THE MAGNETIC PROPERTIES OF BERYLLIUM IN THE TEMPERATURE RANGE 300 TO 4.2°K

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The angular dependence of χ for beryllium (above 20°K) and indium is found to be described by a cosine law. The temperature dependence of the principal values of χ for beryllium is characteristic for small groups of electrons. In the case of indium, χ is found to be highly sensitive to impurities.

WE have continued our investigation[1] of the magnetic properties of pure elements that show a long-period de Haas–van Alphen effect. The measurements were made by the Faraday method with a vertical gradient in fields up to 10 koe. A spring balance with photoelectric auto-compensation was used (analogous in principle to those described by Deryagin[2] and Hedgcock[3]). The accuracy of the absolute measurements was ~ 2%, the relative ones ~ 0.5%.

The angular dependence of the magnetic susceptibility of two samples of beryllium* (Be-1 and Be-2, 99.99% pure) and two samples of indium (In-1, which was studied in previous work,[1] and In-3) was measured at various temperatures in the range from 300 to 4.2°K.

Up until the appearance of the de Haas–van Alphen effect the angular dependence of χ for beryllium obeys the law (Fig. 1):

$$\chi(\theta) = \chi_{\parallel} \cos^2\theta + \chi_{\perp} \sin^2\theta. \quad (1)$$

In order not to clutter the figure the data for only a few temperatures are shown in it. The dependences calculated according to Eq. (1) are portrayed as continuous curves; the experimental points were taken every 5°, sometimes every 1°.

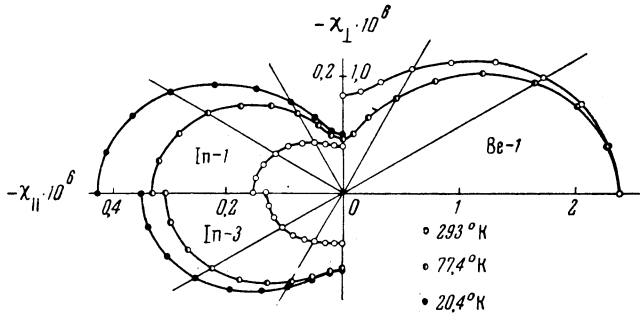

FIG. 1. The angular dependence of the magnetic susceptibility of beryllium and indium at various temperatures. The continuous curves are plots of Eq. (1).

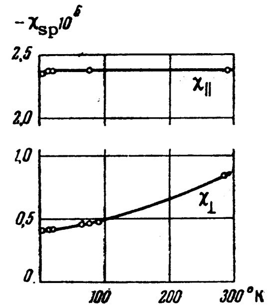

FIG. 2. Temperature dependence of the principal values of the specific susceptibility of beryllium.

The principal values of the susceptibility ($\chi_{\parallel} = 2.38 \times 10^{-6}$, $\chi_{\perp} = 0.80 \times 10^{-6}$ cm³/g) and their temperature dependence agreed well for both samples of Be (Fig. 2). The character of the growth of $|\chi_{\perp}|$ with increasing temperature can be attributed to the contribution of the paramagnetism of groups containing small numbers of electrons (or holes). As in the majority of the elements studied earlier, the anisotropy decreases with increasing temperature, and the temperature-dependent component of the susceptibility tensor asymptotically approaches the independent (or weakly dependent) component. The latter probably constitutes a background for the small groups, caused by the contribution of other mechanisms and of large groups. In beryllium $\chi_{\perp}$ shows not only a temperature dependence, but also a periodic field dependence even at $T \approx 20°K$, confirming, as in the other elements, the correlation of this phenomenon with the presence of small groups of mobile charges. At $T \leq 20°K$ the value of $\chi_{\perp}$ was determined from the average of the dependence of $\chi_{\perp}$ on the magnitude of the reciprocal of the field.

*We express thanks to A. A. Kruglykh for the gift of the monocrystals of pure beryllium.

The curve of $\chi(\theta)$ for the indium samples also follows the cosine law (Fig. 1). However, although both samples were prepared from the very same starting material, the absolute values of χ and their dependence on temperature differ markedly. It is likely that small amounts of impurity have as significant an effect in indium as in bismuth[4] and antimony[5] (interestingly, it differs in different directions). It can be presumed that the high anisotropy of this metal is caused wholly by small groups that do not show up in the electrical and galvanomagnetic properties.

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[1] Aleksandrov, Verkin, and Svechkarev, JETP **39**, 37 (1960), Soviet Phys. JETP **12**, 25 (1961).

[2] B. V. Deryagin, Doklady Nauk SSSR **61**, 275 (1948).

[3] F. T. Hedgcock, Phys. Rev. **104**, 1564 (1956).

[4] A. Goetz and A. B. Focke, Phys. Rev. **45**, 170 (1934); D. Shoenberg and M. Zaki Uddin, Proc. Roy. Soc. (London **A156**, 687 (1936).

[5] S. H. Browne and C. T. Lane, Phys. Rev. **60**, 895 (1941).

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103