Title: Far Infrared Study of Magnetic Field Induced Normal States of La1.94Sr0.06CuO4

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Abstract: We report on the ab-plane optical properties of the magnetic field inducednormal state of underdoped La_{1.94}Sr_{0.06}CuO₄(T_c=5.5 K), the first such study. We apply strong magnetic fields (4 T and 16 T) along the c-axis. We find that a 4 T field is strong enough to destroy the superconducting condensate. However at higher fields we observed a gap-like depression in the optical conductivity at low frequency along with parallel growth of a broad absorption peak at higher frequency just above the 5 meV gap. The loss of low frequency conductivity in the gap region is in good agreement with dc magneto resistance measurements on samples from the same batch. The spectral weight loss in the depression at low frequency is recovered by the spectral weight in the broad peak. Significantly, this spectral weight equals the spectral weight of the superconducting condensate. The broad peak tracks the SDW order seen by neutron scattering[1] and we suggest offers an optical signature of magnetism.

Far infrared study of magnetic field induced normal states in $La_{1.94}Sr_{0.06}CuO_4$

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* crystal growers

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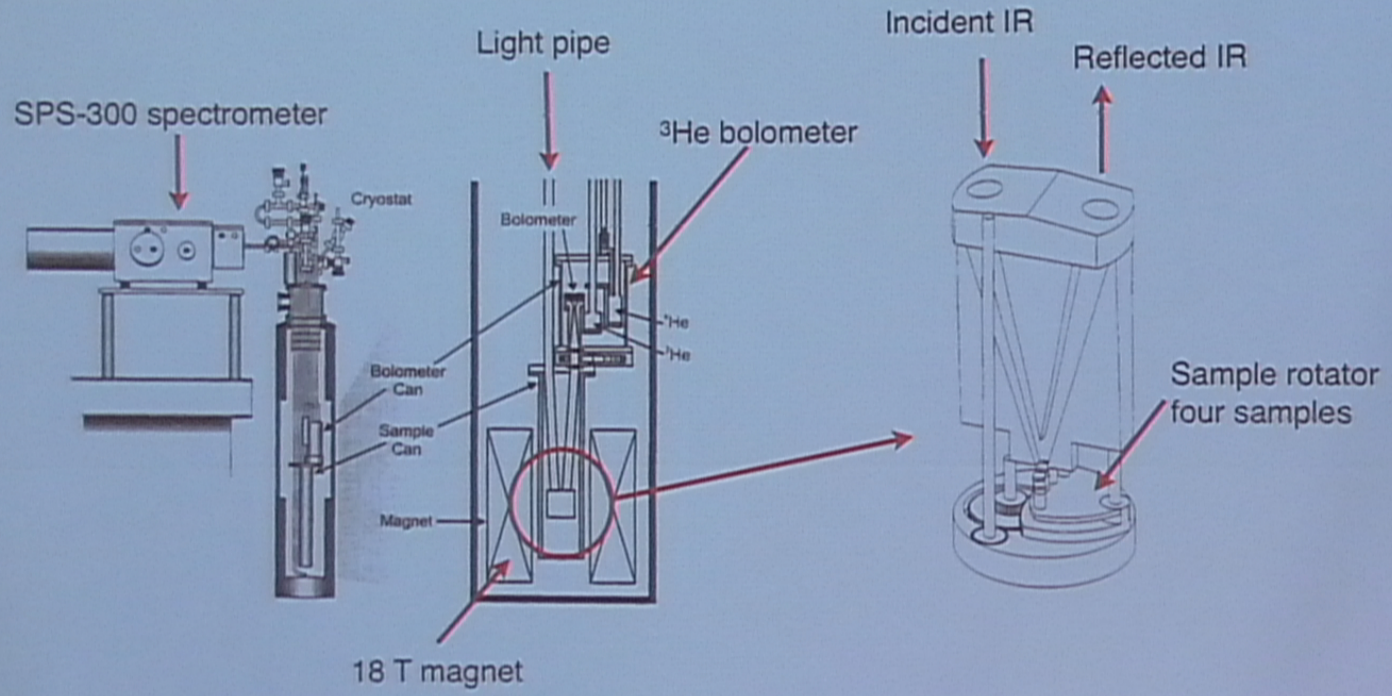
Motivation

- Test new high field insert 18 T in Toronto, 12 T in Tallinn for optical spectroscopy
- Compare optical data with magneto-resistance and neutron scattering.
- Recent magneto oscillation data suggest Fermi surface reconstruction
- Theoretical prediction of SDW state in high field

High field infrared reflectance apparatus

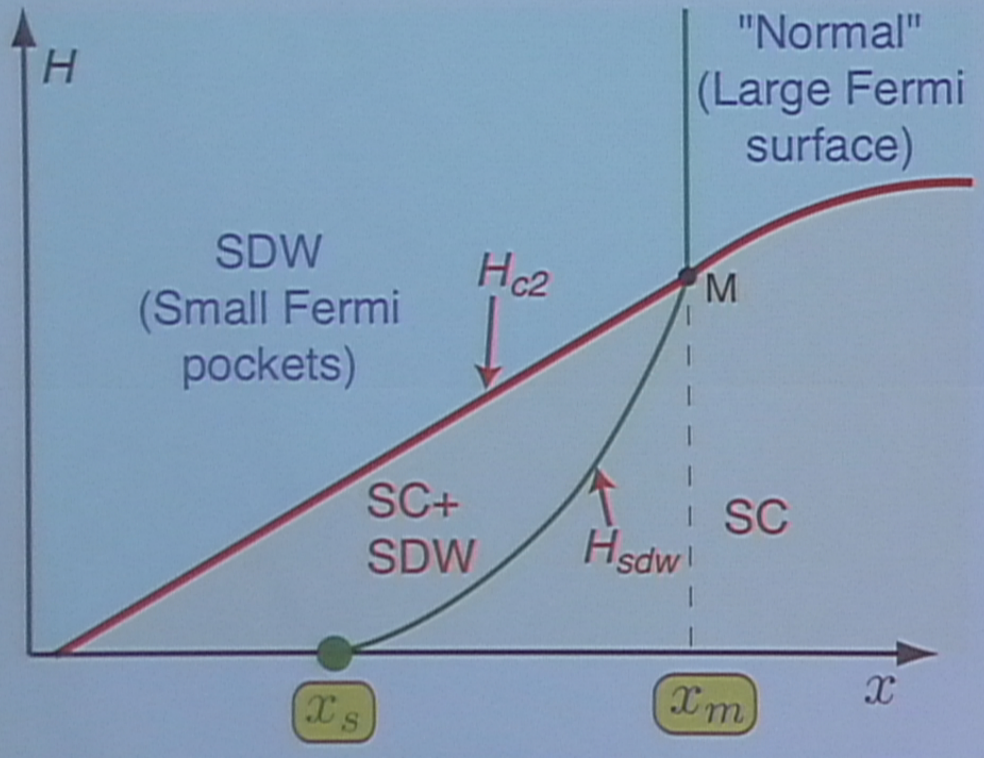
Low frequencies
$1 < \omega < 30$ meV

High fields
$0 < H < 18$ T

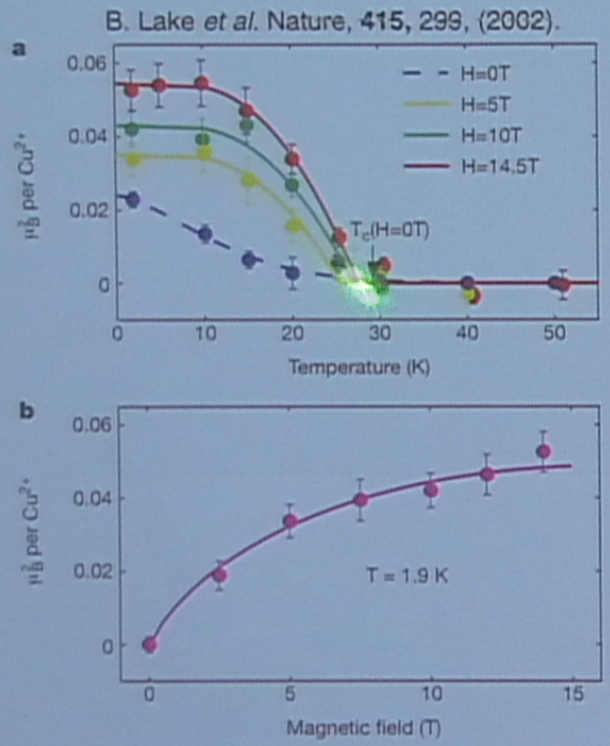


Demler et al. phase diagram of LSCO

E. Demler, S. Sachdev and Y. Zhang, Phys. Rev. Lett. 87, 067202 (2001).

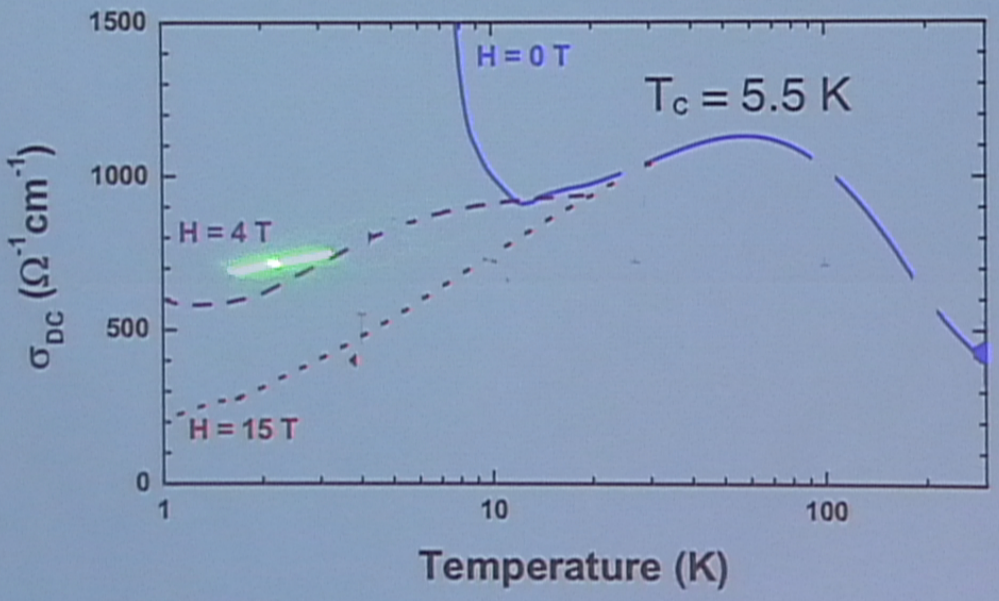


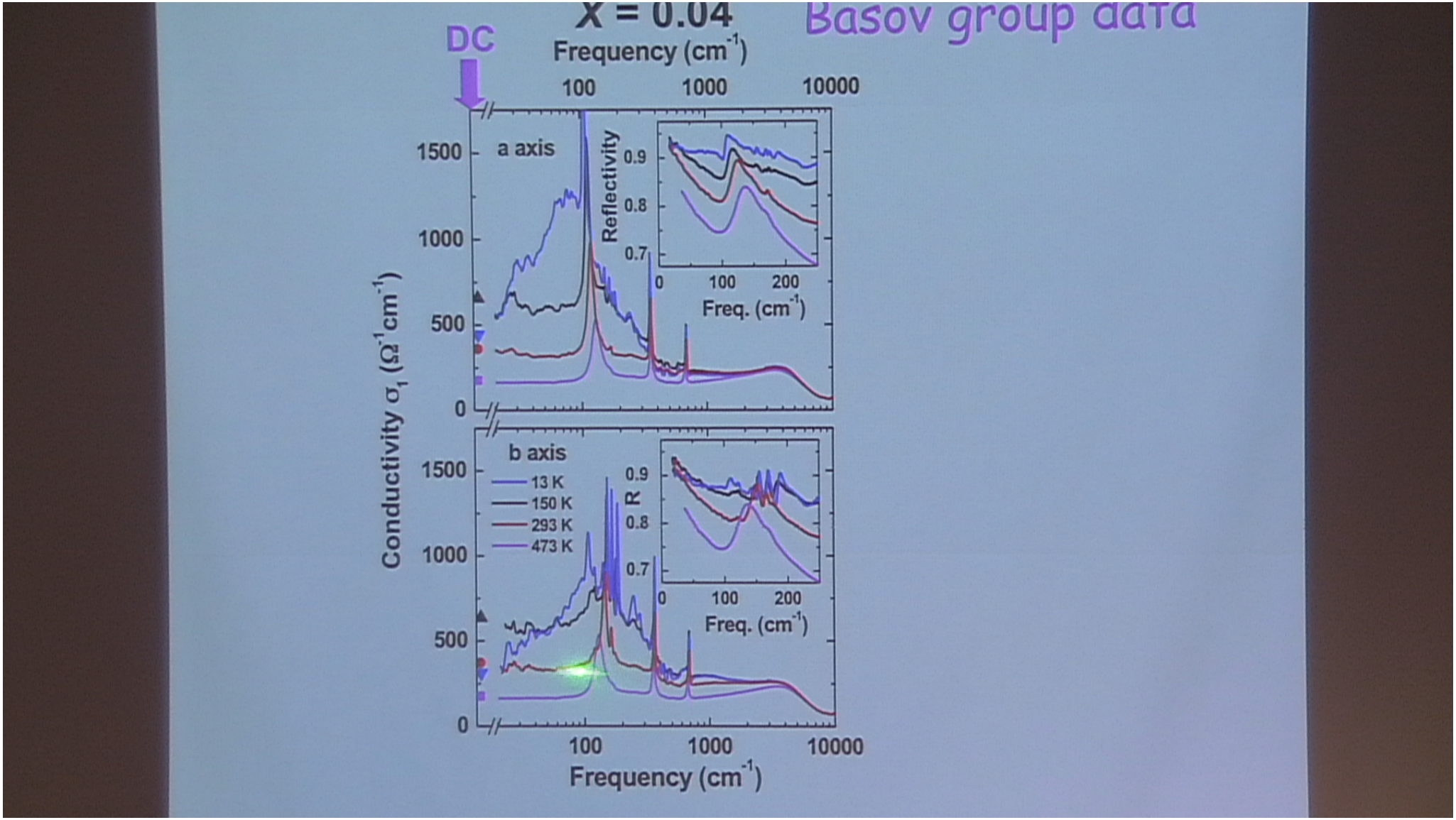
Neutron scattering evidence of SDW state



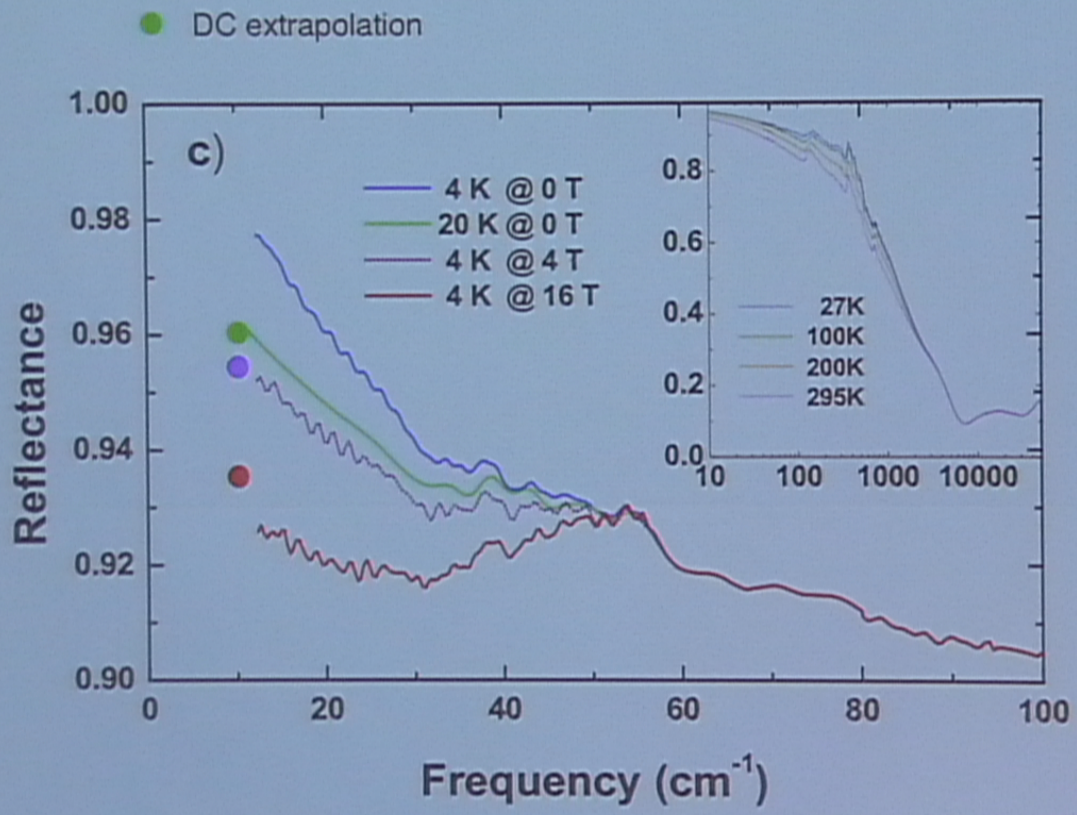
LSCO x=0.1
B ll c
μ ll ab

DC conductivity in a magnetic field x=0.06

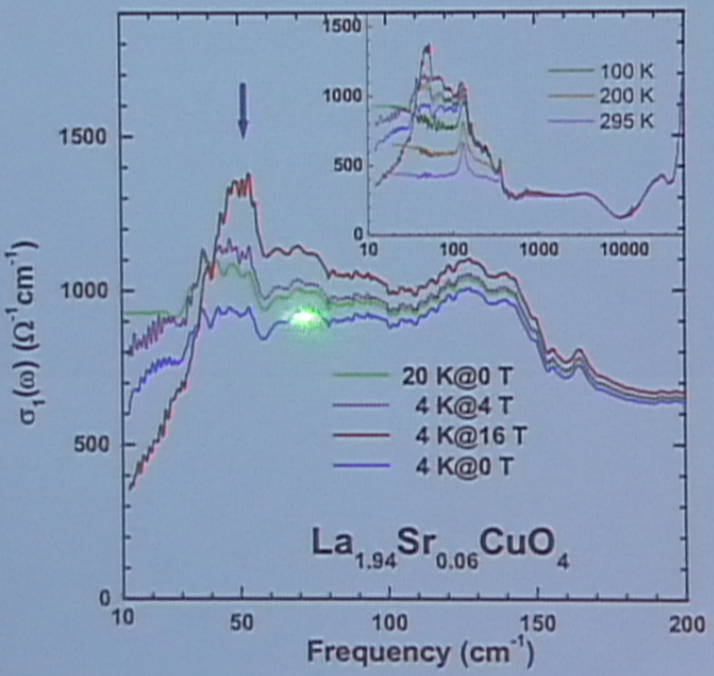



X = 0.04
Basov group data
DC
Frequency (cm-1)
100
1000
10000
a axis
Reflectivity
0.9
0.8
0.7
0
100
200
Freq. (cm-1)
1500
1000
500
0
b axis
13 K
150 K
293 K
473 K
R
Conductivity σ1 (Ω-1cm-1)

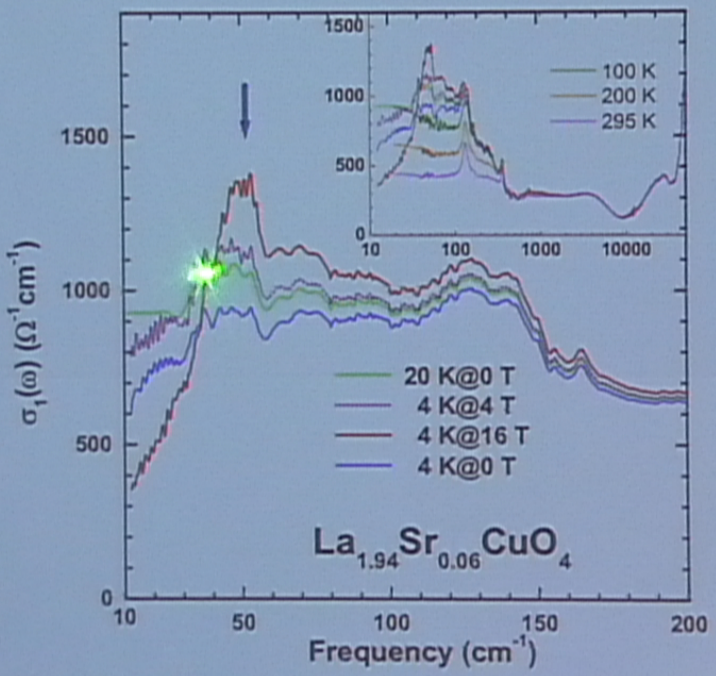
Reflectance of $La_{1.94}Sr_{0.06}CuO_4$



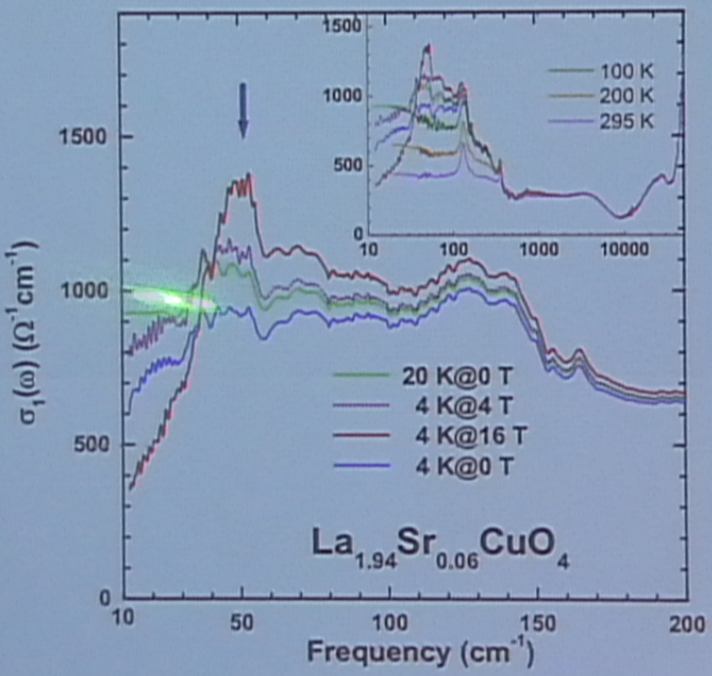
The optical conductivity



The optical conductivity

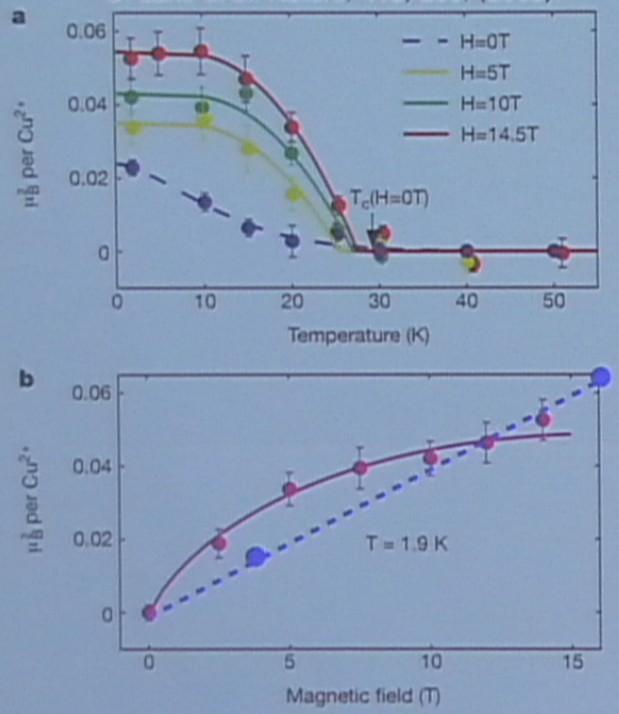


The optical conductivity



Neutron scattering

B. Lake *et al.* Nature, **415,** 299, (2002).

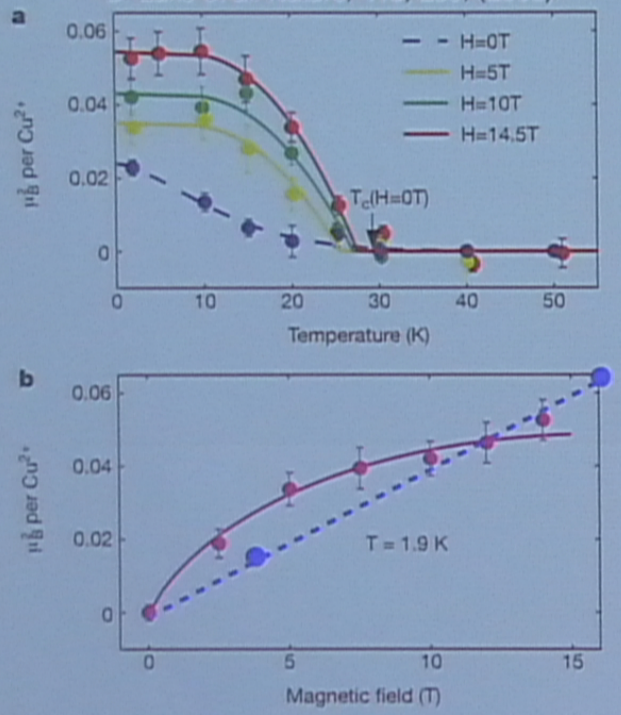


LSCO x=0.1
B ll c
μ ll ab

Optics:
LSCO x=0.06
B ll c
gap amplitude

Neutron scattering

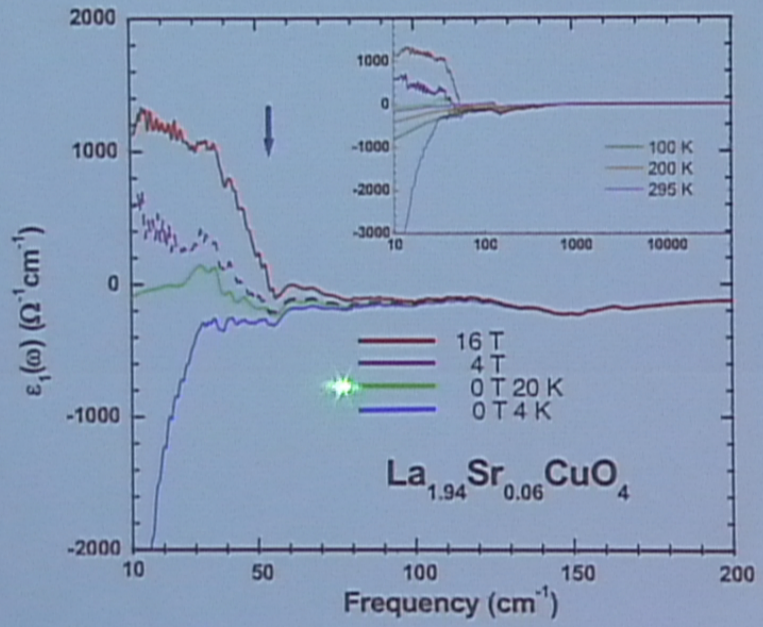
B. Lake *et al.* Nature, **415,** 299, (2002).

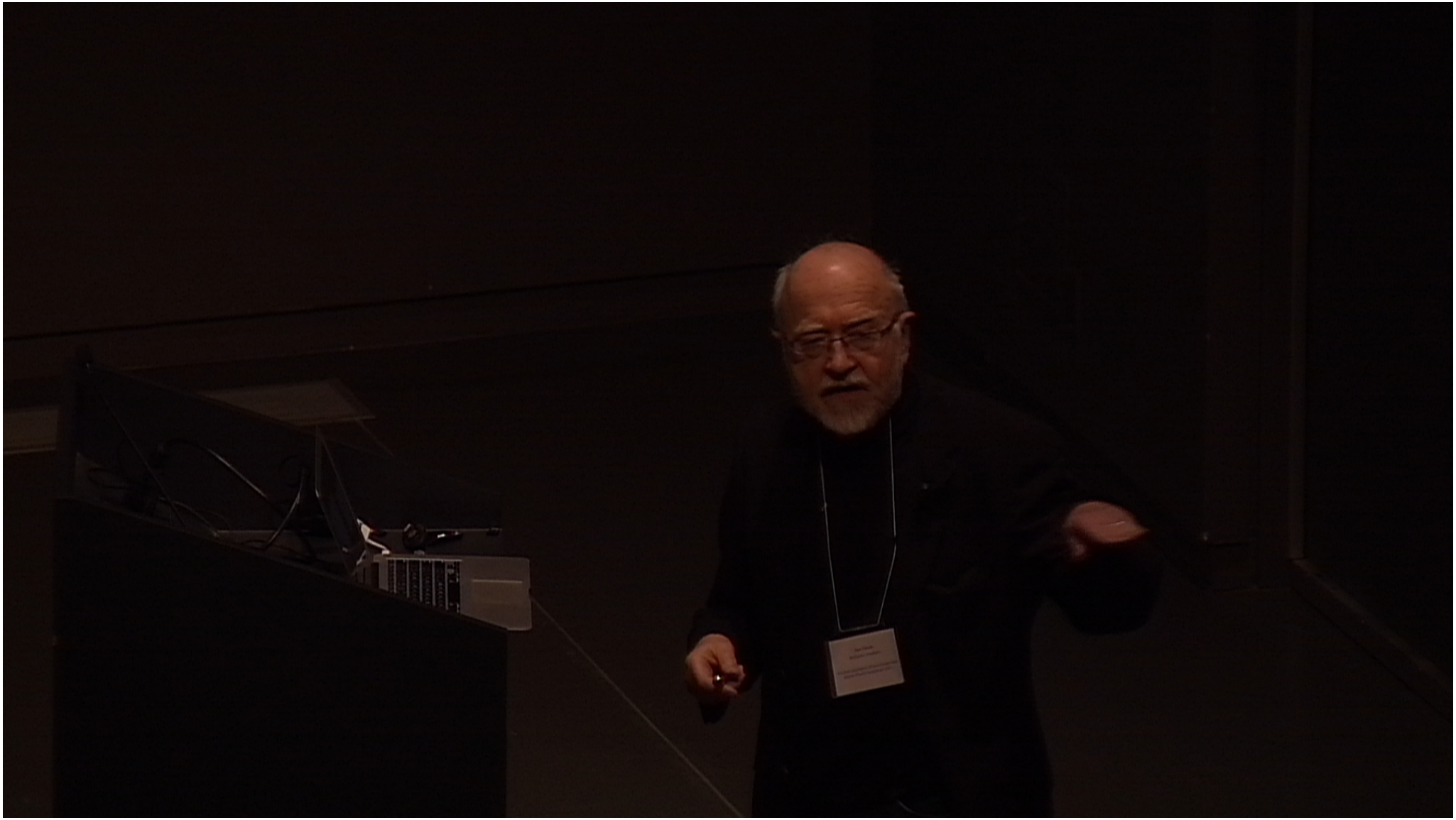


LSCO x=0.1
B ll c
μ ll ab

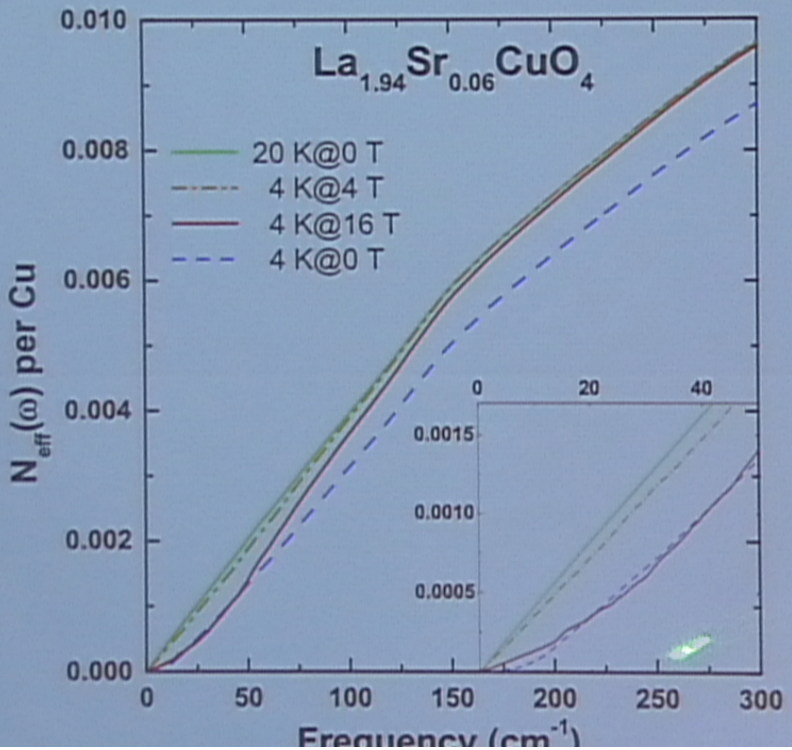
Optics:
LSCO x=0.06
B ll c
gap amplitude

Dielectric function $\varepsilon_1(\omega)$





Integrated spectral weight



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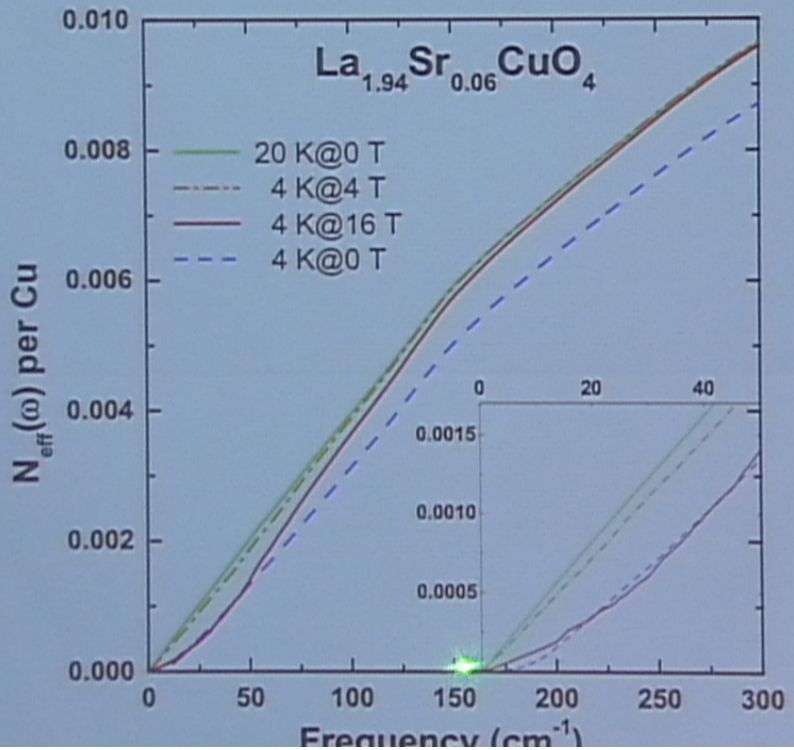
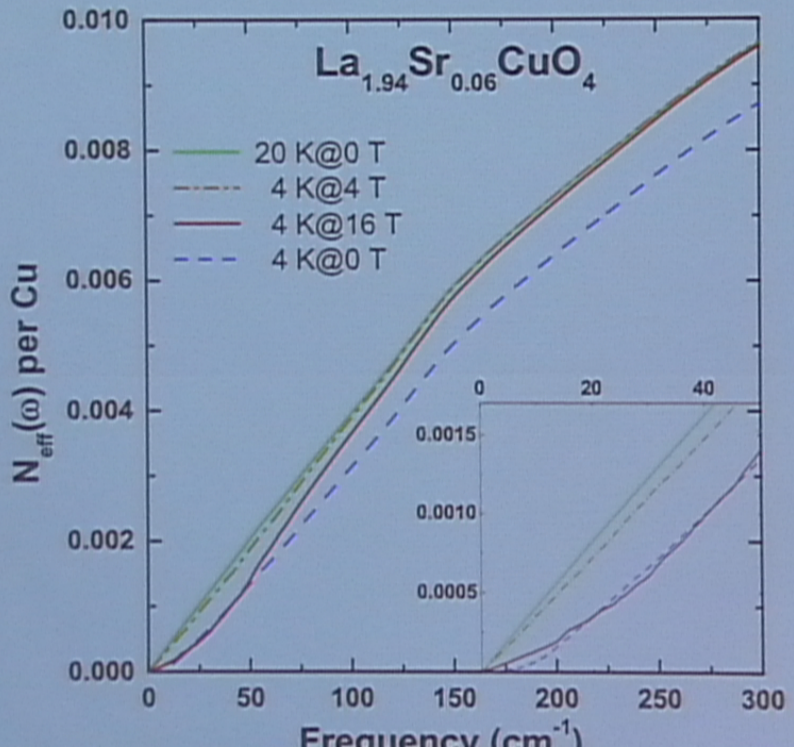


Integrated spectral weight



Summary

- New setup for 18 T, 1.8 K optical measurements
- Underdoped LSCO x=0.06 shows field induced gap
- Spectral weight is conserved, SDW order?
- SDW weight equals SC spectral weight