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CRITICAL PROPERTIES OF T. G. S. AND R. S. AS DETERMINED BY a d. c. ELECTRIC FIELD METHOD

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Résumé. — La dépendance de la polarisation sur la température en présence d'un champ électrique statique, a été mesurée pour les diélectriques ferroélectriques de sulfate de triglycine T. G. S. et de sel de Rochelle R. S. De même le coefficient critique β a été mesuré.

Les résultats sont en accord avec ceux fournis par la théorie des champs moyens, ceci pour $\varepsilon = (T_c - T)/T_c \geq 1,2 \times 10^{-4}$ pour T. G. S. et $\varepsilon \geq 2,4 \times 10^{-3}$ pour R. S. Des écarts à la théorie ont été observés pour des valeurs de ε inférieures à celles données ci-dessus.

Abstract. — The dependence of the polarization on the temperature under the influence of a constant electric field has been measured for ferroelectric triglycine sulfate (T. G. S.) and Rochelle salt (R. S.), and the critical exponent β has been determined. The results are consistent with the prediction of the mean field theory for $\varepsilon = (T_c - T)/T_c \geq 1.2 \times 10^{-4}$ in T. G. S. and $\varepsilon \geq 2.4 \times 10^{-3}$ in R. S. Below these values of ε deviations from the mean field theory were observed.

When measuring critical properties of ferroelectric crystals under an a. c. electric field, the determination of critical exponents is influenced by the magnitude of the electric field and the electrocaloric effect. At temperatures very close to T_c the error in the measurements of the spontaneous polarization increases and it is impossible to determine the critical exponents of crystals with a small value of polarization like R. S.

When we investigated critical properties of T. G. S. and R. S. under a constant electric field we have used the same circuit as R. E. Oettel [1]. It consists of the sample, parallel to which there is a linear capacitor C_1 . The source of the d. c. voltage was a battery or a power supply. The charge transferred to the series capacitor from the sample is proportional to the polarization of the crystal

$$P = \frac{C_s V_s}{A} = \frac{C_1 V_1}{A}.$$

The voltage on the series capacitor was measured using a Keithley model 610 C electrometer and recorded on the y-axis of a Moseley $x - y$ recorder. On the x axis of the recorder we led the voltage of the battery of four Cu-constantan thermocouples to record the spontaneous polarization as a function of temperature. The sample was in a Dewar and the temperature was varied by a flow of a hot N_2 .

The sensitivity of the temperature measurement was ± 0.005 °K and precision of the polarization determination was ± 1 % at $T_c - T = 0.05$ °K. The Curie temperatures T_c were determined from the plot of P_s^2 vs. T (Fig. 1, Fig. 2) by extrapolating to $P_s = 0$. The values are T_c (T. G. S.) = 322.40 ± 0.01 °K and T_c (R. S.) = 297.75 ± 0.02 °K. The absolute value

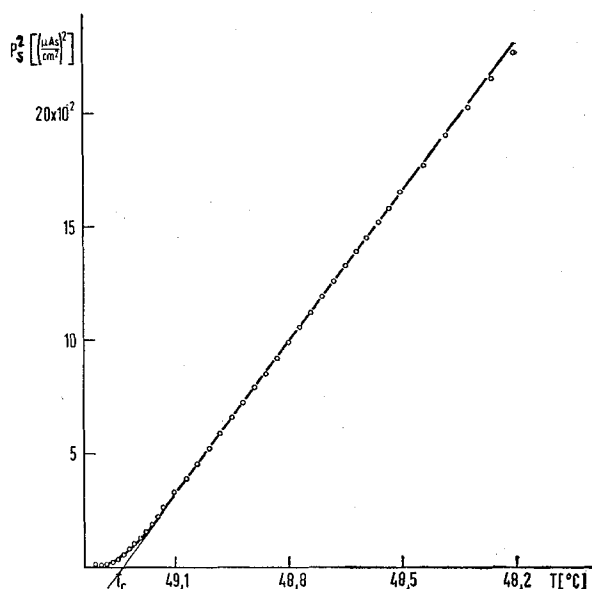


FIG. 1. — Temperature dependence of the square of the polarization in T. G. S. at $E = 0.43$ V/cm.

of spontaneous polarization of T. G. S. is very close to our measurement [2] from the hysteresis loop. The expression of the free energy F in terms of polarization

$$F = F_0 + \frac{1}{2} a P_s^2 + \frac{1}{4} b P_s^4 + \dots \quad (1)$$

which predicts

$$P_s^2 = -\frac{a}{b} = -\frac{a'}{b} (T - T_c) \quad (2)$$

is correct in T. G. S. up to

$$\varepsilon = \frac{T_c - T}{T_c} = 1.2 \times 10^{-4}.$$

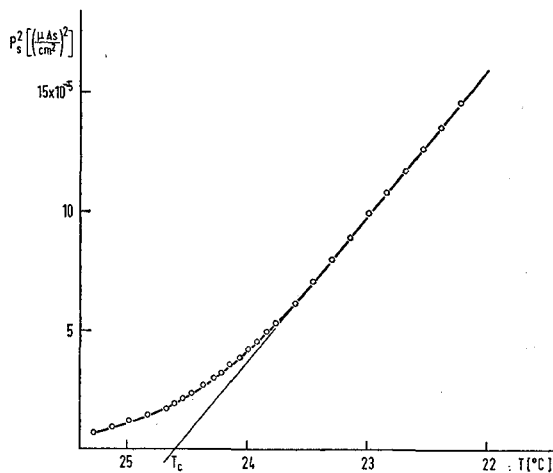


FIG. 2. — Temperature dependence of the square of the polarization in R. S. at $E = 11.8$ V/cm.

The value of a' obtained from measurement of dielectric constant is $a' \epsilon_0 = 4.6 \times 10^{-4} \text{ } ^\circ\text{K}^{-1}$. From figure 1 we determine the value of b as

$$b = 7.8 \times 10^{11} \text{ Vm}^5 \text{ A}^{-3} \text{ s}^{-3}.$$

From the log-log plot of P_s^2 vs. $T_c - T$ (Fig. 3) for T. G. S. (a) and R. S. (b) the critical exponent β which is defined

$$P_s \propto (T_c - T)^\beta \quad (3)$$

can be determined. From

$$T_c - T = 1 \text{ } ^\circ\text{K} \text{ to } T_c - T = 0.05 \text{ } ^\circ\text{K}$$

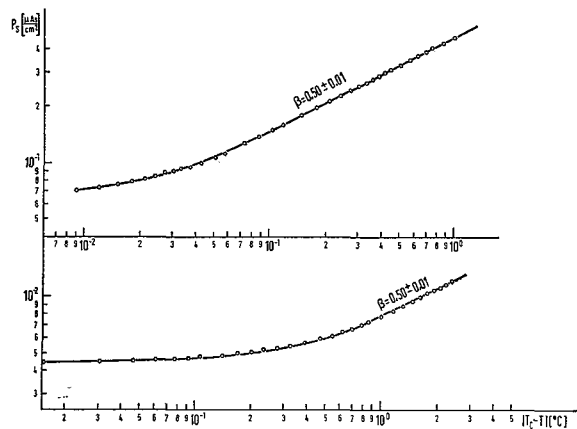


FIG. 3. — Log-log plot of spontaneous polarization vs. $T_c - T$ in T. G. S. (a) and R. S. (b).

the data for T. G. S. are in agreement with the classical value $\beta = 0.5$ as we find $\beta = 0.50 \pm 0.01$. For R. S. we get the classical value of from $T_c - T = 2.5 \text{ } ^\circ\text{K}$ to $0.7 \text{ } ^\circ\text{K}$. Below these regions the value of β decreases for both crystals. For T. G. S. we have calculated the contribution of the electric field to the polarization but it gives at $T_c - T = 10^{-2} \text{ } ^\circ\text{K}$ only few percents higher value than the extrapolation with $\beta = 0.5$. The difference between the measured and calculated value of polarization exceeds the experimental error in the region below $T_c - T = 0.05 \text{ } ^\circ\text{K}$.

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References

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- [2] BLINC (R.), BURGAR (M.) and LEVSTIK (A.), *Solid State Comm.*, 1970, 8, 317.