Letters to the Editor

A NOTE ON THE THERMAL DIFFUSIVITY AND THE SPECIFIC HEAT OF THE Fe DOPED TGS CRYSTALS

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In the investigation of the thermal properties near the critical point today it seems to be of special interest to analyse the quantities not treated in the majority of theoretical and experimental works so far. Such quantities are the thermal diffusivity and the thermal conductivity. There seems to be a lack of information on the behaviour of both quantities near the critical point and the theoretical explanations are still within the limits of phenomenological descriptions.

From this point of view our work starts from the results [1] which presented the thermal characteristics of Ca doped $NaNO_3$ crystals near the critical point. The aim of the present paper is to confirm or to compare the results [1] with the thermal characteristics of the Fe doped TGS crystals. Regarding the present state of theory we shall try to interpret our results only qualitatively.

Similar as in [1] the pulse method [2] was used for the measurement of the thermal diffusivity and the specific heat. Heat pulses were realised by a current switching of $I \sim 0.5$ A for a time $\Delta t = 1$ sec through the resistance $R \sim 5-7\ \Omega$. Dimensions of the samples were 10 mm × 10 mm × 2−3 mm. The TGS pure crystals or crystals having a 1 % and 2 % Fe content were made by the firm "Monokrystaly Turnov".

The thermal diffusivity characteristics are shown in Fig. 1. The drop of the thermal diffusivity dependences proportional to the content of the defects in the crystal is caused similarly as in the Ca doped $NaNO_3$ crystals by impurities. For a better analysis of the specific heat values near the critical point the relative values $C/C_{21.5\,°C}$ are shown in Fig. 2. From Fig. 2 it follows that the sharper peaks on the specific heat curves are proportional to the defect concentrations. The bahaviour of the specific heat of the defect crystals is more typical for the λ transition than for the specific heat behaviour of the pure crystals.

The results of Mushinskij [3] were used for the interpretation of our measurements. In [3] the Ising model was analysed in the presence of different defect types. According to Mushinskij in the presence of defects either the shift of the critical point occurs or the transition region is wider and the position of the specific heat maximum depends on the impurity concentrations. In the presence of planar defects — block boundaries, grains — with the exception of the critical point an anomaly can arise at a point the position of which depends on the defect dimensions.

Our measurements do not exclude the existence of planar defects near 30 °C. It would be very necessary to support this hypothesis by structural measurements. It is more

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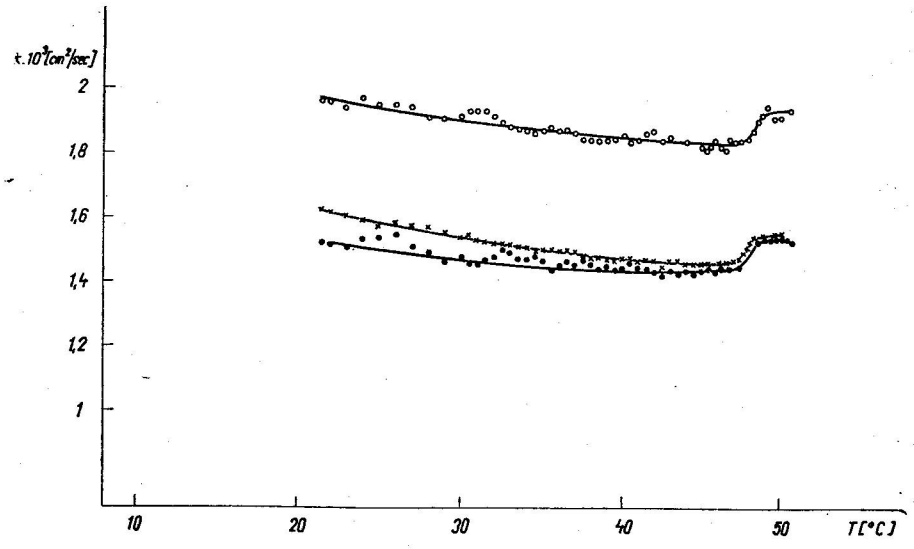

Fig. 1. Thermal dependence of the thermal diffusivity. ○ — TGS pure; × — TGS + 1 % Fe; ● — TGS + 2 % Fe.

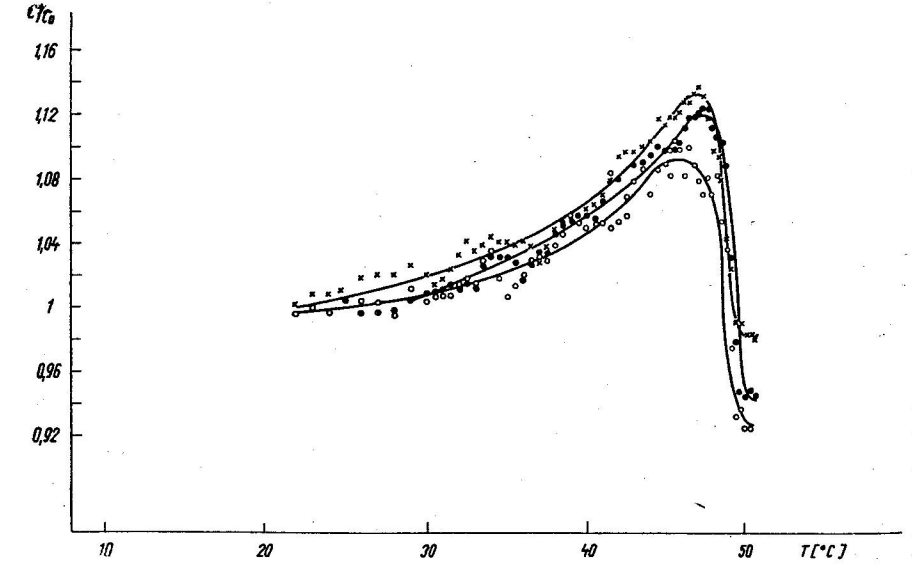

Fig. 2. Thermal dependence of the relative specific heat. ○ — TGS pure; ● — TGS + + 1 % Fe; × — TGS + 2 % Fe.

suitable to account for the shift of the critical point ΔT_c direct from the registrations of the heat response; the shift is −0.3 °C for TGS + 1 % Fe and −0.9 °C for TGS + 2 % Fe. The thermal characteristics are drawn as averages from several sets of measurements. The sharper peak of the specific heat curves for defect crystals near the critical point is in good agreement with the Watson conclusions [4]. According to him the change of the critical indices occurs in the defect lattices.

The drop of the thermal diffusivity typical near the critical point was observed also in [5] and from the phenomenological point of view is explained — with the thermal diffusivity

$$k = \tfrac{1}{3}\bar{v}\bar{l},$$

where $\bar{l}$ is the phonon free mean path, $\bar{v}$ the phonon mean velocity — by the change of the phonon group velocity and by the change of the phonon free mean path near the critical point. As the disorder of the system gets rather pronounced near the critical point and the sounnd velocity changes near the critical point are too small, it is supposed that the thermal diffusivity anomaly is caused first by the change of phonon free mean path resulting from the phonon scattering on the critical fluctuations. In the crystals containing defects we must add to the general scattering mechanism the scattering on the defects. An additional drop of the thermal diffusivity values proportional to the defect concentrations observed also in [1] is caused by the scattering on the defects.

The comparison of our results with the results in [1] shows a great importance of the thermal diffusivity measurements near the critical point, as the quantity gives direct information on the phonon free mean path behaviour near the critical point.

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