Highly Frustrated Magnetism - Scientific Report

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The measurements at the Paul Scherrer Institut (PSI) were about two subjects : "spin fluctuations in geometrically frustrated rare earth oxides", and "spin dynamics in the frustrated pyrochlore $Er_2Ti_2O_7$, a field dependence study".

Firstly, before the stay at the PSI, heat capacity measurements were carried out on a crystal of $Tb_2Ti_2O_7$ [1]. So we used μSR technique to investigate further the analysis at low temperature, from 60 mK to around 5 K, at 60 mT, in field cooling and zero field cooling. The transverse polarization is given by the following relation: $a_0 P_X(t) = a_0 \exp[-(\Delta_X t)^2/2] \cos(\omega t)$. We draw the frequency shift, $\delta = \omega/(\gamma_\mu B_{\rm ext}) - 1$, versus temperature (fig. 1). And, up to 300 K, we compare this data with the relaxation rate Δ_X (fig. 2).

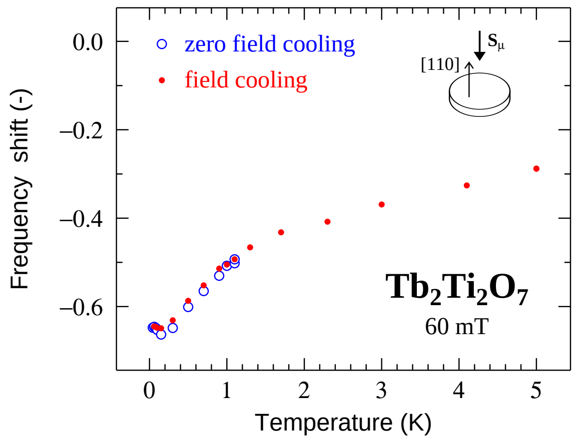

Figure 1: The temperature dependence of the frequency shift was recorded with the Low Temperature Facility instrument (LTF) and the General Purpose Surface-Muon instrument (GPS), at 60 mT and for $\mathbf{S}_\mu \parallel [110]$.

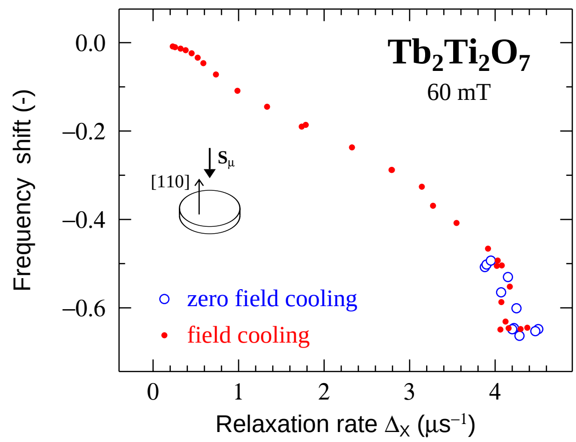

Figure 2: In this graph, the temperature is an implicit coordinate. We applied a transverse magnetic field of 60 mT, and $\mathbf{S}_\mu \parallel [110]$. These data are approximately linear for temperatures greater than 1 K, *i.e.* for Δ_X less than 3.5 μs^{-1}.

It will be interesting to compare this frequency shift with susceptibility that could be obtained by magnetization measurements, because the frequency shift is a microscopic susceptibility.

In addition, we studied the behaviour of some parameters versus the external magnetic field, for different temperatures: the asymmetry a_0, the relaxation rate λ_z and the exponent β of the polarization $a_0 P_z(t) = a_0 \exp[-(\lambda_z t)^\beta]$ (a stretched exponential function). But, for this moment, we have not finished the analysis.

Moreover, we carried out μSR measurements on a crystal of $Er_2Ti_2O_7$, with $\mathbf{S}_\mu \parallel [111]$, and on zero field, in order to compare our results with the ones of Lago *et al* [2]. Our results are qualitatively consistent with this publication (fig. 3), and we can note that the relaxation rate abruptly decreases, when the temperature increases, at about 1 K. Whereas the heat capacity measurement gives a phase transition at 1.19 K.

We also do measurements at several temperatures, 21 mK, 0.4 K and 1.35 K, and we studied the magnetic field

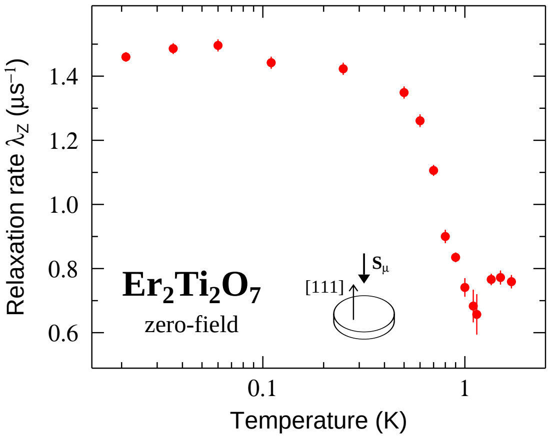

Figure 3: Temperature dependence of the relaxation rate for $Er_2Ti_2O_7$, in zero field.

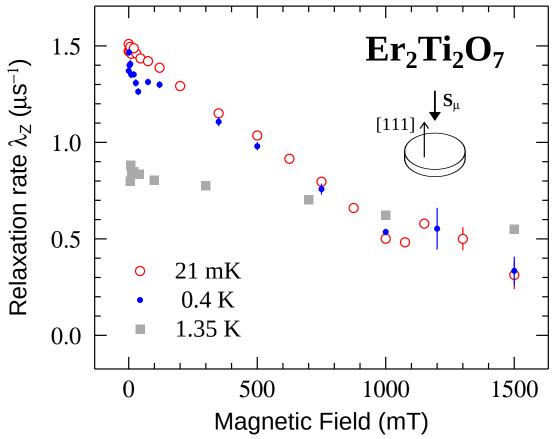

Figure 4: Field dependence of the relaxation rate for $Er_2Ti_2O_7$ for three temperatures : 21 mK (red empty circle), 0.4 K (blue full circle) and 1.35 K (grey full square).

dependence of the relaxation rate λ_Z (fig. 4). We can observe that the relaxation rate decreases when the magnetic field increases.

All being well, we should come back to the Paul Scherrer Institut on the next Autumn to pursue our measurements on pyrochlore compounds and complete the analysis. Before the next stay, other heat capacity, magnetization and neutrons measurements are forseen on $Tb_2Ti_2O_7$ and $Er_2Ti_2O_7$.

Then, a publication about low energy spin dynamics in the $Tb_2Ti_2O_7$ is projected to present some results of μSR measurements realised at ISIS Facility (Rutherford Appleton Laboratory, Chilton, UK) and PSI (Villigen, Switzerland) [3].

References

[1] Y. Chapuis, Post M. Sc., Physics of Condensed Matter, Etude des propriétés magnétiques du composé géométriquement frustré $Tb_2Ti_2O_7$.

[2] J. Lago, T. Lancaster, S.J. Blundell, S.T. Bramwell, F.L. Pratt, M. Shirai and C. Baines, J. Phys.: Condens Matter, 17 (2005) 979-988.

[3] A. Yaouanc, P. Dalmas de Réotier, Y. Chapuis, C. Marin, P.C.M. Gubbens, S. Sosin, C. Vaju, S. Giblin, C. Baines and A. Amato, in preparation.