Experimental report

13/02/2019

Proposal: **5-41-955** **Council:** 4/2018

Title: Magnetic structure of the pressureinduced antiferromagnetic phase ofFeSe at low temperature

Research area: Physics

This proposal is a new proposal

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Samples: FeSe

Instrument	Requested days	Allocated days	From	To
IN22	7	6	22/10/2018	28/10/2018

Abstract:

We have recently studied by XRD (at ESRF) and RIXS (at SOLEIL) the pressure and low temperature phase diagram of superconducting (SC) FeSe. The Cmma phase of FeSe transforms at 1GPa in a distorted structure, found antiferromagnetic (AFM) by muons spectroscopy. Above 6.5GPa a second high pressure (HP) phase (Pnma) appears which shows a higher magnetic moment (deduced from the K beta'(Fe) emission line). In this proposal we want to determine the unresolved magnetic structure of the AFM phase by neutron scattering on single crystal pressurized at 2GPa in a hybrid clamp-type cell using the IN22 instrument. More generally our work will allow to better understand the low temperature part of the controversial P,T phase diagram of FeSe, in particular the interplay between the SC phase and the AFM phase in the 1-2GPa range.

The objective of our **proposal 5-41-955** on the **3-axis IN22 spectrometer** was to definitively determine the magnetic structure of the pressure induced antiferromagnetic phase of FeSe in the 1-6 GPa range (see phase diagram Fig.1(a) and ref.[1-3]). We performed the corresponding neutron scattering experiment in Oct. 2018 on a thick FeSe single crystal (grown by chemical vapor transport (CVT) transport [4]), at low T and ~ 2 GPa. A FeSe crystal with <110> edges (in the tetragonal cell) of platelet shape (2.5mm x 2.0mm) and 0.9mm of thickness along [001] was mounted vertically in an hybrid CuBe/NiCrAl clamp-type cell (Fig.1(b) [5]). In such geometry we probe the [HHK] plane. The PTM was deuterated glycerol. A small piece of lead, used as a low T pressure marker (inside a coil), and a wire of manganin (strain sensor at RT) were also mounted in the cell to check for the pressure reached before the ILL experiment. The T_c value of lead obtained by AC susceptibility measurements showed a pressure of 2.3GPa reached at low T. At this pressure the T_c value of our FeSe crystal was measured to be 20K, which is consistent with the literature [2]. We have probed different nuclear Bragg peaks ((110), (001), (111)) below (1.6K) and above (60K) the magnetic transition (around 45K at 2.3GPa [2]). We have also measured different positions in reciprocal space where magnetic reflections could be expected from the µSR study conclusions [6,7] ((1/2 1/2 0), (1, 1, ½), (0, 0, ½), etc…) but no signal above the background signal due to the HP-cell was found. Then we have measured Q-scans along (h h 0), (1 1 h), (h, h 1), (h, h, ½), (h, h, h), (h, h, -h), (½ ½ l) directions at 1.6K and 60K. We have noticed that the background changes a little bit during some scans because of the un-optimized position of the cadmium shielding. Nevertheless we were able to detect a signal at (¾ ¾ 1), equivalent to (¼ ¼ 0), probably of magnetic origin (Fig.1(c)). This peak is present at 1.6K and 60K. We had not enough time to study its full temperature dependence.

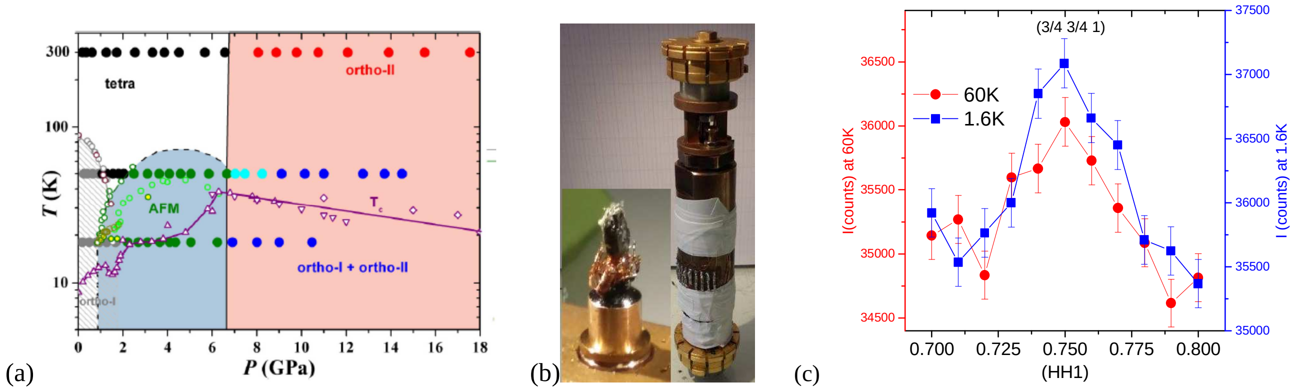

Fig. 1.: (a) Phase diagram of FeSe under hydrostatic pressure established by XRD under pressure and low temperature at ESRF/id27 beamline (V. Svitlyk *et al.* [1]); (b) left: FeSe crystal mounted on its holder ; right: the clamp-type cell closed with FeSe crystal inside [exp. 5-41-955, IN22, ILL (oct.2018)] (c) Q-scan along (HH1) of FeSe at 2.3GPa and 60K or 1.6K.

References

[1] V. Svitlyk, P. Toulemonde et al. Phys. Rev. B 96, 014520 (2017).

[2] J. P. Sun et al. Nat. Comm. 7, 12146 (2016).

[3] K. Kothapalli et al. Nat.Comm. 7, 12728 (2016).

[4] M. Ma et al. Phys. Rev. X 7 (2017) 021025.

[5] S. Raymond et al. Phys. Rev. B 77, 172502 (2008).

[6] M. Bendele et al. Phys. Rev. B 85, 064517 (2012).

[7] R. Khasanov et al. Phys. Rev. B 95, 180504(R) (2017).