Ultrafast Structural and Electronic Dynamics of the Metallic Phase in a Layered Manganite

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Ultrafast structural and electronic dynamics of the metallic phase in a layered manganite

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Chinese Academy of Sciences, Beijing 100190, People's Republic of China
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New York 11973, USA
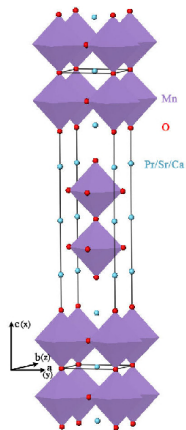
Structural Dynamics
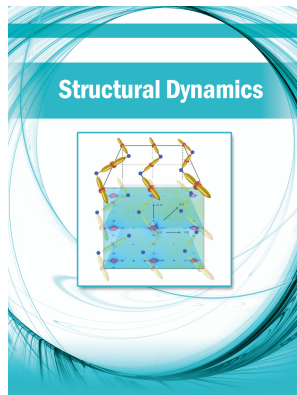
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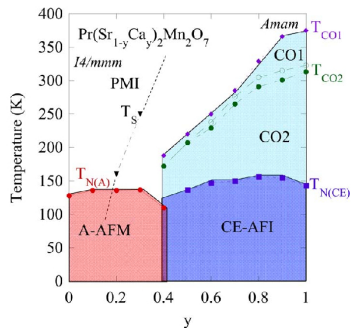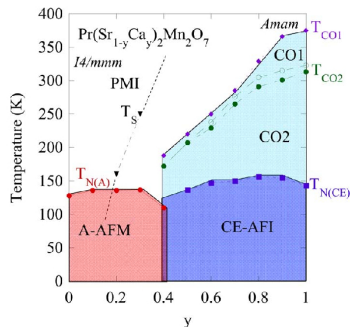
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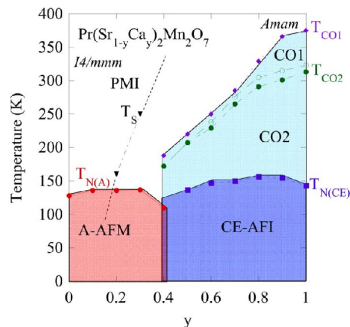

Strongly correlated electron systems

- Spin   - Charge
- Orbital   - Crystal field

- Chemical doping   - Magnetic field
- Temperature   - Pressure

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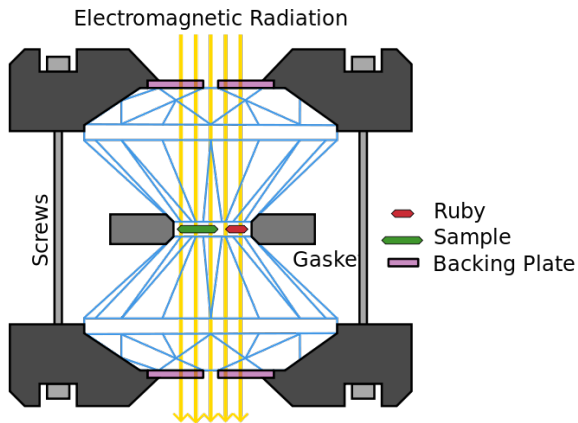- layered material
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How to measure the energy gap?

Optical absorption spectroscopy in diamond envil cells

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Optical absorption spectroscopy in diamond envil cells Limitations:

- for energy gaps of ~0.1eV we need wavelengths of ~10μm
- pressure limited to ~10^2GPa
- it's necessary a *big sample* (mm^3)
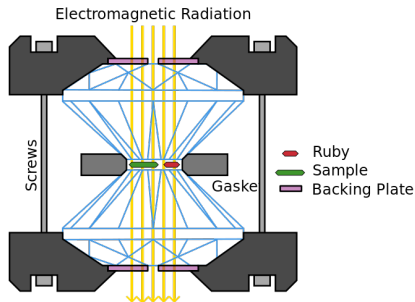
The *fs*-TEM approach

Stimulate a pressure wave with a laser pulse:

- not isotropic, we can choose which axis of the sample to analyze

- no intensity restrictions

- dimension of the monocrystal not critical, we can work on flakes to rule out border effects in polycrystals

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Measure the system with fs-TEM:

- have access to atatic and time-dependent diffraction and electron energy loss spectroscopy
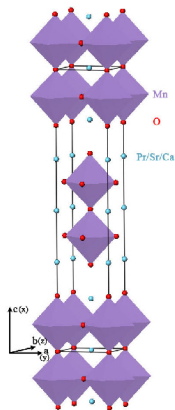- straightforward observation of both structural and electronic properties of the same μ-size sample
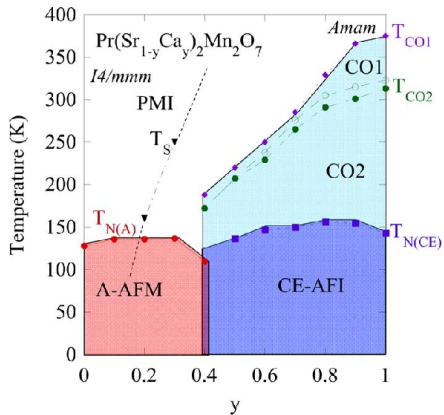
PrSr$_{0.2}$Ca$_{1.8}$Mn$_2$O$_7$
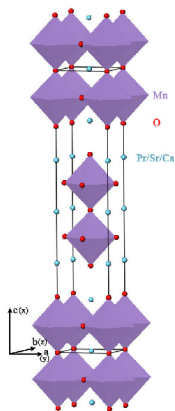
Crystal structure

PrSr$_{0.2}$Ca$_{1.8}$Mn$_2$O$_7$

Crystal structure

Phase diagram

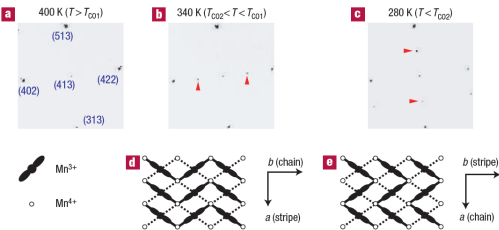# PrSr$_{0.2}$Ca$_{1.8}$Mn$_2$O$_7$

Charge and orbital ordering

Phase diagram

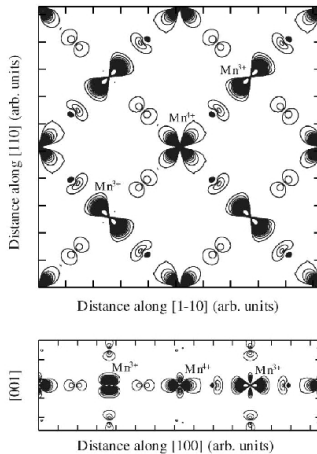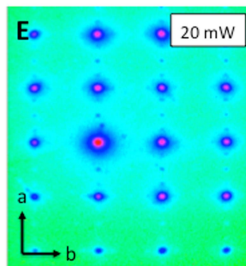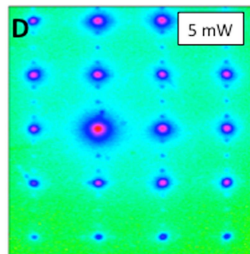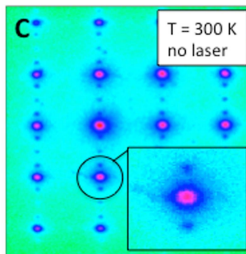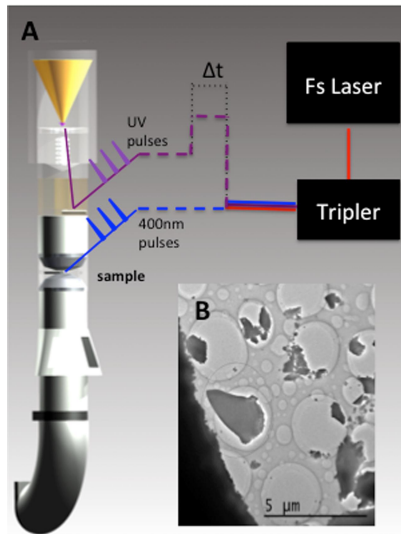# $PrSr_{0.2}Ca_{1.8}Mn_2O_7$
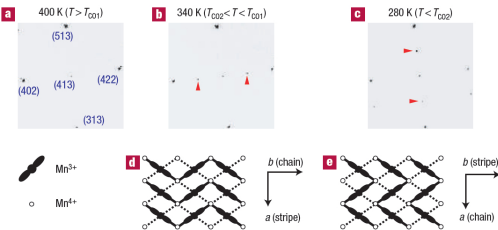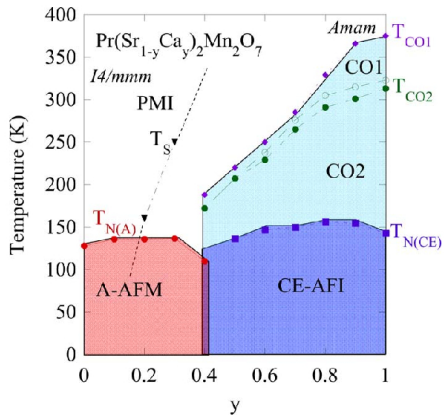
Charge and orbital ordering

Mixed valence state

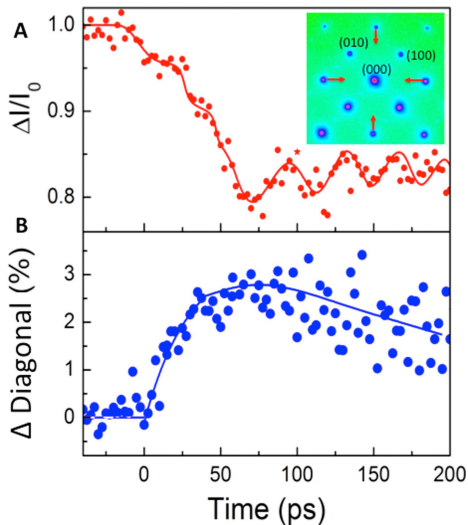# Diffraction - temperature dependence
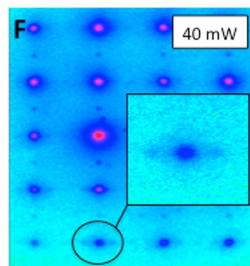
Diffraction - time dependence

- system in the metallic phase
- decrease of the intensity of Bragg peak due to Debye-Waller effect
- drum-like oscillation of the flake
- termal expansion of the sample

EELS - time dependence

DFT simulations
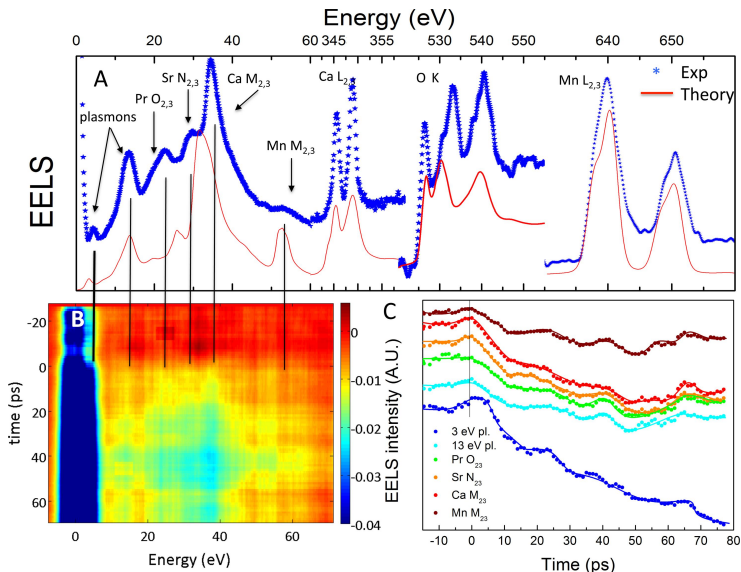
Differential EELS spectra
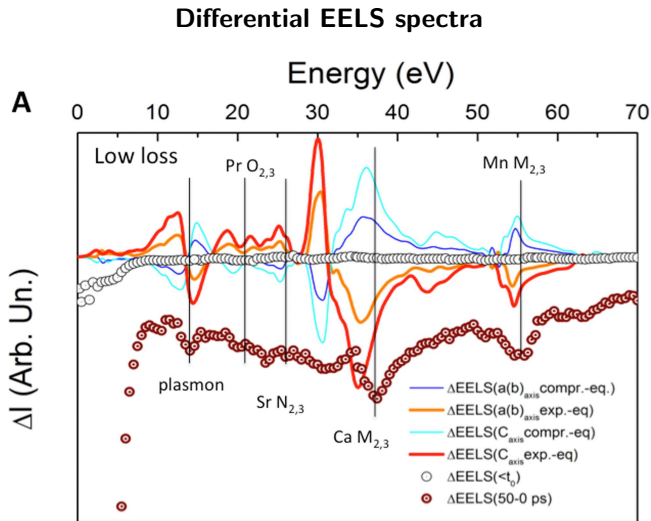
DFT simulations

Differential EELS spectra - Oxygen K-edge and energy bandgap

Conclusions

- **we cannot directly observe the evolution of the energy gap due to insufficient energy resolution**

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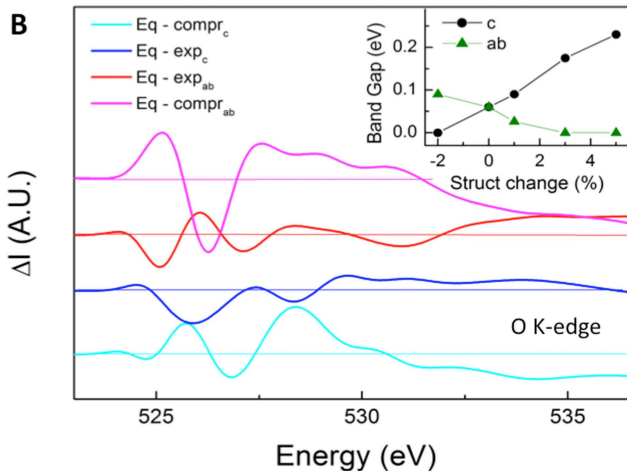- we cannot directly observe the evolution of the energy gap due to insufficient energy resolution

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Thank you for your attention!