THE MOSSBAUER EFFECT IN METALLIC TIN AT PRESSURES UP TO 110 kbar

V. N. Panyushkin and F. F. Voronov
Institute of High Pressure Physics, USSR Academy of Sciences
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In several recent experimental investigations [1-4] the Mossbauer effect was used to study the properties of solids at high pressures. In particular, work on the Mossbauer effect in iron at high pressures [3] yielded important information on the properties of metallic iron up to 240 kbar. Besides experiments, some recent theoretical investigations [5,6] are connected with the use of the Mossbauer effect in high-pressure physics. An interesting subject in such investigations is metallic tin (β-Sn). Its large compressibility gives grounds for hoping to obtain distinctly noticeable pressure effects. In particular, a large increase is expected in the probability of emission of recoilless γ quanta [5], and also an increase in the isomeric shifts with pressure.

The high-pressure chamber used in the described investigations is similar to chambers with flat anvil and tablet of amorphous boron, used in work on x-ray structural analysis at high pressure [7]. The use of boron in this chamber makes it possible to divert the investigated γ quanta from the pressure zone. A β-Sn source in the form of a foil 20 μ thick, containing Sn^{119m}, was placed in the pressure chamber. The pressure in the chamber was calibrated against the jumps of the electric resistivity at known polymorphic transitions in bismuth (25.3, 26.8, and 89 kbar), in thallium (37 kbar), and in barium (59 kbar) [8]. The calibration curve was linear and was linearly extrapolated to 110 kbar. In addition to preliminary calibration of the chamber, a control sample of bismuth was placed in the chamber during each experiment to check on the calibration at the corresponding points.

The setup for the observation of the Mossbauer effect is similar to the constant-speed setup described in [9]. The electrodynamic vibrator was calibrated in velocity against the Mossbauer spectrum of $Fe_2^{57}O_3$ with a Co^{57} source in stainless steel. The instability of the vibrator speed amounted to 0.5% daily. The Doppler shift of the γ-quantum energy was produced by moving a resonant absorber relative to the source. The absorber used in the experiments was tin dioxide. The thickness of the absorber was 20 mg/cm^2. All the measurements were made with the source and absorber at room temperature.

The resonance curves for each experiment were plotted at pressures of 1 atm and 45, 90, and 110 kbar. In each experiment, the effect was plotted 15 - 20 times for each pressure, and the count accumulated during that time for one point of the spectrum was 200 - 500 thousand. Sample resonance curves for different pressures are shown in Fig. 1. Here ϵ (%) is the magnitude of the effect and v the velocity of the absorber. The effect is observed when the absorber moves away from the source (negative relative velocities). As can be seen from the figure, the depth of the resonance increases with increasing pressure, and the half-widths of

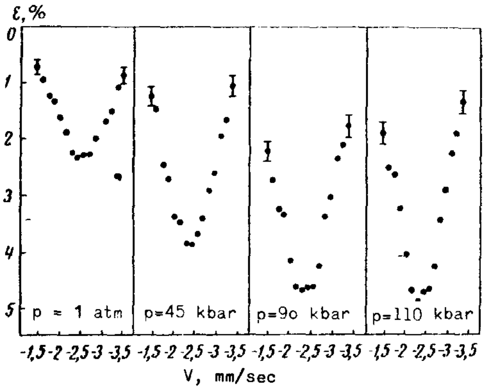

Fig. 1. Resonance curves for different pressures

the resonance curves remain constant (within the limits of errors). Comparing the areas of the resonance curves for different pressures with the area of the curve at atmospheric pressure, we obtain the pressure dependence of the probability of recoilless γ-quantum emission. Taking for atmospheric pressure for the absolute probability of the effect in β-Sn the value $f = 0.06 \pm 0.006$ obtained in [10], we get the absolute values of f_p for different pressures (Fig. 2; the value of f at atmospheric pressure is assumed to be exact). If we assume that the Debye approximation [11] can be used for a rough estimate of the effect in our case, then we can estimate from the pressure dependence of f_p the increase of the corresponding "effective Debye temperature Θ" with increasing pressure (Fig. 2). From the obtained dependence we can estimate the Gruneisen constant for atmospheric pressure. Its value is $\gamma = 2.4 \pm 0.3$, which agrees well with the value $\gamma = 2.25$ calculated by the Gruneisen formula [12].

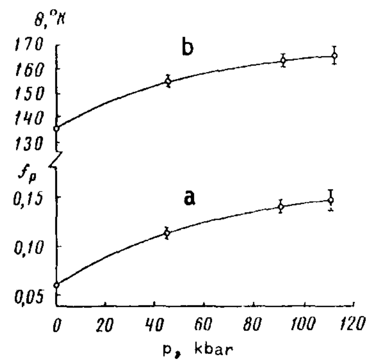

Fig. 2. Dependence on the pressure P: a - of the probability of recoilless γ-quantum emission f_p, b - of the effective Debye temperature Θ.

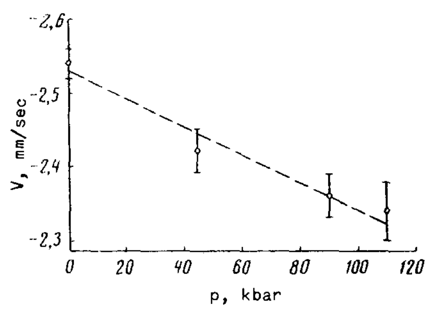

Fig. 3. Pressure dependence of the position of the resonance line of β-Sn relative to the energy of the resonance in SnO_2.

Another result of the experimental curves is the shift in the energy of the resonance in β-Sn towards the energy of the resonance in SnO_2 (Fig. 3). On the initial section, this shift amounts to $\sim 2.5 \times 10^{-4}$ cm/sec-kbar, which is approximately three times the corresponding value for metallic iron [3]. It is interesting to note that the compressibility of tin is also three times larger than that of iron.

In conclusion we call attention to the following. It is known [11] that with decreasing density of the valence electrons in the tin atom the energy of the radiated resonant γ quanta decreases. For example, the energy of the γ quanta emitted by SnO_2 or $SnCl_4$ is smaller than that from SnO or $SnCl_2$, respectively, etc. From this point of view, the decrease in the energy of the resonance in β-Sn with increasing pressure is equivalent, as it were, to a decrease in the density of the valence electrons in the atom of metallic tin. It must be noted that all the pressure effects observed in β-Sn are fully reversible, within the limits of errors.

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UNITARY SYMMETRY AND THE POINCARE GROUP

V. I. Fushchich
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The question of combining the Poincare group P with the group of internal symmetries S (simple Lie group) is now under discussion in many papers [1-5]. It is necessary to clarify first whether this unification is not trivial. The most convincing result in this direction was obtained by Michel [3]. However, even this result was obtained under rather stringent limitations on the group G, which is the combination of the groups P and S (it is assumed that each element $g \in G$ is of the form $g = sp$, $s \in S$, $p \in P$). However, as can be seen from [4,5] and other papers, the union of the two groups $G \supset PS$ contains elements which cannot be represented in the form sp. The Lie algebra of such a group always contains generators which belong neither to the algebra P nor S. It is therefore natural to clarify in this case the question of the triviality or nontriviality of the given union.