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THE MÖSSBAUER EFFECT IN THE ANTIFERROMAGNETIC COMPOUND $MnSn_2$

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The temperature dependence of the effective magnetic field in Sn^{119} nuclei in the antiferromagnetic compound $MnSn_2$ is studied by means of the nuclear gamma resonance absorption technique. At 83°K the effective field strength in Sn^{119} nuclei is 65 kOe. It is shown that the Néel temperature for the given compound is about 324°K.

THE investigation of the magnetic properties of compounds by means of the Mössbauer effect is widespread. Of special interest is the investigation of the magnetic fields on nuclei of diamagnetic atoms. Heusler-type alloys, to which the compounds of the Mn–Sn system also belong, are prominent among the intermetallic compounds with magnetic properties.

Three compounds of the Mn–Sn system are known: Mn_4Sn, Mn_2Sn, and $MnSn_2$. The first two compounds have been investigated with the aid of the Mössbauer effect.[1] Below we are publishing the results of a study of the Mössbauer spectra of the Sn^{119} nuclei in $MnSn_2$.

The compound $MnSn_2$ has a tetragonal body-centered lattice of the $CuAl_2$ type (Fedorov space group I4/mcm) with the lattice parameters: a = 6.659 Å, c = 5.436 Å, and c/a = 0.810, and according to the binary state diagram it is formed following a peritectic reaction at 548°C, there being no appreciable region of solubility on the diagram of state.[2]

Investigations of the magnetic susceptibility[3] have shown that at 342°K $MnSn_2$ goes over into an antiferromagnetic state. The magnetic structure of $MnSn_2$ is analogous to the magnetic structure of the compound $FeGe_2$[4] and its magnetic unit cell is in magnitude the same as the chemical one with an appropriate spin orientation where the first and second nearest neighbors are oriented antiferromagnetically and the third nearest neighbors ferromagnetically. The authors of[5] who investigated the compound $MnSn_2$ by means of neutron diffraction propose another magnetic structure in which the spins of the first and third neighbors are oriented antiferromagnetically and the spins of the second neighbors–ferromagnetically. The magnetic moments of manganese measured in[3] and[5] are 3.48 μ_B and 2.36 μ_B respectively. It is assumed that the magnetic interaction occurs by means of the nonmagnetic tin atoms.

As the starting material for obtaining the $MnSn_2$ compound we used electrolytic manganese purified by vacuum distillation and chemically pure tin. The alloys were prepared in an induction furnace by a method described in[6]. In order to check the composition of the alloy and the phase we carried out an x-ray phase analysis, as well as a chemical, microscope, thermal, and local x-ray analysis which showed good correspondence between the sample and the given stoichiometric composition.

The Mössbauer experiment was carried out on an electrodynamic setup with constant acceleration (the linearity of the velocity was no worse than 1 percent) in a temperature chamber with a temperature stability no worse than ±0.5°. The investigations were carried out in a range of temperatures near the antiferromagnetic transition point. Figure 1 shows a series of experimental Mössbauer spectra.

At temperatures up to 303°K the Mössbauer spectra had an insufficiently well resolved six-component structure whose interpretation was complicated by the presence of quadrupole splitting of the line (ΔE = 0.8 mm/sec) due to the presence of an electric field gradient on the Sn^{119} nuclei. The measured isomer shift of the spectrum referred to a β-Sn source was -0.30 ± 0.05 mm/sec.

At a temperature of 321°K the spectrum of the compound consisted of a broadened quadrupole line and at 328°K and above the magnitude of the quadrupole splitting was independent of the temperature. This allows one to conclude that the Néel temperature of this compound lies in the range between 321 and 328°K, which is in good agreement with the previously determined Néel

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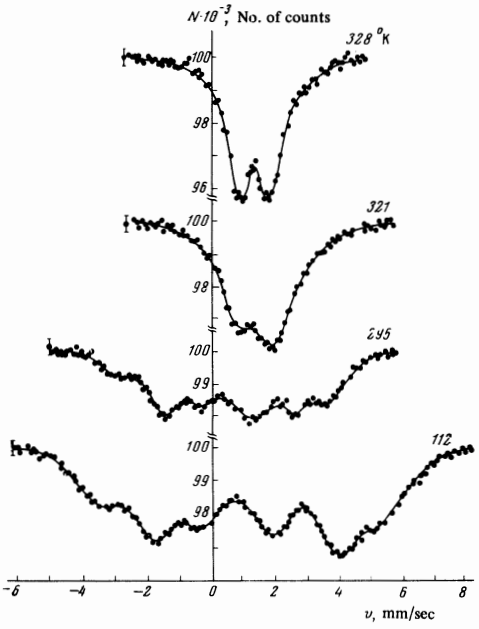

FIG. 1. Mossbauer spectra of $MnSn_2$ obtained at various temperatures.

temperature of 324°K.[3]

We measured the effective fields on the Sn^{119} nuclei and established that H_{eff} at 83°K is 65 kOe, and at room temperature (295°K) it is 44 kOe. Figure 2 shows the temperature dependence of the effective field on the Sn^{119} nuclei (in normalized units). The solid line is the temperature dependence of the magnetization calculated from tables of the Brillouin functions[7] for spin J = 2 for which there is better agreement of the experimental data with the calculated dependence. Quite good agreement is also obtained for J = 3/2. For the antiferromagnetic compound $FeSn_2$ with an analogous structure the effective field on the Sn^{119} nuclei is considerably smaller[8]—of the order of 25 kOe. This can be explained by means of the fact that in many manganese compounds, and in particular in the compound $MnSn_2$, the magnetic moment per manganese atom is greater than 2 μ_B whereas iron in the analogous compound $FeGe_2$ has a magnetic moment of ~1.2 μ_B.[9]

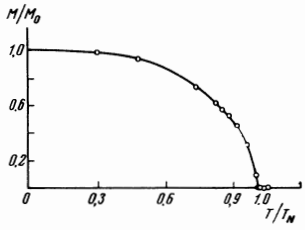

FIG. 2. The temperature dependence of the spontaneous magnetization M/M_0 superimposed on the experimental values of H_{eff} (normalized units). The solid line corresponds to values of the Brillouin function for J = 2.

If it is assumed that the difference in the effective fields on the diamagnetic Sn^{119} nuclei measured for the compounds $MnSn_2$ and $FeSn_2$, without allowance for the difference in their magnetic structures, is only due to the difference in the magnetic moments of the manganese and iron atoms, then if the proportionality of the internal magnetic fields and magnetic moments is retained we obtain a magnitude of the magnetic moment of manganese (2.1 μ_B) close to the value 2.36 μ_B measured from the neutron data.[5]

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