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PRESSURE DEPENDENCE OF THE MAGNETIC ANISOTROPY ENERGY OF NICKEL BETWEEN 300 K AND 4.2 K

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The effects of hydrostatic pressure on the magnetic anisotropy energy of nickel have been studied between 300 K and 4.2 K with pressures up to 6 kbar, with special attention for the complicated angle dependence of this energy at low temperature. The relative change with pressure (in 10^{-2} /kbar) of the first anisotropy constant varies between 300 K and 4.2 K from -0.75 to -0.15. Experiments in the (100) -plane do not show any influence of pressure on the higher order contributions to this energy.

TORQUE experiments on the magnetic anisotropy energy of a ferromagnetic single crystal with cubic symmetry can be described in the (100) -plane by the expression:

$$L_A^{100}(\nu) = -\sin 2\nu \times \cos 2\nu$$
$$(B_1 + B_2 \sin^2 2\nu + B_3 \sin^4 2\nu + ..) \qquad (1)$$

where ν is the angle between $\vec{M}$ and the [001]- direction, $B_1 = K_1$, $B_2 = \frac{1}{2}K_3$, etc., with K_1, K_3, etc., the anisotropy constants, defined in the usual way.[1] The extrema in expression 1, denoted by L_{ex}, are found for $\nu = \pi/8, 3\pi/8, ..$ and are equal to $\pm\frac{1}{4}(K_1 + \frac{1}{2}K_3 + ...)$.

In addition to previous experiments at 77 K and 296 K,[2] these extrema have now been studied under pressure between 4.2 K and 300 K. The torque measurements were performed on a pure nickel sphere (diameter 7.6 mm) in nearly the same manner as described in reference 2. By using a capillary tube with an outer diameter of 1 mm and a length of 700 mm, the connection between the high pressure vessel and the pressure generating system is sufficiently weak to permit an accurate study of the magnetic torque in nickel.

Between 77 K and 300 K helium gas was used as the pressure transmitting medium. At the 4.2 K we made use of the solid helium technique. To get at this temperature the pressure as hydrostatic as possible the helium gas was frozen from the bottom of the vessel under constant pressure in a way as described by Schirber.[3] The pressure was measured with a manganine cell and checked by strain gauges on the outer side of the high pressure vessel. At 4.2 K the pressure was determined directly with these strain gauges.

The effect of pressures on the extrema in the torque curve is purely linear as is shown in Fig. 1, where the decrease in the maximum torque with pressure at 77 K is demonstrated as an example. In Fig. 2 we present the relative and the absolute changes of the extrema under pressure as a function of temperature. At 77 K two results are shown, one with a more accurate technique that was needed in order to perform the experiments at 4.2 K. From the four extrema at 77 K we found for the relative change with pressure of the maximum torque: $(-0.20 \pm 0.005) \times 10^{-2}$/kbar. Literature data at room temperature[2,4,5] at 77 K[2] and between 260 K and 300 K[6] are in agreement with the data of Fig. 2.

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