Experimental report

11/02/2019

Proposal: 4-02-531 **Council:** 4/2018

Title: Polarized neutron scattering studyof the nematic spin correlations in uniaxial strained BaFe2As2

Research area: Physics

This proposal is a new proposal

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Samples: BaFe2As2

Instrument	Requested days	Allocated days	From	To
IN22 CPA	8	8	02/10/2018	10/10/2018

Abstract:

The electronic nematic in iron pnictides has been discovered in many properties and thought to be crucial for understanding the origin of the intertwined orders in iron pnictides. It has also been discovered in spin excitation. Our previous experiment has observed clear spin excitation difference between Q1 = (1, 0) and Q2 = (0, 1) in the tetragonal state of uniaxial strained BaFe2-xNixAs2 (termed nematic spin correlations). This nematic spin correlation has been proposed to be essential for sorting out the origin of the electronic nematic. One effective way to obtain a complete understanding of the nematic spin correlations is to study its structure in spin space, that is, the spin fluctuations along a, b and c axes (Ma, Mb, Mc) of uniaxial strained sample and its temperature dependence across TN. Moreover, nuclear magnetic resonance measurements on strained sample suggested that the spin nematic along c axis diverges at TN while its in-plane counterparts not, indicating a strong coupling between strain and c axis spin polarization. To sort out the nature of the nematic spin correlations and the coupling, we propose to study strained BaFe2As2 by polarized neutron scattering.

Polarized neutron scattering study of the nematic spin correlations in uniaxial strained $BaFe_2As_2$

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The origin of the in-plane electronic nematic is one of the most important unresolved problems in the quest for the mechanism of high-T_c superconductivity in iron pnictides [1]. The electronic nematic was firstly discovered in the resistivity measurements of underdoped $Ba(Fe_{1-x}Co_x)_2As_2$ [2], which undergoes structural and magnetic transitions (T_S>T_N) and forms twinning domains in the orthorhombic antiferromagnetic state [2]. Resistivity measurements on uniaxial-stress detwinned $Ba(Fe_{1-x}Co_x)_2As_2$ revealed strong in-plane resistivity anisotropy (ρ_a<ρ_b) persisting to a temperature (T^*) well above T_S. This non-trivial nematic in the uniaxial-strained paramagnetic tetragonal state was proposed to be crucial for understanding the origin of the intertwined orders in iron pnictides, and has received intensive studies by various techniques [1-4]. This nematic has also been discovered in spin excitations [4].

The nematic spin correlation is intimately correlated with the resistivity anisotropy [2] and proposed to be crucial for sorting out the origin of the electronic nematic [1]. One effective way to obtain a complete understanding of the nematic spin correlations is to study its structure in spin space, that is, the spin fluctuations along a, b and c axes (M_a, M_b, M_c) of uniaxial strained sample, M_a is the longitudinal mode, M_b is transverse mode along b axis and M_c transverse mode along c axis (out of plane).

In this experiment, we have measured the fully detwinned (Fig.1) $BaFe_2As_2$ sample which $T_N \approx 143K$ and obtained the Ma, Mb, Mc components. Fig.2 shows the constant-Q scan at two AF wave vectors Q_1=(1 0 1) and Q_2=(1 0 3) at T=135K((a)-(c)) and 180K((d)-(f)). Fig.2(c) shows our calculated M_a, M_b, M_c (M_c>M_b>M_a), it is similar to spin excitations of $BaFe_2As_2$ [5]. Fig.2(f) confirms the isotropic paramagnetic of the scattering. Fig.3 shows the constant-Q scan at (H 0 L) and (0 K L) scattering plane at T=135K. Fig.3(c) revealing M_a>M_c>M_b, it indicates that M_b increases above T_N. It is different from the case in twinned $BaFe_2As_2$ sample where M_a>$M_c \approx M_b$ [6].

Figure.4 summarizes the main results of our experiment. In a twinned $BaFe_2As_2$ sample, Fig.4 (e) shows that the longitudinal mode (M_a) at E=2 meV diverges at T_N while the transverse modes evolve smoothly across T_N [6]. In a detwinned $BaFe_2As_2$ sample Fig.4 (f) shows that not only the longitudinal mode M_a diverges, but the transverse mode M_c also shows a clear diverging tendency, while M_b changes less compared with that in twinned sample. This result is very clear in the raw data [Figs. 4(a)-4(d)].

Reference:

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[2] J. Chu *et al.*, Science **329**, 824 (2010).

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[4] Xingye Lu *et al*., Science **345**, 657 (2014).

[5] C.Wang *et al*., Phys. Rev. X **3**, 041036 (2013).

[6] Yu Li *et al*., Phys. Rev. B **96**, 020404(R) (2017).

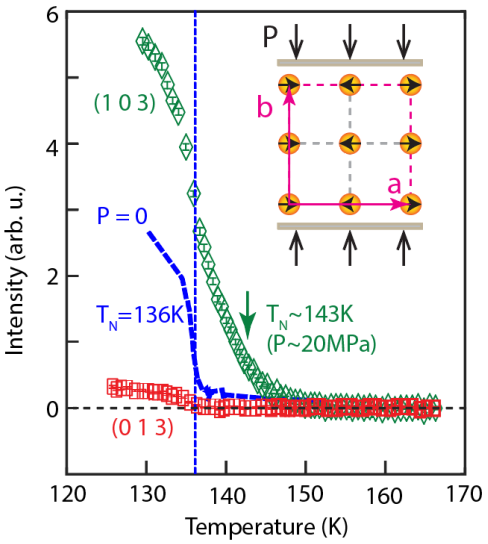

Fig.1 Temperature dependence of magnetic order parameter measured at Q=(1 0 3) and (0 1 3) with fully detwinned sample. The blue line is measured at Q=(1 0 1) on twinned sample.

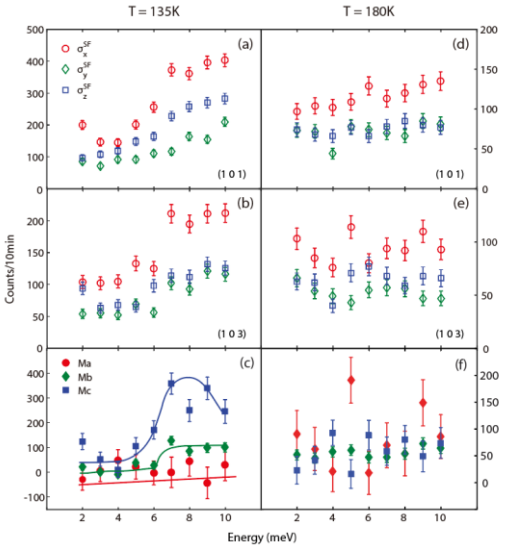

Fig. 2 Constant-Q scan at two AF wave vectors Q_1=(1 0 1) and Q_2=(1 0 3) at T=135K, 180K.

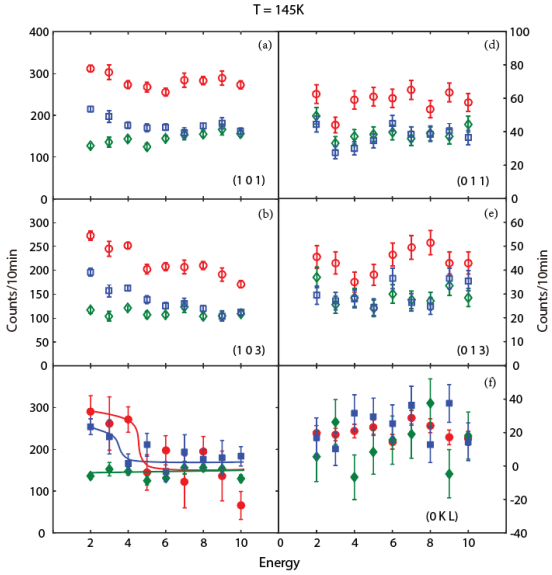

Fig. 3 Constant-Q scan at two AF wave vectors Q=(1 0 1), (1 0 3), (0 1 1), (0 1 3) at T=145K.

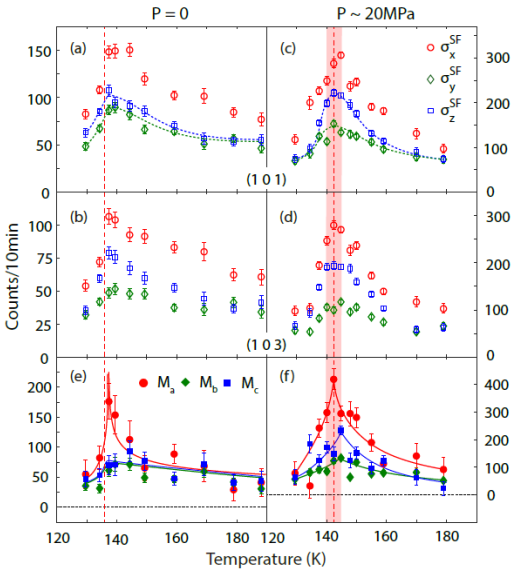

Fig.4 (a)-(d) Temperature dependence of twinned and detwinned sample at (1 0 1) and (1 0 3). (e)-(f)The calculated temperature dependence of M with twinned and detwinned sample.