Experimental report

12/10/2018

Proposal:	**4-02-526**	**Council:**	4/2018

Title: Detailed study of low-energy spin excitations in underdoped LSCO withx=0.08 (superconducting) and x=0.05 (non-superconducting)

Research area: Physics

This proposal is a continuation of 4-02-488

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Samples: La_(1.95)Sr_(0.05)CuO_(4)
La_(1.92)Sr_(0.08)CuO_(4)

Instrument	Requested days	Allocated days	From	To
THALES	10	5	28/06/2018	03/07/2018

Abstract:

The pairing mechanism responsible for superconductivity in high temperature superconductors (HTSC) is still, to a large extend, an unresolved question. It is believed that the relationship between spin and charge orders holds some of the answers to the pairing mechanism. We therefore propose a detailed study of the spin modulation fluctuations, so called dynamic stripes.
Contrary to previous observations on optimally doped samples, our highly underdoped La_{2-x}Sr_xCuO_4 (LSCO) single crystal with x=0.08 showed a suppression of the dynamic magnetic stripes signal by an applied magnetic field. We now want to perform a detailed investigation of the magnetic field dependence of dynamic stripes in a x=0.08 (superconducting) and a x=0.05 (non-superconducting) as to compare results inside and outside of the superconducting dome.

A study of elastic and dynamic stripes in non-superconducting LSCO with x = 0.05, at Thales

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The purpose of the experiment was to confirm the presence and study the temperature and magnetic field dependence of the incommensurate static and dynamic stripes in strongly underdoped cuprate superconductors LSCO with x = 0.08 and the non-superconducting LSCO crystal with x = 0.05. However, given the time constrains we were only able to measure the x = 0.05 sample.

The sample

The sample is a LSCO single crystal with doping value x = 0.05. The dimensions of the crystal are as follows: cylindrical shape with length 1.7 cm, diameter 0.6 cm and mass ~3.3 g. The sample has been previously aligned at Orient Express such that the a-b place is the scattering plane.

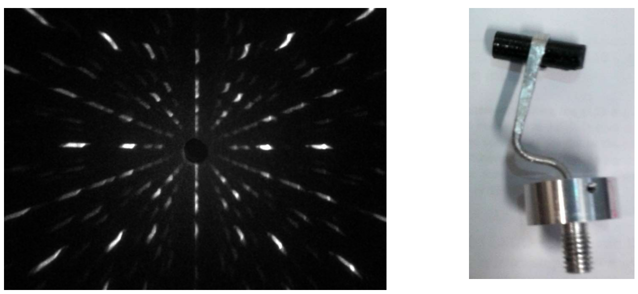

Figure 1: (left) Laue pattern taken along the a or b axis. **(right)** Sample inside the aluminium sample holder aligned in the b-c plane (image taken previous to alignment).

Results

The first step of the experiment was to confirm the 45 degrees rotation of the incommensurate signal compared to samples inside the superconducting dome. For this reason we have made a grid scan around the (0 1 0) reflection at 0.8 meV energy transfer which indeed showed a stronger signal along the orthorhombic main directions (Figure 2). However, the incommensurability of the signal in this region, being directly proportional to the strontium doping, is very low meaning that we were not able in this grid scan to resolve the 4 individual peaks.

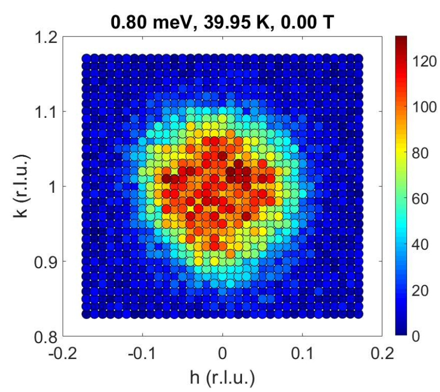

Figure 2: Grid scan around (0 1 0) reflection at 0.8 meV energy transfer.

We then proceeded to measure the field and temperature of the inelastic signal. We observed gapless excitations to the lowest energy transfer that we could measure The effect of a magnetic field is to induce an incomplete gap in our sample at temperatures below 20 K (Figure 3).

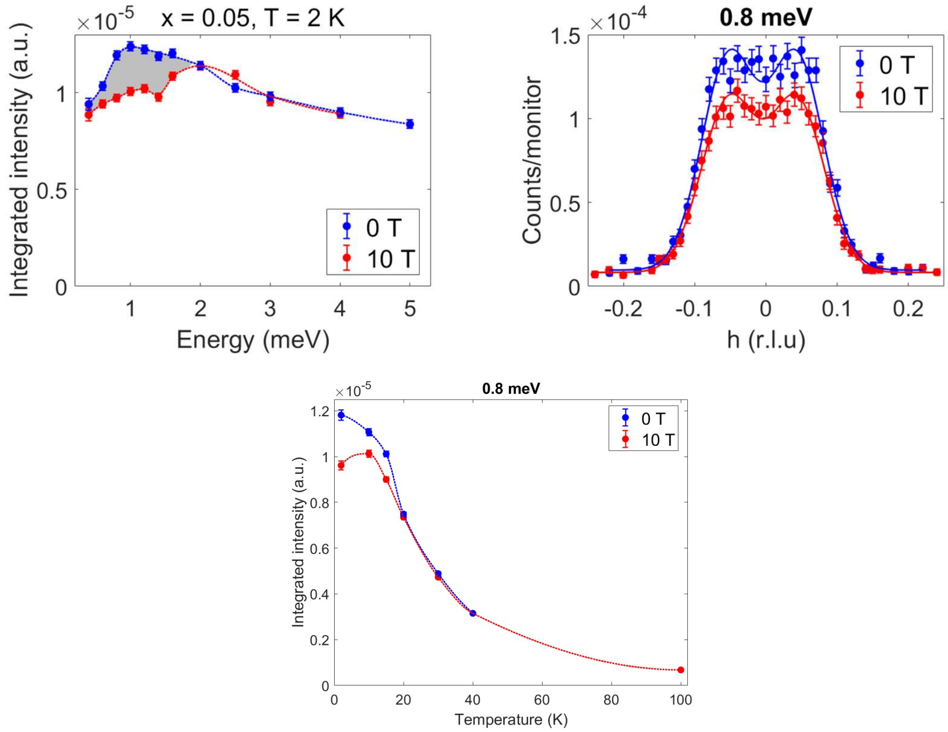

Figure 3: (top-left) Integrated intensity of the inelastic incommensurate signal as a function of energy transfer and applied magnetic field. **(top-right)** Representative data set. The integrated intensity is defined as the amplitude of the Gaussian fit. **(bottom)** Temperature and magnetic field dependence of the inelastic signal measured at 0.8 meV energy transfer.

The elastic signal on the other hand showed no magnetic field dependence. Coincidentally the static stripes are only observed below 20 K (Figure 4).

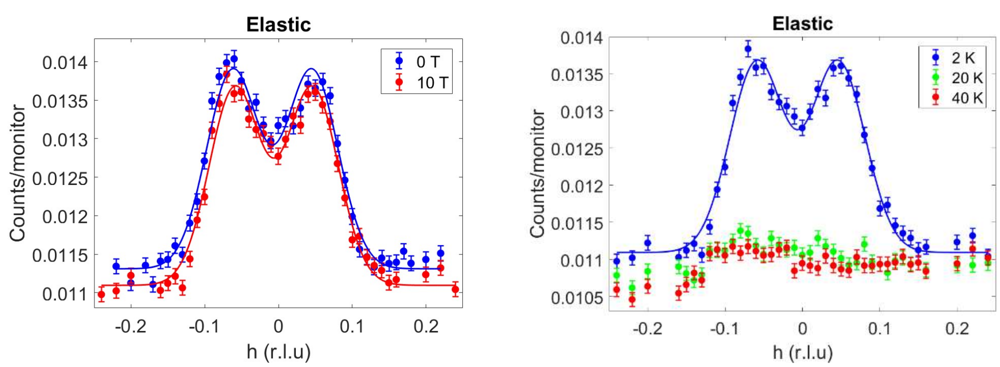

Figure 4: (left) Magnetic field dependence of the incommensurate elastic signal taken at base temperature 2 K. **(right)** Temperature dependence of the incommensurate elastic signal taken without applied magnetic field.