Experimental report

11/03/2019

Proposal: 4-02-496

Council: 10/2016

Title: Polarized neutron scattering on $SrCo_2As_2$ single crystal

Research area: Physics

This proposal is a new proposal

Main proposer: Philippe BOURGES

Experimental team: Yu LI
Philippe BOURGES

Local contacts: Mechthild ENDERLE

Samples: $SrCo_2As_2$

Instrument	Requested days	Allocated days	From	To
IN20 CPA	7	7	05/04/2018	12/04/2018

Abstract:

The systematic measurements on the doping dependence of spin excitation in Fe-based superconductors has been done and it was found that Fermi surface nesting plays a significant role in the low energy spin excitations. In $SrCo_2As_2$ where all Fe ions are replaced by Co with one electron doped, the longitudinally elongated spin excitations was observed by neutron scattering, similar to the case in hole doped $BaFe_2As_2$.Recently, our previous neutron scattering experiment suggests that there exist the ferromagnetic fluctuations in $SrCo_2As_2$ in spite of the existence of strong phonon contamination. Our DMFT calculation demonstrates that there exists a flat band nearby the fermi level, probably being responsible for the ferromagnetic instability. Further analysis shows that the spin excitations spectrum in $SrCo_2As_2$ has different orbital origin from that in $BaFe_2As_2$. However, more experimental detail of the nature of the spin fluctuations in $SrCo_2As_2$ is missing and calls for further studies. Therefore, we propose a polarized neutron scattering experiment on $SrCo_2As_2$ to distinguish the FM fluctuations from the non-magnetic background and help us understand the magnetism in this system.

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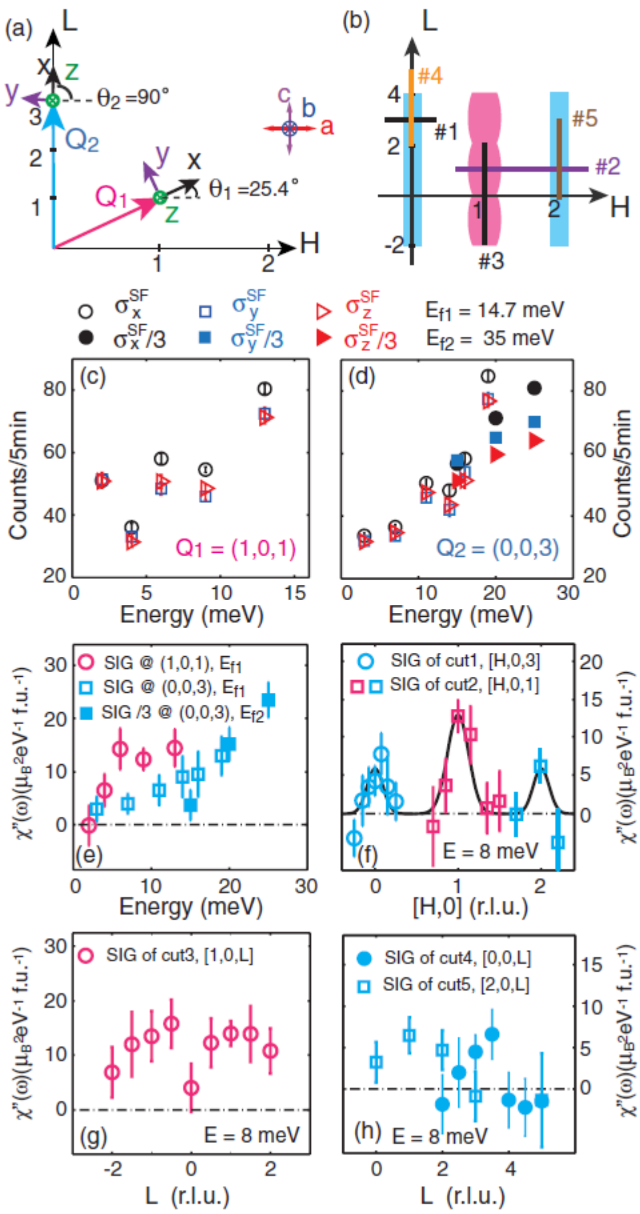
Magnetism in AFe_2As_2 (A=Ba,Sr,Ca) attracts great attention because of its close relationship with unconventional superconductivity. One piece of evidence is that the antiferromagnetic (AFM) fluctuations[1,2] share the same wave vector with the proposed superconducting pairing ($S\pm$)[3,4] between the hole Fermi pockets at the zone center and the electron pockets at the zone boundary. Substituting Fe or A by Co or K introduces charge carriers and then tunes the Fermi surfaces consistent with rigid band shift model [5,6]. This makes the iron pnictides ideal systems to study the doping dependence of magnetism and superconductivity.

We carried out on IN20 polarized neutron scattering experiments with the neutron polarization directions x, y, and z shown in the Fig. which correspond to neutron spin-flip (SF) scattering cross sections σSFx , σSFy , and σSFz , respectively. The magnetic scattering of $SrCo_2As_2$ should then be SIG= $\sigma SFx - (\sigma SFy + \sigma SFz)/2$. The figure (c) and (d) show the energy scans at Q1=(1,0,1) and Q= (0,0,3) [Fig. (a)]. Figure (e) shows energy dependence of SIG at Q1 and Q2, confirming the presence of magnetic fluctuations at the AF and FM wave vectors, respectively. At Q1 [Fig. (c)], $\sigma SFy \approx \sigma SFz$ implies that the AF spin fluctuations are isotropic in spin space, different from the anisotropic spin fluctuations in $BaFe_{2-x}Co_xAs_2$ induced by spin-orbit coupling. These results suggest that the spin-orbit coupling in $SrCo_2As_2$ is weaker than that of $BaFe_2As_2$. At Q2 [Figs. (d), (e)], magnetic scattering increases with increasing energy with no spin gap above E~ 3 meV, providing direct evidence for the FM spin fluctuations in $SrCo_2As_2$. To further demonstrate the coexisting FM and AF spin fluctuations, we performed constant-energy scans along the [H; 0; 3] and [H; 0; 1] directions at E ~ 8 meV [Fig. (b)]. Figure (f) indicates that the FM spin fluctuations are confined near (0,0,3) and are about half the size of that of the AF signal around (1,0,1). The DFT+DMFT calculations predict the dominant FM spin fluctuations around 10 meV. Constant-energy scans along the [1; 0; L] [Fig. (g)] and [0; 0; L] [Fig. (h)] directions reveal weakly L dependent scattering at both the AF and FM positions, respectively, confirming the quasi-two-dimensional nature of the magnetic scattering.

These results are published in Phys. Rev. Lett: Yu Li et al, PRL 122 (march 2019).



Caption: (a) Schematic of the [H,0,L] scattering plane for neutron polarization analysis. The AF and FM wave vectors are labeled as Q1 and Q2, respectively. The neutron polarization directions are along the x, y and z. (b) Locations of FM (blue) and AF (magenta) spin fluctuations in reciprocal space. Lines indicate scan directions. (c,d) Constant-Q scans of σSFx, σSFy and σSFz at Q1=(1,0,1) and Q2=(0,0,3),respectively, at T = 1.5 K. (e) Constant-Q scans of pure magnetic scattering at Q1 and Q2. (f,g,h) Constant-E scans of the AF (magenta) and FM (blue) pure magnetic scattering at E = 8 meV along the H and L directions. The scan directions are marked in (b).

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