THE MÖSSBAUER EFFECT IN $FeSn_2$

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AMONG the many binary alloys, the intermetallic compound $FeSn_2$[1] is probably one of the most interesting objects for study using the Mössbauer effect. Each of the components of this compound contains an isotope which is very suitable for investigating resonance absorption of γ rays by nuclei of atoms in a crystalline lattice. These isotopes are Fe^{57} and Sn^{119}. The compound $FeSn_2$ is antiferromagnetic with a Neel point T_N at approximately 380°K.[1] In the present communication, we give preliminary results of a measurement of the resonance absorption of 14.4- and 23.8-keV γ rays in $FeSn_2$ at temperatures below and above the temperature of the magnetic transition.

The source of the 14.4-keV γ rays was the Co^{57} isotope (half-life $T_{1/2} = 270\,d$), introduced into stainless steel 1X18H9T by diffusion at 900°C in a hydrogen atmosphere (duration of diffusion 1 hr). The source of the 23.8-keV γ rays was the isotope Sn^{119m} ($T_{1/2} = 250\,d$) in the form of tin dioxide deposited on a lucite backing; the thickness of the active layer was 5 mg/cm^2. The absorber was prepared by depositing a powder of $FeSn_2$ on a beryllium disk 0.2 mm thick. In all the experiments the absorber thickness was 28 mg/cm^2 (normal mixture of isotopes). The source, kept at room temperature, was moved relative to the absorber by means of a cam mechanism. The intensity of the γ rays passing through the absorber was recorded using a NaI(Tl) crystal which was about 0.5 mm thick and a single-channel pulse analyzer. When the SnO_2 source was used, an 0.06 mm palladium filter was used to absorb the characteristic x rays of tin.

At room temperature (i.e., at approximately 80° below the Neel point) the absorption spectrum of the 14.4 γ rays by the Fe^{57} nuclei in the absorber consists of six well-resolved components (Fig. 1). The distance between the outermost lines corresponds to a source velocity of 3.9 ± 0.1 mm/sec. Using the data for the spectrum of resonance absorption by Fe^{57} nuclei in iron,[2] one can determine the effective internal magnetic field acting at the iron nuclei in $FeSn_2$. This value was 121 ± 4 kOe. The center of gravity of the absorption spectrum is shifted relative to the emission line of the source at rest toward positive velocities by an amount equal to 0.6 ± 0.1 mm/sec.

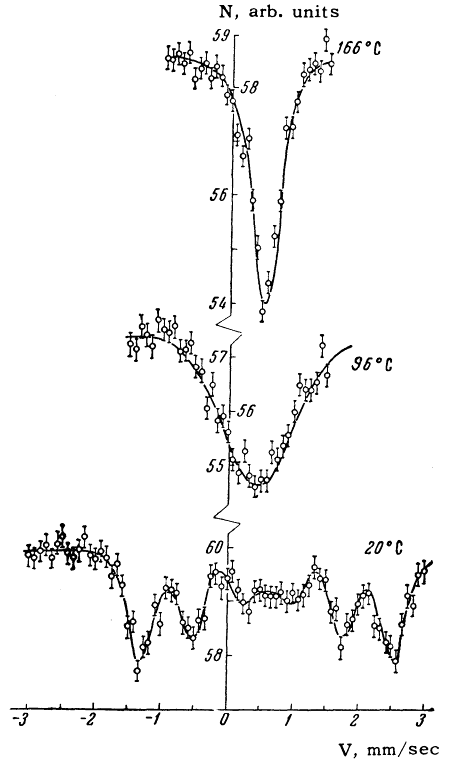

FIG. 1. Spectrum of resonance absorption of 14.4-keV γ rays by Fe^{57} nuclei in $FeSn_2$ at temperatures below and above the Neel point. N is the counting rate; a positive velocity v corresponds to motion of the source toward the absorber.

At temperatures above the Neel point, the components of the spectrum coalesce into a single absorption line. The half-width of the absorption line at temperatures of 96 and 166°C are $(6.7 \pm 1.0)\Gamma$ and $(2.7 \pm 1.0)\Gamma$ respectively, where Γ is the natural linewidth. We note that in our experiments with an 0.013 mm stainless steel absorber the half-width of the absorption line at room temperature was $(3.3 \pm 0.5)\Gamma$.

The spectrum of absorption of the 23.8-keV γ rays by Sn^{119} nuclei (cf. Fig. 2) at 20°C has a characteristic doublet structure. With increasing temperature the separation of the lines decreases, and for $T > T_N$ they coalesce into a single line as is the case for the 14.4-keV γ rays. This justifies the assumption that the splitting of the 23.8-keV γ ray absorption line in $FeSn_2$ has a magnetic origin. In this case the observed spectrum would correspond to incomplete resolution of the hyperfine structure pattern. The chemical shift of the absorption line is +2.2 ± 0.1 mm/sec.

One noteworthy point is the comparatively large resonance absorption of the Sn^{119} γ rays in $FeSn_2$. Control measurements with tin dioxide absorbers showed that at room temperature the cross section

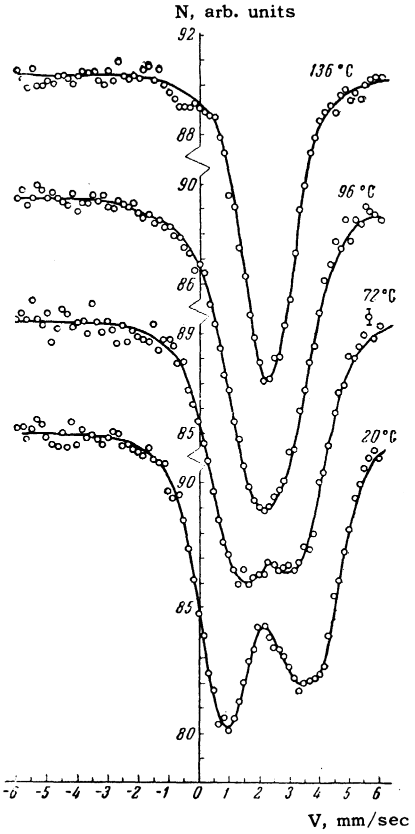

FIG. 2. Spectrum of resonance absorption of 23.8-keV γ rays by Sn^{119} nuclei in $FeSn_2$ at temperatures below and above the Neel point (notation as in Fig. 1).

for absorption of the 23.8-keV γ rays in $FeSn_2$ is approximately the same as in SnO_2. Possibly this is related to the special importance in the Mössbauer effect of the optical vibration branches of the crystal.[3] Detailed measurements are now being made of the Mössbauer probability f′ as a function of temperature for both components of the alloy.

It is interesting to note that the absorption spectrum of the 23.8-keV γ rays at 20° has an unsymmetrical shape. Special experiments are proposed to find the source of this asymmetry.

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[1] Kanematsu, Yasukochi, and Ohoyama, J. Phys. Soc. Japan **15**, 2358 (1960).

[2] Hanna, Preston, and Heberle, Second International Conference on the Mössbauer Effect, John Wiley and Sons, New York, 1962, p. 85.

[3] Yu. Kagan, JETP **41**, 659 (1961), Soviet Phys. JETP **14**, 472 (1962).

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