Experimental report

23/07/2018

Proposal: **CRG-2433** **Council:** 4/2017

Title: Polarization analysis on the magnetic resonant mode in the superconducting Li0.8Fe0.2ODFeSe (Tc=41 K)

Research area: Physics

This proposal is a new proposal

Main proposer: **Jitae PARK**

Experimental team: Yu FENG
Hongliang WO
Zheng HE
Die HU
Qisi WANG
Jitae PARK

Local contacts: Alexandre IVANOV

Samples: Li0.8Fe0.2ODFeSe

Instrument	Requested days	Allocated days	From	To
IN22 CPA	8	7	19/06/2018	26/06/2018
IN3	1	1		

Abstract:

The anisotropy of resonance mode in magnetic superconductor provides improtant information on nature of the resonance mode which is essential for establishing the mechanism behind the superconductivity. Previous results on iron pnictides have shown that spin anisotropy is due to their proximity to the AF ordered state and the resonance modes in iron pnictides are more complex than a simple spin exciton and the precise nature of the resonance mode in the iron-based superconductors remains elusive. Here we propose to measure the anisotropy of the resonance mode in newly discovered iron based superconductor Li0.8Fe0.2ODFeSe. Since superconducting Li0.8Fe0.2ODFeSe is not close to a magnetically ordered state, it provides an excellent opportunity to study the spin anisotropy of the resonance mode not subject to the influence of an AF ordered state.

CRG-2433 Experiment Report

Scientific background

Elucidating the origin of the neutron spin resonance mode widely observed in unconventional superconductors is essential for revealing the mechanism of their superconductivity. The neutron polarization experiment enables people to study the spin-space anisotropy of the resonance mode and the related spin excitations, which provides important information about the pairing symmetry of the superconductivity and the nature of the underlying magnetic interactions. A lot of efforts have been made on the polarized neutron scattering measurements on the cuprate and iron-based superconductors. Isotropic resonance mode has been observed in optimally hole-doped $YBa_2Cu_3O_{6+x}$, which is consistent with a spin exciton excitation and *d* wave pairing symmetry [1,2]. On the other hand, anisotropic resonance mode has been revealed in electron-doped iron pnictide $Ba(Fe_{1-x}Ni_x)_2As_2$, electron-doped $NaFe_{1-x}Co_xAs$ and hole-doped $Ba_{1-x}K_xFe_2As_2$. Here the anisotropy is attributed to their proximity to the AF ordered state in the parent compound [3-5], in which state the spin-orbit coupling is strong. Therefore, the resonance modes in iron pnictides can be more complex than a simple spin exciton scenario and the 3d orbits of Fe must be taken into consideration. As yet the precise nature of the resonance mode in the iron-based superconductors remains unsettled.

The recently discovered electron doped iron-selenide superconductor $Li_{0.8}Fe_{0.2}ODFeSe$ (T_c = 41 K) with only electron Fermi surfaces has attracted intense interest, not only because of its atypical magnetism and band structure, but also because it is the first electron doped iron-selenide superconductor for which phase-pure single-crystalline samples can be synthesized [6-8]. Our recent neutron scattering measurements on single crystalline $Li_{0.8}Fe_{0.2}ODFeSe$ have revealed a strong resonance mode at 21 meV at an incommensurate wave vector (0.5π, 0.69π) (1-Fe unit cell) [Fig. 1, ref. 9]. Since superconducting $Li_{0.8}Fe_{0.2}ODFeSe$ is not close to a magnetically ordered state, it provides an excellent opportunity to study the spin anisotropy of the resonance mode not subject to the influence of an AF ordered state.

Experiment results

In this experiment, 4 grams of high quality single crystal have been co-aligned in (*H*, *K*, 0) plane (1-Fe unit cell). The E_f has been chosen to be 14.7meV with the PG filter after the sample. The polarized beam has been obtained by the monochrometor made of Heusler crystal, and Cryopad has been used for the polarization analysis. Constant-energy scans along *K* direction has been measured at 21meV below (T = 2K) and above (T = 45K) superconducting transition temperature (Fig. 2), and the resonance mode is found to be isotropic. In order to study the spin-space anisotropy in the full energy range, we performed the constant-Q scan at (0.5π, 0.69π) (not shown in this report) and found that the spin excitation is isotropic from 7meV to 30meV, which is the highest energy transfer we could get in this experiment. Our result resembles the one of over-doped $Ba(Fe_{1-x}Ni_x)_2As_2$ [10], indicating that the spin-orbit coupling may be weaker in this system than in under- or optimal- doped iron pnictides.

References

[1] H. A. Mook *et al.*, Phys. Rev. Lett. 70, 3490 (1993).
[2] H. F. Fong *et al.*, Phys. Rev. B 54, 6708 (1996).
[3] O. J. Lipscombe *et al.*, Phys. Rev. B 82, 064515 (2010).
[4] C. Zhang *et al.*, Phys. Rev. B 90, 140502(R) (2014).
[5] C. Zhang *et al.*, Phys. Rev. B 87, 081101(R) (2013).
[6] X. Lu *et al.*, Nat. Mater. 14, 325 (2015).
[7] L. Zhao *et al.*, Nat. Commun. 7, 10608 (2015).
[8] X. Niu *et al.*, Phys. Rev. B 92, 060504(R) (2015).
[9] B. Pan *et al.*, Nat. Commun. 8, 123 (2017).
[10] M. Liu *et al.*, Phys. Rev. B 85, 214516 (2012)

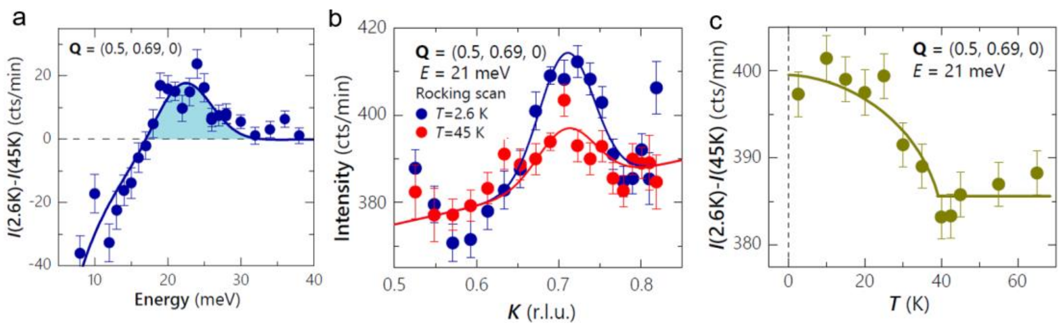

Fig.1. Magnetic resonance mode in $Li_{0.8}Fe_{0.2}ODFeSe$ (Tc = 41 K). **a**, Energy dependence of the intensity difference between the superconducting state and normal state [I(2.6K)-I(45K)] spin excitations for $Li_{0.8}Fe_{0.2}ODFeSe$ at **Q**= (0.50, 0.69, 0). **b**, Rocking scan near (0.50, 0.69, 0) at E = 21 meV at T=2.6 K and 45 K. **c**, Temperature dependence of the scattering at (0.50, 0.69, 0) and E = 21 meV.

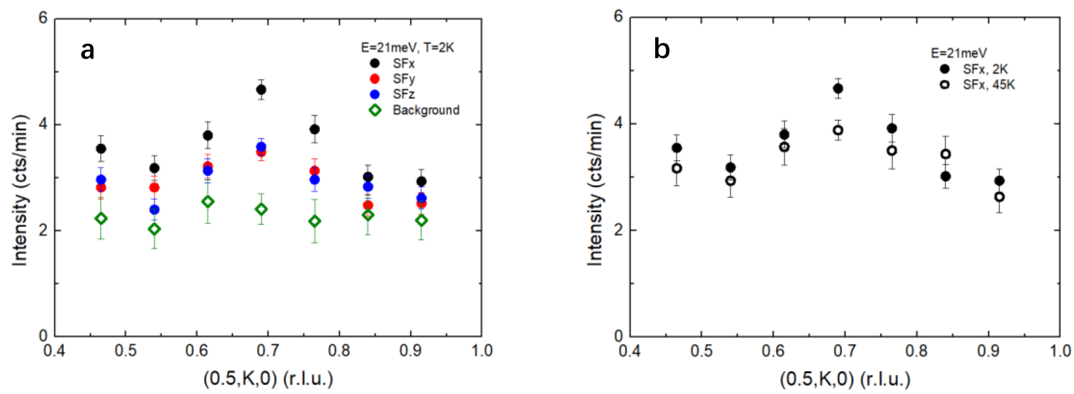

Fig. 2 **a**, Constant-energy scans along K direction for the three spin-flip channels at T = 2K and at the resonance energy, the background is determined by SF_y+SF_z-SF_x. **b**, Constant-energy scans along K direction in the spin-flip x channel below and above superconducting phase transition temperature.