Non-equilibrium Spectroscopy on Correlated Materials

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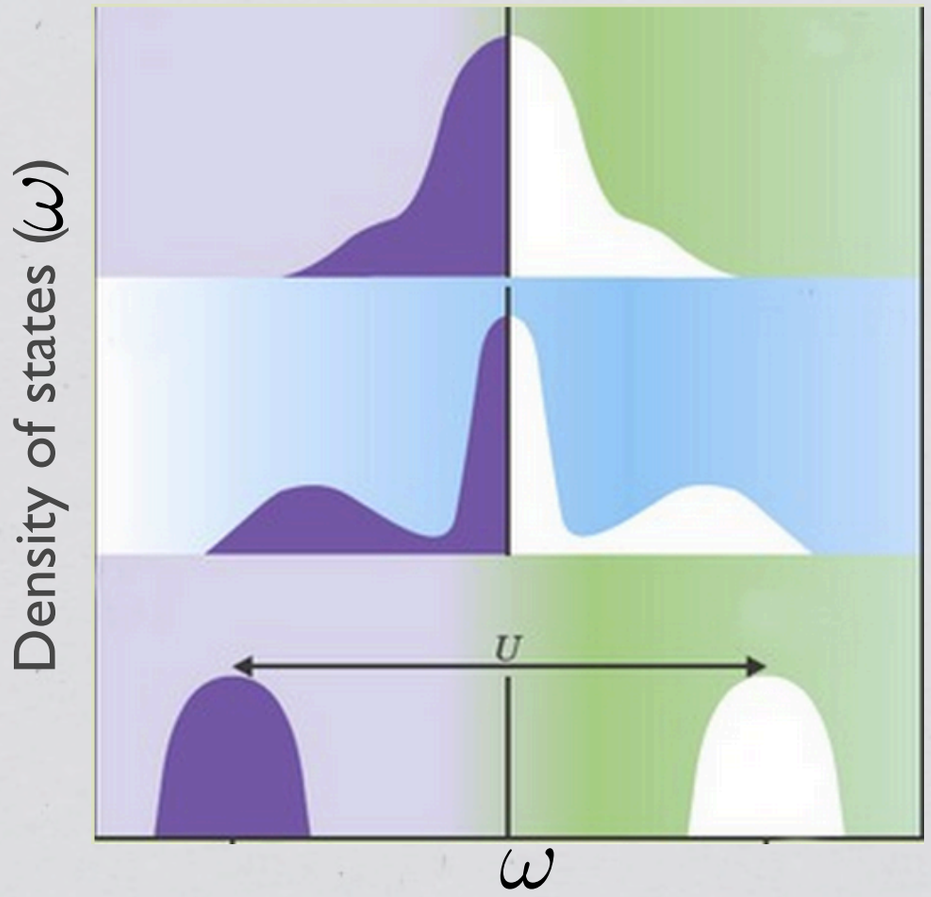
First Year Workshop, 16 October 2012, Milan

Beyond the Drude Band Structure

Drude Metals

- Single electron approximation



Metal

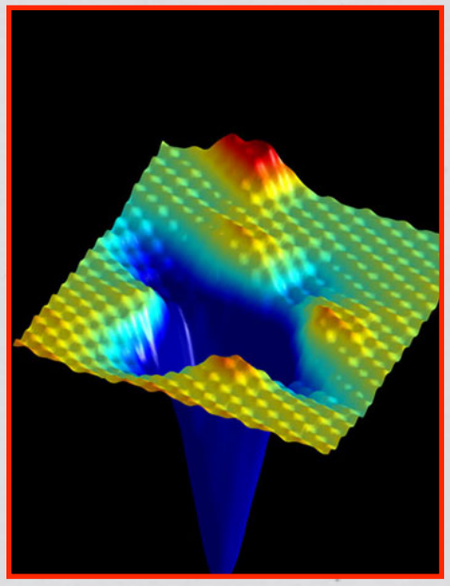
Insulator

Semi-filled band structure

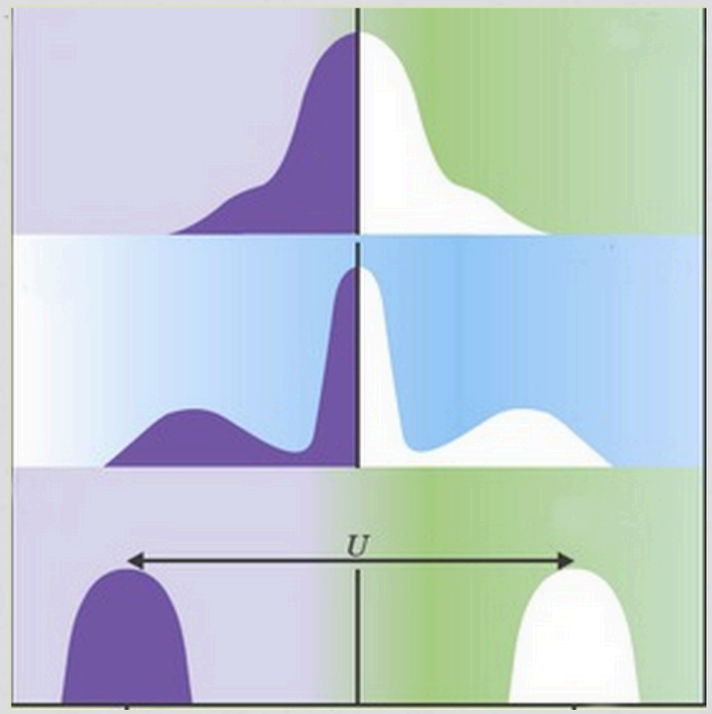
Mott Insulators

- Interaction between electrons

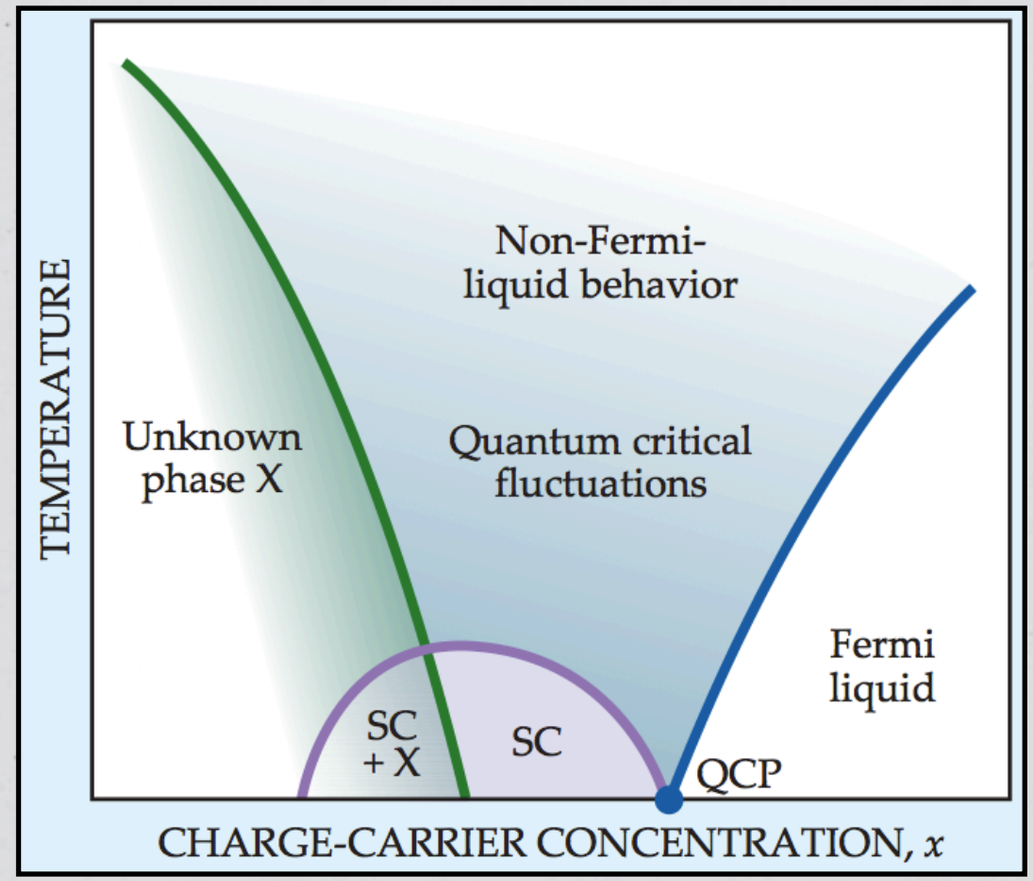
Correlated Materials



- Strong electron-electron interaction
- Incompletely filled d- or f-electron shells
- Complex phase diagram
- Possibility to drive the phase with hole doping

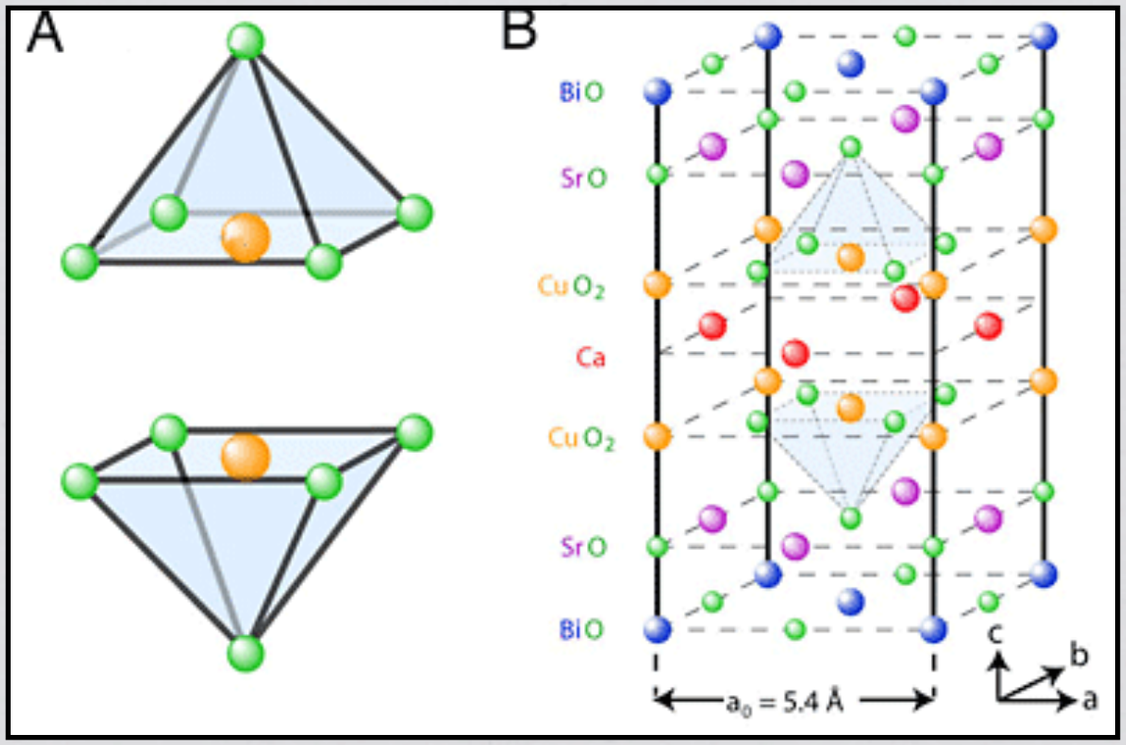


Charge-carrier concentration



J.Orenstein, *Physics Today*, **65**, 9, 44 (2012)

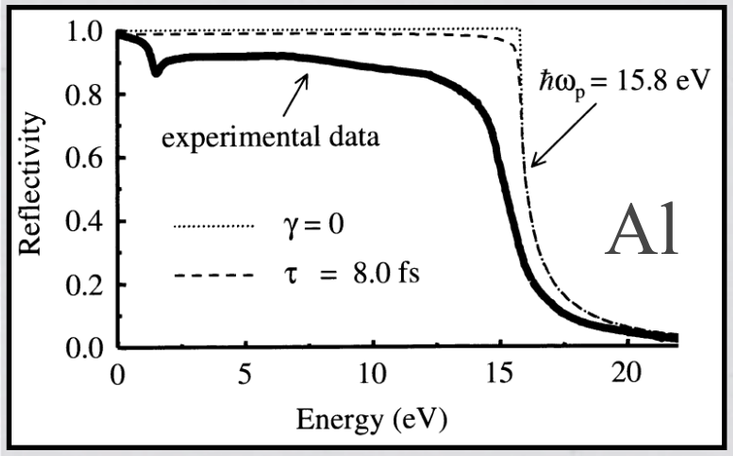
Cuprates



- Layers of copper oxide interleaved with layers of other atoms.
- Electrons electrically pushed away and confined to the edges of the squares forming the layers
- The superconductive phase rises at a critical temperature (Tc) of the order of 100 K

The origin of cuprates superconductivity is still unknown

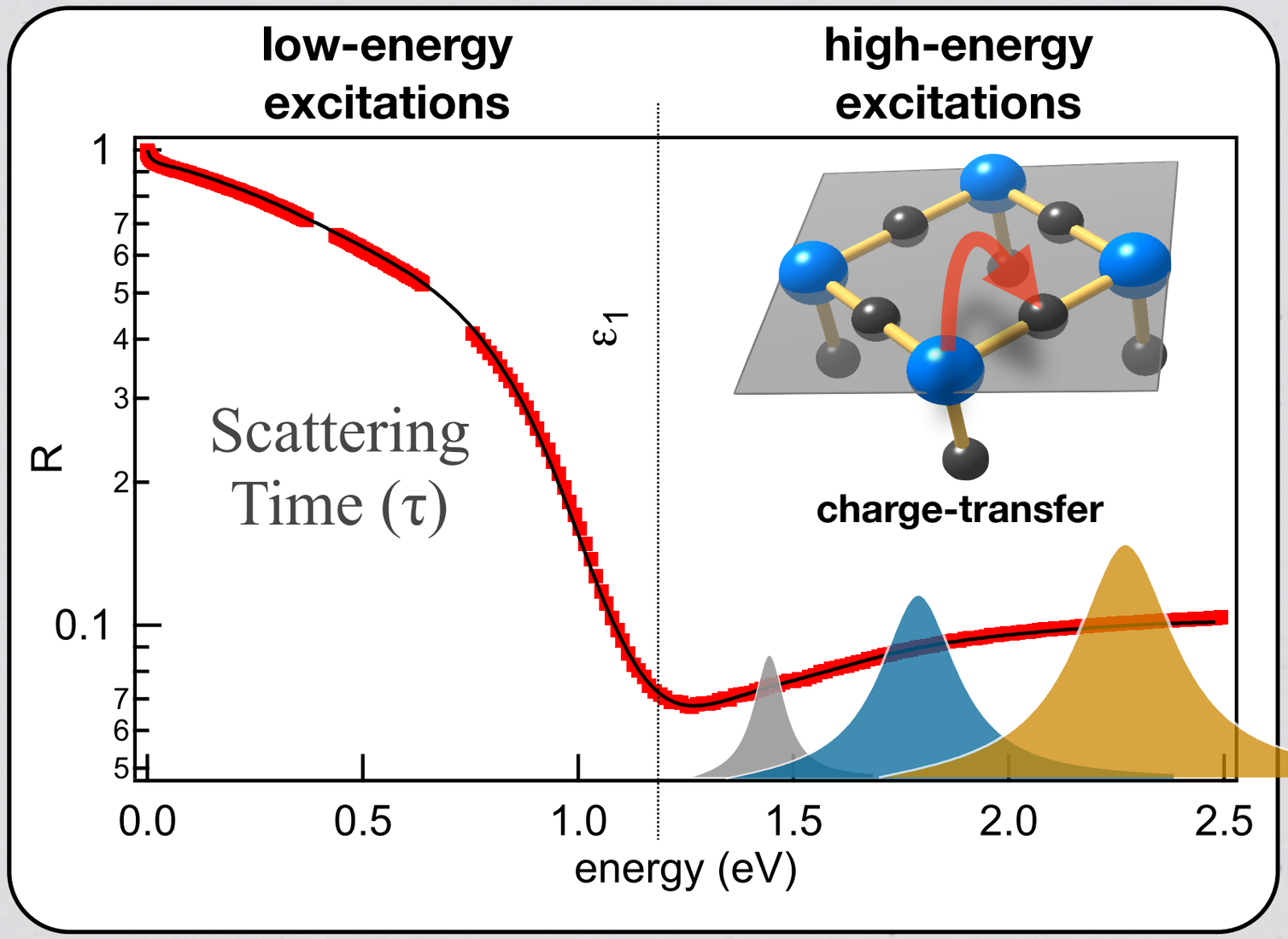
Optical Properties of Correlated Systems



Good Metals

Extended Drude Model

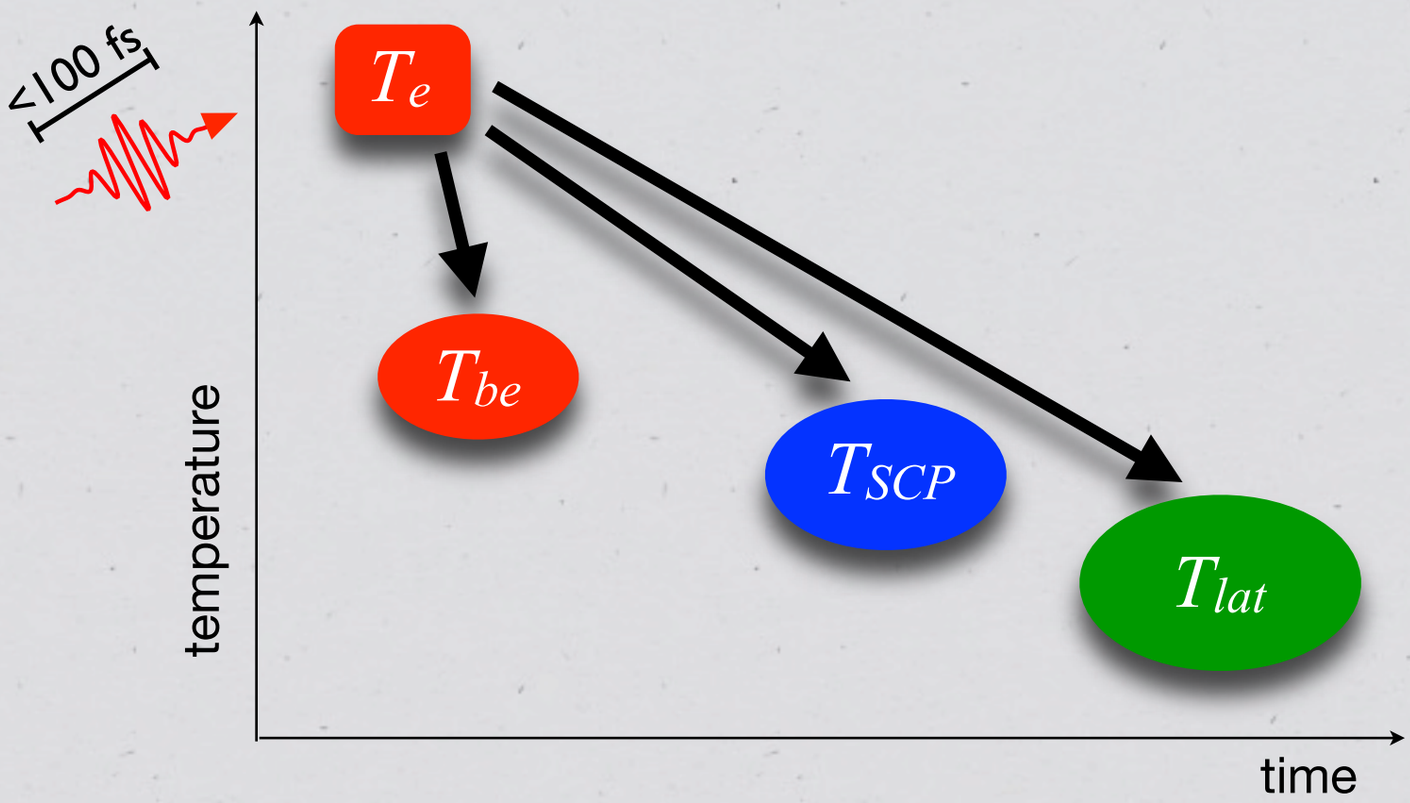
Cuprates



Lorentz Oscillator

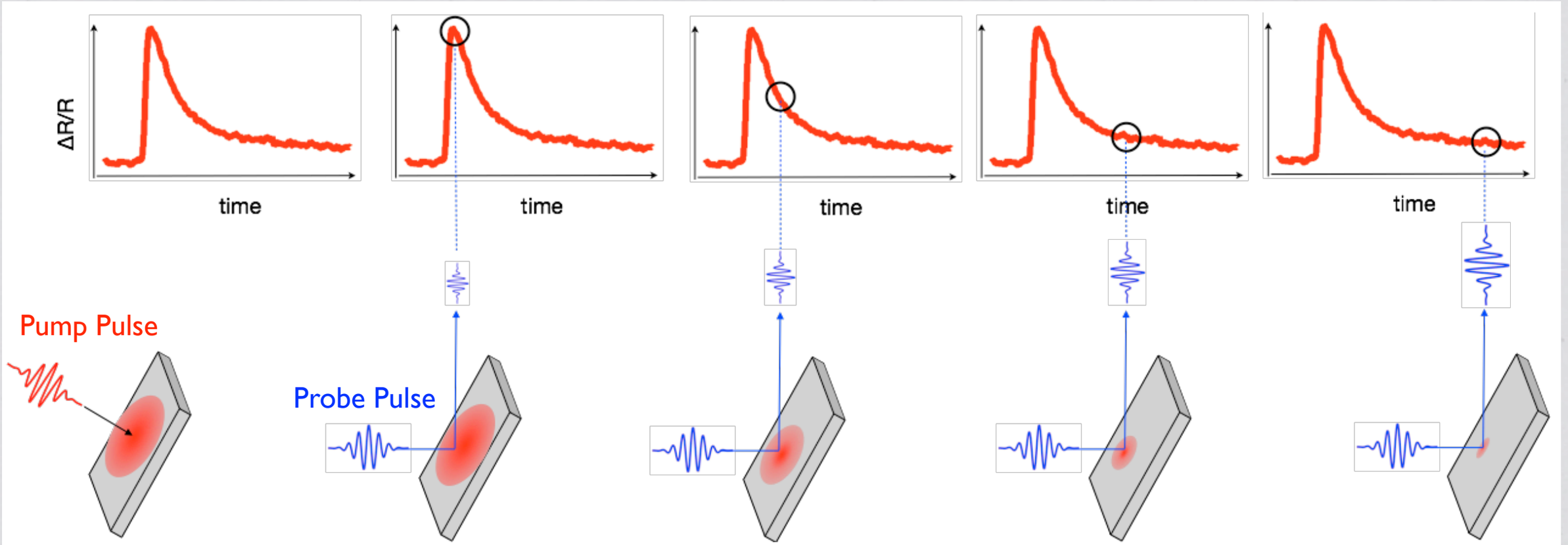
$$\epsilon_D(\omega) = -\frac{\omega_p^2}{\omega(\omega + M(\omega, T))}$$

Non-Equilibrium Spectroscopy



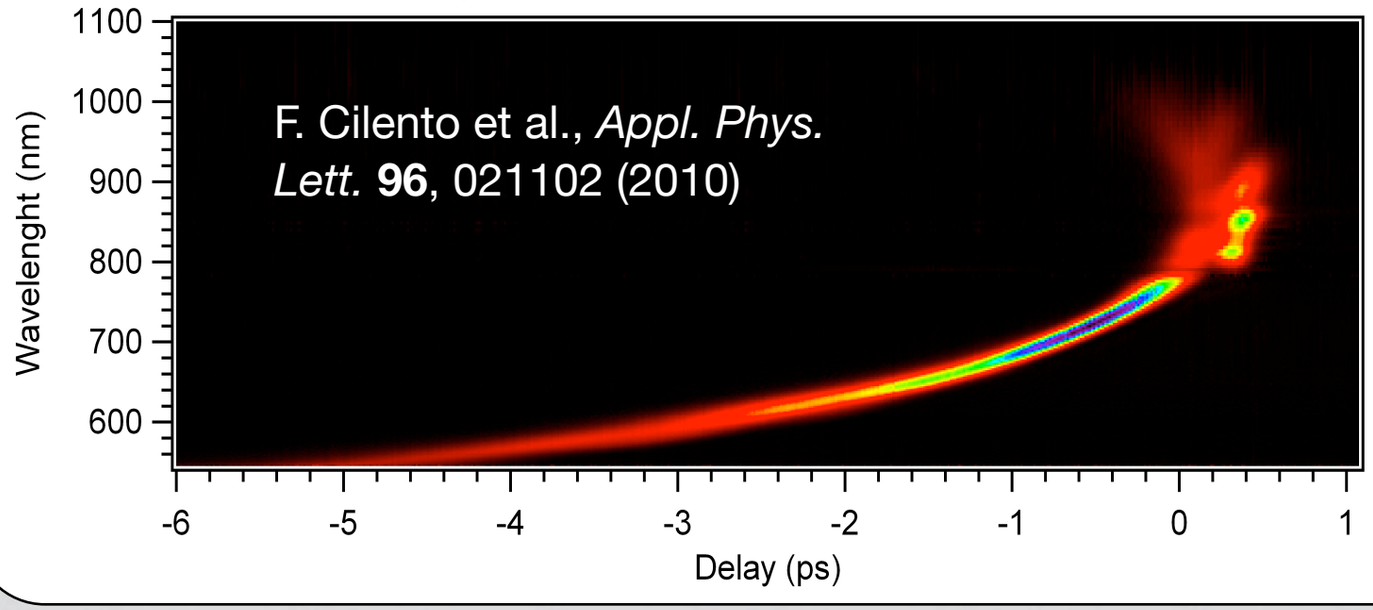
T_{be}	Bosonic excitations of electronic origin (spin fluctuations)	<100 fs
T_{SCP}	Energy exchange with Strongly Coupled Phonons (part of the whole lattice)	100 fs - 500 fs
T_{lat}	Energy exchange with the rest of the lattice	500 fs - 5 ps

Time-Resolved Optical Spectroscopy: PUMP & PROBE

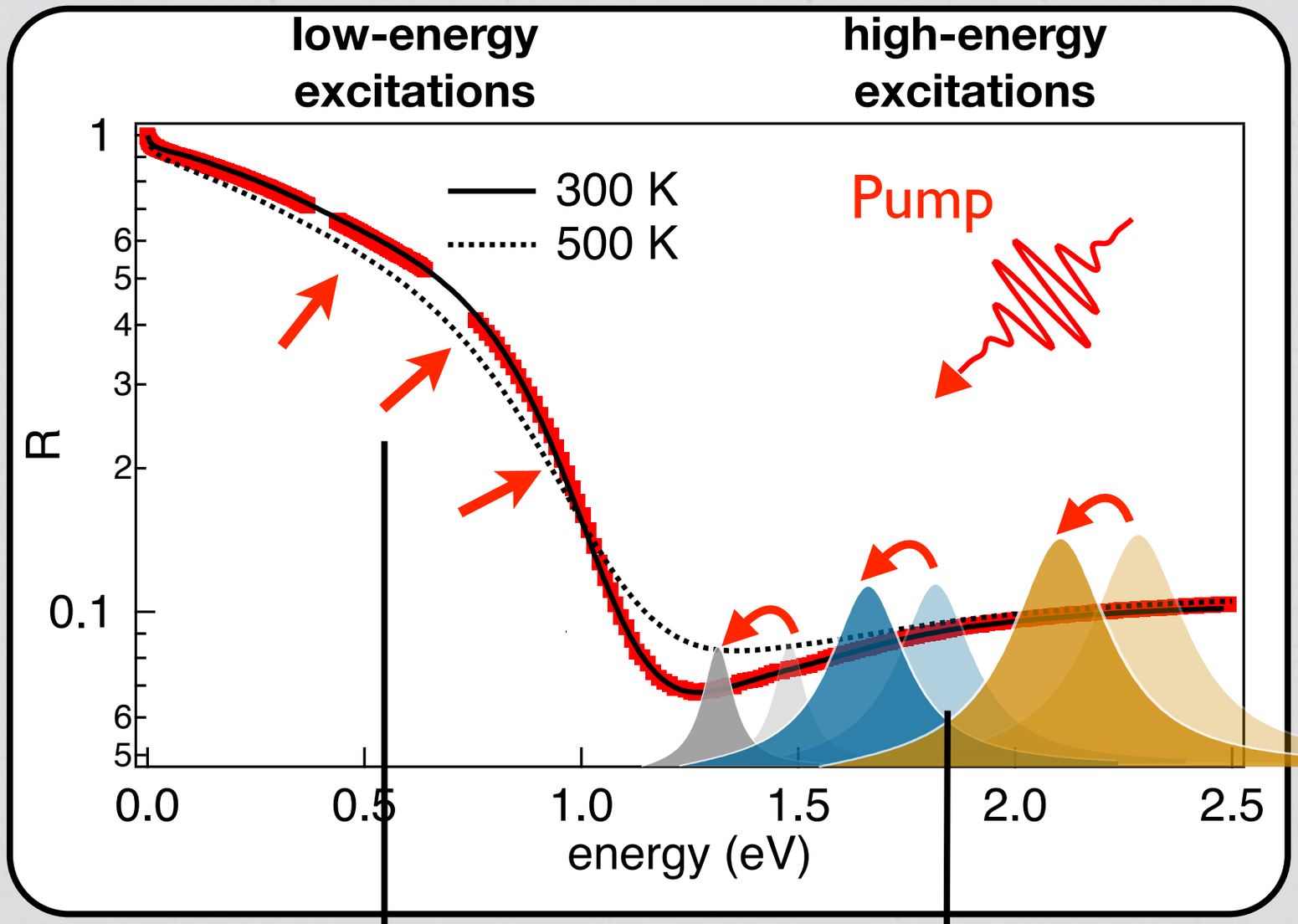


Spectroscopic character of the measurements

Spectrogram of a supercontinuum



Impulsive Perturbation



Broadening of the Drude Peak

Lorentzians Shift

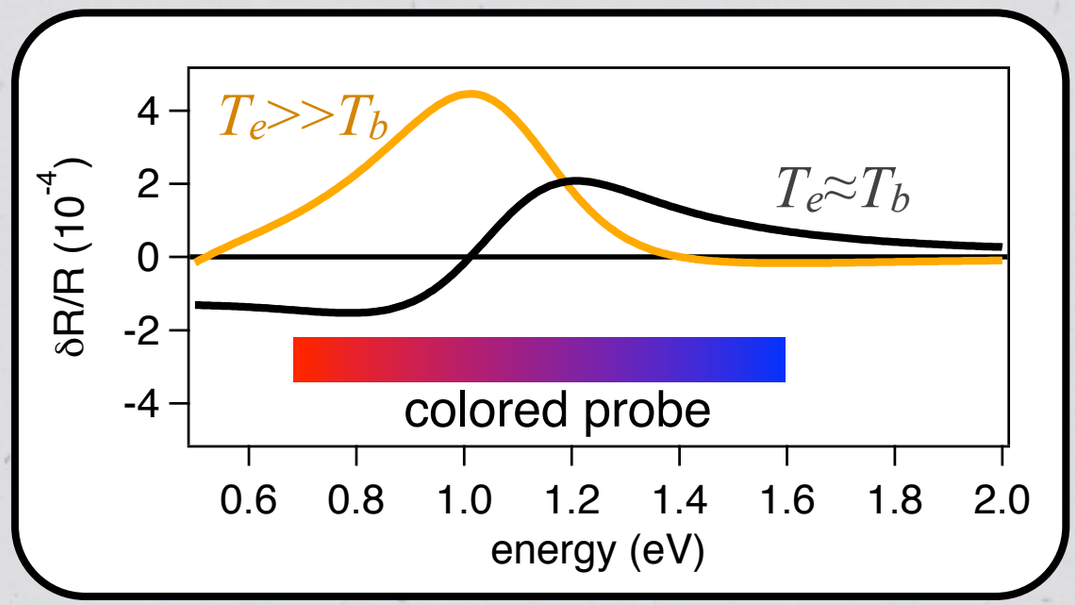
First Results

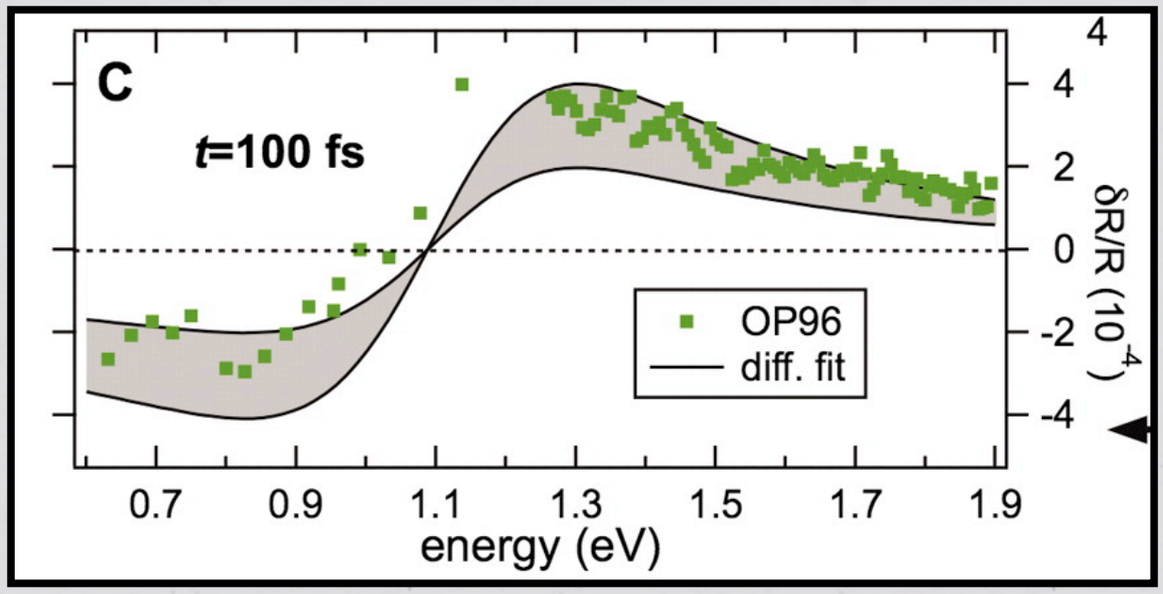
Electrons, excited by a laser pulse, can exchange energy with bosonic excitations.

Total bosonic function is:

$$\Pi(\Omega) = \Pi_{be}(\Omega) + \Pi_{SCP}(\Omega) + \Pi_{lat}(\Omega)$$

OP $Bi_2Sr_2Ca_{0.92}Y_{0.08}Cu_2O_{8+8}$



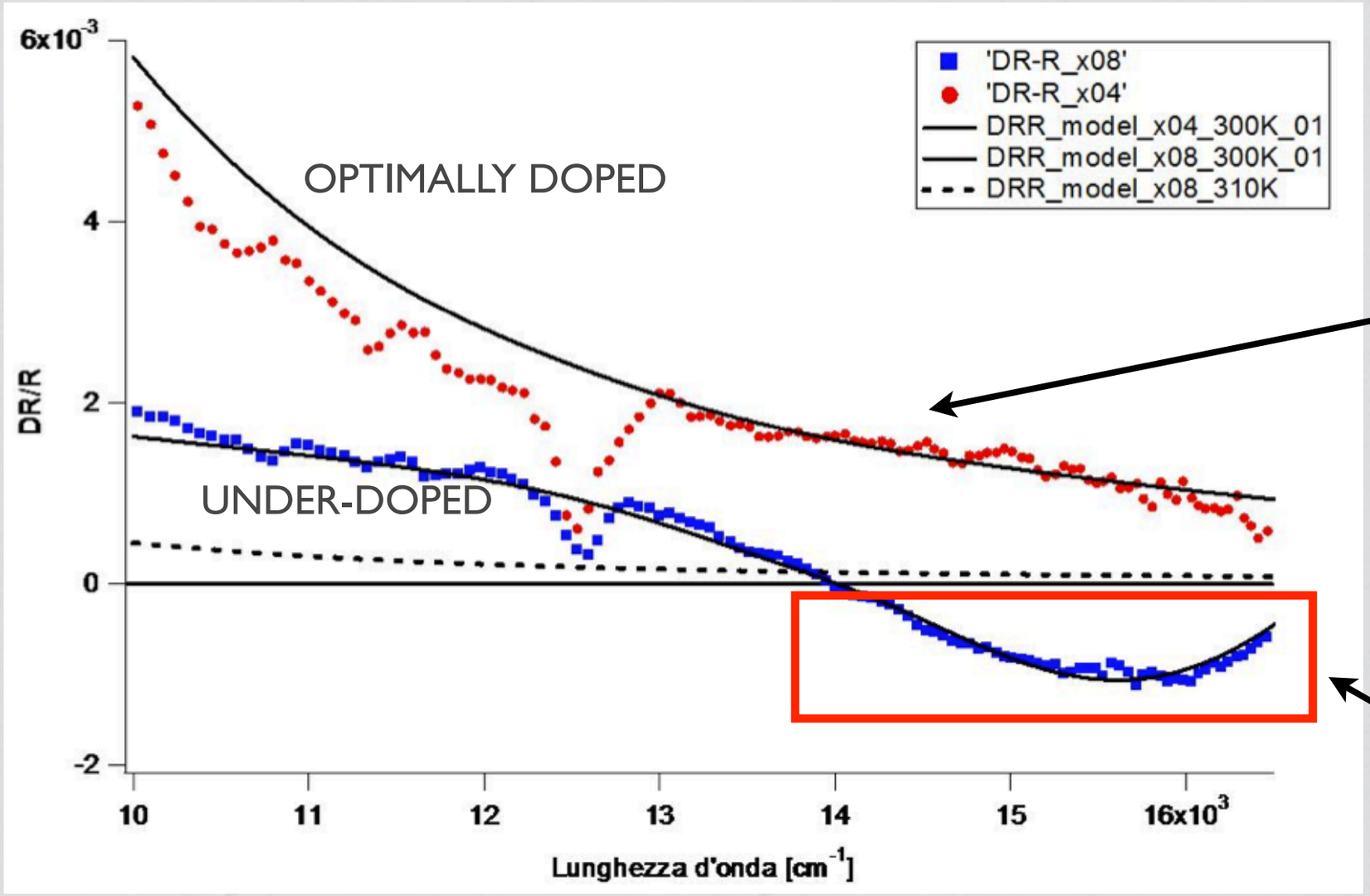


S. Dal Conte et al., *Science* **335**, 1600 (2012)

Within the time-resolution electrons are never decoupled from bosonic excitations!

Comparison with different doping

Is it true for the under-doped sample?



Effect of a simple temperature increasing

Signature of a modification in Lorentz Oscillators

In under-doped samples the pump excitation modify the interband transitions at high-energy.

Perspectives

Perform measurements as function of:

- Temperature
- Doping

Perform measurements on different samples:

- Conventional superconductors (MgB_2)
- Iridates (Na2IrO3)
- Iron Pnictides

These samples are kindly provided by the group of Andrea Damascelli in UBC Vancouver

THANKS FOR YOUR ATTENTION