

ZDELENIA

**ANISOTROPY OF THERMAL CONDUCTIVITY,
THERMAL DIFFUSIVITY AND PERMITTIVITY
OF NaNO_3 SINGLE CRYSTALS AT THE PHASE TRANSITION**

EUDOVÝT KUBIČÁR, EMIL MARIANI, Bratislava

Many physical characteristics of the NaNO_3 crystal show certain anomalies near 275°C . This anomalous feature is connected with a phase transition of second order [1, 2]. From the microscopical point of view at this temperature a reorientation jump of the NO_3^- groups around the trigonal axis was suggested to explain the anomalous behaviour.

The structure of the NaNO_3 crystal at temperatures below the phase transition is rhombohedral with the space group $R\bar{3}c$ of the calcite type. By means of X-ray diffraction analysis at temperatures below the phase transition it is possible to distinguish planes in which the orientation of the NO_3^- groups, which are planar, alternates along the trigonal axis periodically [3]. Every other plane has the same orientation. The orientation of the NO_3^- groups in the nearest neighbouring planes is changed by a 180° rotation along the trigonal axis. With increasing temperature the NO_3^- groups begin to jump by 180° around the trigonal axis. At 275°C the NO_3^- groups take random position and the difference between the planes disappears.

Most physical measurements on the NaNO_3 crystals show some kind of anisotropy. An excellent example is given by elasticity constant measurements. In the direction of the trigonal axis (111) a jump was found. In the other directions there was a knee.

In this paper the thermal conductivity, thermal diffusivity, specific heat and permittivity were measured in the main crystallographic directions to complete the experimental data.

The single crystals were grown by the method described in paper [4]. The samples were cut in the direction of the trigonal axis (111) and perpendicularly to the trigonal axis (direction *a*).

The samples used for permittivity measurements are provided with vacuum evaporated electrodes of gold. The measurements were performed at 100 kHz. Fig. 4 shows clearly anisotropy of permittivity. Its features are similar to those of the other physical characteristics. The permittivity at low tempera-

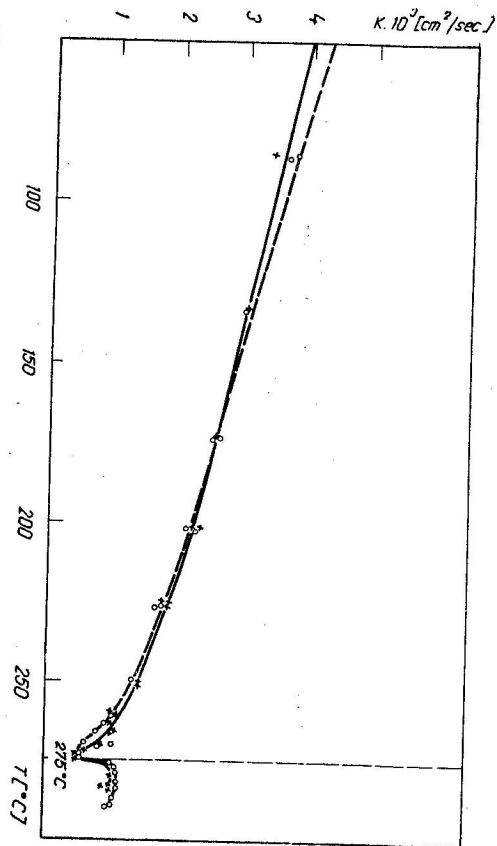


Fig. 1. Thermal diffusivity of NaNO_3 . Broken line — direction (111), full line — direction α .

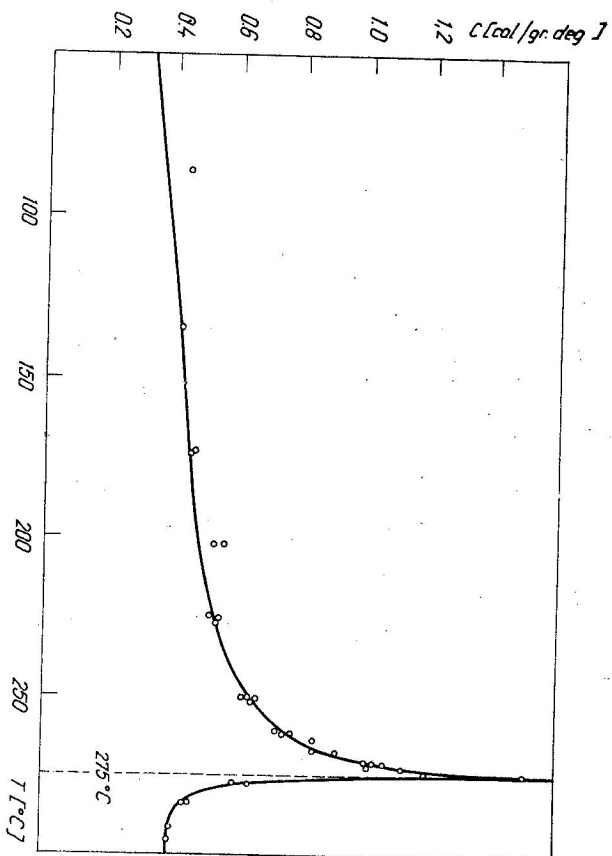


Fig. 2. Specific heat of NaNO_3 .

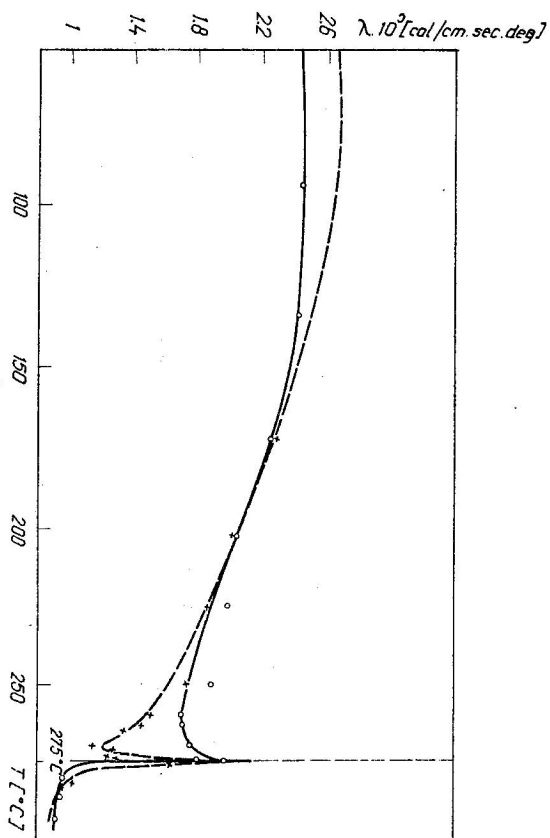


Fig. 3. Thermal conductivity of NaNO_3 . Broken line — direction (111), full line — direction α .

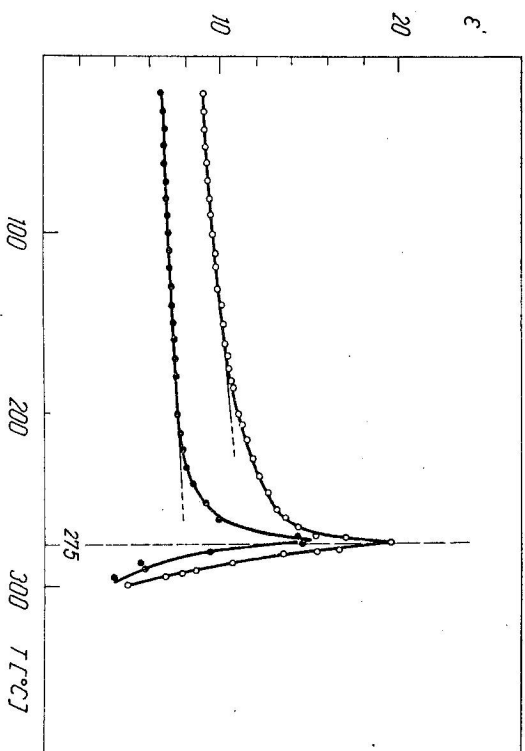


Fig. 4. Permittivity of NaNO_3 . \circ — direction (111), \bullet — direction α .

tures changes only very slowly in both directions. The NO_3^- groups are fixed. Polarization is due only to lattice and electron polarization. The unusual increasing of permittivity begins in the direction (111) at about 180 °C, and in the direction *a* at about 220 °C. At these temperatures orientational polarization begins. The bindings in the direction (111) become more weak than in the direction *a*. This follows from the results of the linear dilatation measurements [7, 8], and of the elasticity constant [2]. The crystal have in the direction (111) a greater orientational polarizability than in the direction *a*. At 275 °C the fixed position of NO_3^- ions does not exist. The permittivity decreases again.

The thermal measurements were done by the method described in papers [5, 6]. The curve of thermal conductivity (Fig. 3) was constructed from the curves of thermal diffusivity (Fig. 1) and specific heat (Fig. 2) according to the relation $\lambda = k \cdot c \cdot \rho$, where *c* is the specific heat, ρ the density of the crystal, λ the thermal conductivity and *k* the thermal diffusivity.

In paper [5] measurements of the thermal diffusivity in the direction (1011) were already described. It was shown that the jump in thermal diffusivity is due to the jump of the elasticity constant. In the present measurements the jumps are found in both directions. This is a consequence of the contribution of all types of phonons.*

REFERENCES

- [1] Дзигаловичский И. Е., Лифшиц Е. М., ЖЭТФ 1 (1967), 299.
- [2] Корнфельд М. И., Чудинов А. А., ЖЭТФ 1 (1967), 33.
- [3] Shinnaka Y., J. Phys. Soc. of Japan 19 (1964), 1264.
- [4] Mariani E., Eckstein J., Rubinová E., Czech. J. Phys. B 17 (1967), 552.
- [5] Kubíček L., Fyz. časop. SAV 18 (1968), 58.
- [6] Křemepaský J., Čas. pro fyz. A 16 (1966), 136.
- [7] Kratoch F. C., Posnjak E., Hendricks S. B., J. Amer. Chem. Soc. 53 (1931), 3339.
- [8] Austin J. B., Pierce R. H. H., J. Amer. Chem. Soc. 55 (1933), 661.

Received July 9th, 1968

*Fyzikální ústav SAV,
Bratislava*

* We wish to express our thanks to Mr. J. Eckstein for preparing the single crystals of NaNO_3 , which he kindly gave us for our measurements.