Multidimensional high energy experiments with X-rays and electron pulses.

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LUMES

Motivation: Comparison between electons and X-ray sources for diffraction:

	X-FEL	10 KV e^-	100 KV e^-	1 MV e^-
Pulse duration	1 fs	500 fs - 1 ps	50-500 fs	1-30 fs
Particles per pulse	10^{13}	10^2 - 10^4	10^4 -10^6	10^6 - 10^8
Cross section (barns)	1-10	10^7	10^6	$5*10^5$
Relative spatial Coherence length L/D	0.1-0.2 (full coherence = 1)	10^{-5} (10^3 e^-)	10^{-4} (10^6 e^-)	10^{-2} – 10^{-3} ($5x10^6$ e^-)
Spatial resolution	0.1 nm	pm (diffraction)	0.2 nm (image) pm (diffr.)	0.05 nm (image) pm (diffr.)
Particles per image (100x100 nm, 2 A res.)	10^{12}	10^6	10^6	$5*10^6$
Radiation dose per image Gy	10^7 Gy	$5*10^6$ Gy	$5*10^6$ Gy	10^7 Gy
Probe depth	~ 100 μm	10-50 nm	50-200 nm	200-500 nm

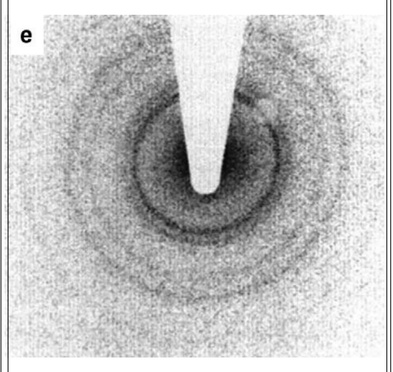
A perspective on novel sources of ultrashort electron and X-ray pulses
F. Carbone , P. Musumeci , O.J. Luiten , C. Hebert. Chemical Physics (2011)

Electron diffraction set-ups (probe):

10-50 KV, Reflection/transmission Geometry, stroboscopic, ~ 100 fs resolution

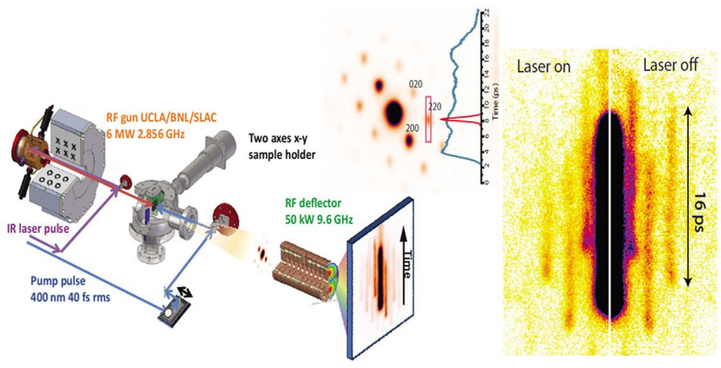
G. Mancini et al, in preparation

100 KV, Transmission geometry.
10^6 e^-/pulse, ~ 60 fs resolution.
single shot per time delay.



T. van Oudheusden et al., Phys. Rev. Lett. 105 (2008) 264801.

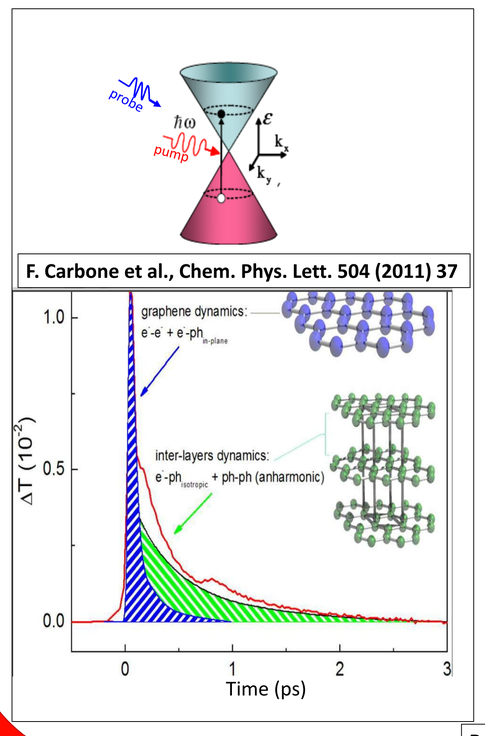
MV, Transmission geometry.
10^8 e^-/pulse, ~ 50 fs resolution.
single shot all transient.



P. Musumeci et al., J. Appl. Phys. 108 (2010) 114513

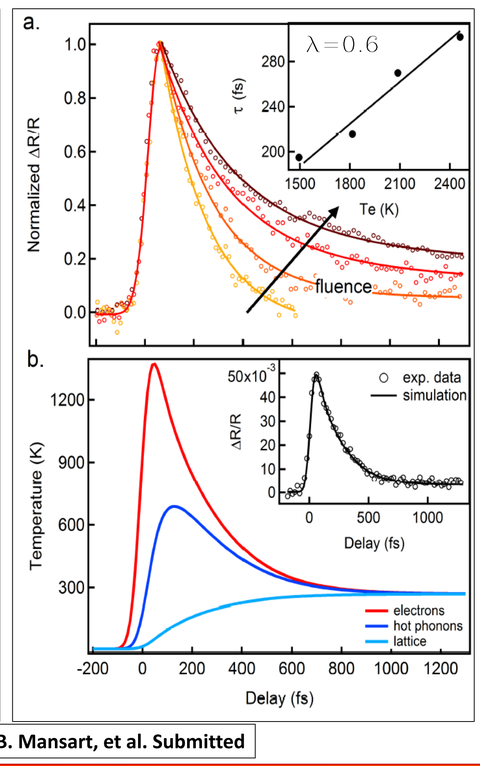
Excitation with photons: pump

Electron-hole pair excitation



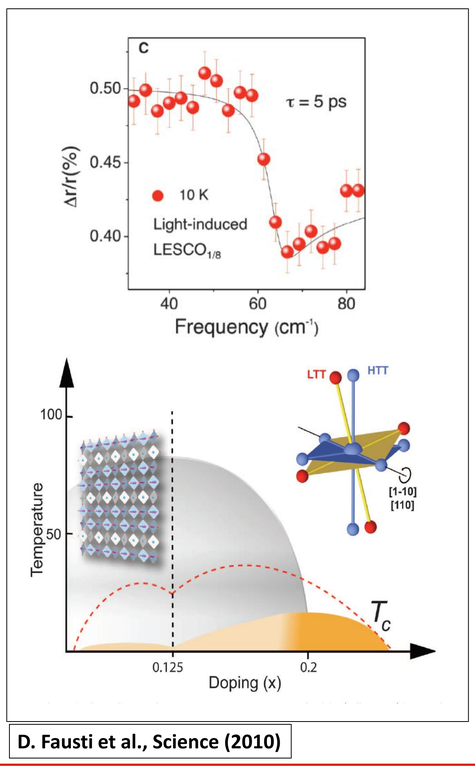
F. Carbone et al., Chem. Phys. Lett. 504 (2011) 37

Temperature jump



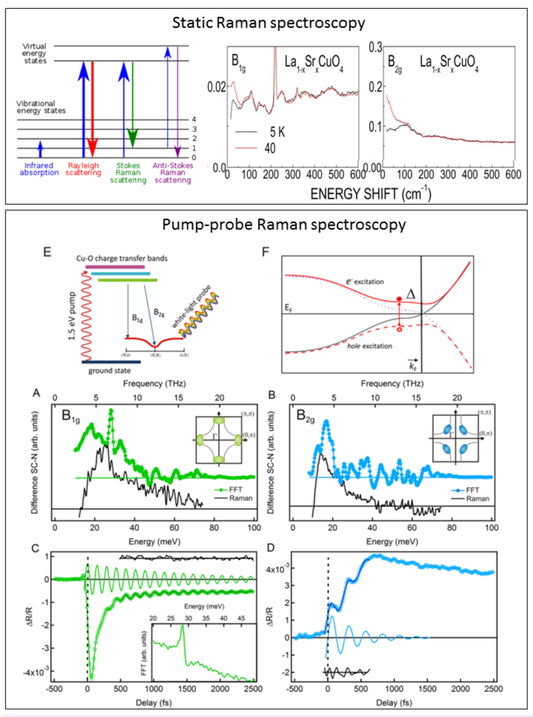
B. Mansart, et al. Submitted

THz excitation



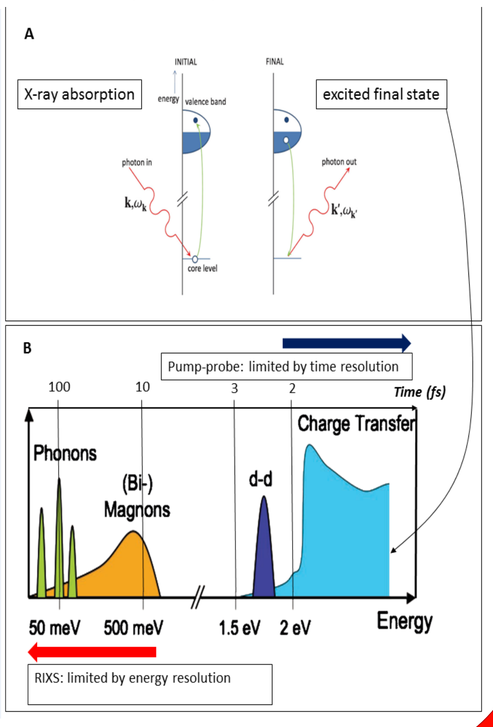
D. Fausti et al., Science (2010)

Raman excitation



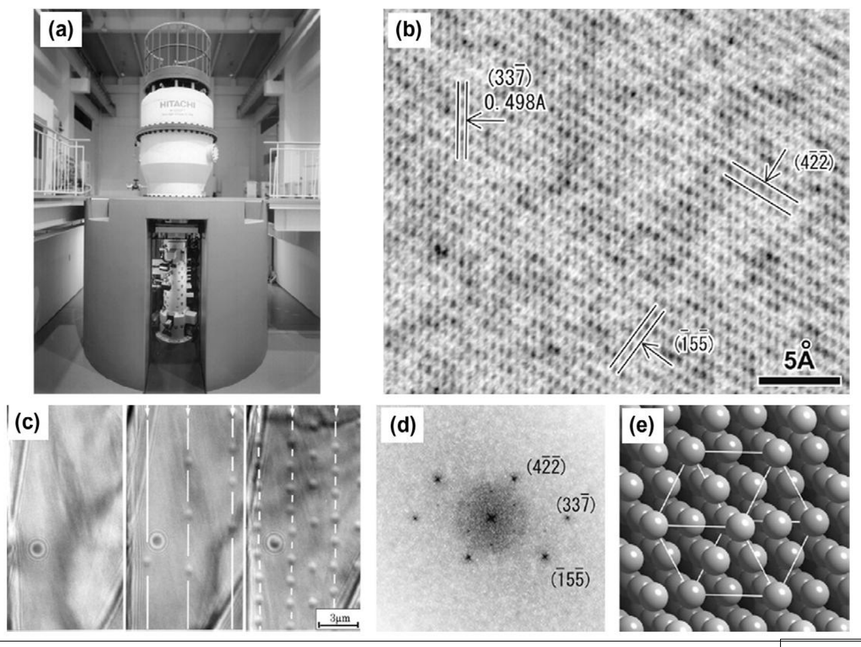
B. Mansart, in preparation

High energy Raman processes

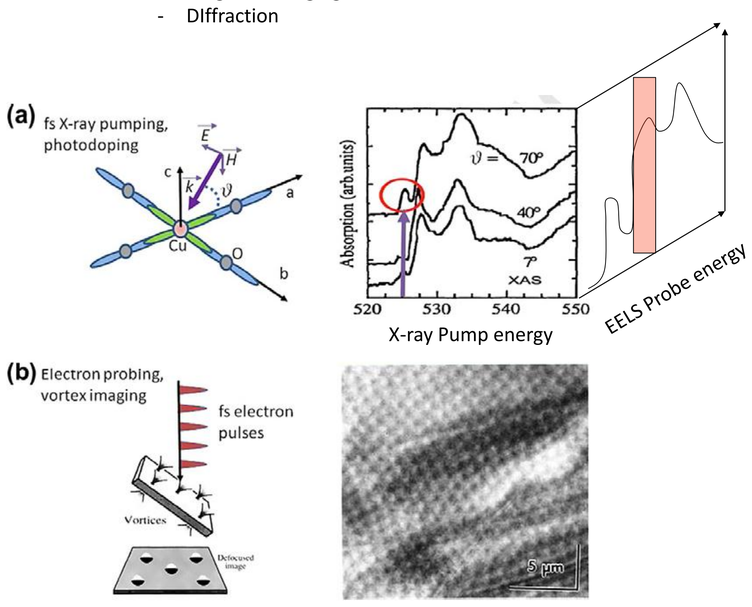


X-ray/electrons pump-probe experiments

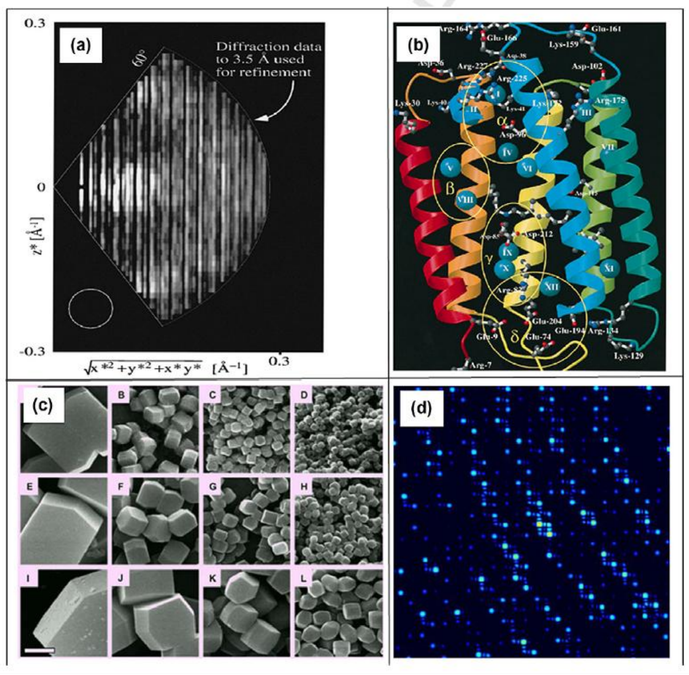
High energy electron diffraction, imaging, spectroscopy



- Multidimensional high energy spectroscopy
- Chemically selective photodoping
- Magnetic imaging
- DIffraction



Single shot protein imaging and radiation damage



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Propositions:

Technically:

- Realize a beamline for high-energy electron diffraction, imaging and spectroscopy
- Make it possible to interface such an instrument with advanced photon sources.
- Create a «critical mass» laboratory for ultrafast science capable of accessing different excitations energies

Scientifically:

- These tools provide a unique way of observing phase transitions in solids, liquids, gases and aggregates
- High energy electrons have enhanced contrast to magnetism via Lorentz microscopy
- Radiation damage can be studied in hybrid single shot experiments using electrons, X-rays or ion beams