ESRF	**Experiment title:** Diffraction imaging investigation of magnetic phases occuring within the fan-ferromagnetic phase boundary in MnP	**Experiment number**: MA-743
Beamline: BM05	**Date of experiment**: from: 25th to 26th May, and 6th to 8th July, 2009	**Date of report**: 25th September 09
Shifts: 12	**Local contact(s):** José Baruchel	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

David Ghigo*, Fabio Masiello*, *ESRF, France*

The coexistence of the ferromagnetic and fan phases in a crystal of MnP, under a magnetic field applied along the **b** direction, was investigated in real time, by synchrotron radiation Bragg diffraction imaging in the neighbourhood of the triple point (which occurs at T~ 46 K and H~ 1.7 10^5 A m^{-1} [1]). The magnetic phase diagram, shown on figure 1, displays regions of phase coexistence between the of ferromagnetic, helimagnetic and fan phases that result from the difference between internal and applied field, associated to the demagnetizing field.

Previous work [2] has pointed out that the ferromagnetic-fan interface includes, in the immediate neighbourhood of the triple point, bulk transition regions, elongated along **a** and thick enough along the **b** direction (~ 10^{-4} m, in sharp distinction with the usual two-dimensional character of magnetic walls and phase boundaries) to produce a substantial contribution to diffraction. The Bragg condition changes continuously across these regions. This configuration involves magnetic charge distribution, a fact that suggested a model where the observed thick interfaces comprise a set of intermediate, "fan-like", magnetic states, which do not occur otherwise, this reducing the total energy through a reduction of the magnetization gradient, as indicated by the the Landau equation:

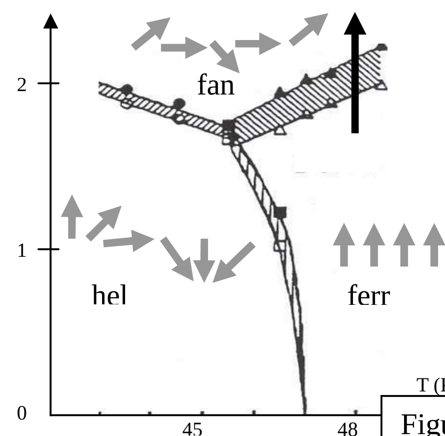


Figure 1

$$\Delta E_{ex} = \frac{Na^2}{12}\iiint_v \{(\nabla M_x)^2 + (\nabla M_y)^2 + (\nabla M_z)^2\} dxdydz$$

The present experiment wished to investigate more deeply if this model corresponds to the reality. The visualization of these hypothetical phases can (if they actually exist!) be performed with X-ray Bragg imaging ("topography") because their lattice parameters should be different from the ones of the fan and ferro magnetic phases. We therefore intended to record lattice parameteters within the thick interface, the expectation being that their values should be in between those of the ferromagnetic and fan phase.

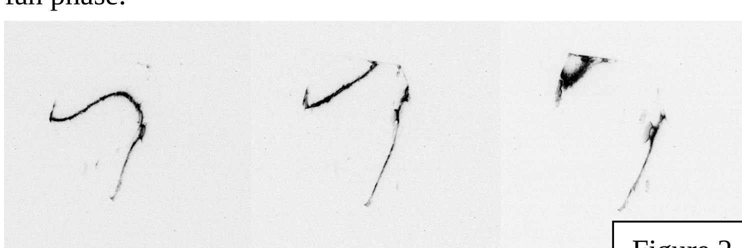


Figure 2

The original proposal wished to use, for that, the images, obtained on the different points of the rocking curve, but this revealed not to be feasible because the crystal distortion was higher than the one expected from the phase transition, as shown by the images in Figure 2, which correspond to various angular points of the rocking curve. The experiment was therefore modified, and provided a lot of new information, extracted from the integrated image in monochromatic and white beam. These images allowed us to reveal new aspects of the ferro-fan interface, which support the suggested model.

- The interface varies as a function of the “distance” (temperature, field) from the triple point, the “thick” segments only occuring in the immediate neighbourhood of the triple point (Figure 3A-3B), and the interface evolving towards a singular continous stripe (Figure 3C) far (about 2-3 K) from the triple point.
  This is in keeping with the assumption that the “thick” segments could correspond to new phases, intermediate between the helimagnetic and fan ones, which are expected to have an energy very similar to these heli / fan phases only near the triple point.

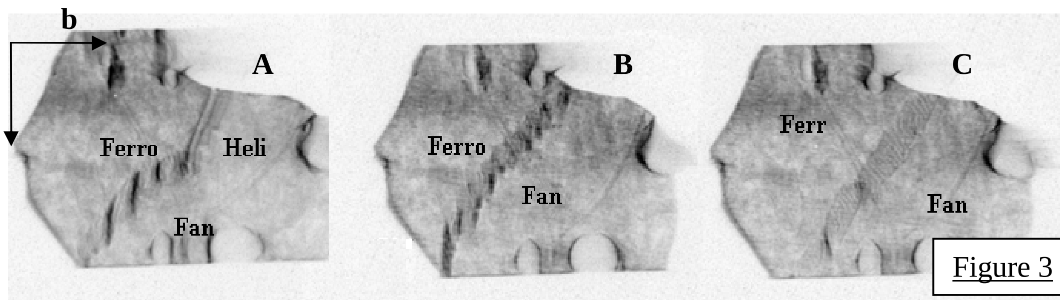
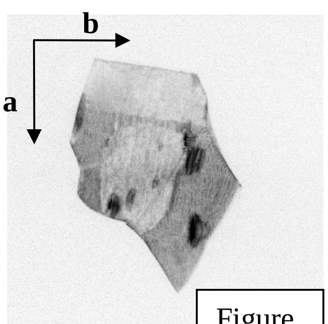


Figure 3

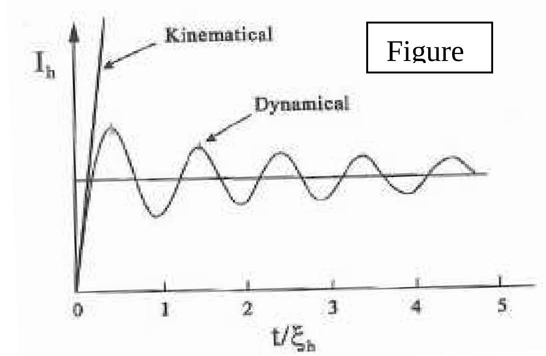
- The second result concerns the influence of defects, which can lead to the stabilization of large surface interfaces parallel to the magnetization along **b**. Figure 4 shows a ferro-fan interface lying, practically, in the **ab plane** (which is the main surface of the sample). Its contrast is due to the integrated image intensity acquired as sum of two superposed layers with a different lattice parameter. This is a direct consequence of the dynamical theory curve for integrated intensity shown on Figure 5.
  This result suggests that the “thick” interfaces only occur if no “extra-energies” (like pinning on the defects) are present.



Figure

.

We wish, to pursue (and conclude?) this investigation with 1) a high-quality crystal to confirm our theory of “**like-fan**” phases existence and 2) with crystals with several thicknesses and orientations to check the influence of these factors on the transition, and to be able to extract conclusions on the magnetic transitions geometry in MnP.



Figure

References:

[1] Medrano C., Pernot E., Espeso J.I., Boller E., Lorut F., Baruchel J., J. Magn. Magn. Mater., **226-230** (2001) 623

[2] Baruchel J. Medrano C. Schlenker M., J. Phys.D: Appl. Phys., **38** (2005) A67