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THE DEPENDENCE OF THE POLARIZATION RELAXATION TIME AND THE LANDAU KINETIC COEFFICIENT ON THE DEGREE OF DEUTERATION IN $K(H_{1-n}D_n)_2PO_4$ CRYSTALS*

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ЗАВИСИМОСТЬ ВРЕМЕНИ РЕЛАКСАЦИИ ПОЛЯРИЗАЦИИ И КИНЕТИЧЕСКИХ КОЭФФИЦИЕНТОВ ЛАНДАУ ОТ СТЕПЕНИ ДЕЙТЕРИРОВАНИЯ В КРИСТАЛЛАХ $K(H_{1-n}D_n)_2PO_4$

It is well known that the ultrasonic waves exhibit anomalous attenuation in the neighbourhood of the phase transition of the ferroelectric crystals $K(H_{1-n}D_n)_2PO_4$.

We have measured the coefficient of the attenuation of ultrasound waves in these crystals when $n = 0$ and $n = 0.92$ both below and above the Curie temperature T_c. In the following we shall denote crystals with $n = 0$ as KH_2PO_4 and crystals with $n = 0.92$ as KD_2PO_4. Measurements were made on transverse waves in the frequency region from 60 MHz to 500 MHz [1, 2, 3].

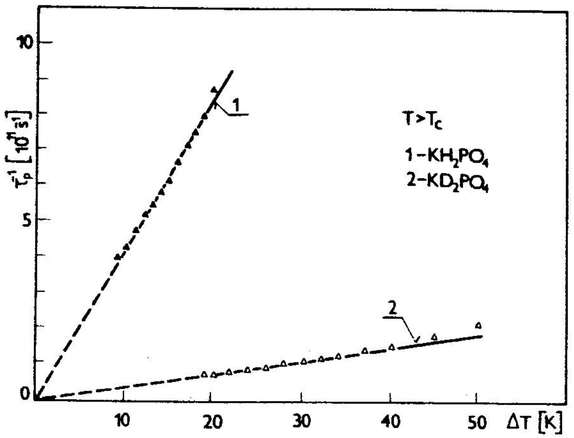

Fig. 1. The dependence of τ_p^{-1} on $\Delta T = |T - T_c|$ for $T > T_c$

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From measurements of the coefficient of this anomalous attenuation we can calculate the polarization relaxation time τ_P on the basis of the Landau—Khalatnikov theory [4].

The dependence of the polarization relaxation time on the temperature of the crystal is shown in Figs. 1 and 2. In our case the polarization relaxation time is independent of the frequency of the ultrasound waves.

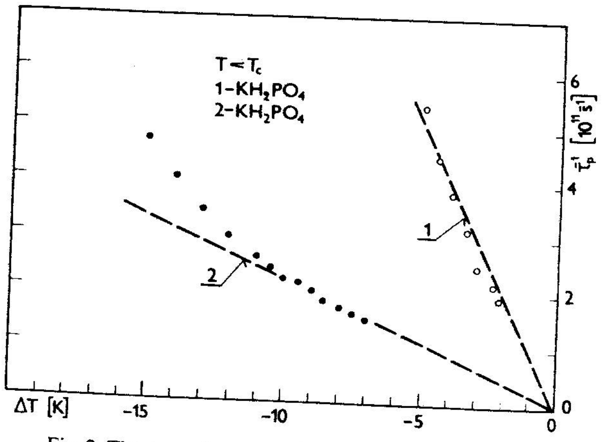

Fig. 2. The dependence of τ_P^{-1} on $\Delta T = |T - T_c|$ for $T < T_c$

The authors [1—3, 5—7] found in the region of the validity of the Landau phenomenological theory a linear dependence of τ_P^{-1} on $\Delta T = |T - T_C|$

$$\tau_P^{-1} = b\,|T - T_C|, \tag{1}$$

where T is the temperature of the crystals, T_C is the Curie temperature and b is a temperature independent coefficient.

Comparing the data on b from [5—7] with our results [1—3] we come to the conclusion that the coefficient b in $K(H_{1-n}D_n)_2PO_4$ crystals depends on the degree of deuteration n, $b = b(n)$. The b values are shown in Table 1 and Fig. 3.

Table 1

	$T<T_C$ b	$T>T_C$ b	n	b $[10^{10}\,s^{-1}\,K^{-1}]$
KH_2PO_4	—	4.2	0	[6] C. V. Garland and B. Novotny
	10.1	4.25	0	[2, 3] our measurements
KD_2PO_4	3.0	0.4	0.84	[5] E. Litov and E. A. Uehling
	—	0.27	0.9	[7] R. M. Hill and S. K. Ichiki
	2.2	0.24	0.92	[1, 2] our measurements

From Fig. 3 it can be seen that b depends on the degree of deuteration in the first approximation as follows

$$T > T_C: b(n) = [4.05(1-n) + 0.05] \times 10^{10}\,s^{-1}\,K^{-1} \tag{2}$$

$$T < T_C: b(n) = [8.41(1-n) + 1.7] \times 10^{10}\,s^{-1}\,K^{-1}. \tag{3}$$

The polarization relaxation time τ_P is connected with the Landau kinetic coefficient L by the following relation

$$\tau_P^{-1} = \frac{L}{C}\,|T - T_C|, \tag{4}$$

where C is the Curie—Weiss constant.

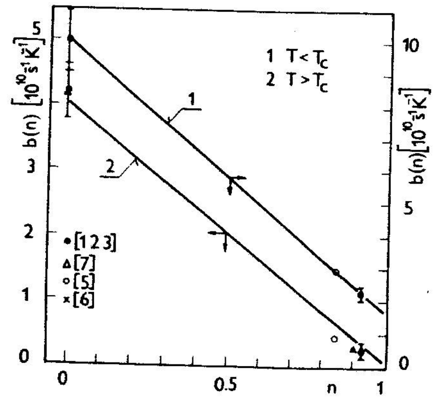

Fig. 3. The dependence of b on the degree of deuteration n for (2) $T > T_c$ and (1) $T < T_c$ in $K(H_{1-n}D_n)_2PO_4$ crystals

Samara [8] investigated the Curie—Weiss constant as a function of the degree of deuteration n in $K(H_{1-n}D_n)_2PO_4$ crystals. He has found for $T > T_c$ that C depends on n as follows

$$C(n) = 230 + 100n \quad [K]. \tag{5}$$

From Eqs. (1) and (4) it results that also the Landau kinetic coefficient L depends on n

$$L(n) = b(n)C(n) \tag{6}$$

and we obtain for $T > T_c$ the following dependence of L on n

$$L(n) = L_0 + L_1 n + L_2 n^2, \tag{7}$$

where $L_0 = 9.33 \times 10^{12}\,s^{-1}$, $L_1 = -5.21 \times 10^{12}\,s^{-1}$, $L_2 = -4.05 \times 10^{12}\,s^{-1}$.

Unfortunately we do not know the dependence of C on n for $T < T_c$ and thus we cannot determine $L(n)$ for $T < T_c$.

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