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Magnetic Properties of the Spinel SnCo_2O_4

V. Sagredo, B. Watts* and B. Wanklyn**

Physics Department, Universidad de los Andes, Mérida, Venezuela

** MASPEC/CNR Institute, Via Chiavari 18/A, Parma, Italy*

*** Clarendon Laboratory, Oxford University, Oxford, U.K.*

Abstract. The compound SnCo_2O_4 is an inverted IV-II spinel with the Co ions equally distributed among the octahedral and tetrahedral sites. The Sn ions occupy the remaining octahedral sites. This compound was previously thought to order as a Néel p-type ferrimagnet with the residual magnetization of $1 \times 10^{-2} \mu_B$ per Co^{2+} ion.

This paper extends the magnetic measurements to ZFC and FC data at low temperatures and low applied magnetic field. Magnetic measurements on the SnCo_2O_4 single crystals grown by the flux method suggest a re-entrant ferrimagnetic behaviour at low temperature. Suggestions are made for the origin of canting.

1. INTRODUCTION

Spinel compounds are of current interest owing to their physical properties, which are essentially due to: (i) the existence of two types of crystallographic sublattices, tetrahedral (A) and octahedral (B), available for the metal ions; (ii) the great flexibility of the structure in hosting various metal ions. In the last few years it has been definitely shown that disordered magnetic structures, such as the spin-glass state, can also be stabilized if a sufficient degree of frustration and disorder in the distribution of magnetic interactions is produced in the lattice [1].

The case of systems with two magnetic sublattices is particularly interesting because they have been the object of intensive experimental studies and they can exhibit at least one particular disordered magnetic phase. At low temperature localised canted state is phenomenologically equivalent to the re-entrant state or semi-spin-glass phase [2,3].

We report magnetic measurements on the SnCo_2O_4 compound in which the nonmagnetic Sn ions occupy the octahedral or B sites of the spinel structure. The Co^{2+} ions occupy the remaining B sites and the tetrahedral sites. At low temperature the spin configuration differs strongly from the Néel collinear structure observed in most of the magnetic compounds of spinel structure. It is known that no long-range magnetic order takes place if the magnetic ions are so diluted that there is percolation and spin-glass like behaviour is usually observed around the percolation threshold.

2. EXPERIMENTAL

The samples have been obtained by the flux growth technique using platinum crucibles and KF as flux. This technique is especially useful for the synthesis of new compounds because it enables crystals of both congruently and incongruently melting point materials (4). X-ray diffraction patterns show an inverse spinel structure at room temperature with a lattice parameter of $a = 8.639(2) \text{ \AA}$ in a good agreement with the value obtained by P.Poix (5).

Most of the low temperature magnetic measurements were carried out with a commercial SQUID magnetometer in the temperature range of 2-70 K and magnetic fields up to 5 T. High temperature magnetic susceptibility have been carried out with a Faraday system

3. RESULTS AND DISCUSSION

The magnetization varies linearly with the magnetic field above 42 K, as is shown in Fig.1 where the compound becomes paramagnetic. At lower temperature it appears that the magnetic saturation could not be obtained up to 50 KOe suggesting the presence of large degree of spin-disorder. At high temperature the susceptibility follows a Curie-Weiss law, the Curie constant and the Curie paramagnetic temperature are respectively 4.4 emu/mole and -142 K. The curvature of the reciprocal susceptibility above 42 K is typical of a ferrimagnetic and similar to the Hermon's results

The results reported in Fig.2 show the appearance of important thermoremanent magnetization below 42 K where curve(1) corresponds to a zero field cooled data and curve (2) is the zero field data. The obtained results are in very good agreement with Hermon et.al. [6] FC and ZFC magnetization measurements, shown in Fig. 2 seem to demonstrate strong irreversibilities as in spin-glass or spin-glass like phases. These irreversibilities are field dependent in the whole temperature range below $T_N = 42 \text{ K}$.

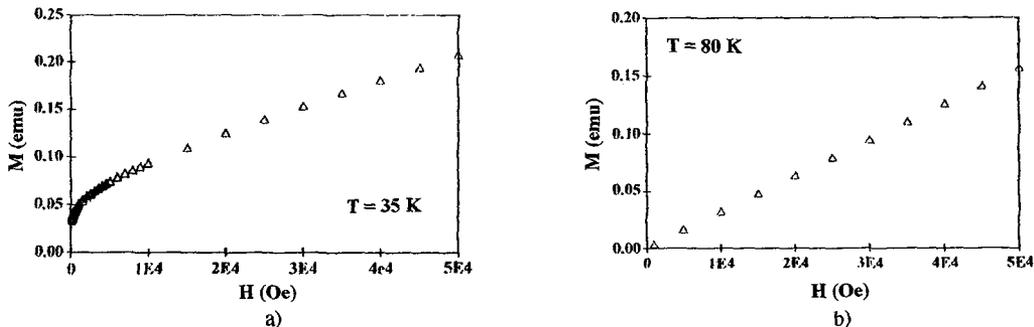


Figure 1: Magnetization curves near the Néel temperature , a) $T = 35$ K b) $T = 80$ K

The overall behaviour of the SnCo_2O_4 compound is ferrimagnetic with a Néel temperature of 42 K. The thermoremanent magnetization and magnetic training are characteristic of disordered spin configurations. It was established by Villain [1] that the system consisting of a nonvanishing average longitudinal spin component and a transverse spin-glass component called semi-spin-glass results from the dilution of the magnetic ions in a highly frustrated compounds. However Villain has predicted two transitions in a semi-spin-glass, the Néel temperature corresponding to the collapse of the longitudinal spin component and a second temperature T_G at which the transverse spin component freezes in. Below T_G all the features of the spin-glass must be observed. Our data did not show any additional transition therefore owing the similarities between our observations and theoretical predictions we claim that the SnCo_2O_4 compound is a reentrant ferrimagnetic material with $T_N = 42$ K assuming that the A and B sites freezes very close each other

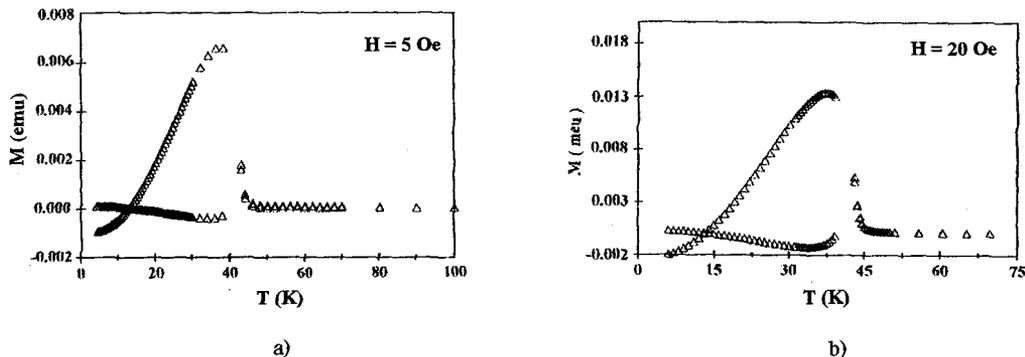


Figure 2: ZFC and FC magnetization vs temperature for two applied field. a) $H = 5$ Oe b) $H = 20$ Oe

The origin of the frustration is not clear and cannot be inferred from the data. However we would like to suggest the following hypothesis. In the spinel structure, the A-B interactions are usually the strongest and a collinear spin configuration results. Then the presence of Sn ions randomly distributed on the B sites may locally break the octahedral symmetry of the crystal field and produce a random anisotropy

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References.

- [1] Villain J., *Z.Physik* **B33** (1979) 31.
- [2] Dormann J.L., and Nogues M., *J.Phys.:Condens.Matter* **2** (1990) 1223.
- [3] Alba M., Hammann J., and Nogues M., *J.Phys. C* **15** (1982) 5441.
- [4] Watts B.E., Dabkowska H., and Wanklyn B.M., *J.Crystal Growth* **94** (1989) 125.
- [5] Poix P., *Ann.Chim.* **9** (1964) 274.