Experimental report

26/02/2020

Proposal: 4-02-573 **Council:** 10/2019

Title: A polarized neutron study of the incommensurate magnetic resonance inLa2-xSrxCuO4

Research area: Physics

This proposal is a new proposal

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Samples: La2-xSrxCuO4 (x=0.16)

Instrument	Requested days	Allocated days	From	To
IN20 CPA	14	5	19/02/2020	26/02/2020

Abstract:

A magnetic resonance - in the sense of a dramatic change in spin excitation spectrum - has not been convincingly established in the archetypal high temperature cuprate (HTC) superconductor La2 xSrxCuO4 (LSCO). Our recent experiment using IN8 on optimally doped LSCO has revealed strong temperature dependence in the excitations at 18 meV at (0.5,0.5+d), which correspond to an incommensurate resonance. However, there is an optical phonon near 18 meV that complicates the extraction of pure magnetic intensity. Here, we propose to use polarized neutrons to isolate magnetic scattering from phonons and measure pure magnetic excitations through 18 meV below and above Tc. Our results should unambiguously reveal the incommensurate resonance in LSCO

Experiment Report

Abstract

Magnetic resonance, a dramatic change in the spin excitation spectrum upon entering the superconducting state, has been observed in a variety of unconventional superconductors [1-3]. It appears at commensurate wave vectors. However, magnetic resonance has not been convincingly established in high temperature superconducting cuprate $La_{2-x}Sr_xCuO_4$ (LSCO). Unpolarized neutron scattering has revealed a pronounce peak in the local spin susceptibility $\chi''(\omega)$ at 18 meV dominated by magnetic excitations at incommensurate wave vectors [4]. Nevertheless, there is an optical phonon near 18 meV which complicates the extraction of the pure magnetic intensity [5]. Here, we use polarized neutrons to separate spin fluctuations and phonons and unambiguously identify the incommensurate magnetic resonance in LSCO.

Experimental details

Four LSCO (x = 0.16) single crystals of a total mass 17.8 grams were co-aligned with (0 0 1) and (0.61 0.5 3) in the horizontal scattering plane. The superconducting transition temperature T_c has been measured by electrical transport to be T_c = 38.2 K. CRYOPAD was used for polarization analysis and to shield the magnetic fields at the sample position to avoid neutron depolarization in the superconducting state.

We performed constant-**Q** scans at an incommensurate wave vector **Q** = (0.61 0.5 3), where magnetic excitations have been detected by unpolarized neutrons, from 4 to 30 meV with full polarization analysis at two temperatures T = 1.5 and 40 K below and slightly above T_c. We expect to observe a dramatic redistribution of the spectral weight upon entering the superconducting state.

Results

Figure 1(a) and (b) shows the constant-**Q** scans at **Q** = (0.61 0.5 3) from E = 4 to 30 meV at T = 1.5 and 40 K, respectively. The definition of x,y and z axis is: x parallel to **Q**, y in the scattering plane but perpendicular to **Q**, z perpendicular to the scattering plane. We find that the intensity in the spin flip channel $\sigma_{xx}^{\uparrow\downarrow}$ is clearly enhanced.

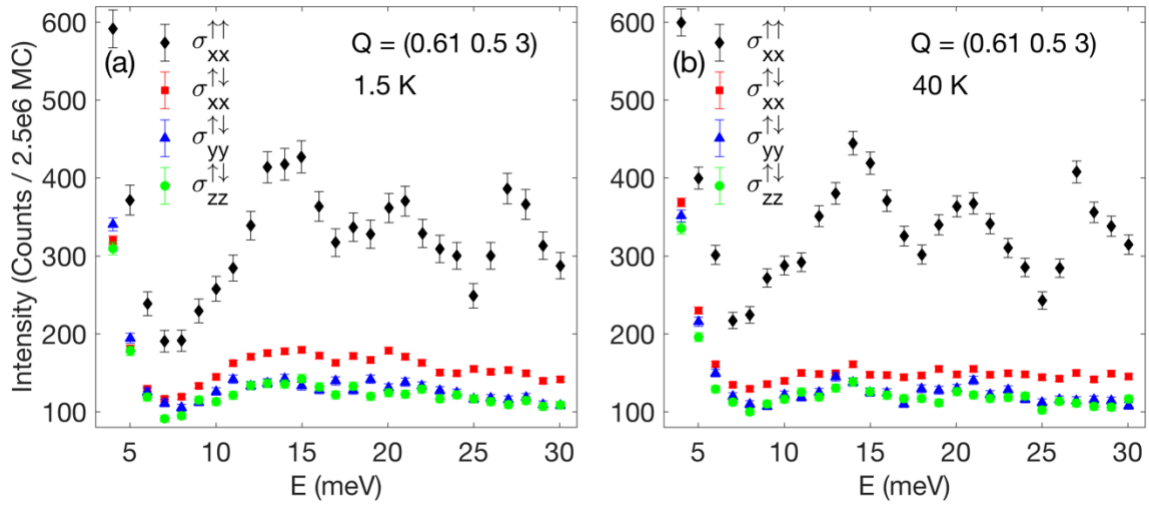

Fig. 1. Constant-**Q** scan at **Q** = (0.61 0.5 3) at (a) T = 1.5 and (b) 40 K, respectively.

The pure magnetic scattering $I = 2I_{xx}^{SF} - I_{yy}^{SF} - I_{zz}^{SF}$ estimated based on Fig. 1 is shown in Fig. 2. We observe a suppression in the spectral weight below 6 meV and an enhancement around 18 meV, as expected for a magnetic resonance.

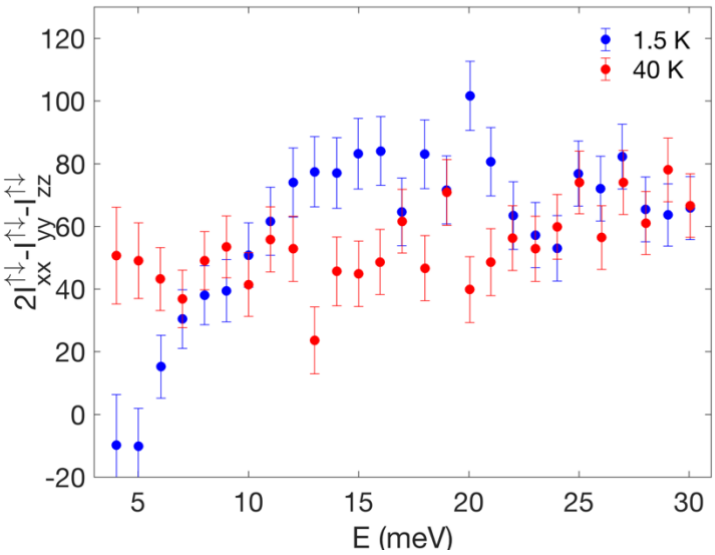

Fig. 2. Pure magnetic scattering estimated from the spin flip channels at T = 1.5 and 40 K.

Conclusion

Using polarized neutrons we have unambiguously identified the magnetic resonance in optimally doped high temperature superconductor LSCO at an incommensurate wave vector (0.5+δ 0.5 L), $\delta \approx 0.11$. This result resolves the long-standing puzzle about the magnetic resonance in LSCO, and call for theoretical models to account for the incommensurate resonance as opposed to commensurate magnetic resonances in other unconventional superconductors.

References

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