

Possible coherent x-ray imaging of ultrafast processes at XFEL

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Motivation

Strongly correlated electron systems

Coupling between
charge, lattice, spin

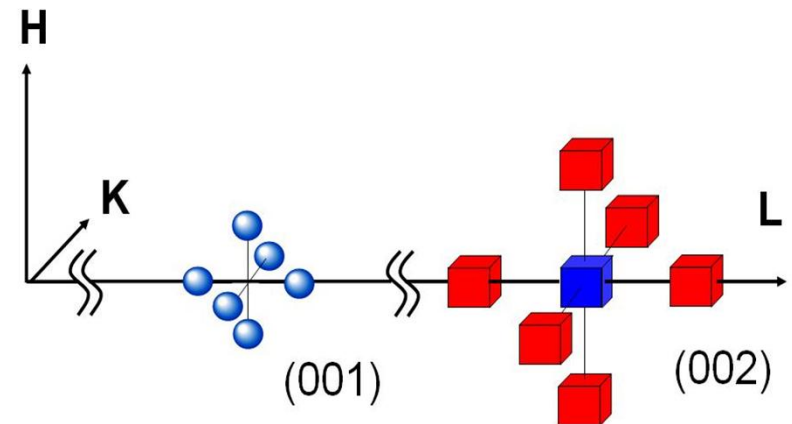


Order parameter

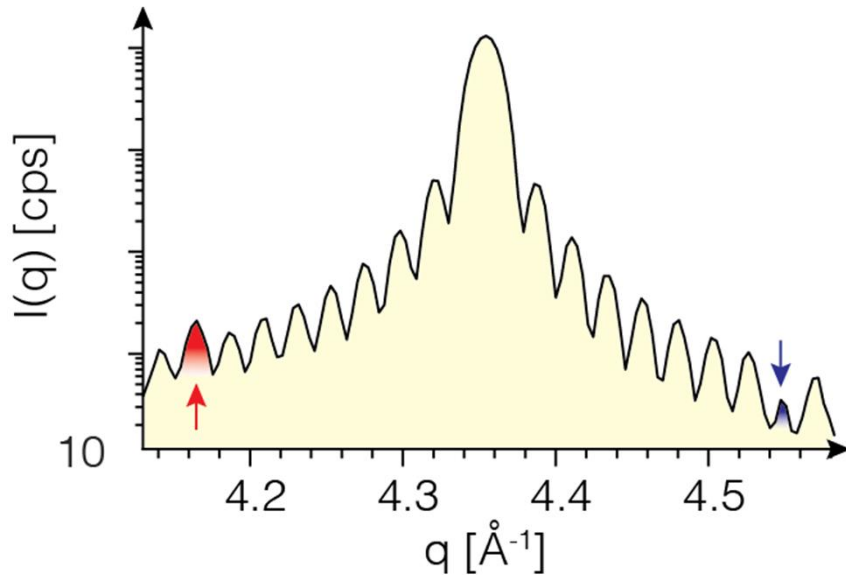
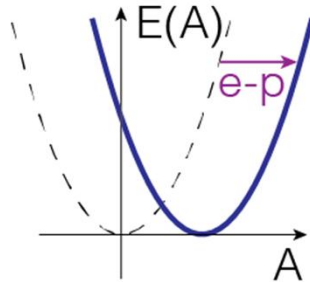
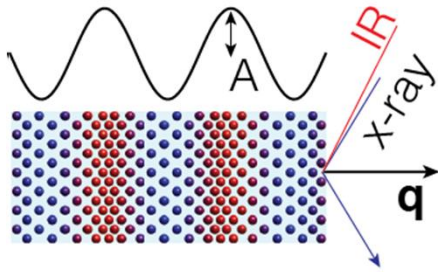
Non-equilibrium?
New phases of matter

Idea of the study

- Elemental Cr:
 - antiferromagnetic ($T_N \sim 290\text{K}$),
 - spin and charge density waves (CDW)
- Perturb the system (photo-excitation)
- Observe time dependent CDW amplitude (x-ray)

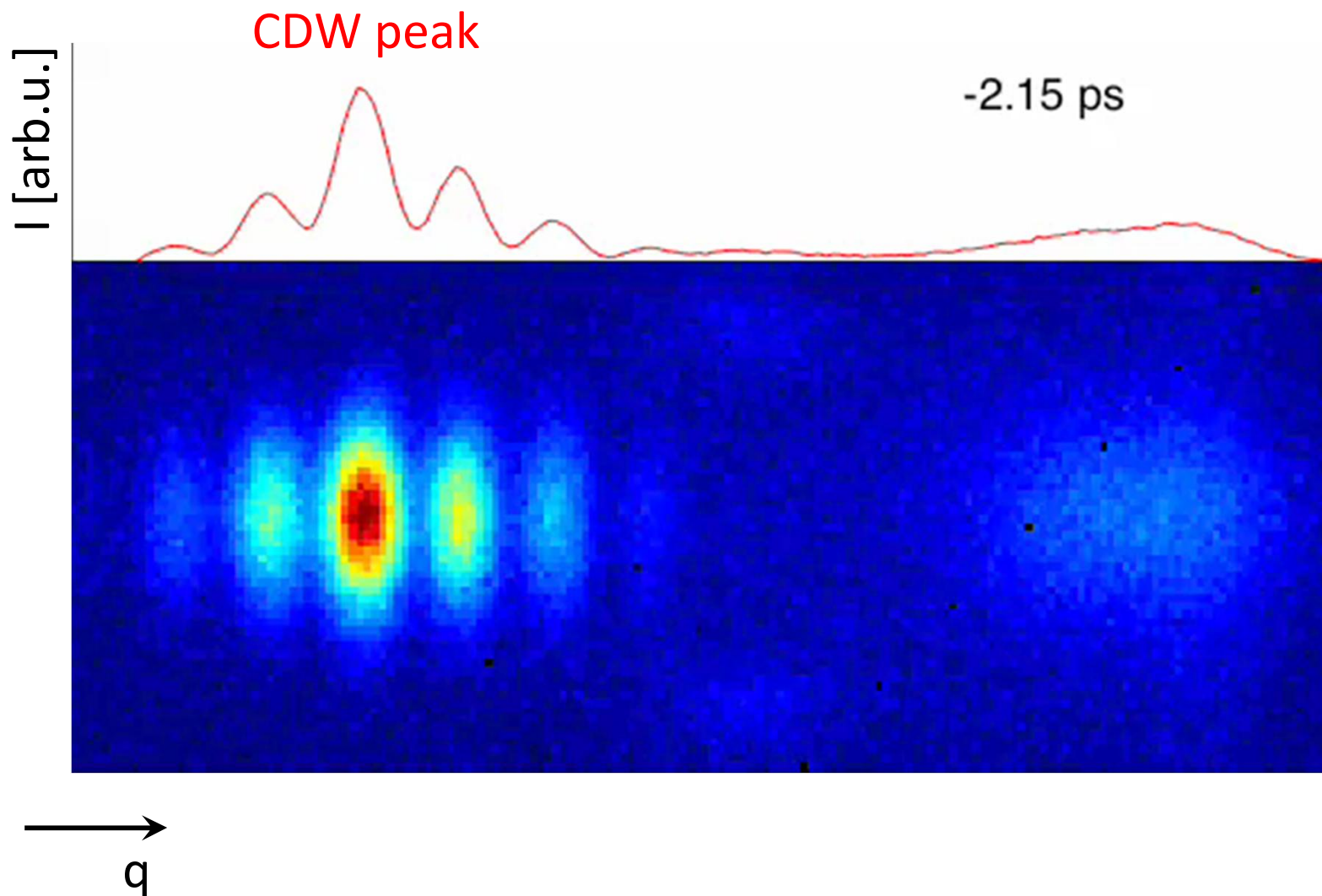


Pump-Probe experiments

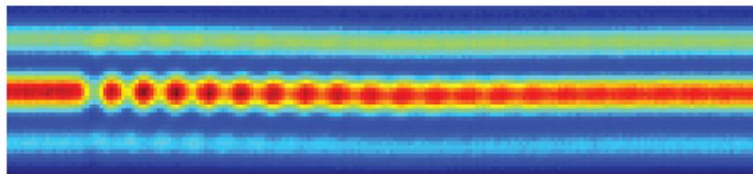


- Laue oscillations (thin film)
- **Constructive interference** (q_{CDWL})
- **Destructive interference** (q_{CDWR})
- XPP instrument of LCLS (SLAC)
 - 800 nm pump (40 fs)
 - 0.14 nm probe (10 fs)

Time dependent x-ray data

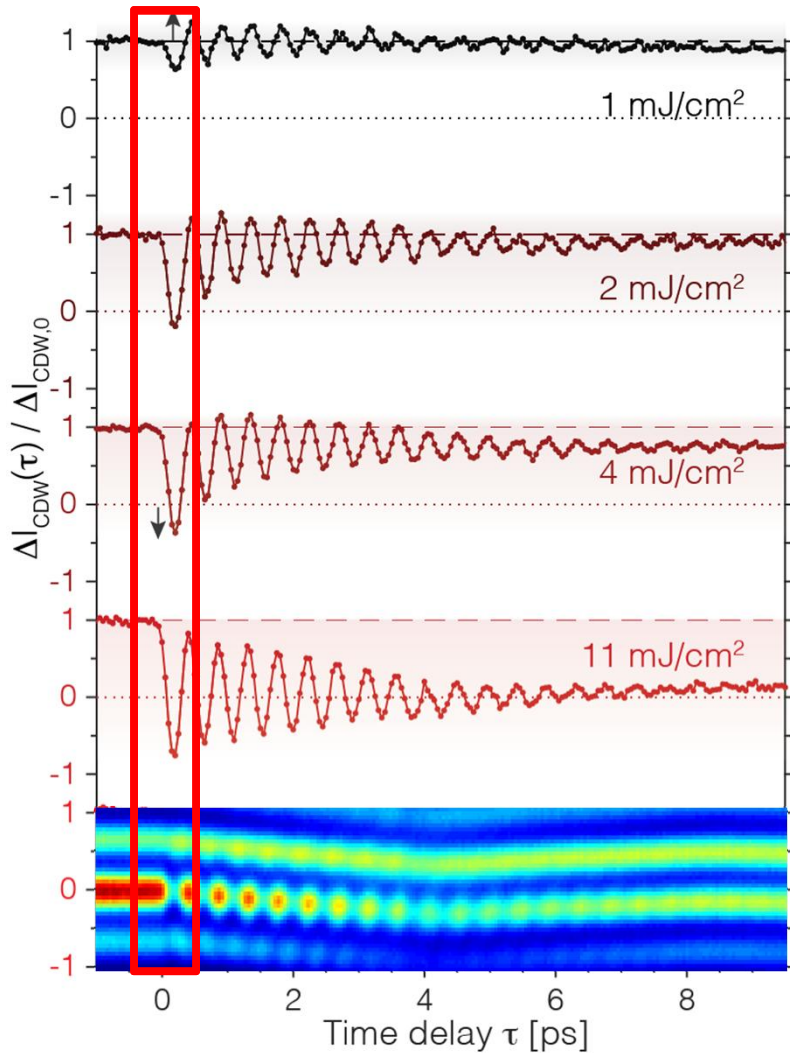


X-FEL experiments



0 2 4 6 8
Time delay τ [ps]

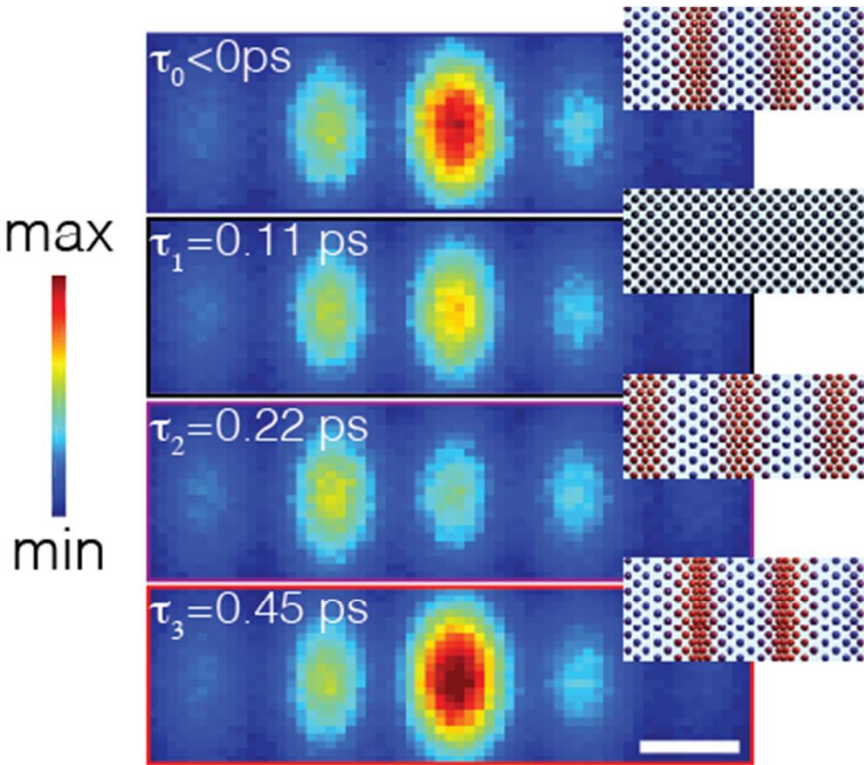
Time dependent CDW amplitude



- Different time scales
 - Longitudinal acoustic phonon (450 fs)
 - Phonon damping (3 ps)
 - Coherent phonon at $q=0$ (8 ps)
 - Shift of the oscillation center (<0.5 ps) for low fluences
- Qualitative difference between below and above 4 mJ/cm^2

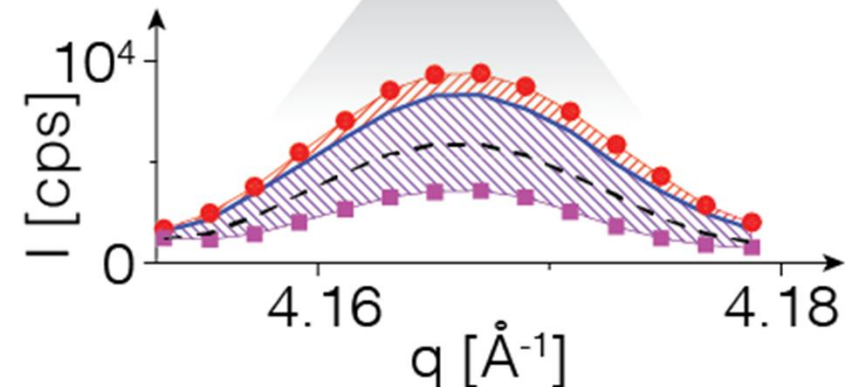
W. Shaw and L Muhlestein PRB (1971)
H. Zeiger et al. PRB (1992)

Ultrafast dynamics



- CDW in the ground state
- Displacement-free lattice after 0.11 ps
- CDW amplitude reversed after 0.22 ps
- CDW amplitude enhanced after 0.45 ps

(up to 30 %)



Motivation for XFEL

Strongly correlated electron systems

Coupling between
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Order parameter

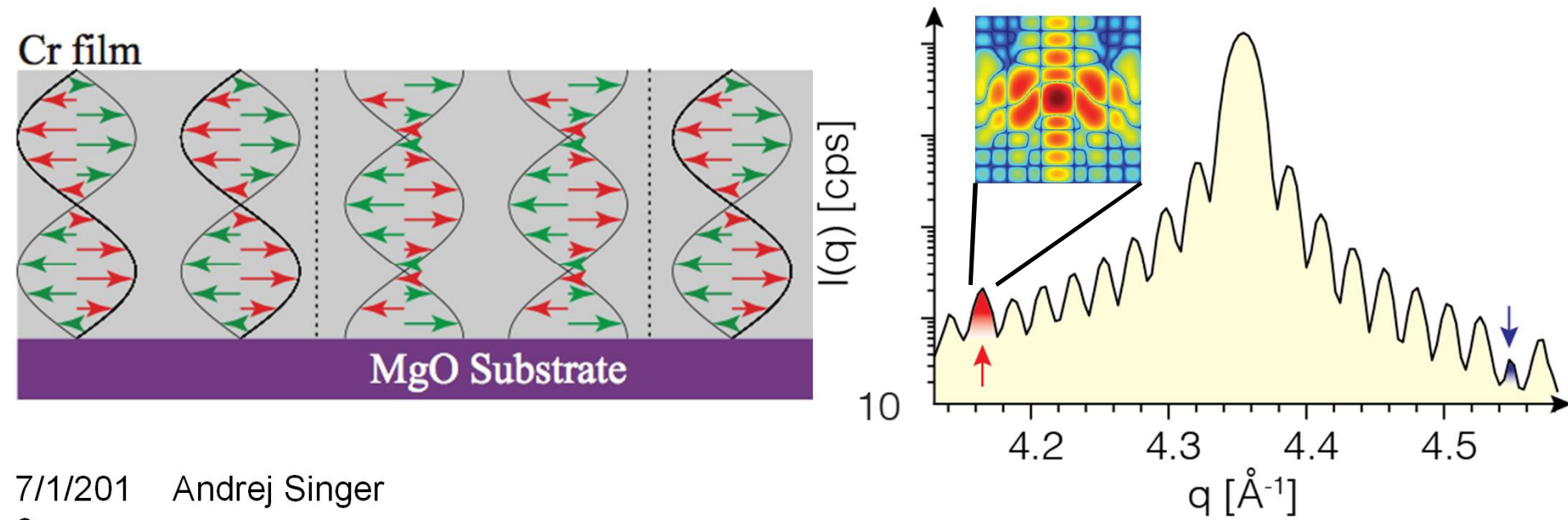
Non-equilibrium?

Enhanced order parameter

**Information on nanoscale disorder (x-ray
coherence)**

Nanoscale disorder at XFEL

- Disorder extremely important for functionality!
 - Focused beam or confined objects (nanoscale disorder)
 - Photon hungry (small effect, 10^{-3} in Cr)
- 100 Hz \rightarrow 1 MHz



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Thank you!