phys. stat. sol. 38, K127 (1970)

Subject classification: 8; 23

Physik-Department der Technischen Hochschule München

Thermal Expansivity and Isothermal Compressibility of Solid Kr between 4 and 115 °K

By

H. J. COUFAL, R. VEITH[1], P. KORPIUN, and E. LÜSCHER

Recent calculations of the thermal expansivity and the isothermal compressibility (1) show that measurements with an accuracy of better than 5% are necessary to test the theoretical predictions. We have interferometrically measured the change of the specimen length as a function of temperature or pressure (2). By this method the thermal expansivity and the isothermal compressibility could be determined with an accuracy of better than 1% in the whole temperature region from 4 to 115 °K.

Crystals were grown in an apparatus constructed by Peter (3) which was similar to that described by Gsänger et al. (4). The krypton gas used had a purity of 99.9995%.[2] The specimens had lengths of about 50 mm and diameters of about 10 mm. The three investigated crystals were transparent. Neutron scattering data

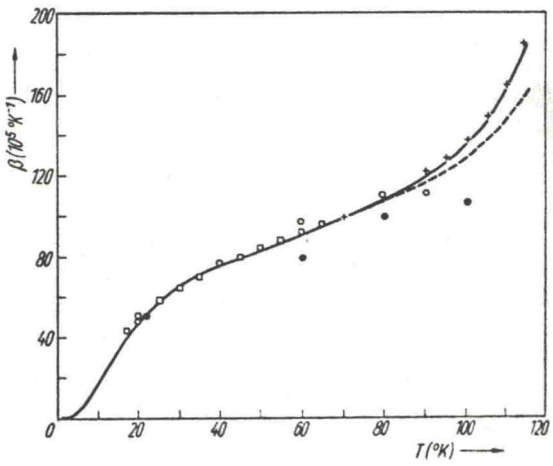

Fig. 1. Volume expansion coefficient β of solid krypton.
● L. H. Bolz and E. R. Maurer (not published), see Pollack (11);
○ Figgins and Smith (12);
□ Manzhelii et al. (6);
+ Gavrilko et al. (7, 8);
– – – – Losee et al. (9);
——— this work

1) Now Forschungslaboratorium der Siemens A. G., München, Germany.

2) Fa. Linde.

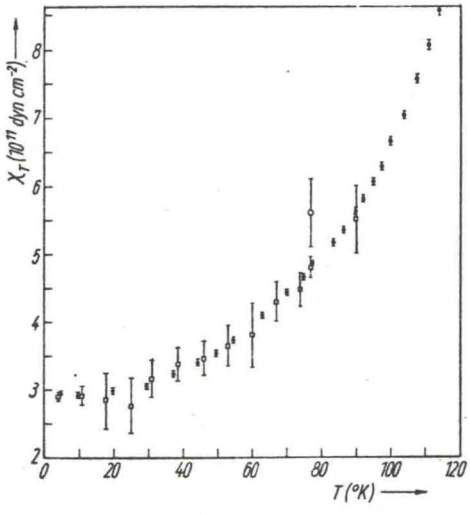

Fig. 2. Isothermal compressibility χ_T for Kr
o Stewart (13); □ Urvas et al. (10);
● this work

on similar crystals revealed that the specimens consisted of grains with diameters of approximately 5 mm (5). After the crystals were grown, they were transferred from the growing tube to the dilatometer chamber.

For the compressibility measurements a pressure from 1 to 20 bar was applied to the specimen by gaseous or liquid helium. The change of sample length was independent of whether the pressure was being raised or lowered; i.e., no hysteresis

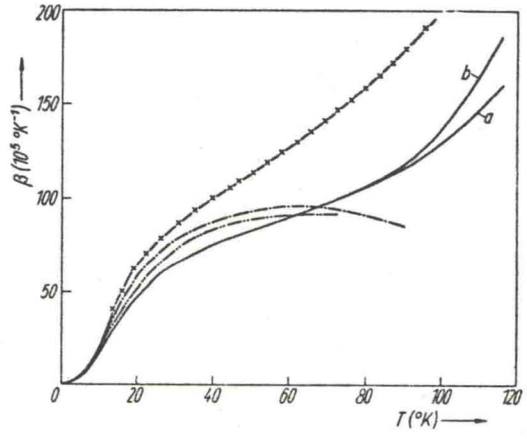

Fig. 3. Comparison of the experimental volume thermal expansion coefficient for Kr with theory (1). MLJ (12, 6) means (12, 6)-Mie-Lennard-Jones potential; qh: quasiharmonic, anh: anharmonic approximation; a: measured with X-rays (9); b: bulk expansivity measured in this work
—×— qh. MLJ (12, 6), —·— anh. MLJ (12, 6),
—··— anh. MLJ (13, 6), ——— experiment

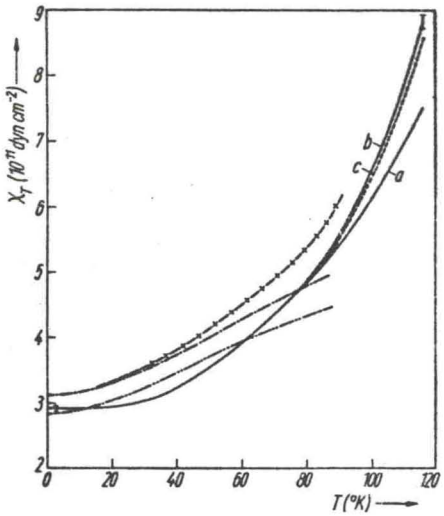

Fig. 4. Comparison of the experimental isothermal compressibility for Kr with theory (1). a: measured with X-rays (9, 10); b: bulk compressibility measured in this work; c: calculated from lattice and vacancy data (9)
—x— qh. MLJ (12, 6),
—·— anh. MLJ (12, 6),
—··— anh. MLJ (13, 6),
——— experiment

effect could be observed. In Fig. 1 and 2 the results for the volume thermal expansivity and the isothermal compressibility of Kr are plotted vs. temperature.

Manzhelii and coworkers have measured the bulk thermal expansivity of Kr in the temperature range from 14 to 69 °K and between 90 °K and the triple point (6 to 8). Their results agree well with our work within the experimental error (Fig. 1).

In the temperature region below 70 °K the curves for the thermal expansivity and the isothermal compressibility agree with those of Losee et al. (9) and Urvas et al. (10) as shown in Fig. 1 and 2. At higher temperatures there is a contribution from thermally created vacancies to these quantities. Above 80 °K the deviations of our measurements of the bulk expansivity from those measured by Losee et al. (9) with X-rays increase with temperature. Within experimental error the isothermal compressibility between 90 and 115 °K agrees with the values calculated by Losee et al. from their lattice data and the vacancy concentration (9).

Feldman et al. have calculated the thermal expansivity and the isothermal compressibility for several Mie-Lennard-Jones potentials in different approximations (1). The results are presented in Fig. 3 and 4.

This work was supported by the Deutsche Forschungsgemeinschaft.

References

(1) M. L. KLEIN, G.K. HORTON, and I. L. FELDMAN, Phys. Rev. 184, 968 (1969).

(2) R. VEITH, H.J. COUFAL, P. KORPIUN, and E. LÜSCHER, to be published.

(3) H. PETER, Diploma work, Physik Department der Technischen Hochschule München, 1968.

(4) M. GSÄNGER, H. EGGER, G. FRITSCH, and E. LÜSCHER, Z. angew. Phys. 26, 334 (1969).

(5) H. PETER, P. KORPIUN, and E. LÜSCHER, Phys. Letters (Netherlands) 26A, 207 (1968).

(6) V.G. MANZHELII, V.G. GAVRILKO, and E.I. VOITOVICH, Soviet Phys.-Solid State 9, 1157 (1967).

(7) V.G. GAVRILKO, V.G. MANZHELII, V.I. KUCHNEV, and A.M. TOLKACHER, Soviet Phys.-Solid State 10, 2524 (1969).

(8) V.G. MANZHELII, V.G. GAVRILKO, and V.I. KUCHNEV, phys. stat. sol. 34, K55 (1969).

(9) D.L. LOSEE and R.O. SIMMONS, Phys. Rev. 172, 944 (1968).

(10) A.O. URVAS, D.L. LOSEE, and R.O. SIMMONS, J. Phys. Chem. Solids 28, 2269 (1967).

(11) G.L. POLLACK, Rev. mod. Phys. 36, 748 (1964).

(12) B.F. FIGGINS and B.L. SMITH, Phil. Mag. 5, 186 (1960).

(13) J.W. STEWART, J. Phys. Chem. Solids 29, 641 (1968).

(Received February 25, 1970)