Experimental report

15/08/2017

Proposal: **4-02-484**

Council: 4/2016

Title: Anisotropy in spin excitations of FeSe

Research area: Physics

This proposal is a new proposal

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Samples: FeSe

Instrument	Requested days	Allocated days	From	To
IN20 Flatcone	7	7	12/09/2016	19/09/2016

Abstract:

By inelastic neutron scattering measurements, we have discovered spin resonance and spin fluctuations in FeSe. It would be rather interesting to see if resonance mode and spin gap are anisotropic in FeSe and how it evolves across TS since it shows no static order but strong spin fluctuation in this compound. If FeSe is a nematic quantum-disordered paramagnet, strong anisotropy is expected since it is close to static ordering. The evolution of spin excitation anisotropy will demonstrate how superconductivity, nematicity and spin fluctuation interplay in FeSe and will provide a brand new understanding of iron-based superconductors.

Experimental Report of Proposal 4-02-484

Anisotropy in spin excitations of FeSe

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FeSe being structurally the simplest iron-based superconductor has attracted tremendous research interest because of its distinctive features. Instead of showing any magnetic order, FeSe exhibits a quantum nematic ground state in which strong magnetic frustration was induced by the competition between stripe and Néel spin fluctuations [1,2]. The atypical magnetism of FeSe is believed to have strong relation with its fascinating superconducting properties. Despite an extensive study, the pairing symmetry of FeSe is still under intense debate [3]. A detailed study of the spin anisotropy may provide crucial information on revealing the pairing mechanism of FeSe. Our proposed experiment is to use inelastic neutron scattering with polarization analysis to study the evolution of spin anisotropy across the superconducting and nematic transition in FeSe.

Our polarized neutron scattering experiment was carried out on the IN20 triple-axis spectrometer equipped with CryoPAD capacity. FeSe single crystals were aligned in the (H, 0, L) scattering plane with a total mass of ~ 6 grams for the measurements. We define the wave vector **Q** at (q_x, q_y, q_z) as (h, k, l) = ($q_x a/2\pi$, $q_y b/2\pi$, $q_z c/2\pi$) reciprocal lattice units (r.l.u.) in the orthorhombic 4-Fe unit cell. We define the neutron polarization directions along **Q** as x, perpendicular to **Q** but in the scattering plane as y and perpendicular to x and y as z, respectively. The flipping ratio was about 20 in our experiment. In this geometry, SFx, SFy and SFz denote the scattering signals in the three spin-flip channels measured with incident neutron spins along x, y and z axis which detect the Mb+Mc+bg, Mb+bg and Mc+bg, respectively, where Mb is the b-axis component, Mc is the c-axis component and bg is the common background.

Figure 1 shows the constant energy scans through (1,0,0) at E= 4 meV in SFy and SFz channels at 1.5 K. Since we have SFy= Mb+bg, SFz= Mc+bg, the c-axis component of the magnetic excitation (Mc) is much stronger than the b-axis component (Mb) which is similar to the spin anisotropy observed in pnictides [4].

To establish the evolution of the spin anisotropy across the nematic transition in FeSe, we measured the energy dependence of the scattering signals in all three spin-flip channels above T_s at **Q**= (1,0,0) and **Q**= (1,0,1) (Fig. 2). Clearly, SFy=SFz is satisfied for all energies measured at both wavevectors which is evidence for a pure isotropic paramagnetic scattering. The isotropic nature of spin excitation above T_s further indicates a strong coupling between spin and electronic anisotropy.

Reference

[1] Q. Wang et al., Nat. Commun. 7, 12182 (2016).

[2] F. Wang, S. A. Kivelson, D.-H. Lee, Nat. Phys. 11, 959–963 (2015).

[3] A. I. Coldea, M. D. Watson, arXiv: 1706.00338 (2017).

[4] P. Dai, Rev. Mod. Phys. 87, 855 (2015).

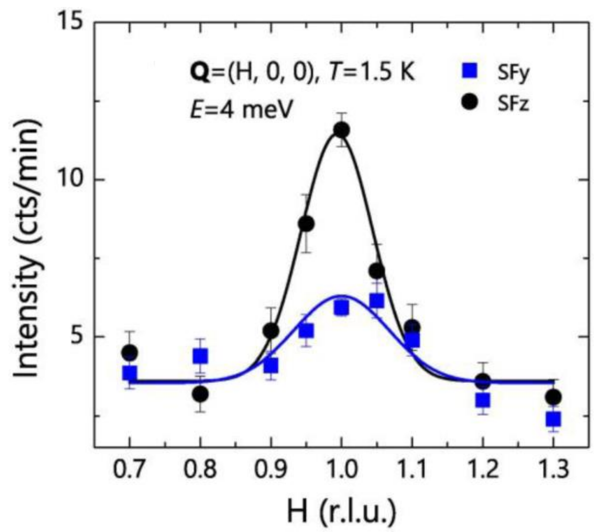

Figure 1. Constant energy scan through (1,0,0) at E=4meV in SFy and SFz channels at 1.5K.

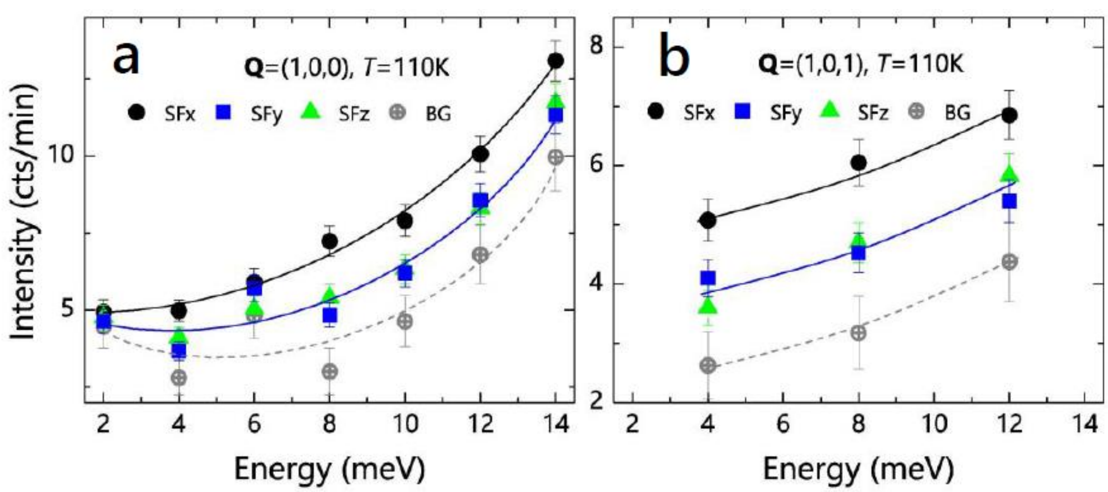

Figure 2. Energy scans measured at (a) Q=(1,0,0) and (b) Q=(1,0,1) at 110K in three different spin-flip channels.