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MAGNETIC SUBLATTICE INVERSION IN UNIAXIALLY COMPRESSED MANGANESE FLUORIDE

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A study has been made of the effect of uniaxial compression on the critical field for inversion of the magnetic sublattice of antiferromagnetic MnF_2 at T = 4.2°K. The method used allows an external pulsed magnetic field to be established along the symmetry axis of the crystal with an accuracy of $\vartheta \leq 5'$, and comparative measurements to be made of H_c for compressed and free specimens. The minimum width of the transition region close to H_c = 91.7 kOe is ~300 Oe and is doubled when $\vartheta \sim 20'$. When uniaxial compression is applied along the four-fold axis the transition region becomes wider, with H_c growing almost linearly with pressure, such that $(1/H_c)(dH_c/dp) = 2.9 \cdot 10^{-12}$ cm^2/dyn. The magnitude of the effect is in agreement with the size of the magnetostriction jump in the critical field, measured earlier. An analysis of the contributions of magnetic-dipole coupling and classical magnetostriction shows that part of the effect is due to the dependence of the exchange integrals J_{12} between ions of opposite sublattices on the interatomic distances, where $-(1/\chi_\perp)(d\chi_\perp/dp) = (1/J_{12})(dJ_{12}/dp) = 1.9 \cdot 10^{-12}$ cm^2/dyn.

Molecular field theory has established [1] a simple link between the magnetic susceptibility $\chi_\perp$ of an antiferromagnet measured in sufficiently strong fields at low temperatures, and the intersublattice exchange integral J_{12}. From this it follows that the relationship between J_{12} and the interatomic distances can be reliably determined by measuring how $\chi_\perp$ is influenced by the external pressure. However, attempts at measurement come up against the difficulty of detecting small increments $\chi_\perp(p)$ against a background of large $\chi_\perp$ values, which is scarcely feasible at the accuracy level of traditional methods. The problem can be resolved, however, through a study of the pressure dependence of the critical field for inversion of the magnetic sublattice H_c, since the field strength can be measured quite accurately. In fact at low temperatures H_c can be written in the form

$$H_c = \sqrt{\frac{K}{\chi_\perp}}, \qquad (1)$$

where K is the anisotropy constant. Since it is often possible to calculate the relationship between K and the pressure, by making an experimental study of H_c we can also determine the sought-for $\chi_\perp(p)$ relationship.

1. MEASUREMENT OF THE CRITICAL FIELD

The inversion field of the MnF_2 magnetic sublattice is equal to $H_c \simeq 95$ kOe [2]. A magnetic field of this value can be obtained without difficulty under pulsed conditions. In the present investigation a pulsed field was developed in a cooled multiturn solenoid (internal diameter 25 mm, length 100 mm), which provided a high, uniform field within the specimen. When the capacitor bank was discharged through the solenoid, with a total charge energy of up to 75 kJ, a magnetic field pulse (H) was created in the solenoid which reached its maximum value (up to 300 kOe) in $7.5 \cdot 10^{-3}$ sec. A field