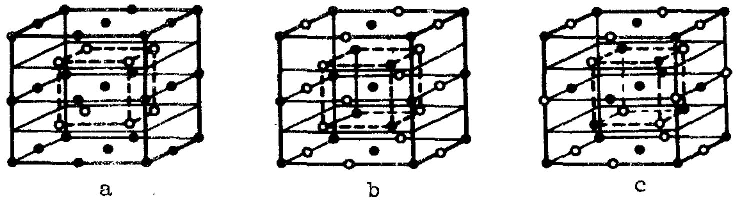

Fig. 2. Magnetic structure of "single-sublattice" garnets: a - $NaCa_2Co_2V_3O_{12}$, b - $Ca_3Mn_2Ge_3O_{12}$, c - $Ca_3Fe_2Ge_3O_{12}$. The dark and light circles correspond to oppositely directed magnetic moments of the transition-metal ions. One each of the two possible enantiomorphic structures are shown in b and c.

TABLE II

hkl	I_{exp}	I_{calc}
200_M	260	254
222_M	100	110
400	240	246
420_{N+M}	280	{159 156
332	1200	1060
422	280	300
431	2020	1970
521	2100	1975
442_M	<50	40
620	770	754

to a low-spin state, but much lower than the S = 1.5 for the high-spin state of the Co^{2+} ion. No magnetic moment was observed in the vanadium ion. Table II lists the values of the nuclear and magnetic intensities, both measured and calculated.

Investigations of the paramagnetic resonance of the Co^{2+} ions in $Y_3Ca_5O_{12}$ at 4.2°K [10] have shown that this system is described by a spin Hamiltonian with an effective spin S = 0.5 (the spin of the free ion is 3/2). Recent measurements of the specific heat of the garnet $NaCa_2Co_2V_3O_{12}$ at helium temperatures [11] yielded a value close to 0.6 for the spin of Co^{2+}. Thus, the effective magnetic moment of the Co^{2+} ion in the garnet near 0°K is apparently much lower than the value $3.7\mu_B$ observed in cobalt ferrites - spinels and customarily employed in the analysis of the magnetic properties of cobalt-substituted iron garnets [12].

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EXPERIMENTAL DETERMINATION OF THE COMPRESSIBILITY OF HYDROGEN AT DENSITIES 0.5 - 2 g/cm^3. METALLIZATION OF HYDROGEN

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The equation of state of hydrogen is of interest because hydrogen is the main component of certain planets and of most stars. Furthermore, it can go over into a metallic superconducting state at high pressures.

A theoretical analysis of the equation of state of hydrogen has been the subject of many papers [1 - 7]. All predict the existence in solid hydrogen (at T = 0°K) of a transition from the molecular to the atomic modification, at densities on the order of 0.5 - 1 g/cm^3. In this density region, an energywise more favored state is one in which the molecules are broken and the hydrogen becomes a monovalent metal. The phase-transition pressure fluctuates in the theoretical estimates in the range 0.25 - 18 Mbar.

There are few known studies of the compressibility of hydrogen. Stewart [8] measured the isotherm of solid molecular hydrogen at T = 4°K up to pressures P = 20 kbar. Mills and Grilly [9] determined experimentally its melting curve up to T = 60°K and P = 3.5 kbar. Van Thiel and Alder [10], in experiments on shock compression of liquid hydrogen (ρ_0 = 0.071 g/cm^3), reached a density 0.19 g/cm^3 at 39.5 kbar.

We have measured by a gamma-graphic method the density of hydrogen in the course of its isentropic compression by a cylindrical shell in the pressure range from 0.4 to 8 Mbar. We used for this purpose a cylindrical explosive charge, the products of which accelerated a shell that compressed gaseous hydrogen to high densities and pressures. Devices of this type are described in [11 - 14]. To register the diameter of the cavity

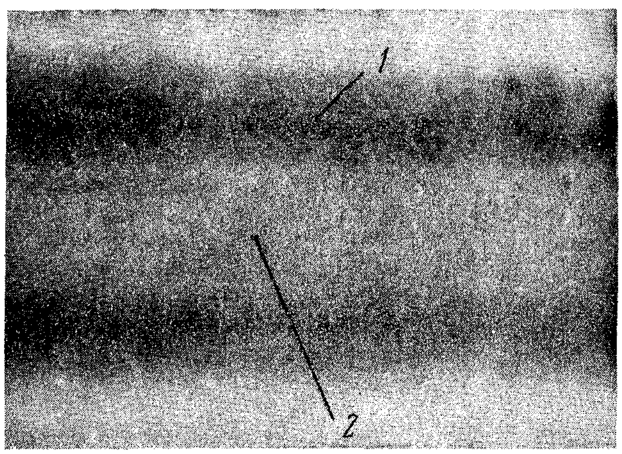

Fig. 1. Experimental gamma-diagram: 1 - metallic shell, 2 - cavity with compressed hydrogen.