Experimental report

17/02/2020

Proposal: 5-31-2722 **Council:** 10/2019

Title: Study of the competition between magnetism and superconductivity in BaFe2Se3

Research area: Physics

This proposal is a continuation of 5-31-2639

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Samples: BaFe2Se3

Instrument	Requested days	Allocated days	From	To
D1B	3	3	10/02/2020	13/02/2020

Abstract:

The Iron-based spin ladder BaFe2Se3 becomes superconducting between 10 and 15 GPa. Recently, a first-principles study reported that the local moment of Fe still exists at the superconductive phase in BaFe2Se3. The coexistence of magnetism and superconductivity is unique and intriguing. In order to study the physical nature involved in this phenomenon, we plane to perform a neutron powder experiment above 10 GPa. The determination of the magnetic structure as a function of pressure will help to understand the competition between magnetism and superconductivity.

Study of the competition between magnetism and superconductivity in $BaFe_2Se_3$

- Objective & expected results : -

The Iron-based spin ladder $BaFe_2Se_3$ becomes superconducting between 10 and 15 GPa. This proposal aimed to perform a powder neutron diffraction experiment at low temperature in order to determine the magnetic structure as a function of pressure in $BaFe_2Se_3$. We expected to measure and refine the powder neutron diffraction data in the superconducting dome (10-15 GPa) of $BaFe_2Se_3$.

- Results and the conclusions of the study (main part): **-**

Recently, $BaFe_2Se_3$ has attracted much attention due to its superconductivity under pressure [1, 2]. At ambient pressure, a Block-type magnetic structure with the propagation vector of (1/2 1/2 1/2) has been found in $BaFe_2Se_3$ [1]. In the previous research, we found that its magnetic structure becomes a CX-type structure with the propagation vector of (1/2 0 1/2). The difference between Block-type and CX-type magnetic structure is shown in Fig. 1(b). This magnetic structure transition corresponds with the first-principle study [2]. But we only reached 10.2 GPa in the last experiment on D1B. In this case, we did not reach enough pressure to determine the magnetic structure of $BaFe_2Se_3$ in the superconducting phase.

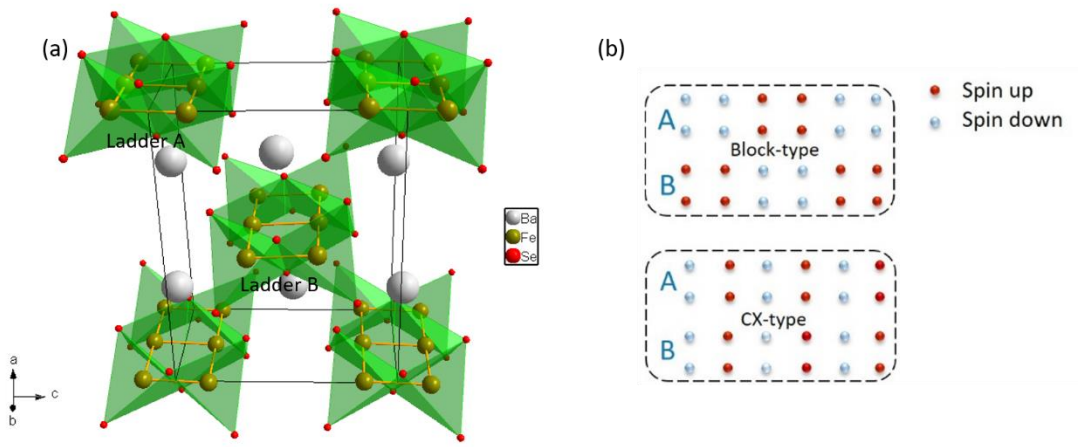

Figure 1: (a) The crystallographic structure of $BaFe_2Se_3$. (b) The difference between Block-type and CX-type magnetic structure.

In this experiment, we reached the pressure of 12.5 GPa which is in the middle of the superconducting dome. The diffraction patterns under different pressure are shown in fig. 2. One can see that the magnetic peak of CX-type still exists at 12.5 GPa. But the intensity of magnetic peak at 12.5 GPa is not as strong as 10.2 GPa. This is not enough to illustrate the existence of magnetism in the superconducting phase. Therefore, an extra experiment around 12 GPa is required.

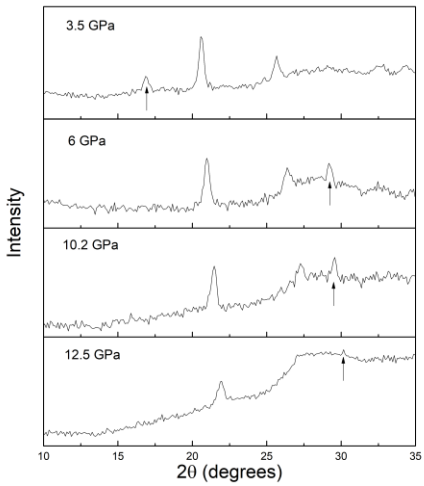

Figure 2: The neutron diffraction at 3.5, 6, 10.2 and 12.5 GPa at 3 K. The black arrows indicate the magnetic peaks.

[1] Caron et al, PHYSICAL REVIEW B 84, 180409(R) (2011)
[2]Yang et al, PHYSICAL REVIEW B 97, 045119 (2018)