Experimental report

12/12/2022

Proposal: **CRG-2781** **Council:** 4/2020

Title: Revisiting the double-k magnetic structure of bulk and nanostructuresTbCu2

Research area:

This proposal is a new proposal

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Samples: TbCu2

Instrument	Requested days	Allocated days	From	To
D1B	2	1	16/09/2020	17/09/2020

Abstract:

Experimental Report – Proposal CRG-2781 (D1B) – 16-17/09/2020

"Revisiting the double-k magnetic structure of bulk and nanostructured $TbCu_2$"

Cristina Echevarria Bonet

Nanostructured Rare-Earth intermetallic compounds present interesting phenomena, with attractive works in this area [1-5]. In this sense, our group has studied the magnetic properties of nanocrystalline RX_2 alloys obtained by mechanical milling [1,2]. $TbCu_2$ evolves from an antiferromagnetic (AFM) transition at T_N =50 K to a spin-glass (SG) behaviour with a freezing temperature of T_f ~ 15K when the compound is milled for up to 15 hours, reaching a nanometric size of D ~ 5 nm [6]. We addressed this coexistence of an AFM core of ordered spins and a shell of disordered spins, leading to a general SG behaviour [6].

However, in a neutron total scattering experiment in NIMROD beamline (at RAL-ISIS) on bulk and nanostructured alloys a new peak, previously not reported in literature was observed in both materials. This peak was not present above T_N (so that is magnetic), reached its maximum intensity at 42 K (at Q ~ 0.12 $Å^{-1}$), and then the intensity decreased as the temperature reached low temperatures, so that at 20 K was diminished. This peak cannot be explained with the proposed magnetic structure known so far [7], so the aim of this experiment was to revisit the magnetic structure of the $TbCu_2$ compound and elucidate the origin of that magnetic peak.

The experiment was carried out on an arc melted bulk $TbCu_2$ alloy. Neutron diffraction spectra were taken at 10 K, 20 K, 30 K, 44 K, 55 K, 100 K and 300 K. Also, a temperature ramp from 30 to 55 K was performed so that we could see the evolution of the magnetic peaks with temperature. In Figure 1 we can, indeed, observe the evolution of the magnetic peaks with temperature in the range 30-55 K. It is possible to see a set of magnetic peaks that disappear at a lower temperature than the other set (~40 K and ~50 K), that corresponds to the well-known magnetic structure, with two propagation vectors, proposed by Sima et al. in Ref. [6]. However, the peak at Q = 0.12 $Å^{-1}$ is not clearly seen, though a broad shape is observed at low angles (with not good resolution). In that sense, neutron diffraction patterns were collected at certain temperatures, improving the resolution of the patterns.

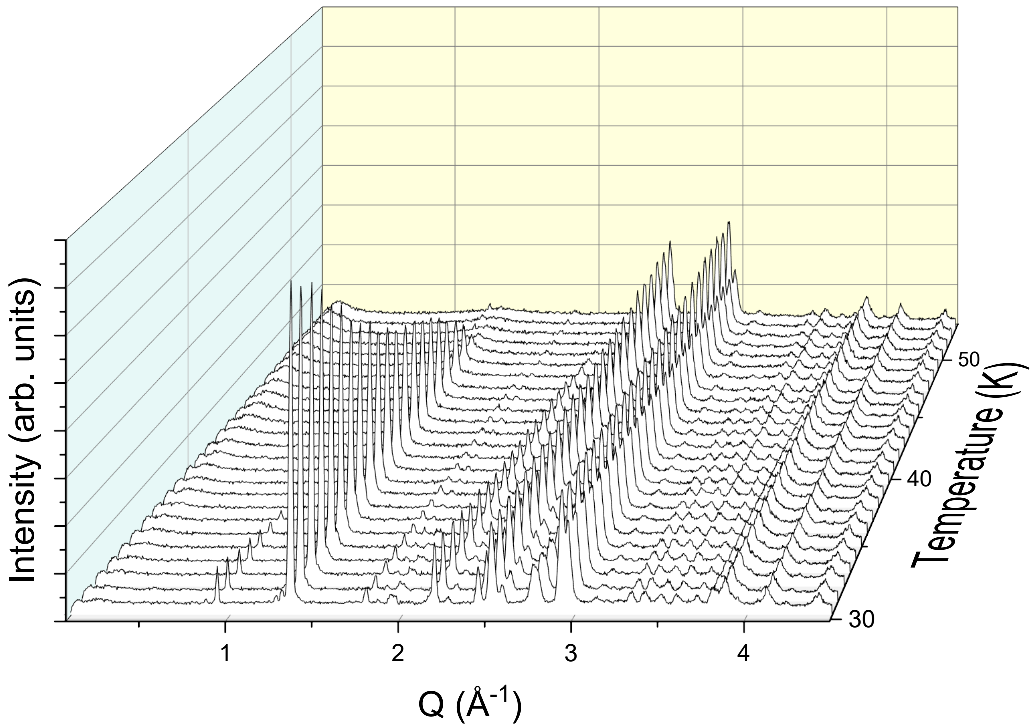

Figure 1. Neutron diffraction patterns for the bulk $TbCu_2$ collected, in ramp, from 55 to 30 K.

Thus, several diffraction patterns were collected at different temperatures in order to see how the magnetic peak evolved at lower temperatures. As these patterns were collected during more time than the previous ones (in a ramp), it is possible to see that evolution (see Fig. 2). However, due to the low resolution (signal-noise ratio) it is not possible to determine properly a magnetic structure for the $TbCu_2$ alloy. Nevertheless, it is clear that the peak that we had observed in neutron total scattering experiments (at RAL-ISIS) is also present here, but with much less intensity, but in the same angular position: $2\theta=2.676^{o}$, that corresponds to $Q = 0.116$ Å^{-1} (as $\lambda=2.52$ Å). There is also another peak that should be noted, at $2\theta=5.176^{o}$, that was already present at room temperature (so that, not magnetic), maybe related to some disorder degree within the alloy.

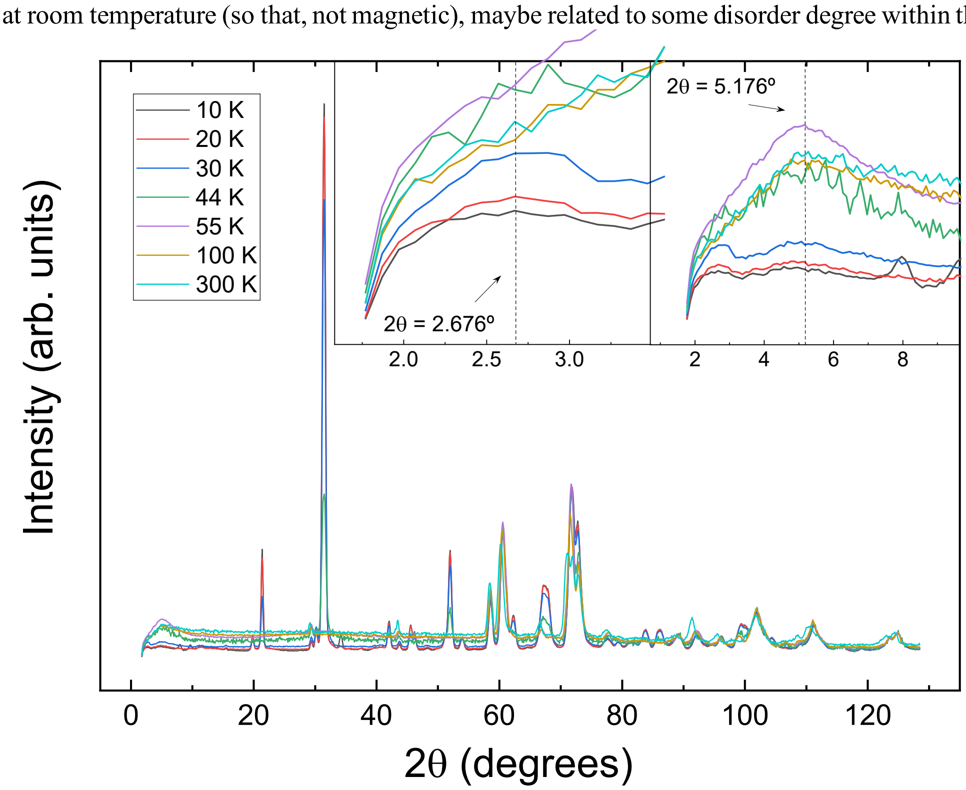

Figure 2. Neutron diffraction patterns for the bulk $TbCu_2$ at certain temperatures, from 300 K down to 10 K. Insets: zooms of different angular regions of the patterns in order to see the evolution of the peaks at (left) 2.676º and (right) 5.176º.

Anyway, as said before, the data had not the proper resolution to be used to our purposes, but definitely confirms previous findings and it would be very interesting to remeasure this sample for longer times in order to reduce the noise and thus, improve the resolution and be able to determine that new component of the magnetic structure of $TbCu_2$.

References

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