Experimental report

15/02/2023

Proposal: **5-41-1146**

Council: 4/2021

Title: Determination of magnetic superstructures in HoTe3

Research area: Physics

This proposal is a new proposal

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Samples: HoTe3

Instrument	Requested days	Allocated days	From	To
D10	6	0		
D19	0	5	09/09/2021	14/09/2021

Abstract:

Rare-earth layer chalcogenides of type RTe3 (R: Ce, Ne, Gd, Tb, Dy, Ho, Er, Tm) are prominent examples which undergo charge (CDW) and magnetic order and superconductivity under pressure. In our preliminary experiments on IN22 (CRG-2702 and 7-02-188) and on THALES (4-01-1670), we found that charge and magnetic orders in TbTe3 are highly entwined. However, while TbTe3 is remarkable in having three very closely spaced transitions between 5.3 and 5.8 K, all of the compounds in the series exhibit two successive magnetic transitions. The goal of the proposed experiment is to determine for the first time the magnetic superstructures in the parent compound HoTe3 ((Tmag1= 3.25K and Tmag2= 2.87K): modulations vectors (incommensurate or commensurate) below TN, temperature dependence and collection of magnetic intensities aiming at a magnetic structure refinement. These measurements are of a great importance with respect to the joint proposal on THALES entitled ¿Determination of the magnetic excitations in the charge density wave compound HoTe3 by inelastic neutron scattering¿. To that end we apply for 6 days on the 4-circle diffractometer D10 featuring low background and high resolution.

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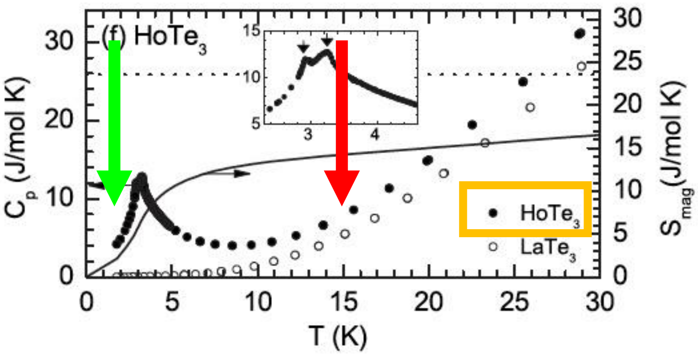
Determination of magnetic superstructures in $HoTe_3$
D19

In order to be able to separate in the reciprocal space the different charge/spin density wave (CDW/SDW) contributions and to extract them from background, the diffractometer has been aligned to deliver a wavelength of 1.45Å, with the HOPG filter option (most intense configuration with most limited $\lambda/2$ contamination).

Several high-quality platelets of $HoTe_3$ were tested on the Laue instrument OrientExpress, prior to the experiment on D19. The best crystal was 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).



Ru et al, Phys. Rev. B 78, 012410 (2008)

Temperature dependence of the specific heat of $HoTe_3$ (black circles) compared to that of the non-magnetic $LaTe_3$ (empty circles) after Ru et al. Not shown, $HoTe_3$ undergoes two different CDW transition at T_{CDW1}~280K and T_{CDW2}~125K

Some 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 D19 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 then extended 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 1.8K, in the most ordered magnetic phase, and performed a limited heating temperature survey.

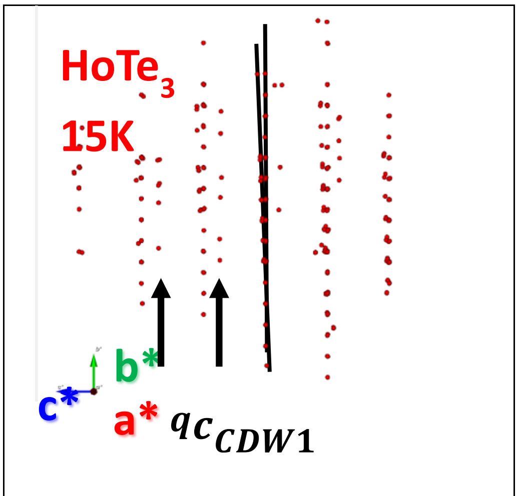
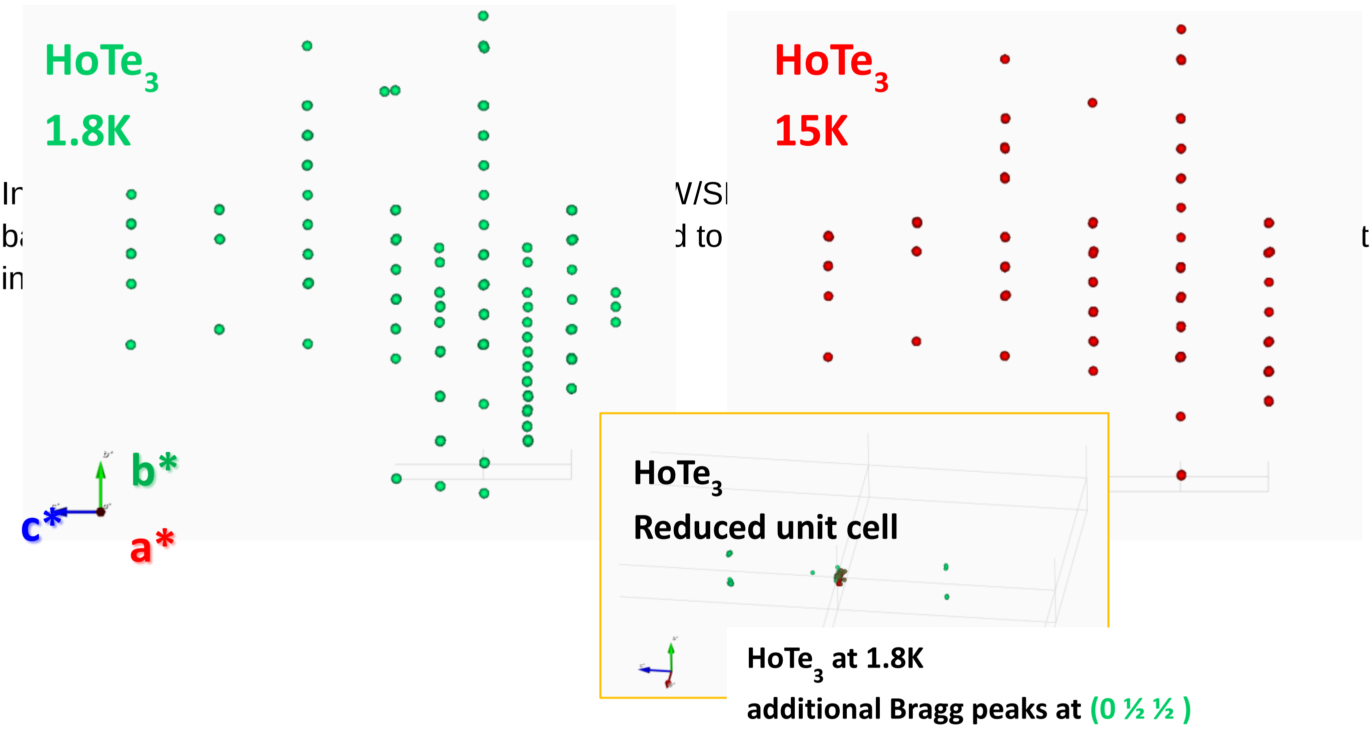


Figure: Partial reconstruction of the (0,k,l) reciprocal space. The two arrows in black represent the lines of CDW superstructure. The central lines represent the 2° misorientation.

At 15K, the diffraction pattern presents two distinct networks, with a mis-orientation of ~2° along a*, one much more intense than the other. If one focuses on the most intense domain, the diffraction pattern agrees well with a *C*-unit cell (although a $\lambda/2$ contamination is suspected) and presents few satellite reflections at (0 0 ~0.27), consistent with the reported CDW superstructure.

At 1.8K, new and intense reflections appear at positions [0 ½ ½]. But the poor quality of the sample and the $\lambda/2$ contamination make the determination of CDW's and SDW's signatures particularly tricky using data collected on D19.



During the experiment, D19 detector presented instabilities, with non-responding sectors in the wide angle region. This problem required several interventions of SCI at the cost of the temperature survey of the transition.