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Neutron diffraction study in magnetic field of antiferromagnetic garnet $Ca_3Mn_2Ge_3O_{12}$

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Résumé. — Des expériences de diffraction des neutrons sous champ magnétique viennent d'être effectuées sur le grenat antiferromagnétique $Ca_3Mn_2Ge_3O_{12}$ de part et d'autre de T_N. Elles mettent en évidence à la fois l'existence sous champ magnétique d'une phase métamagnétique à $T < T_N$ ainsi que celle d'un ordre antiferromagnétique induit lorsque le champ magnétique est appliqué le long de [110].

Abstract. — Neutron diffraction studies of antiferromagnetic garnet $Ca_3Mn_2Ge_3O_{12}$ in magnetic fields have been made above and below T_N. They show the existence of a metamagnetic phase at $T < T_N$ in finite magnetic fields and of an induced antiferromagnetic ordering at $T > T_N$ when the magnetic field is applied along [110].

Recently, neutron diffraction experiments have been performed on powdered antiferromagnetic garnet $Ca_3Mn_2Ge_3O_{12}$ [1], [2], [3] (coined as MnGeG in [4]), at various temperatures, and as a function of magnetic field.

Figure 1 shows the temperature dependence of the (110), (310) and (211) reflections, the two first only being magnetic. The Néel temperature $T_N = 13.85$ K obtained from specific heat measurements [2] is thus confirmed. At 4.2 K, in the presence of a magnetic field aligned along the scattering vector ($H /\!/ k$), we observe at a threshold field of about 27 kOe an increase in the (110) magnetic reflection (Fig. 2).

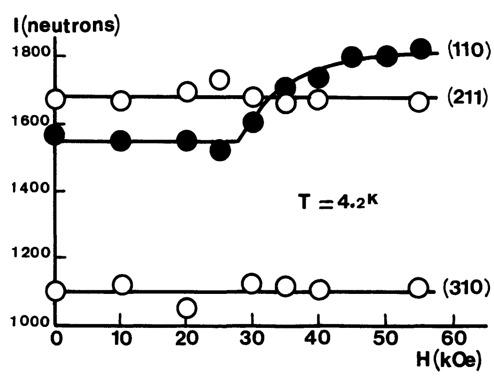

Fig. 2. — Evolution of some magnetic reflections in magnetic fields at 4.2 K.

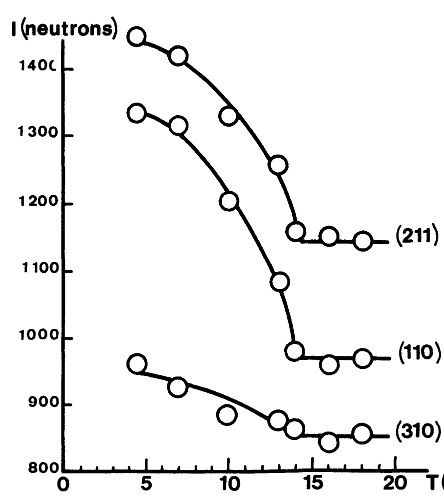

Fig. 1. — Temperature dependence of some magnetic reflections.

No intensity change may be detected in the other reflections at the same temperature and in magnetic fields up to 55 kOe (Fig. 2).

At 4.2 K $< T < T_N$, the magnetic reflections (110), (211) and (310) have been followed in magnetic fields of up to 15 kOe in the ($H /\!/ k$) situation. Except for an increase in the (110) reflection occurring at a critical field $H_c(T)$ decreasing with temperature (Fig. 3), no modification of the other reflections is noticed. It is quite remarkable that the threshold magnetic field at which a jump is observed in the magnetization curves [1] has the same temperature dependence.

Again applying the magnetic field along the scattering vector at $T > T_N$, we observe (Fig. 3), that the (110)

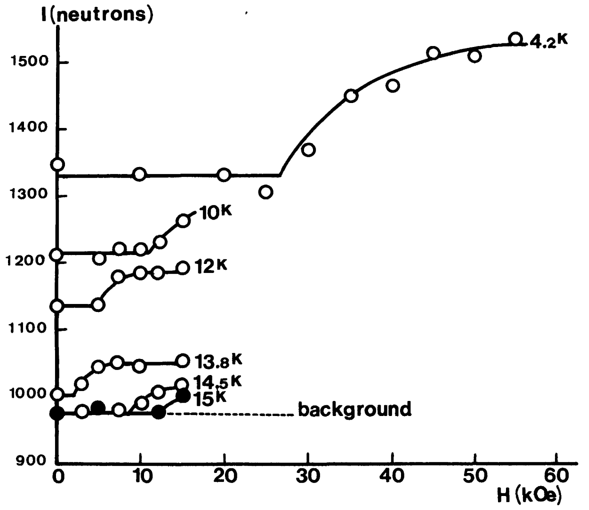

Fig. 3. — Temperature dependence of the threshold field for (110) intensity increase.

magnetic reflection reappears at a threshold field which is now an increasing function of temperature. No change is observed in the other reflections in that range of temperature. With a laboratory field not exceeding 15 kOe, the appearance of the (110) reflection has been followed up to 15.2 K. Careful search indicates that there is no change in the line width of this reflection on both sides of T_N (Fig. 4).

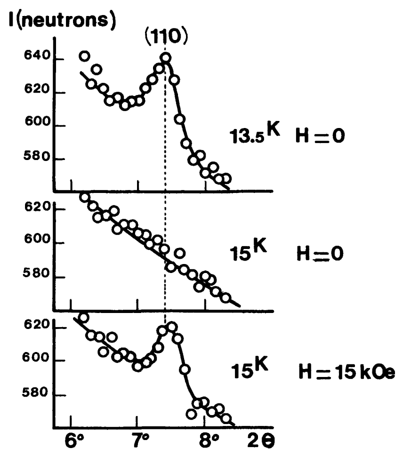

Fig. 4. — Magnetic (110) reflection on both sides of T_N.

These neutron diffraction observations give weight to the expected phase diagram (Fig. 5) previously obtained [2] from specific heat and magnetization measurements and which indicates that even at $T > T_N$ and at finite magnetic fields, a metamagnetic

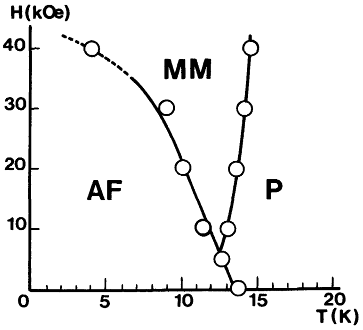

Fig. 5. — Phase diagram of $Ca_3Mn_2Ge_3O_{12}$ from Belov *et al.* [2].

structure becomes more stable than the magnetic structure observed in zero field.

In one of the experiments performed at 4.2 K under magnetic fields, the crystallites were left free to rotate. A further increase in the (110) magnetic reflection is observed, together with an increase of the nuclear reflection (220), indicating that in the metamagnetic phase $Ca_3Mn_2Ge_3O_{12}$ is a weak ferromagnet. No modification may be detected under such circumstances either of the other magnetic or of the nuclear reflections (Fig. 6).

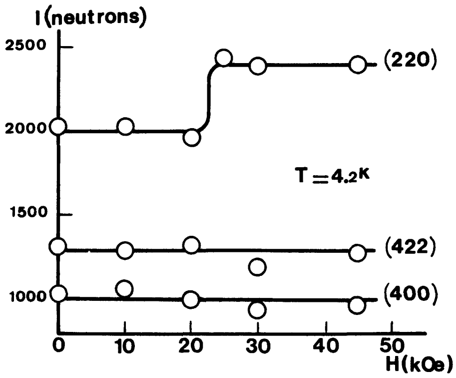

Fig. 6. — Nuclear reflections in magnetic field when free rotation of the crystallites is allowed.

At magnetic field values higher than the threshold field, the [110] direction may thus be regarded as an easy direction of magnetization. The particular part played by this direction has recently been confirmed by magnetization curves obtained with a single crystal of $Ca_3Mn_2Ge_3O_{12}$ [5].

Similar neutron diffraction experiments leading to finite magnetic intensities at $T > T_N$ have recently been reported on the antiferromagnetic compound [6], Cu $(HCOO)_2.4D_2O$.

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