Comment on "Field dependence of the transverse spin freezing transition"

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Transverse spin freezing temperature of amorphous $Fe_{100-x}Zr_x$ ($x=7,8,9$) is determined by ^{57}Fe Mössbauer spectroscopy as a function of the applied magnetic field, and the results are compared to those obtained by longitudinal field muon spin relaxation [D.H. Ryan *et al.*, Phys. Rev. B **63**, 140405 (2001)] (LF-μSR) for amorphous $Fe_{92}Zr_8$. The Mössbauer results are at variance with the LF-μSR results for $x=8$ and do not support the proposed inverse field dependence.

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Only few methods are suitable to measure the applied magnetic field dependence of the transverse spin freezing transition temperature, T_{xy}. Besides the recently used[1] longitudinal field muon spin relaxation (LF-μSR), ^{57}Fe Mössbauer spectroscopy is also appropriate to study the transition. The direction of the Fe magnetic moments is characterized via the intensity of the $\Delta m=0$ nuclear transition corresponding to that of the second and fifth lines of the six-line Mössbauer spectra. It becomes zero above the spin freezing temperature T_{xy} when the magnetic moments are aligned along the external magnetic field B_{ext} applied parallel to the γ-beam direction and perpendicular to the sample plane.

It is worth comparing the results of the two methods in case of a nominally identical amorphous $Fe_{92}Zr_8$ alloy. The Curie temperature of the sample, which is an independent indicator of the composition, is nearly the same ($T_c=168$ K) for the samples.[2,3] The external field dependence of the 2–5 lines was measured at different temperatures and converted into the T_{xy} vs B_{eff} curve in a similar manner[4] as for the amorphous $Fe_{93}Zr_7$ which shows a single spin freezing transition at 122 K. The results are shown in Fig. 1, where $B_{eff}=B_{ext}-B_{demag}$ and B_{demag} is the demagnetization field. The value of B_{demag} is deduced from the Mössbauer spectra and equals 1–1.5 T depending on the temperature. It agrees well with the theoretical value for a magnetic plane perpendicular to the applied field, $B_{demag}=4\pi M$, where M is the magnetization. The experimental values are determined[5] from the difference of the Fe hyperfine fields measured at high magnetic fields (above B_{demag}) and at $B_{ext}=0$. No such inherent control is known for the longitudinal field muon spin relaxation. Indeed, it is difficult to explain the nearly 20 K decrease of T_{xy} found by this method[1] for $\leqq 1$ T applied fields, smaller than B_{demag} at the given temperatures.

Significant deviations can be observed between the LF-μSR and the Mössbauer data. T_{xy} decreases nonlinearly for $x=8$, but our data do not support the proposed[1] inverse field dependence. On the other hand, T_{xy} decreases linearly with the applied effective field for $x=7$ and 9. For all three samples, however, T_{xy} approaches zero below 5 T effective fields according to the Mössbauer measurements. In the Mössbauer measurement the accuracy of T_{xy} is related to the accuracy of the determination of the intensity of the 2–5 lines, which is better than 5%. The main source of error is the correlation between the 2–5 line intensities and the shape of the hyperfine field distribution. However, the consistent evaluation of the spectra measured in the full external field range (up to 7 T, where the 2–5 lines are absent) eliminates this source of error.

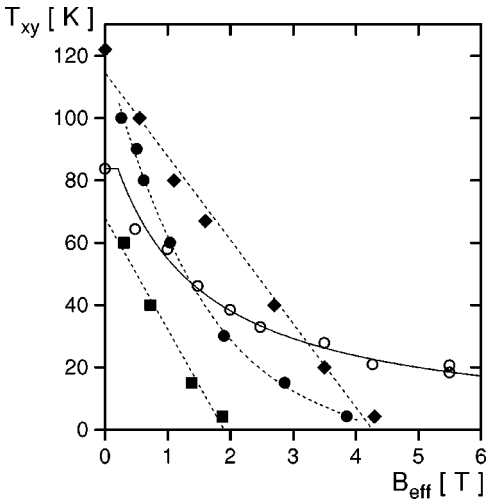

FIG. 1. Field dependence of T_{xy} of amorphous $Fe_{100-x}Zr_x$ ($x=7,8,9$) alloys from ^{57}Fe Mössbauer measurements [$x=7$ diamonds (Ref. 4), $x=8$ full circles, $x=9$ squares]. Longitudinal field muon spin relaxation results for $x=8$ from Ref. 1 are also reproduced in the figure (empty circles). B_{eff} is the demagnetization field corrected external field (B_{ext}-B_{demag}) in the case of the Mössbauer data. No demagnetizing field correction was done for the LF-μSR. The continuous line is the fit of Ref. 1. For our data the broken lines are a guide to the eye.

The observed discrepancy for amorphous $Fe_{92}Zr_8$ might be attributed either to the magnetically inhomogeneous environments indicated[2,5] by the bimodal Fe hyperfine field distributions or to chemical inhomogeneities of the samples. Indeed, polarized neutron scattering study of amorphous $Fe_{90}Zr_{10}$ shows[6] that the noncollinear magnetic structure of these glasses depend on the preparation conditions.

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[1] D.H. Ryan, J. van Lierop, M.E. Pumarol, M. Roseman, and J.M. Cadogan, Phys. Rev. B **63**, 140405 (2001).
[2] D. Kaptás, T. Kemény, L.F. Kiss, L. Gránásy, J. Balogh, and I. Vincze, J. Non-Cryst. Solids **156-158**, 336 (1993).
[3] D.H. Ryan, J.M. Cadogan, and J. van Lierop, Phys. Rev. B **61**, 6816 (2000).
[4] I. Vincze, D. Kaptás, T. Kemény, L.F. Kiss, and J. Balogh, J. Magn. Magn. Mater. **140-144**, 297 (1995).
[5] I. Vincze, D. Kaptás, T. Kemény, L.F. Kiss, and J. Balogh, Phys. Rev. Lett. **73**, 496 (1994).
[6] A.R. Wildes, N. Cowlam, A. Al-Heniti, L.F. Kiss, and T. Kemény, Physica B **276-278**, 712 (2000).