

 ESRF <sup>1</sup>	<b>Experiment title:</b> <b>Moment canting in amorphous alloys</b>	<b>Experiment number:</b> <b>HE-182</b>
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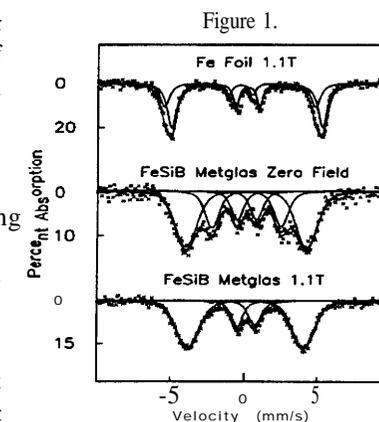
#### Report:

Over the last few years a body of evidence gathered from various experiments has been found to support the conclusion that in some nominally ferromagnetic amorphous alloys the atomic moments are not collinear in the presence of applied fields well in excess of their technical saturation field. Attempts have been made to probe the properties of this non-collinear state using conventional plane-polarised Mössbauer spectroscopy [1]. However, limiting factors are encountered so that the best polarisations currently available in a conventional system are ~90-95%, which presents problems for the unambiguous testing of the moment canting effect. Using recently developed techniques [2] the nuclear resonance beamline at ESRF offers for the first time a fully 100 % polarised ‘synchrotron Mössbauer source’. This experiment represents the first time that this mode of operation has been employed to address an active area of research.

The nuclear resonant part of the broadband synchrotron radiation was obtained using the electronically forbidden (333) plane Bragg reflection from a single crystal of  $^{57}\text{FeBO}_3$  held near its Néel temperature (75.35 °C) in a 10 mT external field along the vertical axis. Under these conditions an almost single line Mössbauer source is obtained, which retains the very high degree of polarisation of the incident x-rays. Subsequently the experimental set-up for recording an absorption spectrum is the same as in conventional Mössbauer spectroscopy, with the sample being mounted on a velocity transducer. Spectra were recorded at room temperature, either in zero field or in an applied field of 1.1 T supplied by a Halbach cylinder arrangement of NdFeB permanent magnets.

As an initial test a spectrum was recorded for a 25  $\mu\text{m}$  natural iron foil in an applied field of 1.1 T (see Figure 1). As expected there is almost complete alignment of the Fe moments with the applied field, as evidenced by the absence of the second and fifth lines of the hyperfine sextet. It is also apparent that the absorption lines are asymmetric. In Figure 1 this has been accentuated by fitting the spectrum as the sum of two subspectra, offset relative to each other. Such an asymmetric pattern might be expected as a consequence of an internal hyperfine field of order 5-10 kOe in the iron borate crystal [3]. Such effects are inevitable given the necessary compromise between intensity and lineshape: as the Néel temperature is approached the initial four-line reflection spectrum collapses into a single pseudoline, but at the same time the nuclear reflectivity decreases [2,3]. Fortunately, for the purpose of the current experiment, this asymmetry is not crucial, as the effect we wish to measure is primarily determined by absorption intensity, and not lineshape.

Spectra were then recorded for 14 mm x 4 mm x 25  $\mu\text{m}$  stress relieved and field annealed ribbons of  $\text{Fe}_{78}\text{Si}_9\text{B}_{13}$  (Metglas 2605-S2). Representative data for the field annealed sample are shown in Figure 1. Typical collection times ranged from 12 to 16 hours per spectrum. The spectra were fitted using the Lines and Eibschütz method for analysing amorphous profiles, with intensity ratios of 3 :  $x$  : 1 for the outer, middle and inner pairs of lines. For the spectra in Figure 1, in zero field  $x = 1.38 \pm 0.08$  and in a 1.1T field  $x = 0.10 \pm 0.03$ , corresponding to in-plane Gaussian distributions of moment directions with standard deviations  $\sigma = 29.9^\circ \pm 1.3^\circ$  and  $6.6^\circ \pm 1.3^\circ$  respectively.



These data are entirely consistent with earlier measurements [1,4], and represent an important validation of the phenomenon of moment canting in 3d-based amorphous alloys. The sensitivity of the technique is also notable: never before has it been possible to directly measure the degree of non-collinearity in a soft magnetic material to such accuracy in such a large applied field as 1.1 T. Further experiments are planned to exploit this technique.

[1] Q. A. Parkhurst et al., ‘In-plane moment canting in amorphous  $\text{Fe}_{78}\text{B}_{13}\text{Si}_9$  in applied fields measured using polarized Mössbauer spectroscopy’, *IEEE Trans. Magn.* 30 4809-4811 (1994).

[2] G. V. Smirnov et al., ‘Synchrotron Mössbauer source’, *Phys. Rev. B* 55 5811-5815 (1997).

[3] G. V. Smirnov, ‘Notes concerning some properties of the rocking curves of the pure nuclear reflections in iron borate in approaching the Néel temperature’, unpublished report, April 1997.

[4] Q. A. Parkhurst et al., ‘Moment canting in amorphous  $\text{FeSiB}$  ribbons in applied fields: unpolarised Mössbauer effect studies’, *J. Phys. C. M.* 7 9571-9593 (1995).