

# How do we control electrons & spins on the nanoscale?

Hermann A. Dürr

LCLS

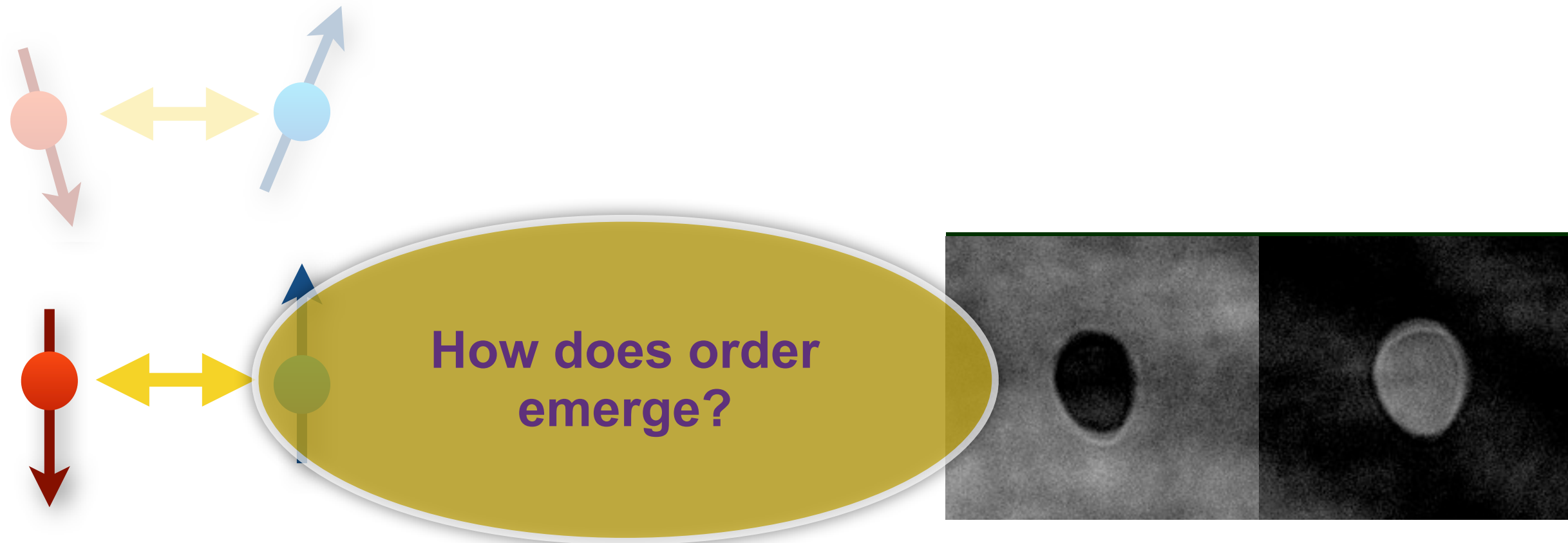


# How do we control electrons & spins on the nanoscale?

Atomic scale  
~1nm

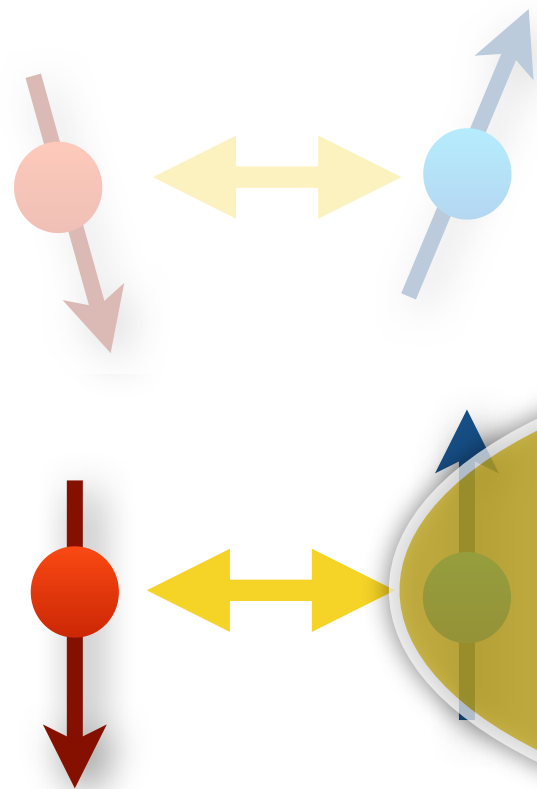
Microscopic scale  
~1micron

Nanoscale



# How do we control electrons & spins on the nanoscale?

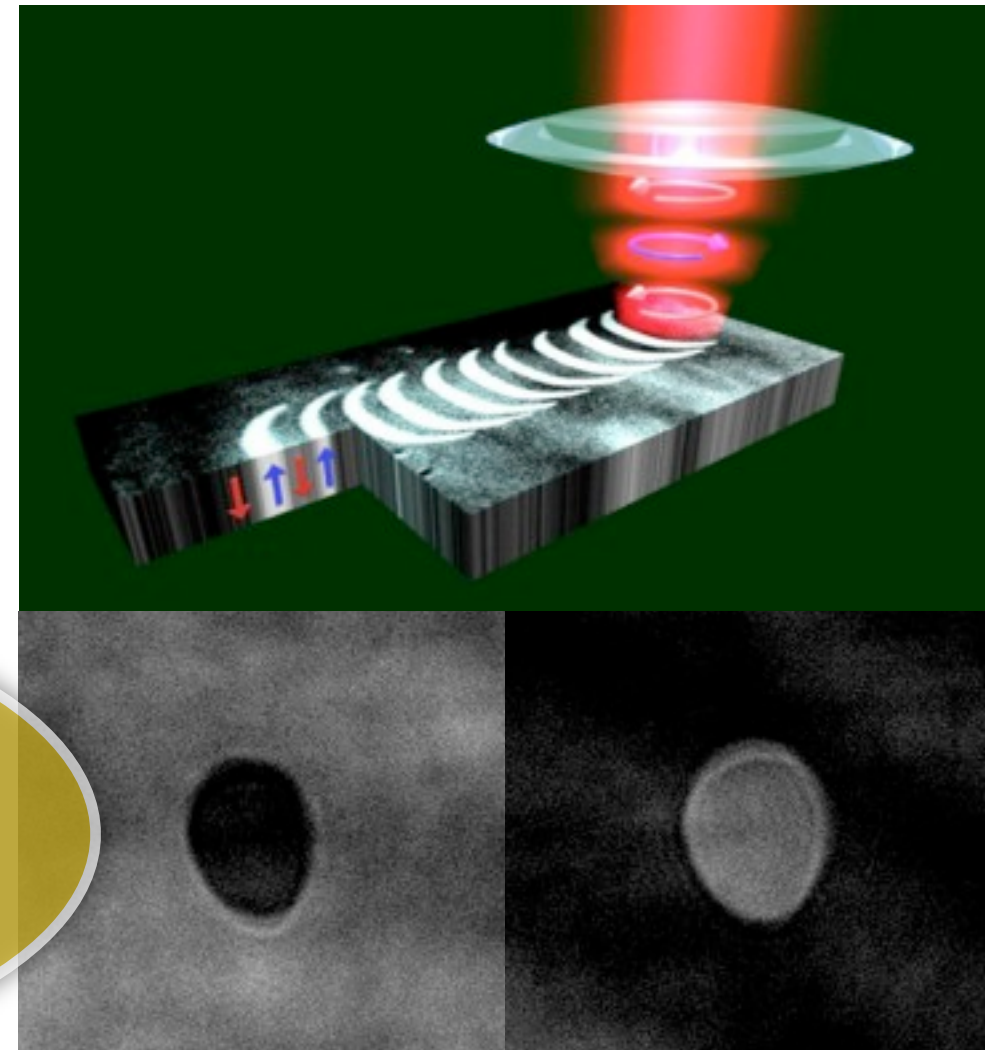
Atomic scale  
~1nm



Nanoscale

can be imaged  
with x-rays!

How does order  
emerge?

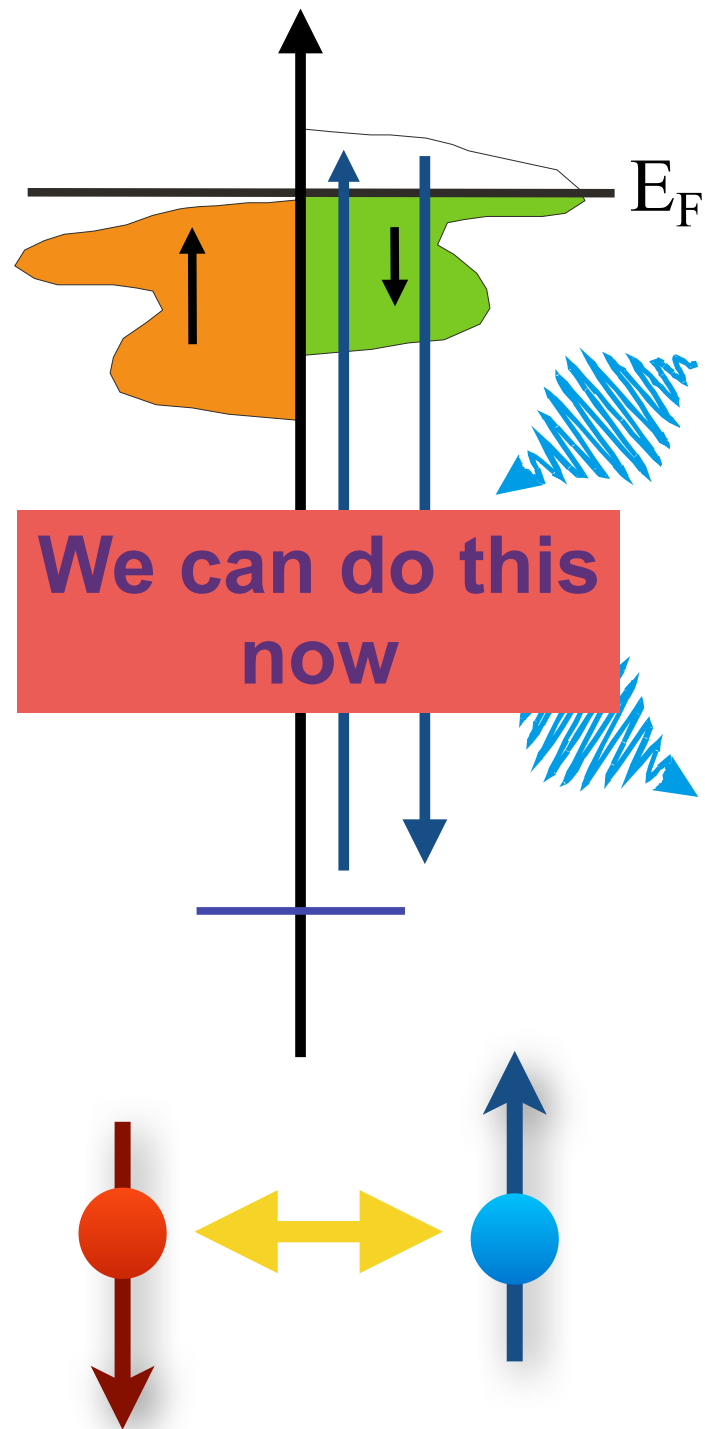


Stanciu *et. al.*, PR, **99**, 047601 (2007)

## Manipulate spins with light



# X-rays can be used to image spins & spin excitations



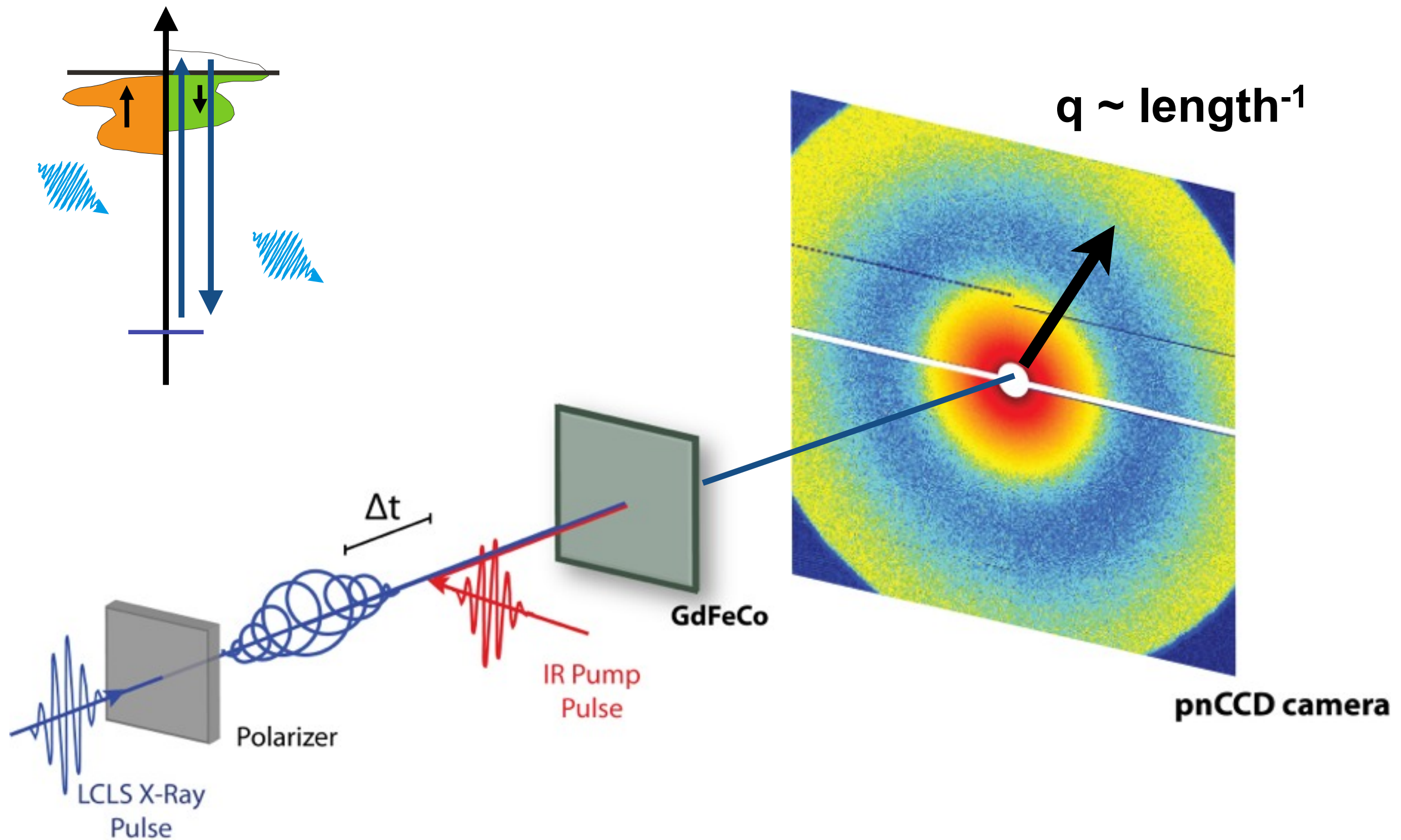
# The FeCoGd Team

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# Emerging magnetic order in FeCoGd





# Emerging magnetic order in FeCoGd

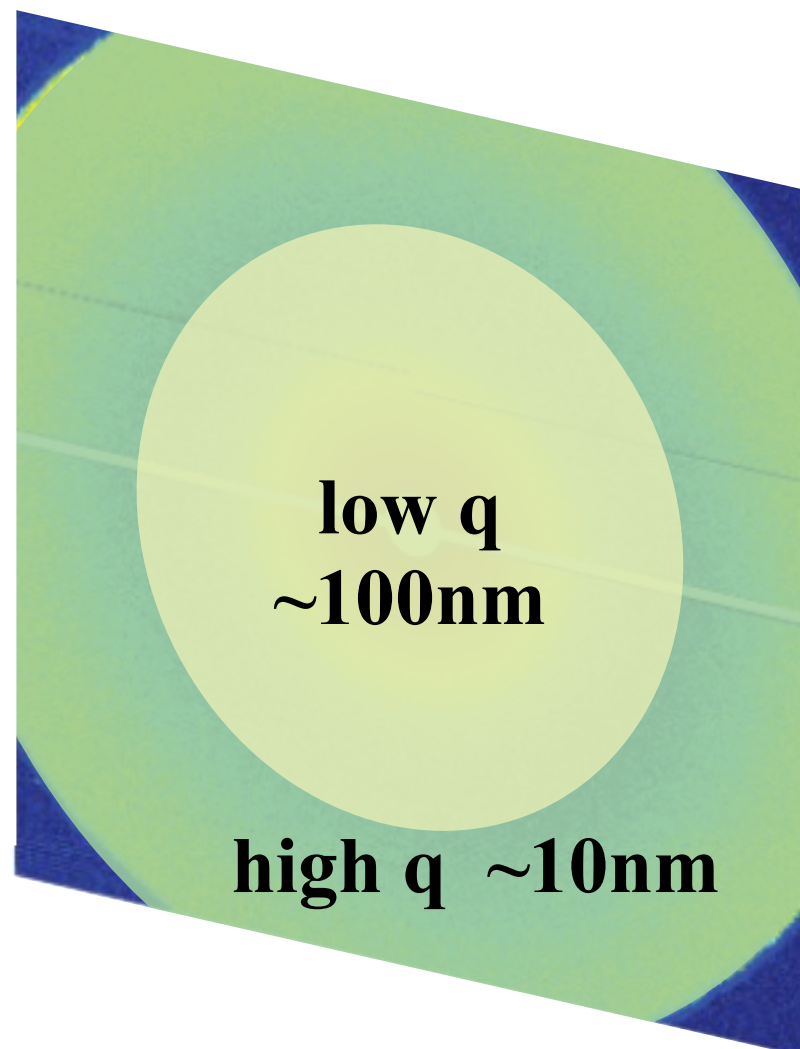
## Summary

We see a new nanoscale form of magnetic order

It develops far from equilibrium

but

We do not know the nature of this magnetic order



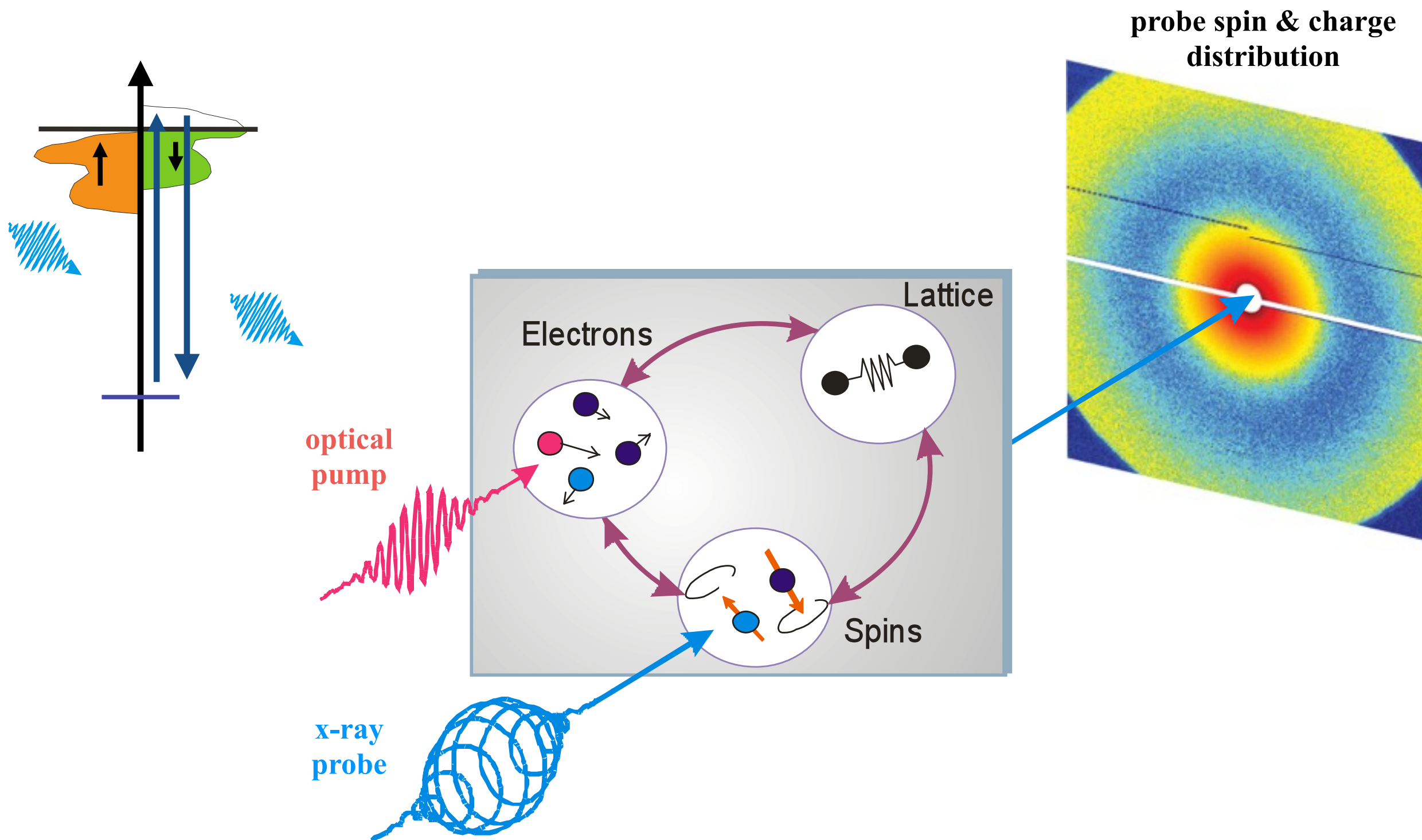
Fe 3d



Gd 4f

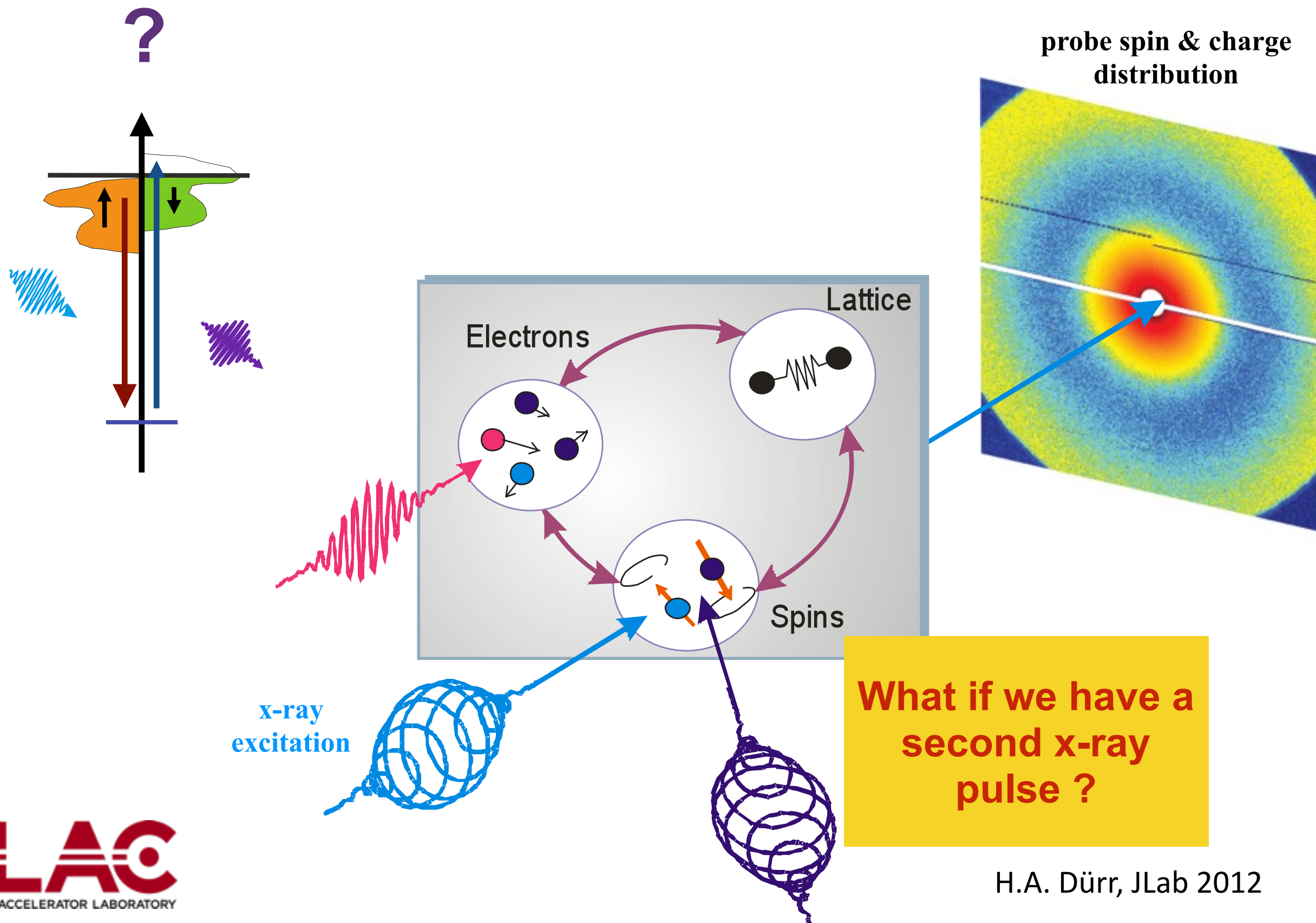


# Femtosecond X-Ray Holography of Charge & Spin Distributions



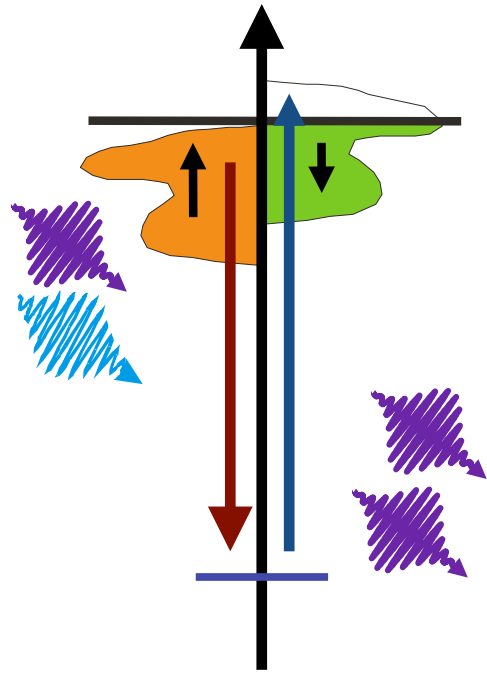


# Femtosecond X-Ray Holography of Charge & Spin Excitations

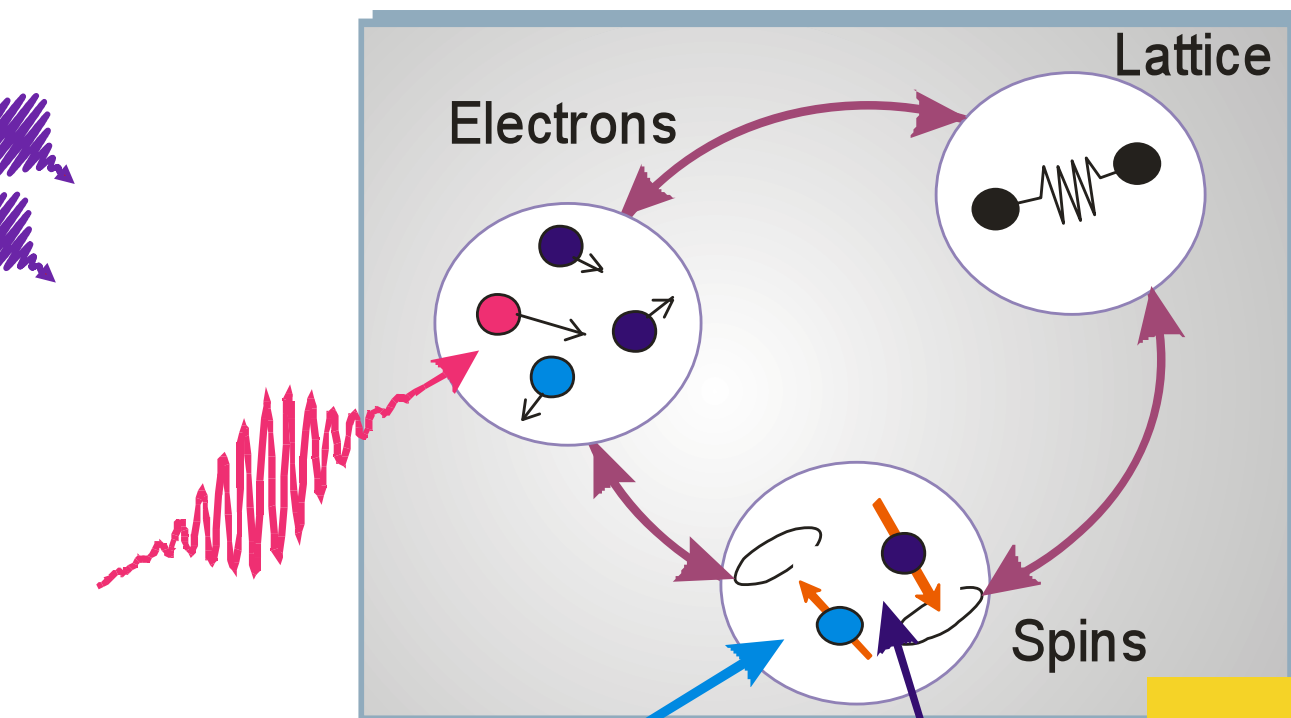
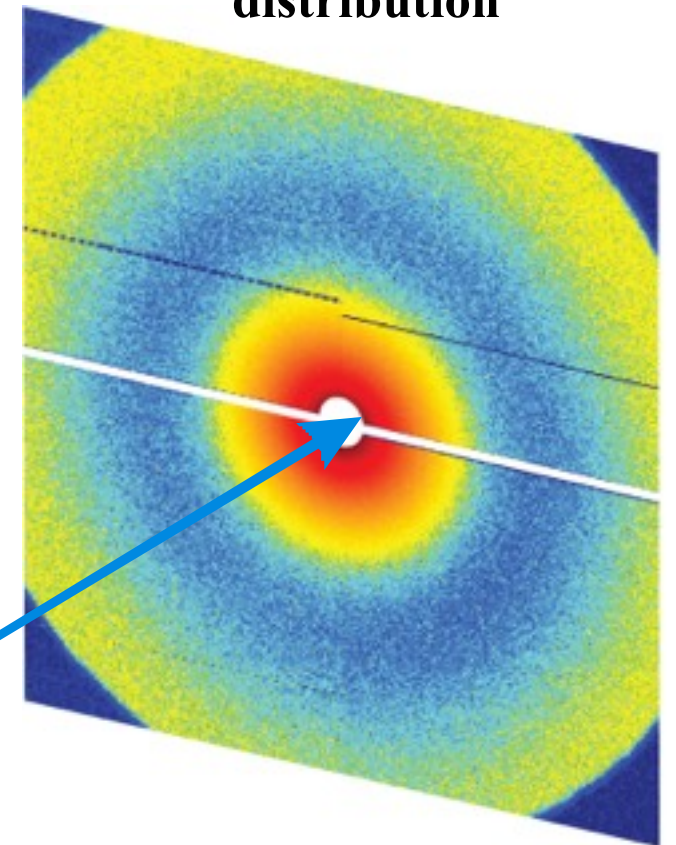


# Femtosecond X-Ray Holography of Charge & Spin Excitations

Stimulated emission



probe spin & charge distribution

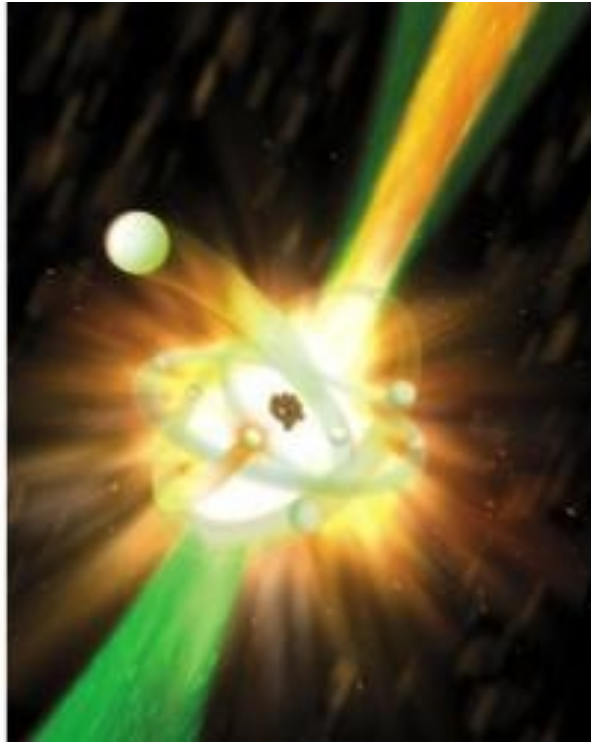


x-ray excitation

What if we have a second x-ray pulse ?

# Can we really do this ?

Rohringer, et al.  
Nature **481**, 488 (2012)



<https://news.slac.stanford.edu/press-release/scientists-create-first-atomic-x-ray-laser>

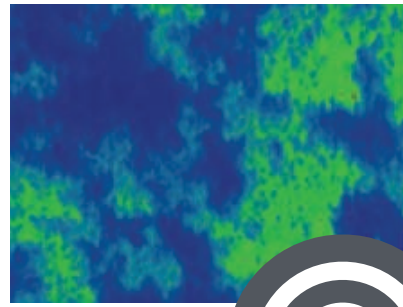
**We have indications that it works for solids below the damage threshold too!**

Wu, Scherz, Stohr, Durr et al (unpublished)

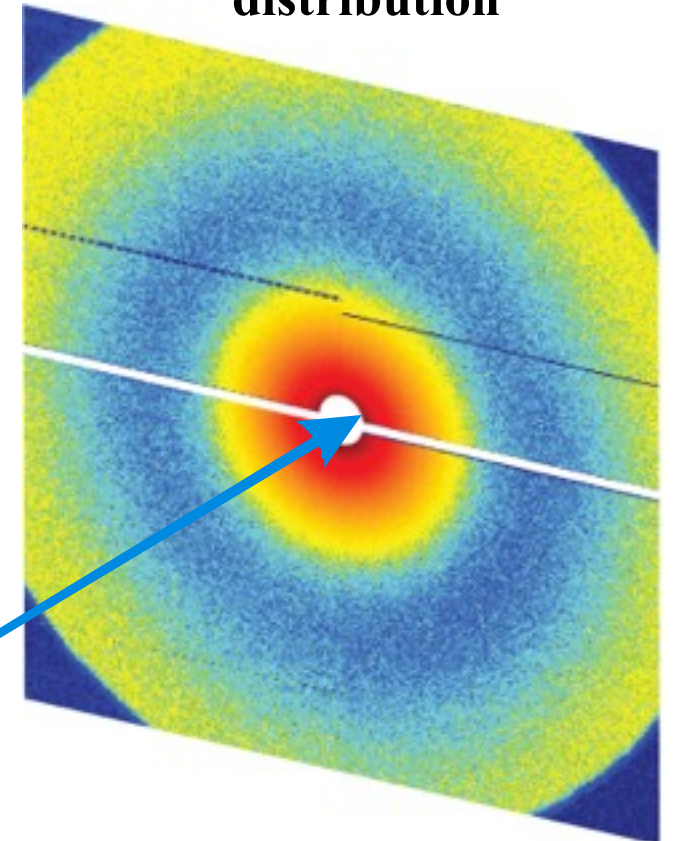


# Vision of the ultimate XFEL experiment

image spin & charge excitations



probe spin & charge distribution



We need two seeded, 'phase locked' XFEL beams (<10fs, 0.1 mJ) with different polarization or energy !

