

# 3-AXIS INELASTIC NEUTRON SCATTERING ON MOLECULAR BEAM EPITAXY GROWN SAMPLES

B. Hennion<sup>1</sup>, W. Szuszkiewicz<sup>2</sup>

<sup>1</sup>Laboratoire Léon Brillouin (CEA-CNRS)

<sup>2</sup>Institute of Physics, Warsaw, Poland

Optimizing the use of neutron beams on triple axis spectrometers implies focusing by **curved monochromators and analysers**, bent vertically as well as horizontally (Figure 1).

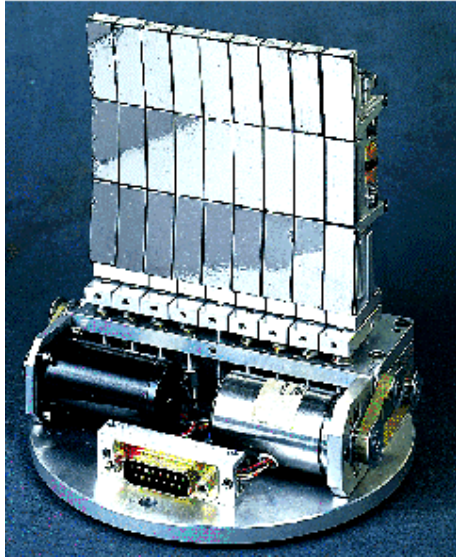


Figure 1. Focusing analyser of the 3-axis spectrometer 1T

The gain in intensity, keeping a low background level, offers new opportunities of **inelastic neutron scattering** measurements on small size samples (a few  $\text{mm}^3$ ).

Thus, **MBE grown samples** have been used to measure **spin waves on MnTe**. Such measurements are illustrated on Figure 2. MnTe is often used to obtain by substitution of Mn by non magnetic ions (e.g. Zn or Cd) diluted magnetic semiconductors. These compounds have the Zinc blende (ZnS) cubic structure and the evolution of their magnetic properties depends on exchange integrals, responsible of the magnetic order of the pure compound. But pure MnTe has not the blende structure, but that of hexagonal NiAs! **Only MBE grown samples of MnTe have the blende structure**, because of uniaxial constraint due to epitaxy. Such samples offer therefore the possibility to **determine exchange integrals** by measuring the **spin wave spectrum of MnTe**, with inelastic neutron scattering. Raw data measured on MBE grown samples are illustrated on figure 2.

They are obtained on samples of **4 and 6 mm width** grown at the Institute of Physics of the Polish Academy of Sciences in Warsaw, on an AsGa

substrate with a buffer of 2 or 4  $\mu\text{m}$  of CdTe. With a surface of about  $2 \text{ cm}^2$ , **the sample volume was about  $1 \text{ mm}^3$** . The only known information was the value of the anisotropy gap of the spin wave spectrum, that previous Raman scattering measurements had determined as  $\approx 1.05 \text{ THz}$ .

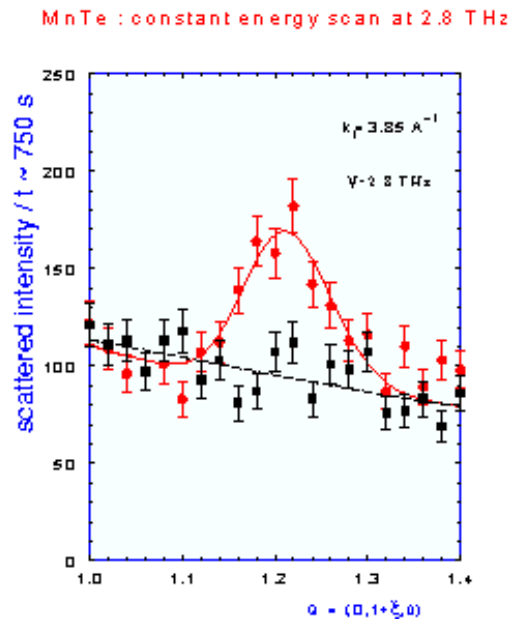


Figure 2: Raw data obtained at  $T=13 \text{ K}$  (•) and  $75 \text{ K}$  (■). Spin-waves only exist at low temperature.

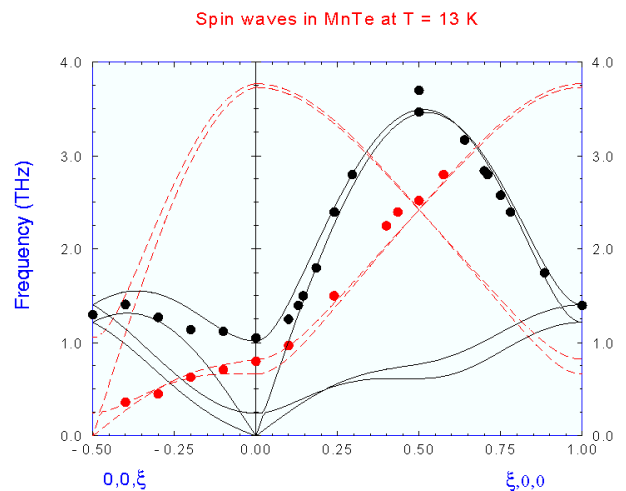


Figure 3. Black lines and symbols are respectively the measured and calculated spin-wave spectra at  $T=13 \text{ K}$  for one magnetic domain in the sample. Red dashed lines and red symbols correspond to modes in the second magnetic domain of the MBE sample.

Study of the sample by elastic neutron scattering [1] confirmed its structural and magnetic characteristics. The magnetic transition takes place at  $T_N \approx 65$  K and is associated to a structural transition (tetrahedral distortion). The low temperature magnetic structure is **antiferromagnetic of type III**. If  $[1,0,0]$  is the crystallographic axis perpendicular to the layers, the doubling of the magnetic cell is along  $[0,1,0]$  or  $[0,0,1]$ , due to the nature of the buffer. Therefore, in the MBE sample, 2 magnetic domains coexist and we have to account for the superimposition of 2 reciprocal lattices. This lowers the scattered intensity and hampers the analysis of the results. Anyhow, a pertinent set of data has been obtained with a counting time of about 15 minutes per step. On

Figure 3 are reported the experimental results and the theoretical dispersion curves, calculated with a Heisenberg hamiltonian

A test measurement has been done on a **MnTe/ZnTe multilayer**, made of alternating 20 MnTe and 3 ZnTe atomic layers. The sample width was 1  $\mu\text{m}$ , but it was a single domain. The long range magnetic order is preserved and spin gap at  $q=0$  as well as the zone boundary mode have been observed.

Even though such experiments benefit of the high value of the Mn moment (spin 5/2) [2], they are very encouraging as a first step towards the study of dynamical properties of magnetic multilayers.

#### References:

- [1] W. Szuszkiewicz, B. Hennion, M. Jouanne, J.F. Morhange, E. Dynowska, E. Janik, T. Wojtowicz, M. Zielinski and J.K. Furdyna, *Acta Physica Polonica*, Vol 93, No 3 (1998) 583-587
- [2] The inelastic results are not yet published.