Experimental report

15/02/2023

Proposal: 5-41-1164 **Council:** 4/2021

Title: Determination of the magnetic structure(s) in the charge density wavecompound TbTe3

Research area: Materials

This proposal is a resubmission of 5-41-1103

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Samples: Tb Te3

Instrument	Requested days	Allocated days	From	To
D23	4	0		
D19	0	5	03/09/2021	08/09/2021

Abstract:

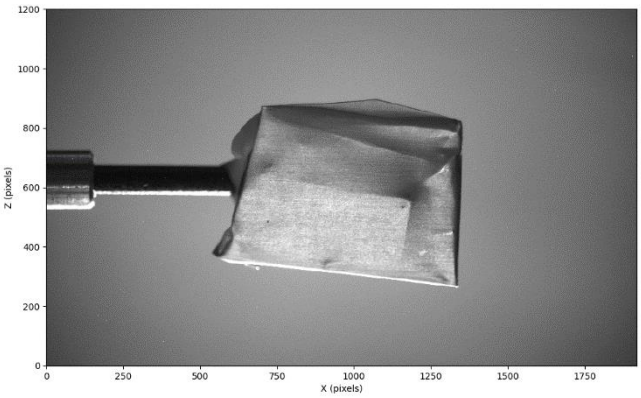
Our preliminary experiments on TbTe3 (see Fig. 1 and experimental reports CRG-2702 and 7-02-188) have shown a complex magnetic ordering with at least 2 (may be three) phase transitions below 6K with coexistence of commensurate and incommensurate structures. Despite the small sample size, the magnetic scattering cross section is so large that counting times at the magnetic Bragg peaks are in the order of 1000-10000 c/s in in22 and in ThALES. The interest of this proposal lies in the observation of an interaction between the ordered magnetic moments and the CDW manifested by the appearance of smaller magnetic peaks indexed as ½-qCDW along the modulation direction, the c-axis. The goal of this proposal is to determine the different magnetic structures that are present in this compound. The outcome of this experiment will be important for the understanding of the measured excitations in the inelastic neutron scattering experiments that we are carrying out, and in particular to the possible interaction between the CDW states and the magnetism in this compound.

Experiment 5-41-1164 report

Determination of the magnetic structure(s) in the charge density wave compound $TbTe_3$

D19

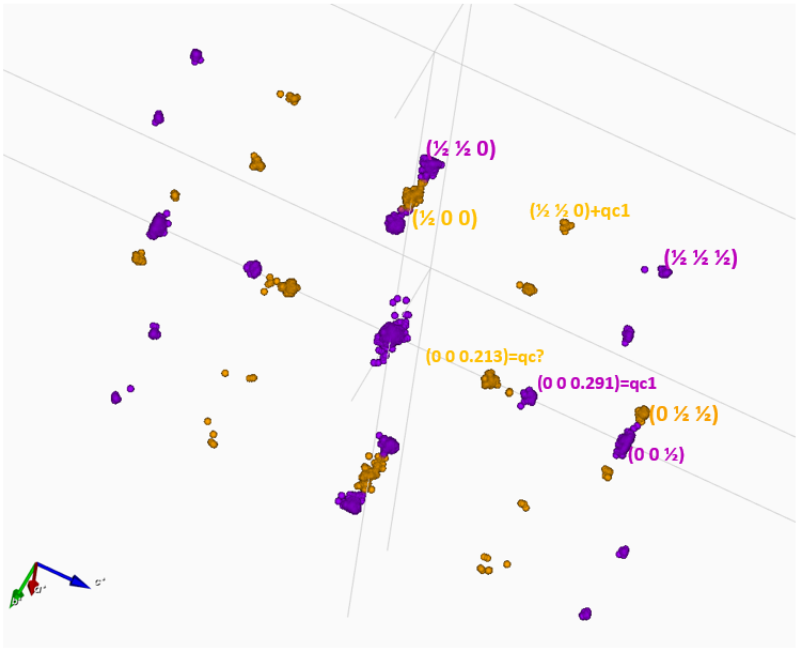
In order to be able to separate the different CDW/SDW contributions and to extract them from background, the diffractometer has been aligned to deliver a wavelength of 1.45Å (most intense configuration).



Prior to the D19 experiment, several high-quality platelets of $TbTe_3$ were characterized on the Laue instrument and using OrientExpress. Amongst them, only one had the proper crystallographic characteristics to be used on D19. This single crystal was then wrapped in an aluminum foil (to avoid possible stress-induced inhomogeneities in the sample at low temperature) and set on an standard Vanadium pin. The D19 Displex, with the Joule-Thompson option and with He as exchange gas around sample was used to cover the temperature range of interest (1.8K – 300K).

Some of the nuclear Bragg peaks of our sample were so intense that it was necessary to limit the incident neutron beam flux. A 250µm Cadmium filter was used to protect the detector, which dynamics is strictly limited (30kHz per 6° sector). The very large D19 detector allows to measure at the same time very broad sections of the reciprocal space, in our case to visualize simultaneously fundamental Bragg peaks and weak or very weak signals coming from CDW of SDW orderings. The option of “measure fundamental peaks with attenuation” and “measure satellites without attenuation” is then not possible. We have extended the measuring time per omega-step to have a correct signal-to-noise for weak reflections. After optimization of experimental conditions, we have collected two data sets: one at 15K above the magnetic transitions, and another one at 3K, in the most ordered magnetic phase. A temperature survey of some sectors of the reciprocal space was carried out between 1.8K-10K upon cooling and heating.

At 15K, space group *Cmcm* was confirmed and Bragg peaks characteristic of the CDW q_{c1} superstructure were visible, albeit not very intense. However, data analysis revealed that, at such a low intensity level a $\lambda/2$ contamination cannot be discarded. And this contamination, after filtering, is of the same order of magnitude as the most intense CDW diffraction spots measured on $TbTe_3$. At 3K, new Bragg spots appear that are related to the magnetic ordering ([0 ½½] and [½ 0 0]) and two new Bragg spots at [½½0]+q_{c1} and at [0 0 0.213], which can be view as [0 0 ½]-q_{c1}. At present, the weak intensities combined with $\lambda/2$ contamination make the analysis difficult, if not impossible, considering the complexity of $TbTe_3$ system, with two CDW, one (or 2) SDW plus coupling effect between spin and charge degrees of freedom.



peaks at T = 15K
(½ ½ ½)
(½ ½ 0)
(0 0 ½)
(0 0 0.291)=qc1

peaks at T = 3K
(½ ½ ½)
(½ ½ 0)
(0 0 ½)
(0 0 0.291)=qc1
additional
(0 ½ ½)
(½ ½ 0)+qc1
(½ 0 0)
(0 0 0.213)=qc?

Bragg spots of $TbTe_3$ at 15K and 3K in reduced reciprocal unit cell.

During the experiment, the detector appeared perturbed over few angular sectors (see figure below). This problem was overcome thanks to the intervention of SCI.