MAGNETIC PHASE DIAGRAM IN THE FERRIMAGNETIC SPIN GLASS SYSTEM $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$

R. Rodriguez, X. Obradors, A. Labarta, J. Tejada, M. Pernet, M. Saint Paul,
J. Tholence

► To cite this version:

R. Rodriguez, X. Obradors, A. Labarta, J. Tejada, M. Pernet, et al.. MAGNETIC PHASE DIAGRAM IN THE FERRIMAGNETIC SPIN GLASS SYSTEM $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$. Journal de Physique Colloques, 1988, 49 (C8), pp.C8-1119-C8-1120. 10.1051/jphyscol:1988514 . jpa-00228721

HAL Id: jpa-00228721

<https://hal.science/jpa-00228721>

Submitted on 1 Jan 1988

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

MAGNETIC PHASE DIAGRAM IN THE FERRIMAGNETIC SPIN GLASS SYSTEM $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$

R. Rodriguez ⁽¹⁾, X. Obradors ⁽¹⁾, A. Labarta ⁽¹⁾, J. Tejada ⁽¹⁾, M. Pernet ⁽²⁾, M. Saint Paul ⁽³⁾ and J. L. Tholence ⁽³⁾

⁽¹⁾ *Fac. Física. Universitat de Barcelona. Barcelona, Spain*

⁽²⁾ *Lab. Cristallographie, CNRS 166X, 38042 Grenoble, France*

⁽³⁾ *CRTBT, CNRS, 166X, 38042 Grenoble, France*

Abstract. - We report here on low field dc and ac magnetic susceptibility measurements on the compounds $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$ with $x = 0$ to $x = 4$. We have determined their magnetic phase diagram and proved that increasing the Ga content in the structure we cross from ferrimagnetic-like ordering and spin glass reentrance to pure spin glass behaviour and finally to the disappearance of any magnetic ordering in $\text{SrCr}_8\text{Ga}_4\text{O}_{19}$ as a consequence of the reduced lattice dimensionality.

Introduction

In a recent report [1] we have shown that the $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$ hexagonal ferrite displays a quenched ferrimagnetic like ordering in the $67 \text{ K} \leq T \leq 250 \text{ K}$ temperature range and a spin glass reentrance below $T_g \simeq 67 \text{ K}$. On the other hand, the extrem series compound $\text{SrCr}_8\text{Ga}_4\text{O}_{19}$ does not display any magnetic ordering above 4.2 K [2] in spite of having very strong antiferromagnetic interactions ($\theta/T_g \simeq 117$). It was argued on the basis of the consideration of the topological features of the octahedral site of the magnetoplumbite structure that a strong magnetic frustration coupled with an effective decrease of the lattice dimensionality lie on the basis of the magnetic behaviour of these compounds.

We report now an experimental investigation of the intermediate $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$ compounds which allow us to determine the complex magnetic phase diagram of this system.

The synthesis of the compounds was done by means of solid state reactions of metallic oxides and Sr carbonate at 1350°C in air. All the obtained compounds were single phase as show the X-ray diffraction patterns.

The dc magnetic measurements were performed by using a Faraday balance in the $15 \text{ K} \leq T \leq 1000 \text{ K}$ temperature range and a SQUID magnetometer from 4.2 K to 300 K . Ac susceptibility measurements were carried in a rms field of 10 Oe and a frequency of 110 Hz .

The dc high temperature magnetic susceptibility data show that strong deviations from the Curie-Weiss behaviour does occur at temperatures much higher than the Curie Temperatures, T_c , deduced from Mössbauer spectroscopy [1], indicating the existence of magnetic correlations which may strongly perturb the magnetic ordering in the ferrimagnetic phase.

Fig. 1. - dc magnetic susceptibility dependence on temperature for the compound with $x = 0.5$. The external applied field was 600 Oe .

Fig. 2. - Temperature dependence of the out of phase ac susceptibility for the compound with $x = 1.0$.

The low temperature reentrant spin glass or simply spin glass transitions were easily detected in the low field measurements of both dc and ac suscepti-

bilities. It is remarkable that for those compounds showing reentrant-like features ($0 \leq x \leq 2$), the freezing temperature, T_g , is very strongly field dependent while in the spin glass compounds ($2 \leq x \leq 3.5$), T_g is very weakly field dependent. This differentiating feature seems to be a general rule in systems having a quenched ferromagnetic order [3] or correlated spin glass behaviour [4].

The resulting phase diagram is displayed in figure 3 where the low temperature spin glass transition T_g have been unambiguously determined while the paramagnetic ferrimagnetic transition of compounds hav-

ing $x > 0$ appear only as tentative because they were "identified" as the temperatures at which a second peak is observed on the out of phase component of the ac susceptibility.

Summarizing, the proposed magnetic phase diagram of the $\text{SrCr}_8\text{Fe}_{4-x}\text{Ga}_x\text{O}_{19}$ system clearly show that the topological magnetic frustration associated to octahedral Cr^{3+} ions is the major responsible of the occurrence of spin glass reentrance and spin-glass ordering. It is also important to remark that the composition dependence of T_g suggest that the three sublattices of the $\text{SrCr}_8\text{Ga}_4\text{O}_{19}$ extreme compound do not display any kind of magnetic ordering down to zero temperature. Hence this system can be used to test many of the theoretical predictions on two dimensional systems [5].

Fig. 3. - Magnetic phase diagram: ($\square$) denotes χ''_{ac} or Mössbauer spectroscopy determination and ($\bullet$) denotes the T_g determination by extrapolated zero field χ_{dc} and χ'_{ac} measurements. SG, F and P denote the spin glass, ferrimagnetic and paramagnetic behaviour respectively.

- [1] Obradors, X., Labarta, A., Tejada, J., Pernet, M., Tholence, J. L., Saint-Paul, M., Barbara, B., *J. Appl. Phys.* (in press).
- [2] Obradors, X., Labarta, A., Isalgue, A., Tejada, J., Rodriguez, J., Pernet, M., *Solid State Commun.* **65** (1987) 189.
- [3] Rhyne, J. J., *Physica B* **136** (1985) 30.
- [4] Goldfarb, R. B., Rao, K. V., Chen, H. S., *Solid State Commun.* **54** (1985) 799.
- [5] Bray, A. J., Moore, M. A., Young, A. P., *Phys. Rev. Lett.* **56** (1986) 2641.