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The Influence of Hydrostatic Pressure on the Phase Transition Temperature of Ferroelectric Crystals of the KH_2PO_4-Type

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The shift of the transition temperature with pressure for KH_2AsO_4 ($dT_c/dp = (-3.3 \pm \pm 0.2)$ deg/kbar) and for RbH_2PO_4 ($dT_c/dp = (-8.2 \pm 0.3)$ deg/kbar) was determined by dielectric-constant measurements under hydrostatic pressure up to 1.2 kbar. The experimental data are analysed using a formula for the shift of T_c with pressure derived from Kobayashi's theory.

Aus dielektrischen Messungen unter hydrostatischem Druck bis zu 1,2 kbar wurde die Druckverschiebung der Umwandlungstemperatur für KH_2AsO_4 ($dT_c/dp = (-3{,}3 \pm \pm 0{,}2)$ grd/kbar) und für RbH_2PO_4 ($dT_c/dp = (-8{,}2 \pm 0{,}3)$ grd/kbar) bestimmt. Die experimentellen Daten werden auf der Grundlage einer Formel für die Druckverschiebung der Umwandlungstemperatur, diskutiert die aus der Theorie von Kobayashi abgeleitet wurde.

1. Introduction

KH_2PO_4 is the most typical substance among a group of hydrogen-bonded ferroelectrics. If hydrogen is substituted by deuterium, the transition temperature increases strongly, which has stimulated the experimental and theoretical work on KH_2PO_4 and KD_2PO_4. The influence of hydrostatic pressure on the phase transition of these substances was determined from neutron scattering by Umebayashi, Frazer, Shirane, and Daniels [1]; from dielectric-constant measurements on KD_2PO_4 by Samara [2], and on KH_2PO_4 by Hegenbarth and Ullwer [3]. Based on the tunneling model [4, 5], theoretical investigations on the influence of pressure on the phase transition have been made by Novaković [6] in the molecular-field approximation and by Blinc and Žekš [7] in the cluster approximation of Blinc and Svetina [8].

These authors explained the shift of the transition temperature with pressure in KH_2PO_4 and KD_2PO_4 thereby emphasizing the great importance of the tunneling motion of the hydrogen isotope in the O–H · · ·O bonds for the understanding of the isotope effect.

It is of interest to know how the other constituents of the lattice influence the phase transition and the ferroelectic behaviour. For this reason we measured the dielectric constant as a function of temperature under hydrostatic pressure up to about 1.2 kbar for KH_2AsO_4 and RbH_2PO_4 within the region of phase transition.

From the equation for T_c in Kobayashi's theory for KH_2PO_4-type ferroelectrics [9, 10] we derived a closed expression for the shift of T_c with pressure