Experimental report

02/05/2022

Proposal: **5-41-1113** **Council:** 10/2020

Title: Magnetic structure of magnetic Weyl semimetal Co3Sn2S2

Research area: Physics

This proposal is a new proposal

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Samples: Co3Sn2S2

Instrument	Requested days	Allocated days	From	To
D3 CPA	3	3	08/06/2021	11/06/2021
D10	5	5	28/05/2021	02/06/2021

Abstract:

One of the major themes in solid-state physics is the realization of exotic types of relativistic electrons which travel at speeds much slower than the speed of light. These electrons live in crystals with very specific structural properties. One such material is the magnetic Weyl semi-metal, which forms through a very specific type of magnetic order. The presence of Weyl electrons in Co3Sn2S2 is indicated by experiments that probe the electronic structure, but up to now there is no definitive confirmation that the necessary type of magnetic order is present. We shall use the D10 and D3 diffractometers to investigate the magnetic properties of Co3Sn2S2. We aim to establish conclusively whether or not Co3Sn2S2 is a Weyl semi-metal.

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The proposal relates to the rapidly-expanding field of topological materials, specifically the search for materials which host topological electrons that are strongly coupled to the magnetic order. The aim is to identify a system where the topological character of the electronic bands can be controlled by altering the spin structure with an external applied field. Very recently, Co3Sn2S2 was proposed as an example of such a system, but the magnetic structure has not been identified. We wish to perform careful single crystal diffraction measurements of the crystal and magnetic structure of Co3Sn2S2 to establish the nature of topological fermions in Co3Sn2S2.

Single crystalline Co3Sn2S2 were measured with polarised and unpolarised neutrons on beamlines D3 and D10 to determine the magnetic order of the Co magnetic sublattice for $T < T_A$ = 125 K and $T_A < T < T_C$= 170 K.

From our D10 measurements, we find that in both phases, Co displays ferromagnetic order with moments along the crystal c axis. However, we were not able to exclude other possible magnetic structures solely based on the unpolarised neutron data.

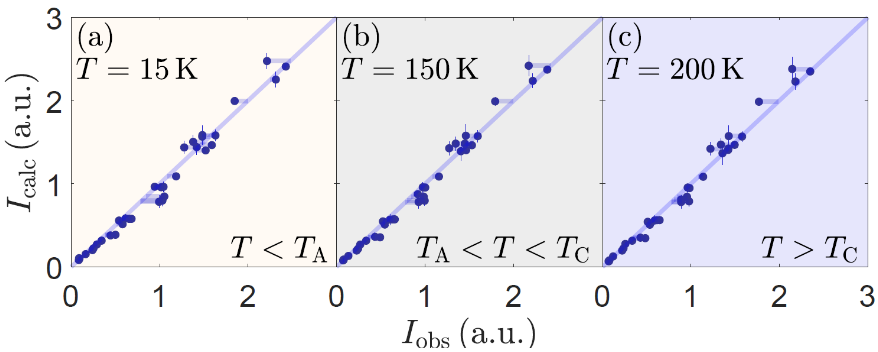

Figure 1. (a)-(c), Comparison between the measured and calculated integrated intensities of Co3Sn2S2 measured at 15, 150 and 200 K.

Hence, we used the polarised neutrons with the spherical neutron polarimetry (SNP) setup on D3. We were able to exclude the AFM magnetic order that was recently proposed to coexist with the FM order between T_A and T_C.

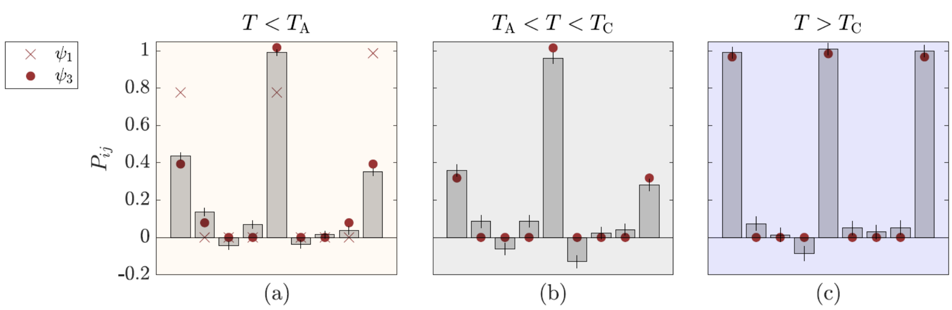

Figure 2. Comparison between the calculated and measured polarization matrices of the 101 reflection below T_A, between T_A and T_C and above T_C assuming and in-plane antiferromagnetic Ψ_1 and a ferromagnetic Ψ_3 order.

To help with the alignment of the crystal to within 0.5 degrees, we used the OrientExpress Laue Diffractometer.