



**HAL**  
open science

# INVESTIGATION OF PHASE TRANSITIONS IN QUASI-TWO-DIMENSIONAL ANTIFERROMAGNETS BY MAGNETIC RESONANCE

H. Greb, P. Greiner, Hervé Sauer, K. Strobel, R. Geick

► **To cite this version:**

H. Greb, P. Greiner, Hervé Sauer, K. Strobel, R. Geick. INVESTIGATION OF PHASE TRANSITIONS IN QUASI-TWO-DIMENSIONAL ANTIFERROMAGNETS BY MAGNETIC RESONANCE. *Journal de Physique Colloques*, 1988, 49 (C8), pp.C8-1487-C8-1488. 10.1051/jphyscol:19888684 . jpa-00228917

**HAL Id: jpa-00228917**

**<https://hal.science/jpa-00228917>**

Submitted on 4 Feb 2008

**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.

## INVESTIGATION OF PHASE TRANSITIONS IN QUASI-TWO-DIMENSIONAL ANTIFERROMAGNETS BY MAGNETIC RESONANCE

H. Greb, P. Greiner, H. Sauer, K. H. Strobel and R. Geick

*Physikalisches Institut, Am Hubland, D-8700 Wuerzburg, F.R.G.*

**Abstract.** – We have measured the temperature and field dependence of the AFMR-linewidth in  $\text{Rb}_2\text{MnCl}_4$  and similar antiferromagnets in the millimeter wave range. An essential difference in the behaviour of the linewidths for the transition AF/P and SF/P is explained by the different character of the AF- and SF-phase.

### 1. Introduction

$\text{Rb}_2\text{MnCl}_4$  is a quasi-two-dimensional weakly anisotropic uniaxial antiferromagnet with a magnetic phase diagram quite different of that of the well known three-dimensional uniaxial antiferromagnets like  $\text{MnF}_2$ . In  $\text{Rb}_2\text{MnCl}_4$  and similar systems like the diluted antiferromagnet  $\text{Rb}_2\text{Mn}_{0.9}\text{Cd}_{0.1}\text{Cl}_4$  and the mixed system  $\text{Rb}_2\text{Mn}_{0.98}\text{Cr}_{0.02}\text{Cl}_4$ , the spin-flop transition which separates the Ising-like antiferromagnetic phase (AF) from the XY-like spin-flop phase (SF) is of second order unlike in the three-dimensional case where it is of first order. This has been shown by neutron diffraction in  $\text{Rb}_2\text{MnCl}_4$  and  $\text{K}_2\text{MnF}_4$  [1]. The transition to the Ising-like antiferromagnetic phase is possible where the magnetic field-dependent out-of-plane anisotropy does not vanish. Furthermore the transition from the paramagnetic phase (P) to the SF-phase is most likely one to a three-dimensional long range order for reasons of a small in-plane anisotropy and maybe the interlayer coupling [2]. Because of the different characters of the AF-phase and the SF-phase, the transitions to the paramagnetic phase are expected to differ strongly from each other.

### 2. Experimental

We have investigated  $\text{Rb}_2\text{MnCl}_4$  and the other quasi-two-dimensional systems mentioned above by means of magnetic resonance in the millimeter wave range with the external field parallel to the crystalline *c*-axis. The experimental setup has been described elsewhere [3]. By sweeping the external field at constant temperature and frequency, resonances have been observed in the AF-phase (AFMR), the SF-phase (SFR) and the P-phase (PMR). We measured the temperature and field dependence of the linewidths of the resonances within a frequency range from 8 to 300 GHz and a temperature range from 4.2 to 150 K.

### 3. Results

Figure 1 shows the temperature dependence of the magnetic resonances for  $\text{Rb}_2\text{MnCl}_4$  for 4 selected fre-

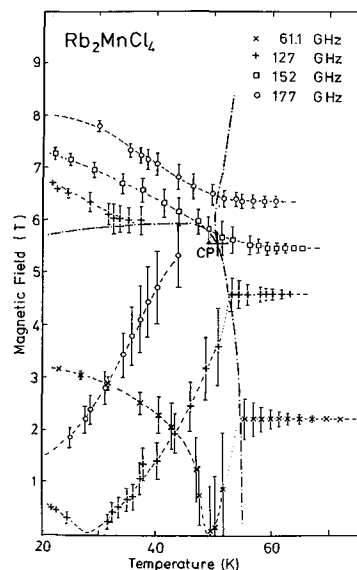


Fig. 1. – Temperature dependence of the resonance field and the linewidth of  $\text{Rb}_2\text{MnCl}_4$  for some selected frequencies.

quencies plotted as resonance field *versus* temperature together with the linewidths. The linewidth at each resonance field is represented by the bars. There is also shown the phase boundaries as determined by neutron diffraction. For the lower fields figure 1 illustrates that there is a strong increase of the AFMR and PMR linewidths when the phase boundary between the antiferromagnetic phase and the paramagnetic phase is approached. The linewidth seems to diverge at that phase transition. For the higher fields above the phase boundary AF/SF there is no such a strong increase. As the phase boundary SF/P is approached the increase of the linewidth is much smaller passing only through a moderate maximum. This maximum is not located at the phase boundary but somewhat away from it in the spin-flop-phase. The linewidths of  $\text{Rb}_2\text{Mn}_{0.98}\text{Cr}_{0.02}\text{Cl}_4$  and the diluted system  $\text{Rb}_2\text{Mn}_{0.9}\text{Cd}_{0.1}\text{Cl}_4$  show a similar behaviour.

We have also investigated the behaviour of the paramagnetic linewidth near the critical temperature. Recent considerations of the linewidths connected with nonlinear excitations show an exponential law for the dependence of the PMR linewidth on the temperature, i.e.  $\Gamma \propto \exp(E/kT)$  [4]. Here  $E$  is the energy of the nonlinear excitation or soliton. We have plotted the logarithm of the PMR linewidth as a function of  $1/T$  (see Fig. 2) and we received nearly straight lines but with different slopes for approaching the AF-Phase and the SF-Phase. In the first case the slope is in good agreement with the theoretical results leading to  $\Gamma \propto \exp(E/kT)$ . For the much smaller slope in the second case there is no theoretical explanation yet.

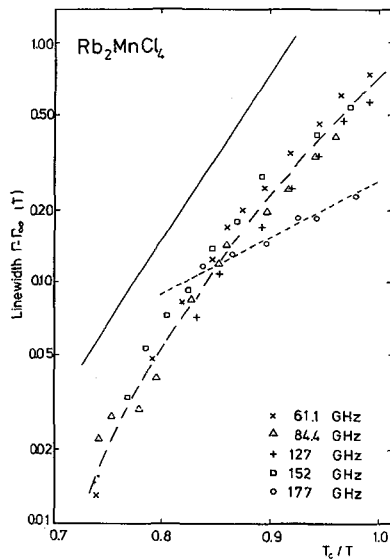


Fig. 2. - Plot of the logarithm of the linewidth versus  $T_c/T$ . Nearly a straight line with slope 12 is obtained in good agreement with the theory leading to  $\Gamma \propto \exp(E/kT)$  and slope  $E/kT_c$  while for 177 GHz the slope is completely different.

#### 4. Conclusion

All our results show that the characters of the transition from the paramagnetic phase to the antiferromagnetic phase and of that to the spin-flop phase are very different. We explain this as a consequence of the fact that a proper transition to the Ising-like antiferromagnetic phase (AF) would be allowed even in two dimensions while such a transition is not possible on universal grounds for an XY-system in two dimensions. The solitons and their interaction with magnons play an important role in the interpretation of the linewidth data for the transition AF/P. It seems possible that these non-linear excitations cause a kind of random disorder, even in a pure antiferromagnet like  $\text{Rb}_2\text{MnCl}_4$ .

#### Acknowledgment

This work has been funded by the German Federal Minister for Research and Technology (BMFT) under contract 03-GE1WUE-6.

- [1] Rauh, H., Erkelens, W. A. C., Regnault, L. P., Rossat-Mignot, J., Kullmann, W. and Geick, R., *J. Phys. C* **19** (1986) 4503-5410.
- [2] de Groot, H. J. M., de Jongh, L. J., *Physica* **141B** (1986) 1-36.
- [3] Geick, R. and Strobel, K. H., *Rev. Infrared and Millimeter Waves* (K. Button Ed.) (Plenum Press) **1** (1983) 249.
- [4] Waldner, F., *J. Magn. Magn. Mater.* **54-57** (1986) 873-874.