Experimental report

13/09/2023

Proposal: CRG-2927 **Council:** 10/2022

Title: Loop currents in the Kagome superconductor CsV3Sb5

Research area: Physics

This proposal is a new proposal

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Samples: CsV3Sb5

Instrument	Requested days	Allocated days	From	To
IN22 CPA	6	6	23/06/2023	05/07/2023

Abstract:

The abstract is in the scientific case pdf file.

Proposal number: CRG-2927

title: "Loop currents in the Kagome superconductor CsV_3Sb_5"

Experimental team: P. Bourges, W. Liège, D. Bounoua, Y. Sidis, F. Bourdarot, Yaofeng Xie, Pengcheng Dai

Report:

CsV3Sb5 exhibits an the hexagonal structure with a Kagome lattice of vanadium atoms. Possible loop currents structure on the David star of the Kagome lattice [Feng21,Lin21,Zhou22,Mielke22**]**. Similarly to copper oxides superconductors [Bourges21], closed loop currents create orbital magnetic moments pointing perpendicularly to the hexagonal plane. The orbital magnetic moments could be detected by polarized neutron diffraction. A structure factor calculation suggests magnetic intensity at different points in Q-space depending of correlations between loop currents in neighboring unit cells. Two situations might occur: i) if the pattern is the same in the next unit cell, intensity is expected on Bragg peaks of the hexagonal lattice [Mielke22]. For instance, magnetic intensity is expected at Q=(1,0,0) where the nuclear Bragg spot is weak. ii) In contrast, if the CDW is modulated the interaction between units cells [Feng21,Lin21,Zhou22], magnetic intensity should occur at the M=(1/2,0,0) point where the CDW peak is showing up [Xie22]. The same way the correlations along the vanadium planes stacking could be in-phase or out-of-phase leading to magnetic contributions at L integer (L=0,1) or half-integer (L=1/2).

A first experiment has been performed on IN22 from 28/09/2021 to 04/10/2021. The sample was mounted in the (H,0,L) scattering plane: that was actually dictated by the sample geometry which was used in a previous experiment on IN8 to look for possible phonon softening at the CDW temperature [Xie22]. About 400 individual single crystals were co-aligned on four aluminum plates to form an assembly with a volume of 0.11 cm3 and an in-plane mosaic spread of 3.5 deg [Xie22]. The crystal assembly was put inside a He Orange cryostat and oriented in the [*H,* 0*, L*] horizontal scattering plane where the (H,0,L) Bragg spots were accessible as well as the M points (H+0.5,0,L). We measured spin-flip and non-spin-flip scattering to identify possible magnetic contributions at H integer and half-integer and for L=0,1 or L=1/2. Within error bars, no magnetic signal was observed in that experiment (see report **:** 5-54-346).

Next, we follow the idea [Zhou22] that the magnetic intensity could be much larger at the position (1/2,1/2,0) along the ΓK direction rather than at the M point= (1/2,0,0) leaving the possibility to still observe the loop currents with polarized neutron scattering. In a second experiment, performed in June 2023 (CRG-2927), we then mount the sample of CsV_3Sb_5 on IN22 in the (H,H,L) scattering plane where the same M-point is accessible. Due to geometrical constraints, the sample was limited in mass to be about 2/5 of the previous sample as only one Al plate could be mounted. Nevertheless, we have a hint of a weak magnetic signal at (1/2,1/2,0) (Fig. 3,4). It was needed to count a long time in total to achieve this result (about 4 hours/point).

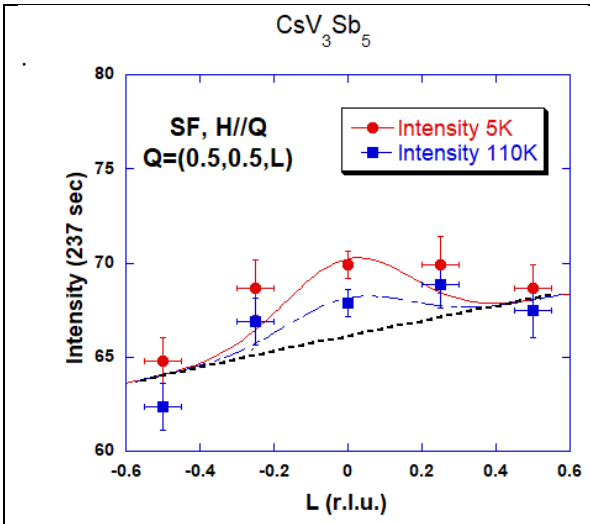

Figure 3: L-dependence of the magnetic intensity along Q=(1/2,1/2,L) in the spin-flip channel with the X polarization at 5K (red) and 110K (blue).

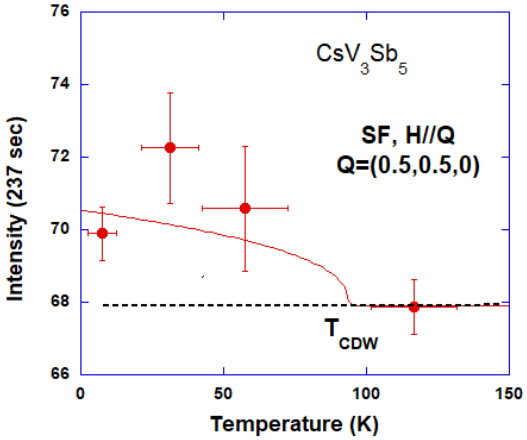

Figure 4: Temperature dependence of The magnetic peak Q=(0.5,0.5,0) of the spin-flip intensity with polarization X polarization.

Unfortunately, we could not perform a polarization analysis with the necessary accuracy although the preliminary polarization analysis suggests a weak magnetic feature at L=0 consistent with Figs. 3 and 4. Further, the polarization analysis had to be performed using the Helmholtz coils as, unfortunately CRYOPAD was not working during that period. To perform a proper polarization analysis, CRYOPAD is necessary to have a more homogenous polarization along the XYZ directions.

It should be stressed that the observed signal reported here is below the threshold of the error bars of our previous experiment at the M-point Q=(0.5,0,0) where we have not counted enough time (about 20 minutes) to see the possible magnetic intensity.

In conclusion, we have observed a hint of time-reversal breaking symmetry using a polarized neutron diffraction experiment in the Kagome superconductor CsV_3Sb_5 below the CDW temperature. If true, the magnetic signal is noticeably much weaker than the different theories have proposed [Feng21,Lin21,Zhou22]. Improved statistics in the (H,0,L) plane should be performed to finalize that project and give a definitive conclusion.

References:

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