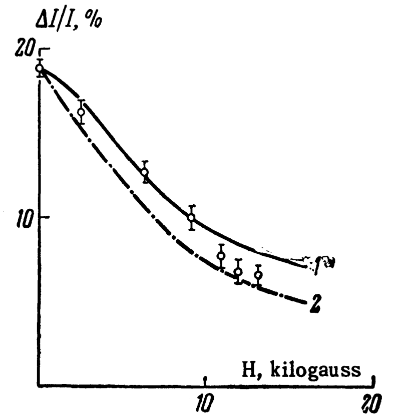


Dependence of intensity difference on magnetic field, for temperatures of source and absorber equal to 90 and 293°K. 1 - theoretical curve for a Debye temperature $\Theta = 170°K$ and a magnetic moment of the excited state of Sn^{119m} equal to $\mu = 1.5\,\mu_0$, where μ_0 is the magnetic moment of the ground state of Sn^{119}; 2 – similar curve for $\mu = 2.0\,\mu_0$.

radiation of tin with energy ~25 kev. When the source was cooled to 90°K, the intensity of the soft radiation recorded by the counter dropped by 12%. When the magnetic field was turned on with source and absorber cooled, the intensity of the soft radiation began to increase with increasing magnetic field. The magnetic field splits the 23.8-kev level and shifts the energy of the recoilless radiation from its resonant energy by an amount of the order of 10^{-7} ev, while the 23.8-kev level in the absorber, which is in a much weaker field, is shifted much less. As a result of this detuning of the energy, the absorption in the absorber decreases and the intensity increases.

The measurements were carried out for three thicknesses of the absorber of natural white tin: 36, 11, and 5 mg/cm^2. In the figure we show the data of the experiment for the thinnest absorber. From all the data we determine with good internal consistency a value for the magnetic moment of the excited state of Sn^{119m} equal to $\mu = -(1.1 \pm 0.1)\mu_0$ or $\mu = (1.72 \pm 0.06)\mu_0$ with a value of the Debye temperature Θ equal to 170°K, which follows from our experiments. The value $\mu = -(1.1 \pm 0.1)\mu_0$ is to be preferred since it is in good agreement with the established level scheme for Sn^{119m}. The value of the magnetic moment calculated from our experiments was only slightly dependent on the value chosen for the Debye temperature of white tin: for $\Theta = 200°K$ we have $\mu = -1.15\mu_0$, while for $\Theta = 140°K$, we get $\mu = -1.05\mu_0$, where μ_0 is the value of the magnetic moment of the ground state of Sn^{119} which is equal to -1.046 nuclear magnetons.

We express our profound gratitude to L. A. Artsimovich for preparing the samples of enriched tin, to G. M. Kukavadze for the mass spectrographic analysis of the samples, and to V. I. Anan'ev for help in the measurements.

[1] R. L. Mössbauer, Z. Naturforsch. **14a**, 211 (1959).

[2] R. L. Mössbauer, M. Hamermesh. Cf. L. L. Lee et al., Phys. Rev. Letters **3**, 223 (1959); Barit, Podgoretskiĭ, and Shapiro, JETP **38**, 301 (1960), Soviet Phys. JETP **11**, 218 (1960).

Translated by M. Hamermesh
368

ELECTRICAL AND GALVANOMAGNETIC PROPERTIES OF LITHIUM FERRITE-CHROMITE NEAR THE COMPENSATION POINT

K. P. BELOV, A. N. GORYAGA, and LIN CHANG-TA

Moscow State University

Submitted to JETP editor March 29, 1960

J. Exptl. Theoret. Phys. (U.S.S.R.) **38**, 1914-1915 (June, 1960)

In certain ferrites one observes a highly anomalous temperature dependence of the spontaneous magnetization, with a so-called compensation point Θ_c at which a "balancing" of the magnetic moments of the sublattices occurs.[1-3] The study of such ferrites is of interest from the point of view of explaining the extent to which one or another sublattice "shares" in the ferrimagnetism, and could contribute to a deeper understanding of the nature of the physical properties of crystalline materials of the ferrite type.

In reference 4 it was established that in gadolinium ferrite-garnet the magnetostriction properties are markedly different in character above and below Θ_c. Below Θ_c they are chiefly due to the "gadolinium" sublattice, and above Θ_c to the "iron" sublattices. With the aim of further studying the role of the sublattices in ferrimagnetism and the physical phenomena which accompany it in ferrites, we undertook the measurement of the electrical and galvanomagnetic properties of

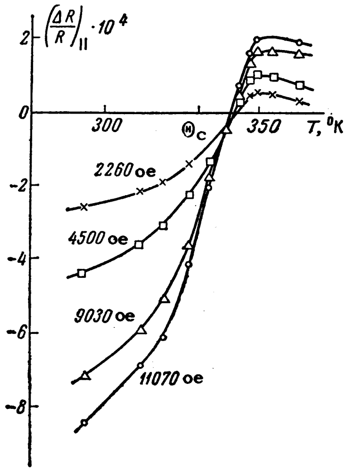


FIG. 1

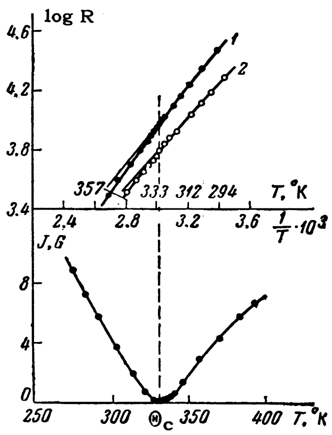


FIG. 2

lithium ferrite-chromite, which has a compensation point. In Fig. 1 are shown the curves of temperature dependence of the longitudinal galvanomagnetic effect $(\Delta R/R)_{||}$ at various magnetic fields for the ferrite $Li_2O \cdot 2\frac{1}{2}Fe_2O_3 \cdot 2\frac{1}{2}Cr_2O_3$ prepared by the usual ceramic techniques. It is evident that after Θ_C has been passed (some 10° to 20° above Θ_C) a change of sign occurs in the longitudinal galvanomagnetic effect. At first sight one would say that, since $(\Delta R/R)_{||}$ is an even-order effect, it should not change its sign upon passing through Θ_C (where the direction of the resultant spontaneous magnetization is reversed). The change in sign of the effect can be understood if it is assumed that the sublattices of the lithium ferrite-chromite under study have different electrical properties, determined obviously by the nature of the ions located on the corresponding sublattices. As a result, the character of the galvanomagnetic effect below Θ_C, where the magnetization of the ions in the octahedral locations is "predominant," differs from its character above Θ_C, where the magnetization of the ions in the tetrahedral locations is "predominant."

At each given temperature the "resultant" galvanomagnetic properties of the ferrite as a whole will be determined by the magnitudes and signs of the galvanomagnetic effects of the corresponding sublattices. Hence the experimentally observed dependence of the galvanomagnetic effect on the temperature and field must be of a very complicated nature. From this point of view, the shift (shown in Fig. 1) of the temperature of the null of the galvanomagnetic effect (the compensation point of the galvanomagnetic effect) relative to Θ_C becomes understandable.

We have also measured the temperature dependence of the electrical resistivity of our ferrite. In Fig. 2 are shown the curves of $\log R(1/T)$ for the ferrite $Li_2O \cdot 2\frac{1}{2}Fe_2O_3 \cdot 2\frac{1}{2}Cr_2O_3$, measured with direct current (curve 1) and with alternating current (200 kcs, curve 2). The same figure shows the curve of temperature dependence of the magnetization at $H = 250$ oe. It is apparent that a noticeable kink in the $\log R(1/T)$ curve occurs in the region of Θ_C. Measurements of $\log R(1/T)$ curves have been carried out on several samples with the composition indicated above, prepared by the ceramic method under differing conditions. In all cases a kink was observed in the curves, with both direct and alternating current. From Fig. 2 it is evident that the kinks in the curves near Θ_C are similar in nature to the kinks in the curves observed in ferrites at the Curie temperature. It should be observed, however, that the electrical resistance anomalies in the region of the compensation point are due to other causes. The presence of a kink in the $\log R(1/T)$ curve at the point Θ_C is explained not by the collapse of spontaneous magnetization, such as occurs at the Curie point, but is connected, according to the theoretical assumptions of Turov and Irkhin,[5] with the compensation of the exchange fields of the magnetic sublattices at Θ_C. It is also possible to explain the appearance of these kinks if the ferrite sublattices have different electrical properties, and if this difference appears somehow near the compensation point. The latter assumption, in our view, is confirmed by the behavior of the galvanomagnetic effect in the region of the compensation point. We are continuing with further studies of the above effects.

---

[1] L. Neel, Ann. de Phys. **3**, 137 (1948).

[2] E. W. Gorter, Phillips Res. Reports **9**, 295 (1954).

[3] R. Pauthenet, Compt. rend. **242**, 1859 (1956);

243, 1499 (1956).

[4]Belov, Zaĭtseva, and Ped'ko, JETP **36**, 1672 (1959), Soviet Phys. JETP **9**, 1191 (1959).

[5]E. A. Turov and Yu. P. Irkhin, Материалы конференции по ферритам, (Proceedings of the Conference on Ferrites), Minsk, June 1959.

Translated by D. C. West
369

LIFETIME OF THE 321-kev LEVEL IN Hf^{177}

G. A. VARTAPETYAN

Physics Institute, Academy of Sciences, Armenian S.S.R.

Submitted to JETP editor April 4, 1960

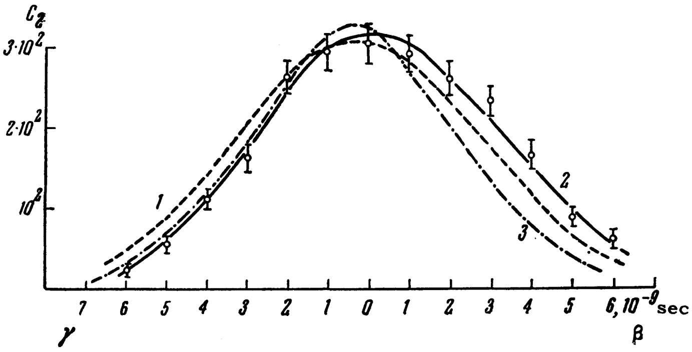
J. Exptl. Theoret. Phys. (U.S.S.R.) **38**, 1916-1917 (June, 1960)

SOME properties of the levels in deformed odd nuclei may be explained within the framework of the model of Bohr-Mottelson and Nilsson.[1] But the intensity rule is not always satisfied; in particular, for Hf^{177} the ratios obtained for the probability of 208- and 321-kev E1 transitions considerably differ from the theoretically calculated values.[2]

It is of interest to find the absolute values of the probabilities of the transitions for γ radiation with $h\nu$ = 208 and 321 kev. These E1 transitions are forbidden by the asymptotic selection rules.[1] M2 transitions may occur if they are not forbidden by the above-mentioned rules. As regards the allowed M2 transitions, in the case of the neighboring deformed nuclei, the experimental values for the transition probabilities coincide with the theoretical values.[2] Knowing the value of the M2 mixture in the 208-kev transition, obtained[3] from the measurement of the 208 — 113 kev angular correlation $[(M2/E1)_{208} = 10^{-3}]$ and the intensity ratio[2] $L_{\gamma_{208}}/L_{\gamma_{321}} = 20$, we can calculate the amount of M2 mixture in the 321-kev transition and the period of the 321-kev level. We find

$$(M2/E1)_{321} \approx 0.35, \quad T_{1/2} \approx 4 \cdot 10^{-10} \text{ sec}.$$

The measurement of the 321-kev level transition was carried out by the method of delayed coincidences with the use of a fast-slow coincidence circuit[2] (resolving time 7×10^{-9} sec). The γ quanta were recorded by a NaI(Tl) crystal, and the β electrons were recorded by an anthracene crystal 2 mm thick. In the latter case, there was a certain difficulty in the measurements, since some of the conversion electrons from the 113 kev γ transition were detected apart from the β radiation with E_{max} = 176 kev. (The period of the 113-kev level is 4.2×10^{-10} sec.[4]) Then the experimental curve of the coincidences $\beta + e^-_{113} - \gamma_{208}$ (curve 1 in the figure) is the sum of the coincidences $\beta - \gamma_{208}$ and $e^-_{113} - \gamma_{208}$. In order to obtain the $\beta - \gamma_{208}$ curve (curve 2), a third channel, which detected the 113-kev γ quanta (curves 1 and 2 were measured simultaneously), was connected in coincidence. The $\beta - \gamma_{208}$ curve was compared with the delayed coincidences curve $\beta - \gamma_{208\,(\text{comp. from } 495)}$ for Ru^{103} (curve 3), which was obtained under the same conditions. (The period of the 495-kev transition is less than 10^{-10} sec.)



Delayed coincidences: curve 1 – Lu^{177}, $\beta + e^-_{113} - \gamma_{208}$; 2 – Lu^{177}, $\beta - \gamma_{208}$; 3 – Ru^{103}, $\beta - \gamma_{208\,(\text{comp. } 495)}$.

Hence, by determining the shift in the centers of gravity of curves 2 and 3, we found the mean lifetime of the 321-kev level [which was equal to $(7 \pm 2) \times 10^{-10}$ sec] and the half-life $T_{1/2} = (5 \pm 1.5) \times 10^{10}$ sec. This value is in good agreement with that obtained from the measurement of the intensities[2] and angular correlation,[3] if one takes into account here the formula of Weisskopf and Alaga, which is valid for the allowed M2 transitions. The probabilities for the 321- and 208-kev transitions may be calculated:

$$P_{\gamma 321}(E1) = 5.5 \cdot 10^7 \text{ sec}^{-1}, \quad P_{\gamma 208}(E1) = 1.4 \cdot 10^9 \text{ sec}^{-1}.$$

From comparison with the theoretical values we find the degree to which the transitions are forbidden: $f_{B_{321}} = 4 \times 10^6$ and $f_{B_{208}} = 3.5 \times 10^4$ from the formula of Weisskopf and $f_{H_{321}} = 4 \times 10^2$ and $f_{H_{208}} = 0.6$ from the formula of Nilsson.[5]

The fact that the 321-kev E1 transition is forbidden is comparable to the fact that the 396- and 282-kev E1 transitions[6] in Lu^{175} and the 147-kev transition[1] in Lu^{177} are forbidden. If it is as-