

substance: MnO
property: magnetic properties

Néel temperature

T_N	118.5 K	heat capacity	81K
	117.9 K	magnetic susceptibility	81J
	116.9 K	Moessbauer data	67S
	116 K	magnetic susceptibility	61B
	117 K	magnetic susceptibility	65L
	117.8 K	heat capacity	51T
	117.7 K	neutron data	66L
	119.7 K	neutron data	74P
	117.5 K	critical neutron scattering	78B

magnetic susceptibility

high temperatures:

Curie-Weiss law satisfied: $\chi = C/(T+\Theta_p)$ with $\Theta_p = 540$ K [65L] = 461 K [61B]. Above $T = 5 T_N$ data is conflicting: according to [65L] Curie-Weiss law not obeyed, but according to [61B] a good fit to the expression was found for $T \leq 1200$ K with $C_m = 3.78$ K cm³/mol, a value considerably lower than the expected spin-only value.

lower temperatures:

susceptibility maximum at 122.5(5) K [66L], 117.9 K [81J] and marked field dependence (Fig. 1) and stress dependence [81J]. Neutron scattering data [51S, 58R1, 58R2, 66B] and Moessbauer [67S] show that the spins order into (111) sheets that are coupled antiferromagnetically. The spins are confined within the (111) sheets and point in the $[1\bar{1}0]$ direction or in one of the two directions at 120° to this. There is little anisotropy within the plane [66B, 79B]. Long-range spin-ordering: Fig. 2. Low temperature magnetic moment is $2.34 \mu_B/\text{Mn}^{2+}$ at 4.2 K, reduced from the expected 2.5 by covalency effects [73J].

spin-wave dispersion: Fig. 3.

spin-wave Hamiltonian parameters

For $T > T_N$ the data can be analysed in terms of a simple Hamiltonian of the form

$$H = \sum_{nn} J_1 \mathbf{s}_i \cdot \mathbf{s}_j - \sum_{nnn} J_2 \mathbf{s}_i \cdot \mathbf{s}_j$$

where the first summation is over all the nearest neighbours and the second sum is over all the next-nearest neighbours. For $T < T_N$, the rhombohedral distortion leads to two distinct nearest neighbour coupling constants J_1^+ and J_1^- corresponding to the nearest neighbours with spins parallel and antiparallel, respectively. The total Hamiltonian also contains an anisotropy term and hence has the form

$$H = - \sum_{nnp} J_1^+ \mathbf{s}_i \cdot \mathbf{s}_j - \sum_{nnn} J_1^- \mathbf{s}_i \cdot \mathbf{s}_j - \sum_{nnn} J_2' \mathbf{s}_i \cdot \mathbf{s}_j + \sum_i D_1 (s_i^x)^2 + \sum_i D_2 (s_i^y)^2. \quad 74P$$

For $T > T_N$ ($J_{1,2}$ in meV)

J_1	- 0.366	nearest neighbour coupling	74P
	- 0.383	constant	74K
	- 0.861	calculated value	72B
J_2	- 0.414	next nearest neighbour coupling	74P
	- 0.458	constant	74K
	- 0.947	calculated	72B
ϵ_1	25.8	$\epsilon_1 = -d \ln J_1 / d \ln r$, where r is	74P
	23.0	the nearest-neighbour distance,	74K
	23.0	similar definition for ϵ_2	72B
	27(5)		73S
ϵ_2	14.0		74P
	11.8	calculated value	72B

for $T < T_N$ ($J_{1,2}$; $D_{1,2}$ in meV)

J_1^+	- 0.428	$T = 4.2$ K	74P
J_1^-	- 0.324		
J_2'	- 0.420		
D_1	0.059		
D_2	0.0015		

References:

- 51S Shu, C. G., Strauser, W. A., Wollan, E. O.: Phys. Rev. 83 (1951) 333.
- 51T Todd, S. S., Bonnickson, K. R.: J. Am. Ceram. Soc. 73 (1951) 3894.
- 58R1 Roth, W. L.: Phys. Rev. 110 (1958) 1333.
- 58R2 Roth, W. L.: Phys. Rev. 111 (1958) 772.
- 61B Benewicz, J., Heidelberg, R. F., Luxem, A. H.: J. Phys. Chem. 65 (1961) 615.
- 65L Lines, M. E., Jones, E. D.: Phys. Rev. A139 (1965) 1313.
- 66B Blech, I. A., Averbach, B. L.: Phys. Rev. 142 (1966) 237.
- 66L Lindsay, R., Michelsohn, F.: Bull. Am. Phys. Soc. 11 (1966) 108.
- 67B Bloch, D., Feron, J. L., Georges, R., Jacobs, I. S.: J. Appl. Phys. 38 (1967) 1474.
- 67S Siegworth, J. D.: Phys. Rev. 155 (1967) 285.
- 68B Bloch, D., Cherbit, P., Georges, R.: Compt. Rend. 266B (1968) 430.
- 72B Bartel, C. L.: Solid State Commun. 11 (1972) 55.
- 73J Jacobsen, A. J., Tofield, B. C., Fender, B. E. F.: J. Phys. C6 (1973) 1615.
- 73S Seino, D., Miyahara, S., Naro, Y.: Phys. Lett. A44 (1973) 35.
- 74K Kohgi, M., Ishikawa, Y., Hawada, I., Motuzuki, K.: J. Phys. Soc. Jpn. 36 (1974) 112.
- 74P Pepy, G.: J. Phys. Chem. Solids 35 (1974) 433.
- 78B Betsuyaki, H.: Nip. Gaish. Keuk., Ann. Rep. Neutron Scatt. Stud. JAERI-M-8089 (1978).
- 79B Bidoux, R., Coute, R., Nasser, J. A.: J. Appl. Phys. 50 (1979) 1683.
- 81J Jagadesh, M. S., Seehra, M. S.: Phys. Rev. B23 (1981) 1185.
- 81K Kleinclauss, J., Mainard, R., Fousse, H., Ciret, N., Bour, D., Pointon, A. J.: J. Phys. C14 (1981) 1163.

Fig. 1.

MnO. Magnetic susceptibility vs. temperature for (a) MoO powder at various magnetic fields [67B], (b) MnO single crystals stressed at 52 bar along $[111]$; χ_{\parallel} : $B \parallel (111)$, χ_{\perp} : $B \perp (111)$ [81J]. χ in CGS-emu.

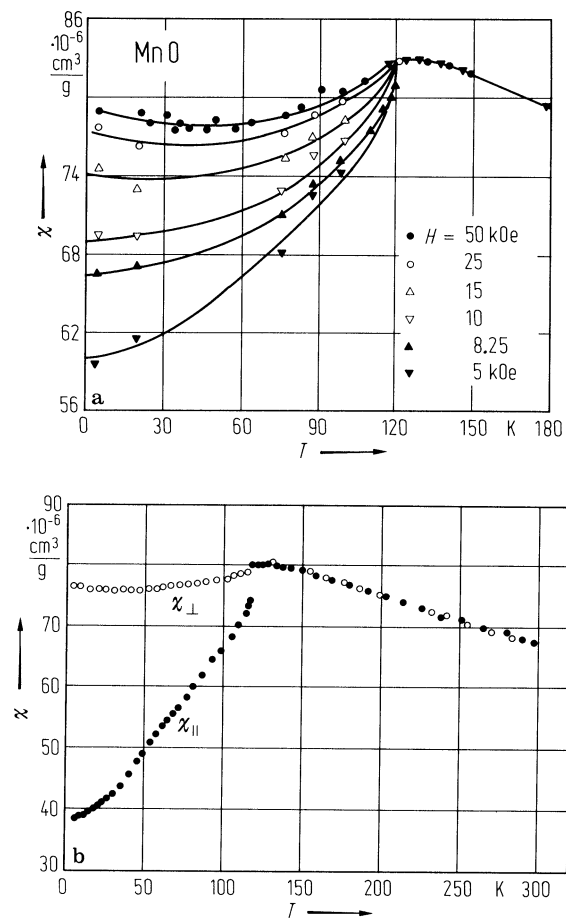


Fig. 2.

MnO. Long range order parameter defined as $S = r_a - w_a = r_b - w_b$ where r_a is the fraction of spin-up sublattice sites occupied by spin-up Mn and w_a is the fraction of spin-up sublattice sites occupied by spin-down Mn and a similar definition holds for the b-sites vs. temperature. Measurements of various authors [66B].

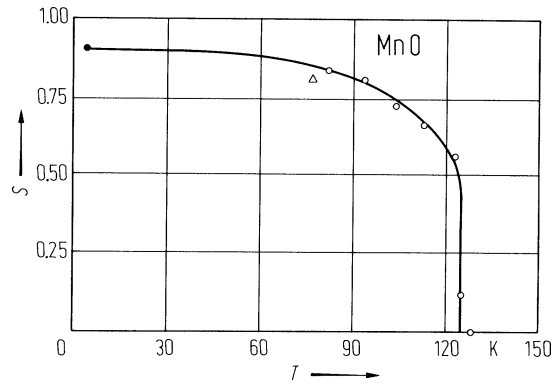


Fig. 3.

MnO. Spin wave dispersion curves at (a) 4.2 K, (b) 88.75 K, (c) 113.75 K obtained by inelastic neutron scattering [74P].

