Experimental report

05/02/2021

Proposal: 5-31-2714 **Council:** 10/2019

Title: Magnetic reorientation in Cobalt, spin-lattice coupling studies

Research area: Physics

This proposal is a new proposal

Main proposer: Radoslaw PRZENIOSLO

Experimental team:

Local contacts: Emmanuelle SUARD

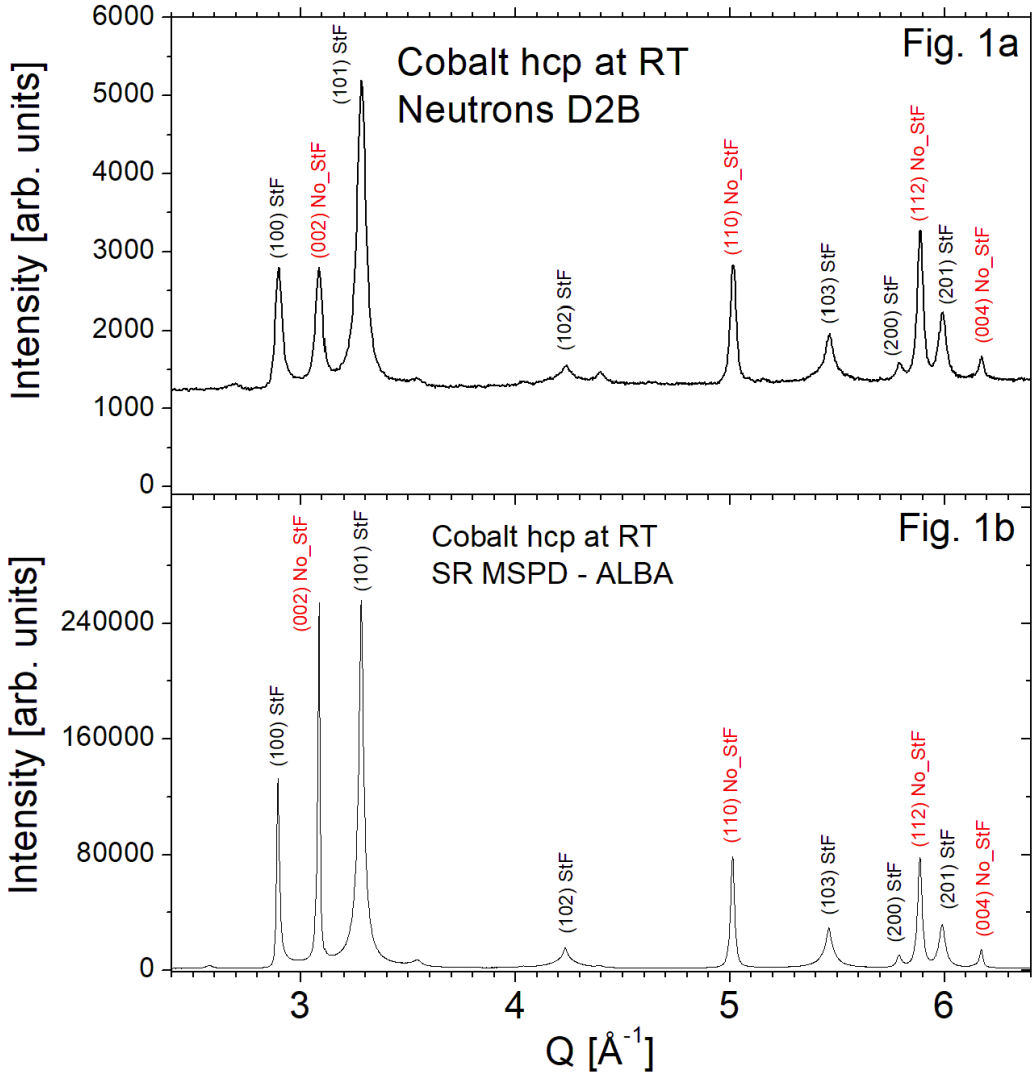
Samples: Co

Instrument	Requested days	Allocated days	From	To
D2B	3	1	04/09/2020	05/09/2020

Abstract:

This proposal is focused on the spin-lattice coupling in the hexagonal close packed Cobalt (hcp-Co) with ferromagnetic ordering. Below 505K the magnetic moments are oriented along the hexagonal [001]. Between 505K and 605K the magnetic moments gradually turn and above 605K they are confined to the (001) plane. Taking into account magnetic space groups ordered magnetic moments perpendicular to [001] are not possible in hexagonal symmetry, so one can propose a possible lowering (probably monoclinic) of the hcp-Co structure symmetry above 605K. We propose to study this question by using both neutron powder diffraction at D2B and SR powder diffraction at MSPD (ALBA in Barcelona – proposal recently submitted).

The neutron powder diffraction pattern of the Co sample with a hexagonal-close-packed (hcp) type structure [1-5], measured with D2B at λ=1.594Å, is shown in Fig. 1a. The synchrotron radiation (SR) powder diffraction pattern of the same hcp-Co sample measured at the beamline MSPD [6] at ALBA-CELLS in Barcelona, using λ=0.413Å, is shown in Fig. 1b for comparison. The same scale with the scattering vector Q = (4π/λ)sinθ is used in both plots, where 2θ is the scattering angle. The Bragg peaks are marked with their (hkl) indices



The hcp-Co phase has the tendency for substantial amounts of stacking faults [1-5]. The Bragg peaks can be divided in two categories. The peaks which fulfill the conditions: {[h-k = $3n_1$] and [l = $2n_2$], where n_1,n_2 are integers} are marked in red colour as No_StF i.e. „without broadening due to the stacking faults" as shown in [1]. The remaining Bragg peaks are marked in black colour as StF i.e. „with broadening due to stacking faults". The broadening due to stacking faults is especially strong for (102) and (103) Bragg peaks, in both neutron and SR diffraction patterns.

The goal of this study is to determine the crystal and magnetic structure of hcp-Co across its spin reorientation proces (observed between 505K and 605K in hcp-Co single crystals [7-9]). The hcp-Co phase shows ferromagnetic ordering as shown in single crystal studies [7,8]. Below 505K the Co magnetic moments are directed along the hexagonal unique [001] axis, while above 605K they are reported to be perpendicular to [001]. The Bragg peaks intensity ratios I(100)/I(002) and I(101)/I(002) observed with neutron (Fig. 1a) and SR (Fig. 1b) diffraction differ. For neutron diffraction the intensity I(002) is relatively smaller and one can conclude that this is due to the magnetic scattering contributions. For the ferromagnetic moments along [001] the magnetic contribution to (002) is zero while the contributions to (100) and (101) are substantial. The quantitative analysis of the neutron powder diffraction pattern of hcp-Co is difficult because of e.g. the background due to the incoherent scattering of Co, the absorption and the influence of stacking faults. The analysis is in development.

References

[1] O.S. Edwards and H. Lipson, *Proc. Roy Soc.* **A180**, 267 (1942).

[2] H. Jagodzinski, *Acta Cryst*. **2**, 208 (1949).

[3] F. Frey and H. Boysen, *Acta Cryst.* **A37**, 819 (1981).

[4] O. Blaschko, G. Krexner, J. Pleschiutschnig, G. Ernst, C. Hitzenberger, H. P. Karnthaler, and A. Korner, *Physical Review Letters* **60**, 2800 (1988).

[5] W. A. Slawinski, E. Zacharaki, H. Fjellvag, and A. O. Sjastad, *Crystal Growth & Design* **18**, 2316 (2018).

[6] F. Fauth, R. Boer, F. Gil-Ortiz, C. Popescu, O. Vallcorba, I. Peral, D. Fulla, J. Benach, and J. Juanhuix, *The European Physical Journal Plus* **130**, 160 (2015).

[7] E.F. Bertaut, A. Delapalme and R. Pauthenet, *Solid State Comm*. **1**, 81 (1963).

[8] E.F. Bertaut, A. Delapalme and R. Pauthenet, *J. de Physique*, **25**, 610 (1964).

[9] J.-E. Bidaux and B. Cao, *J. Phys. Condens. Matter*, **3**, 2263 (1991).