Experimental report

19/02/2020

Proposal: 4-02-549 **Council:** 10/2018

Title: Coupling between magnetic excitations and optic phonons in high-Tc cuprate La2-xSrxCuO4

Research area: Physics

This proposal is a new proposal

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Samples: La2-xSrxCuO4 (x=0,0.12)

Instrument	Requested days	Allocated days	From	To
IN20	14	7		
IN3	1	1	18/06/2019	19/06/2019

Abstract:

La2-xSrxCuO4 is an unusual high temperature superconducting system because it shows both spin and charge order near doping p ~1/8. This may be because the distortions of the LTO structure caused by the charge density wave modulate the exchange coupling J. This scenario is supported by recent neutron measurements which suggest that the inelastic magnetic scattering is anomalously strong where certain phonon branches cross dispersing magnetic excitations. Unfortunately, these unpolarized measurements do not distinguish between magnetic excitations and phonons. Here we propose to use polarization analysis to isolate the magnetic and phonon scattering and determine whether extra scattering is indeed present.

Experimental Report

Abstract

In optimally doped high temperature cuprates $La_{2-x}Sr_xCuO_4$ (LSCO, x = 0.16) there are strong magnetic excitations near 18 meV, coincident with an optical phonon [1]. Previous unpolarized neutron scattering have suggested the presence of spin-phonon coupling, which enhances the magnetic intensity [2]. Here we used polarized neutrons to separate spin fluctuations and phonons, but didn't observe any enhancement in the magnetic scattering at 18 meV.

Experimental details

The LSCO (x = 0.16) single crystal of 6.12 grams was aligned in the (HHL) scattering plane. Heusler monochromators and analysers, and Helmholtz coils were used for polarization analysis. Goniometers were used to access wave vectors out of the scattering plane. The measurements were performed at T = 40 K in the normal state to avoid neutron depolarization. The x,y,z axes were defined as follows: x is parallel to **Q**; y is in the scattering perpendicular to **Q**; z is perpendicular to the scattering plane to complete the right-handed coordinate system.

We have performed: 1) constant-E scans at E = 18 meV; 2) constant-**Q** scans at **Q** = (0.61 0.5 3) from 4 to 30 meV. A vanadium standard was measured prior to the sample to calibrate the intensity to absolute scale. For each scan, the non-spin flip channel was measured as the neutron polarization **P** // x. The spin flip channel was measured for **P** // x, y, z, respectively.

Results

Figure 1(a) shows the constant-**Q** scan at **Q** = (0.61 0.5 3) at T = 40 K. Three phonon modes were observed in the non-spin flip channel $\sigma_{xx}^{\uparrow\uparrow}$ at E = 15, 19 and 27 meV. In the spin flip channels, the intensity for $\sigma_{xx}^{\uparrow\downarrow}$ (**P** // x) is greater than $\sigma_{yy}^{\uparrow\downarrow}$ (**P** // y) and $\sigma_{zz}^{\uparrow\downarrow}$ (**P** // z), suggesting magnetic scattering over the entire energy range. The imaginary part of the generalized susceptibility $\chi''_{\perp}(Q,\omega)$ calibrated to absolute unit is shown in Fig. 1(b). We note there is no clear enhanced magnetic scattering at E = 18 meV, where the optical phonon crosses.

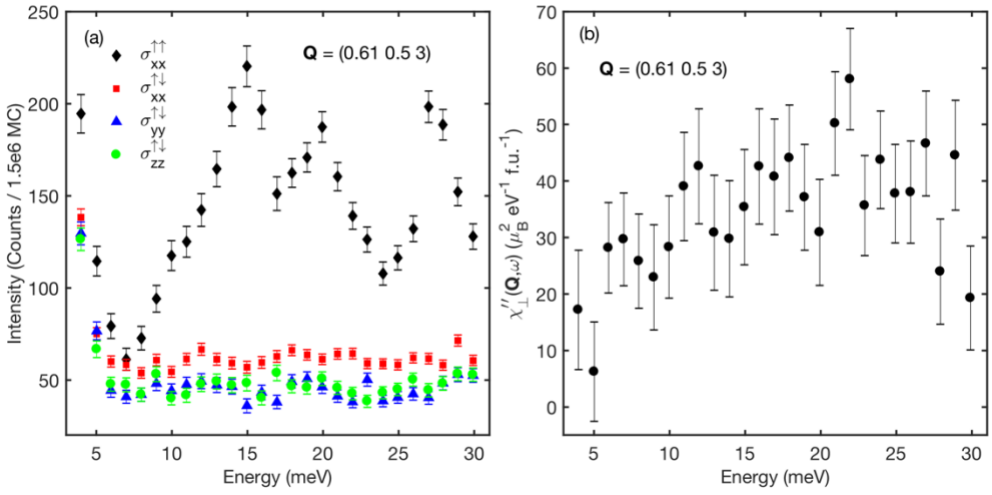

Fig. 1. (a) Constant-Q scans at **Q** = (0.61 0.5 3) of non-spin flip and spin flip channels with **P** // x, y, z, respectively, at T = 40 K. (b) Imaginary part of generalized susceptibility as a function of energy.

Figure 2 shows the constant-E scan at E = 18 meV. Incommensurate magnetic excitations were seen at **Q** = (0.5 0.5-δ 3), and (0.5+δ 0.5 3), δ ≈ 0.11. (b)

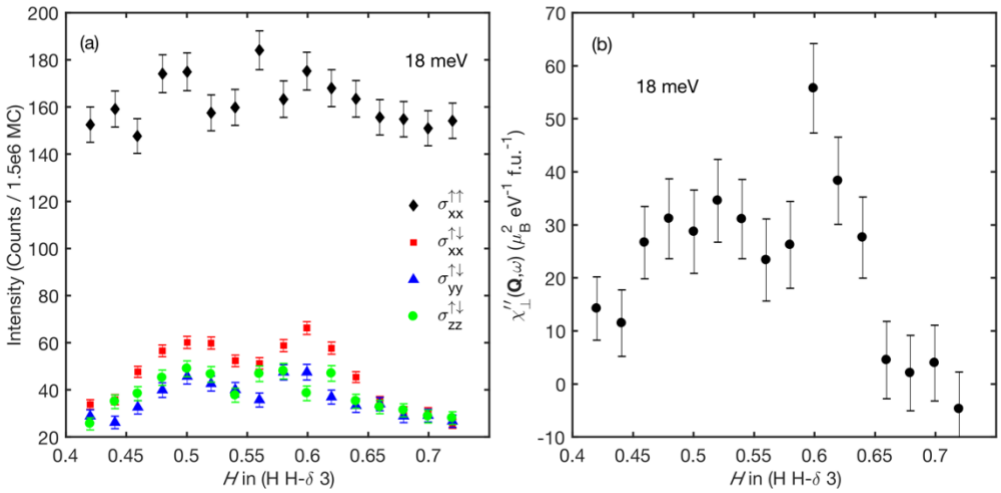

Fig. 2. (a) Constant-E scans at E = 18 meV, T = 40 K. (b) Imaginary part of generalized susceptibility as a function of momentum transfer.

Conclusion and future work

We have used polarized neutrons to search for potential spin-phonon coupling in LSCO (x = 0.16). Contrary to the unpolarized neutron, we didn't observe any convincing enhancement in the magnetic excitations at E = 18 meV, where the optical phonon and the spin fluctuations overlap.

We will using polarized neutron to study how the pure magnetic excitations at E = 18 meV evolve as temperature decreases below T_c. This may correspond to an incommensurate spin resonance on the contrary to the commensurate magnetic resonances observed in other cuprates.

References

[1] B. Vignolle et al, Nat. Phys. **3**, 163 (2007).
[2] J. J. Wagman et al, Phys. Rev. B **93**, 094416 (2016).