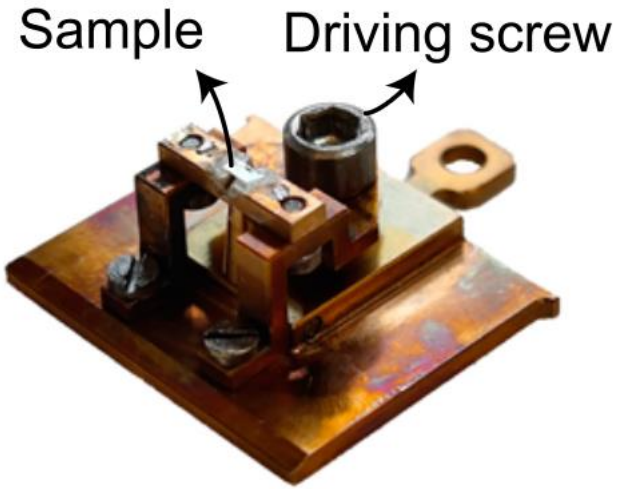
University Zurich

Johan Chang

Squeezing unconventional superconductors

Uniaxial pressure cells

Meeting point for collaboration



PPMS

Coming

Ruthenates

BiS_2-Supercon.

High-energy XRD

J. Choi et al., $La_{2-x}Sr_xCuO_4$
PRL **128**, 207002 (2022)

J. Küspert et al.,
Comm. Phys. **7**:225 (2024)

M. Baumgartner et al., $EuAl_4$
arXiv:2607.07544

Neutron diffraction

G. Stimutis et al., $La_{2-x}Sr_xCuO_4$
Comm. Phys. 5:296 (2022)

ARPES

CsV_3Sb_5
C. Lin et al.
Nat. Comm. 15 10466 (2024)

CrSb
C. Li et al.,
arXiv: 2512.07683 (2025)

RIXS

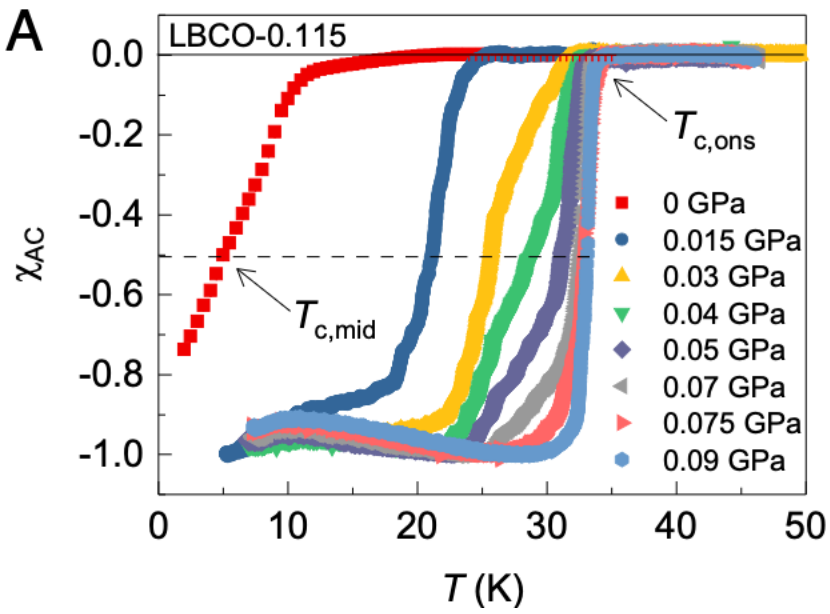
$La_{2-x}Sr_xCuO_4$
Q. Wang et al.,
Nat. Comm. **13**, 1795 (2022)

L. Martinelli et al.,
Phys. Rev. B **112**, L041124 (2025)

I. Biało et al,.
arXiv: 2601.01643 (2026)

Uniaxial pressure cells

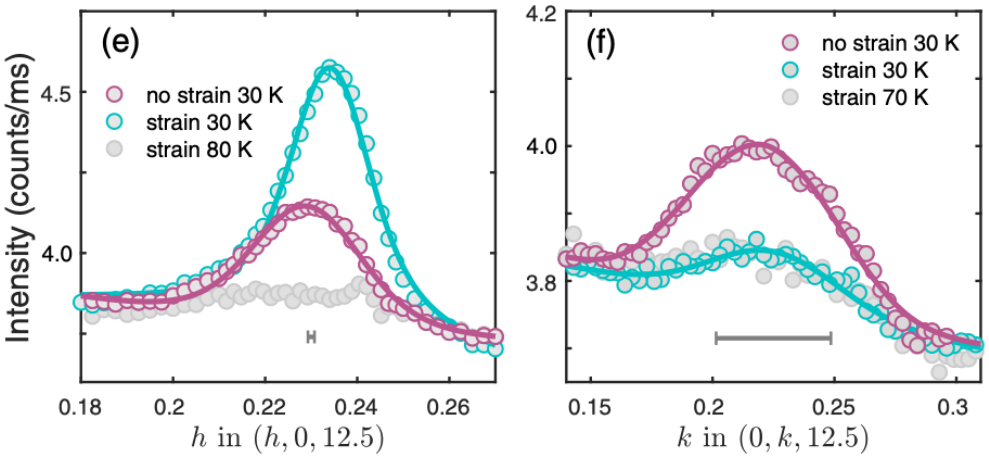
Cuprate superconductivity

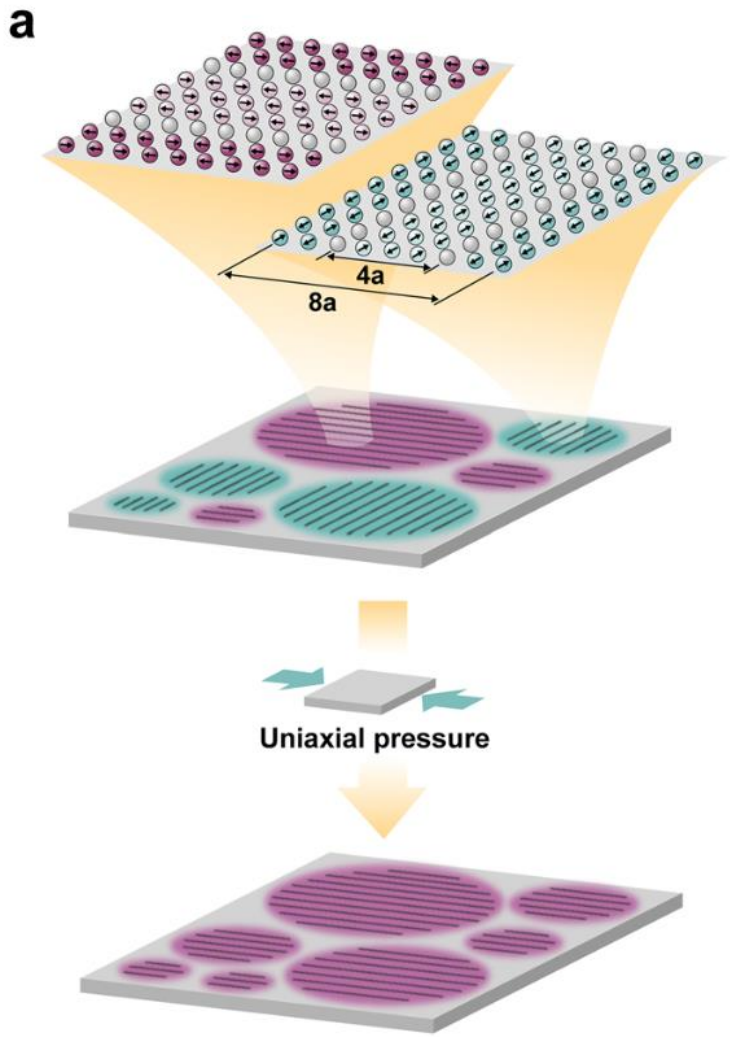


Z. Guguchia et al.,
PNAS 121, e2303423120 (2022)

Detwining of stripe order

$La_{2-x}Sr_xCuO_4$, x = 0.12

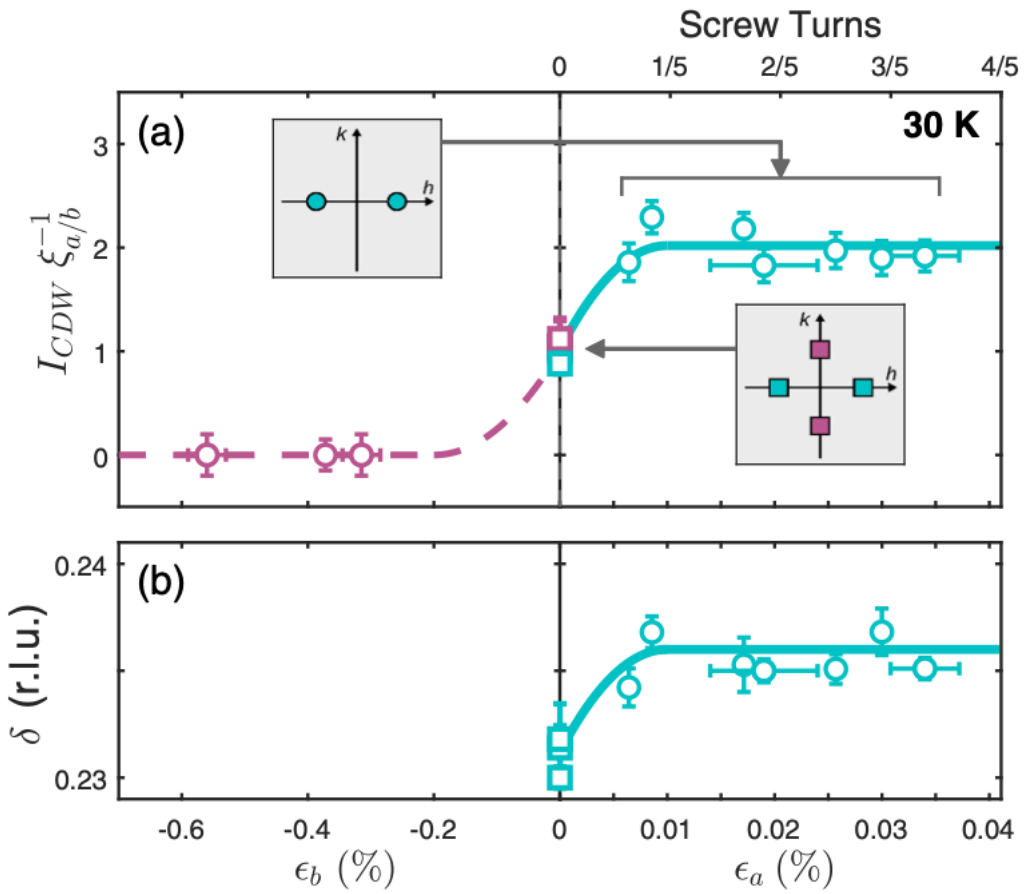




Add spin

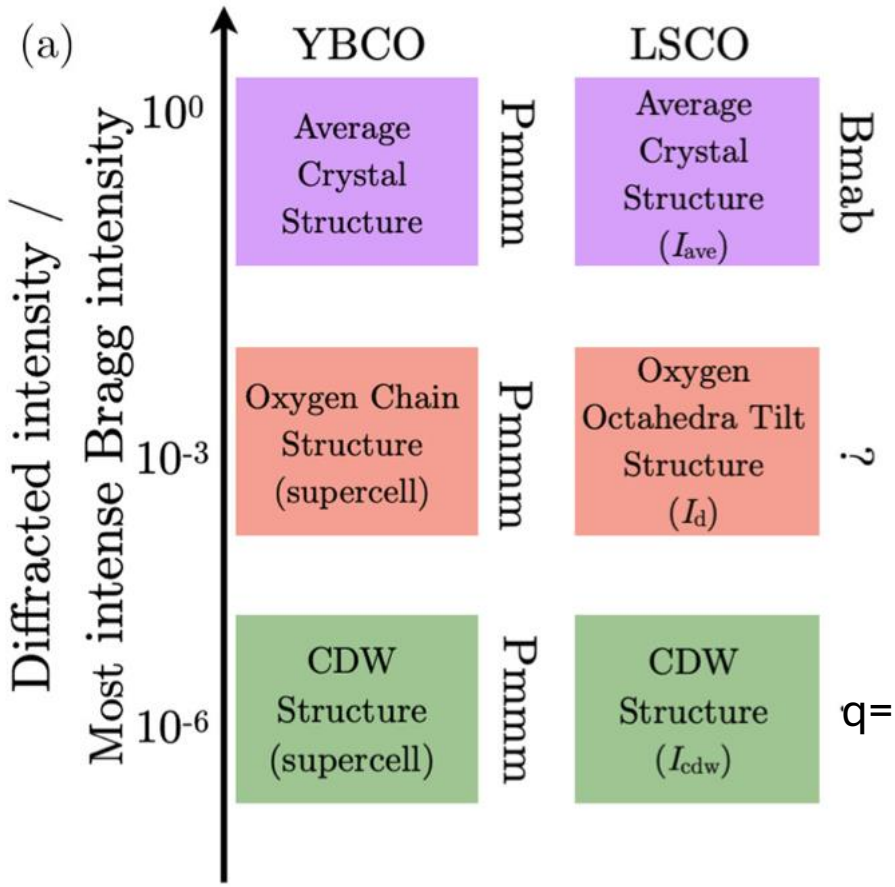
Detwining only

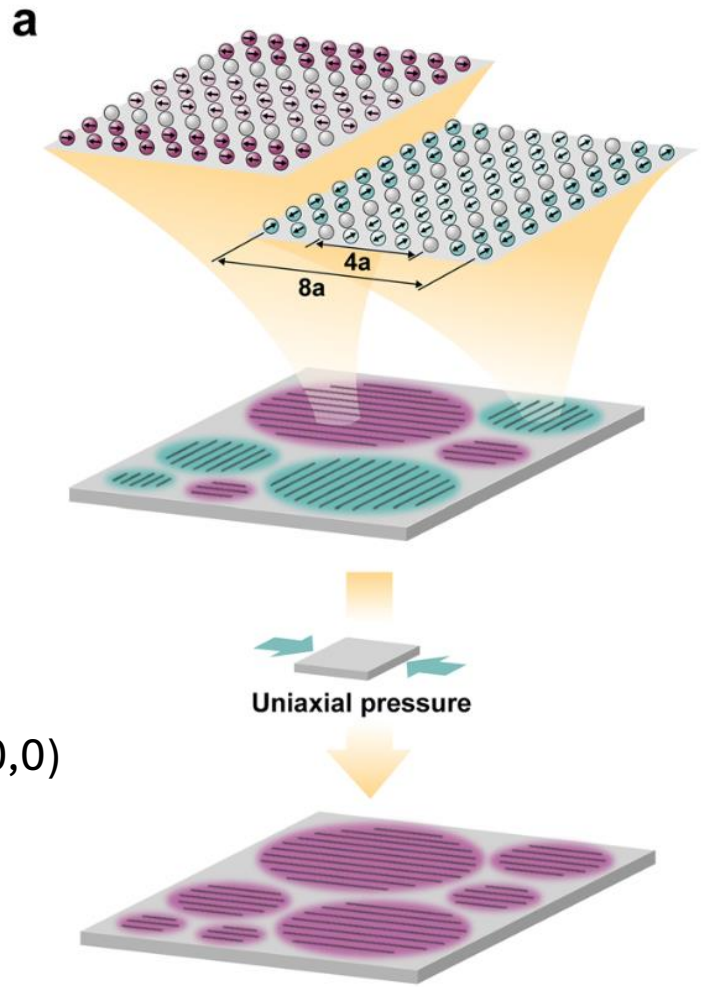
$La_{2-x}Sr_xCuO_4$, x = 0.12



Symmetry problem

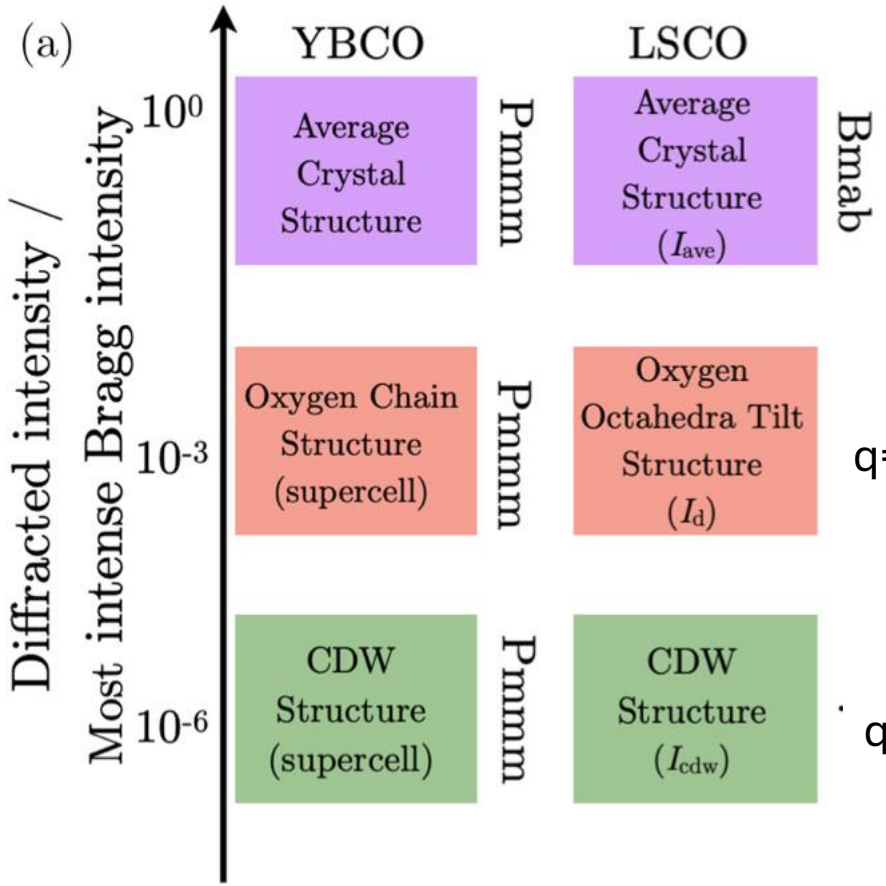
$La_{2-x}Sr_xCuO_4$, x = 0.12

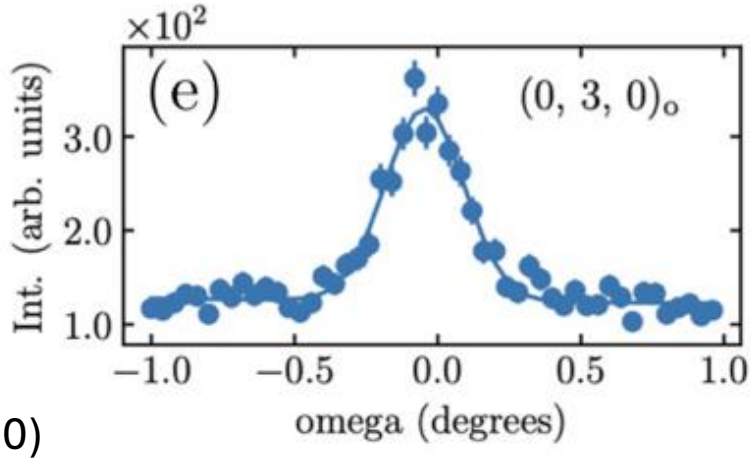




Solution: Monoclinic phase

$La_{2-x}Sr_xCuO_4$, x = 0.12



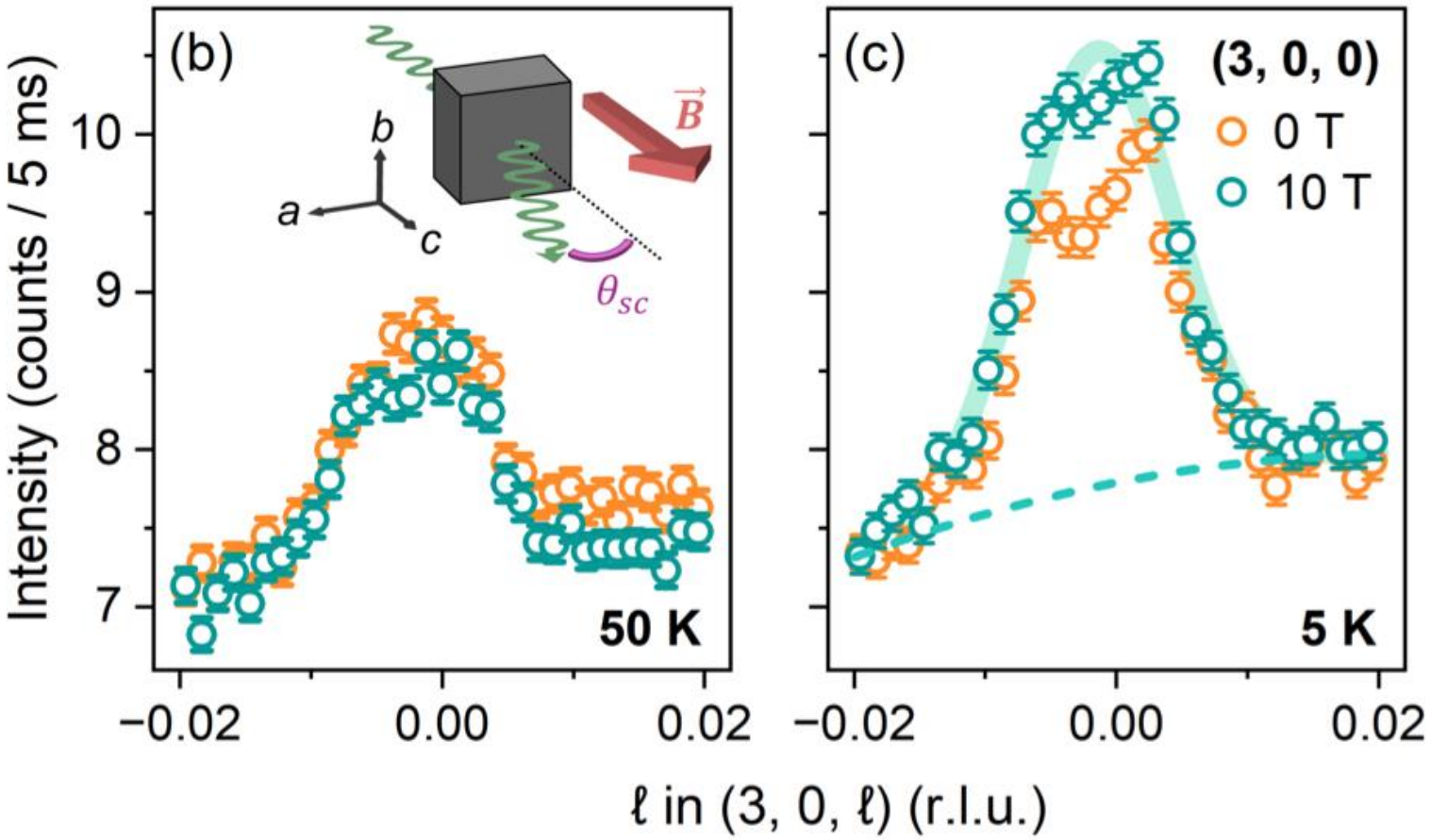


q=(1,0,0)

q=(1/4,0,0)

Phase competition

$La_{2-x}Sr_xCuO_4$, x = 0.12



Phase competition

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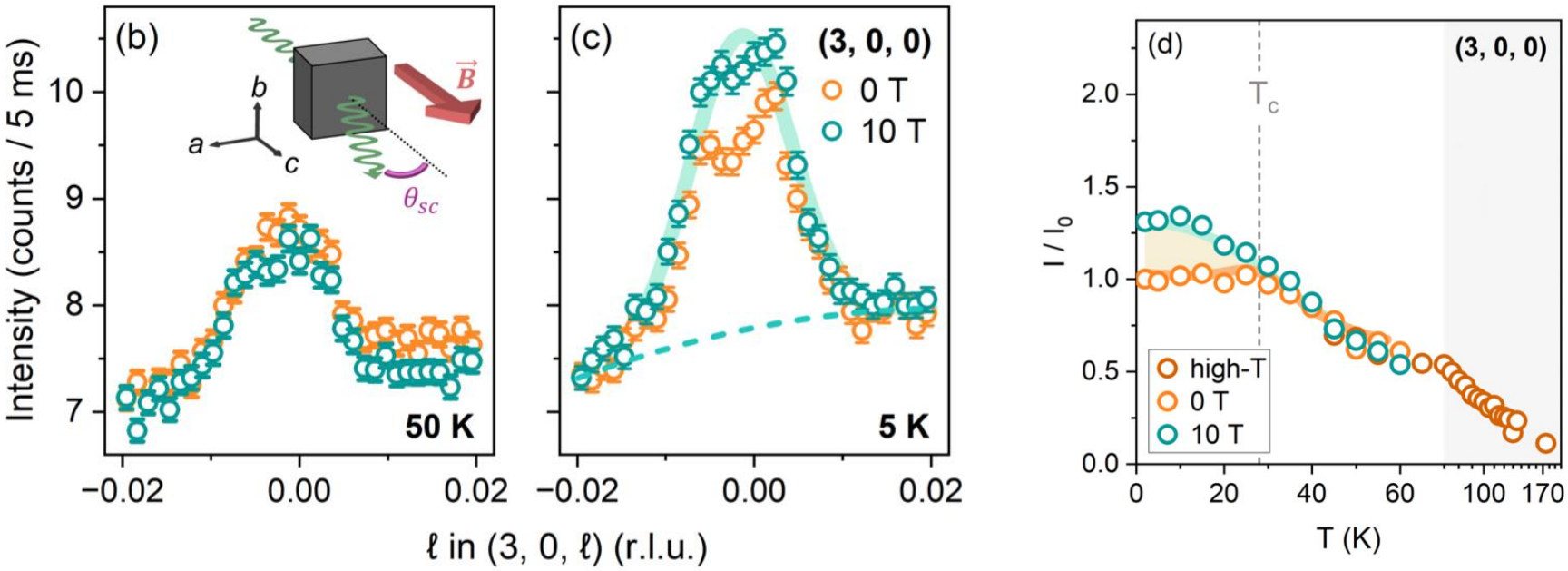
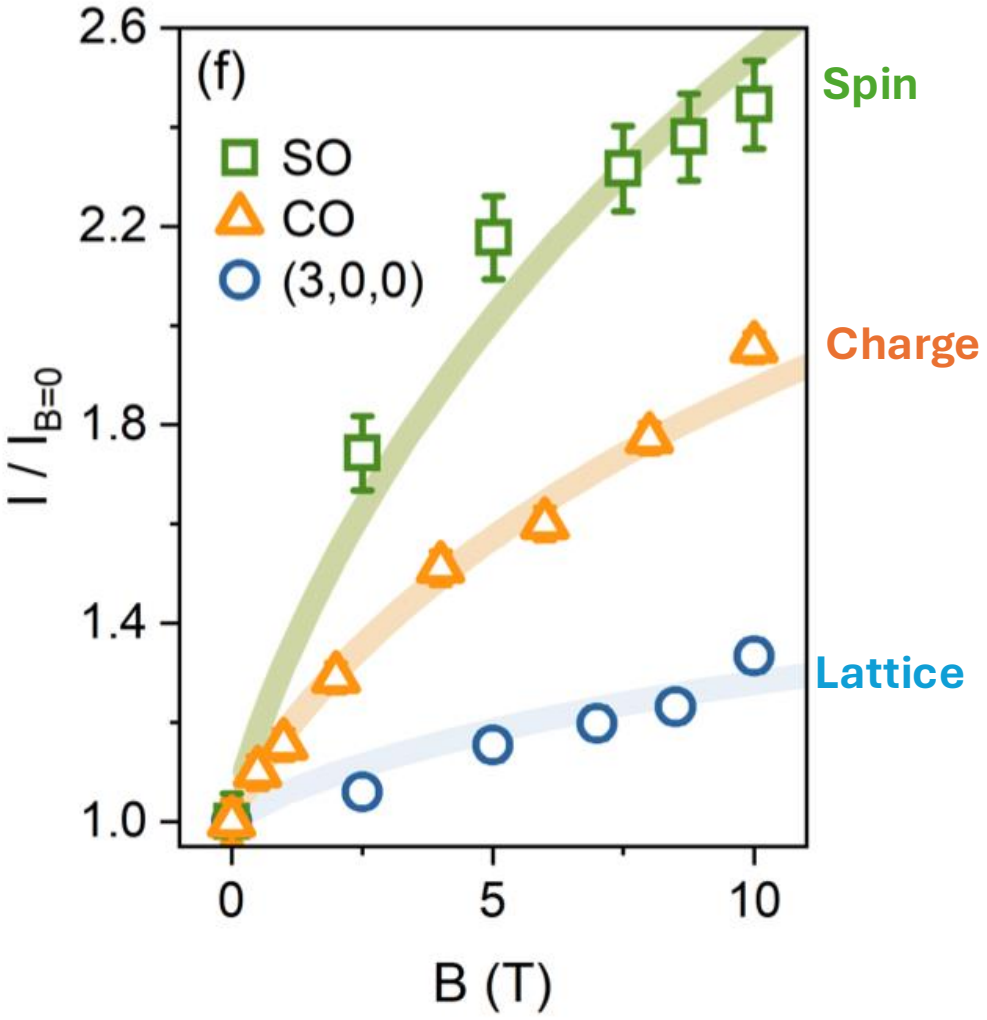


Magnetic field coupling

$La_{2-x}Sr_xCuO_4$, x = 0.12



Magnetic field coupling

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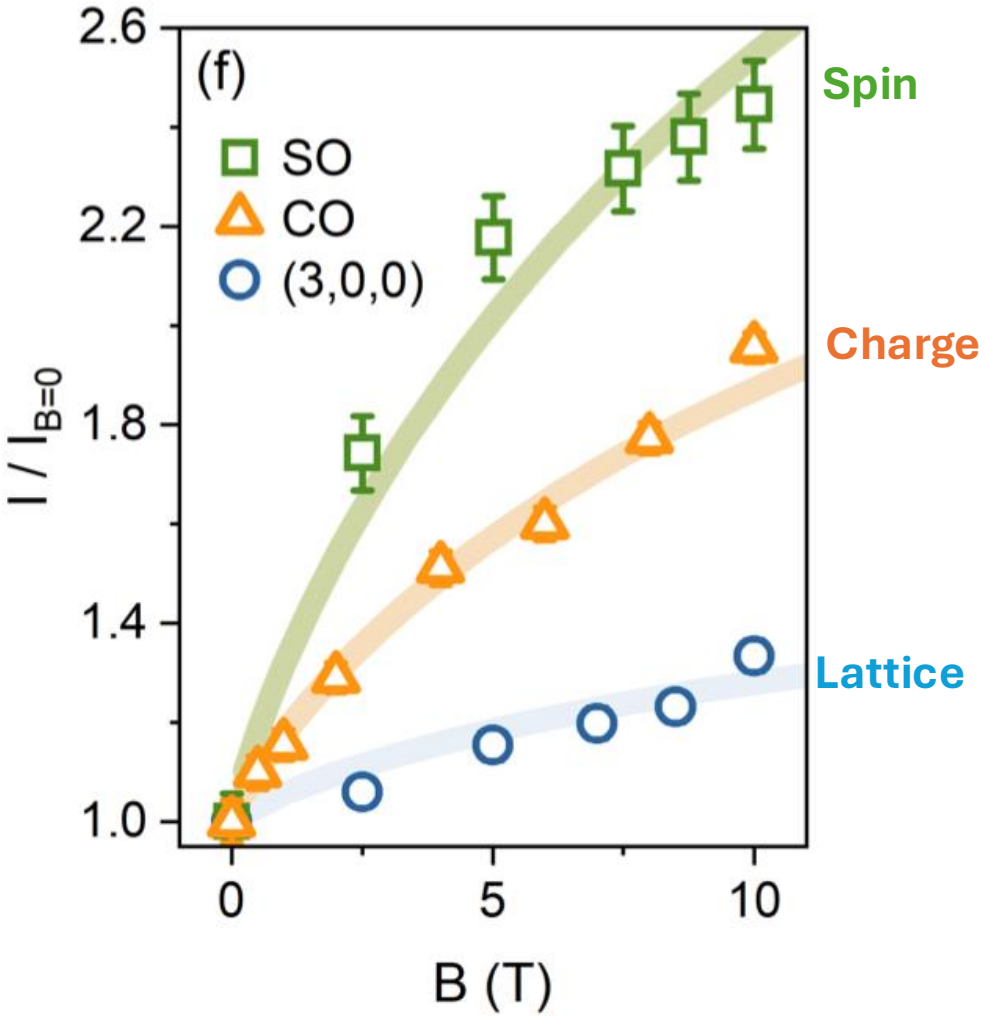
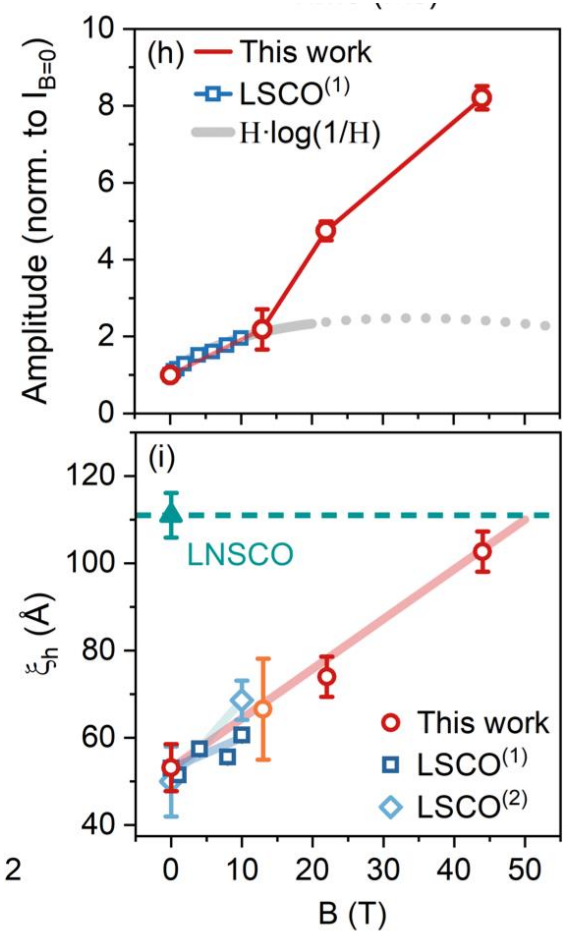
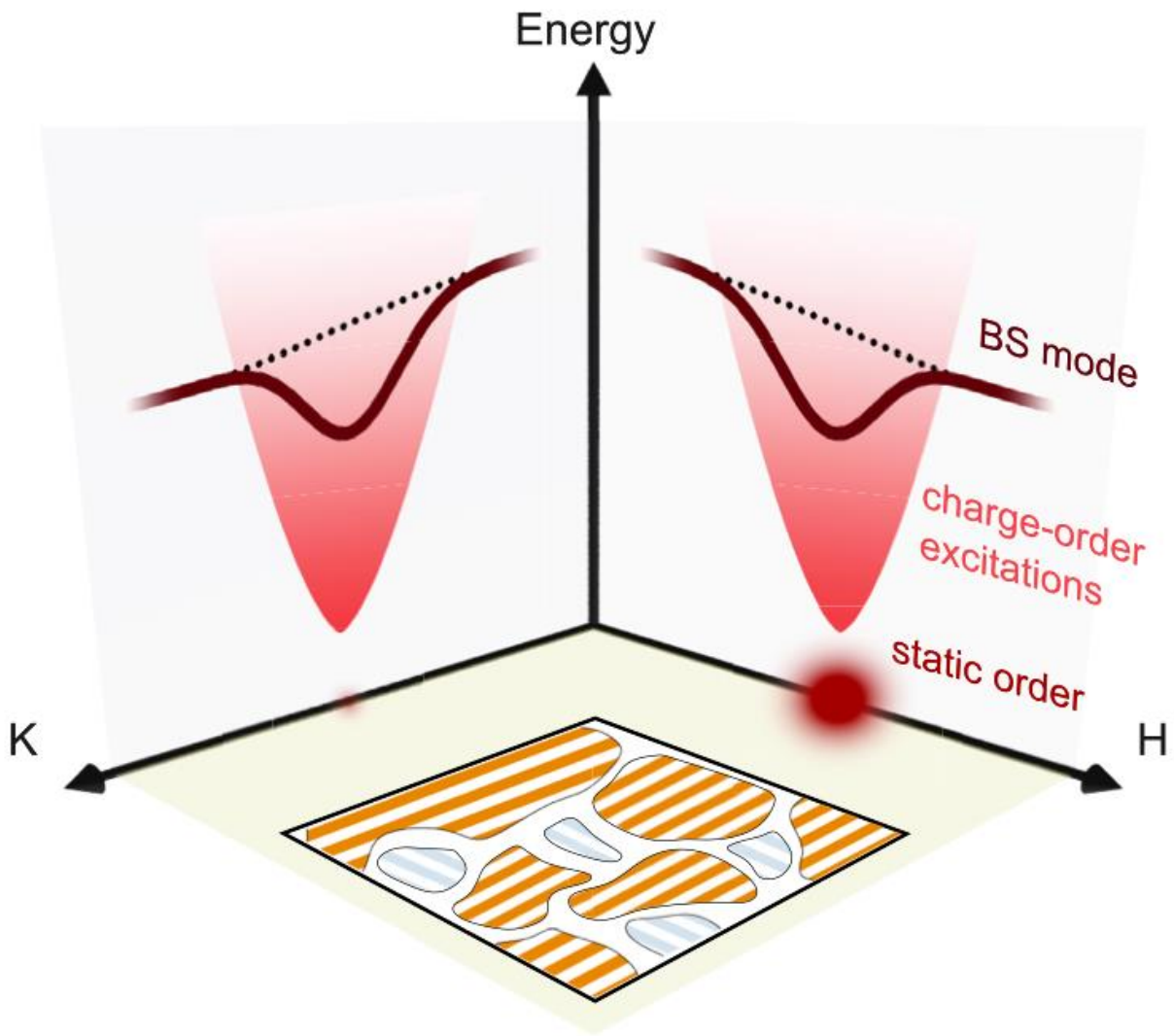




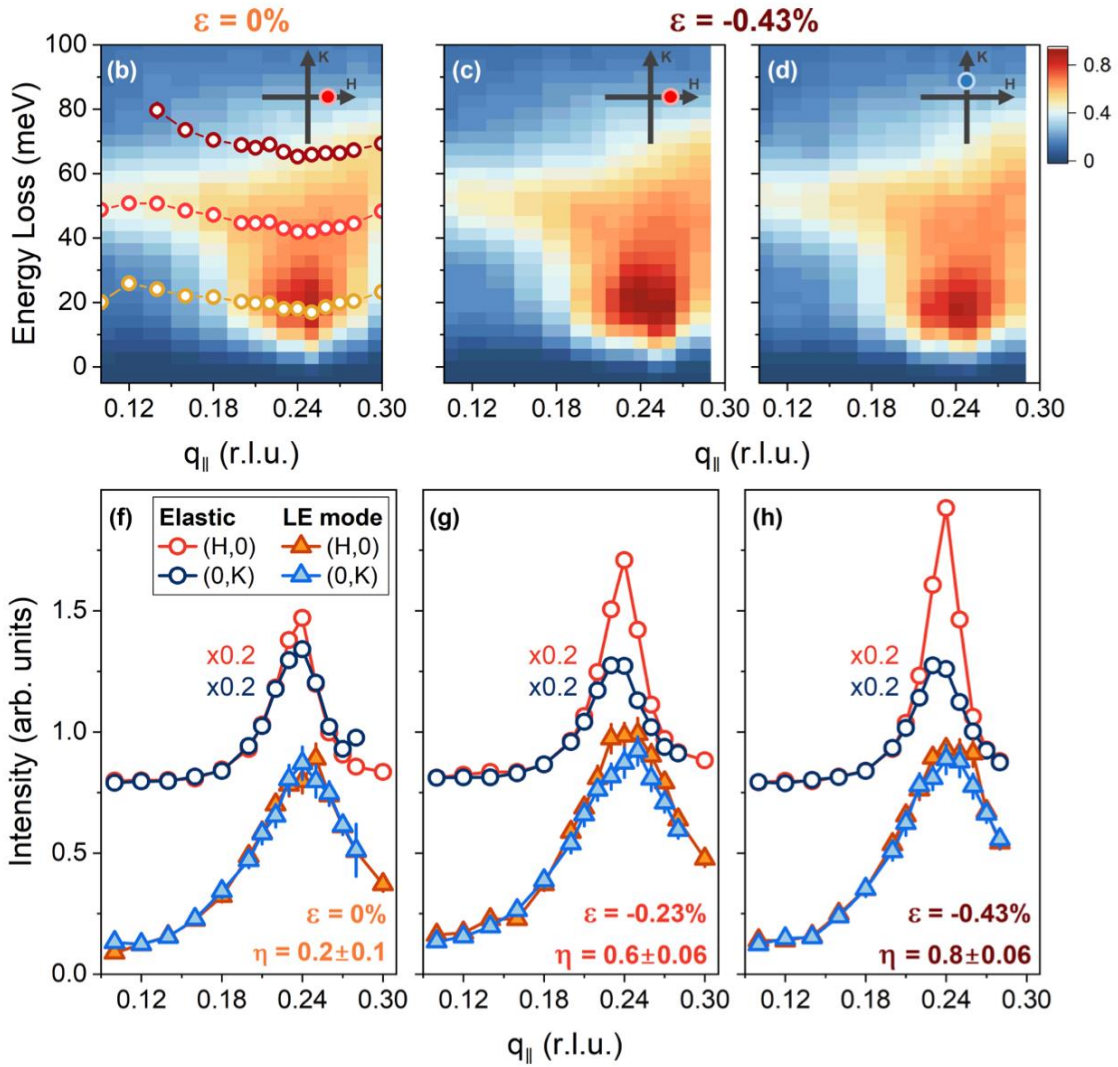
Charge excitations

$La_{2-x}Sr_xCuO_4$, x = 0.12



Charge excitations: Remain C_4

$La_{2-x}Sr_xCuO_4$, x = 0.12



Terminology

Charge density wave order versus Charge order

Charge density wave

Charge order

Terminology: CDW example

Charge density wave order versus Charge order

Charge density wave

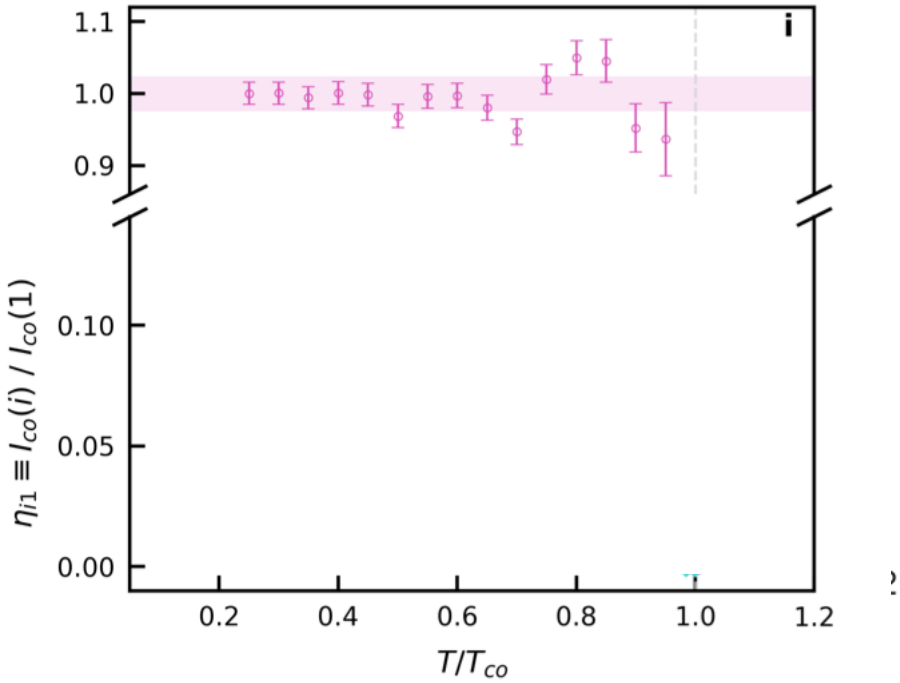
Charge order

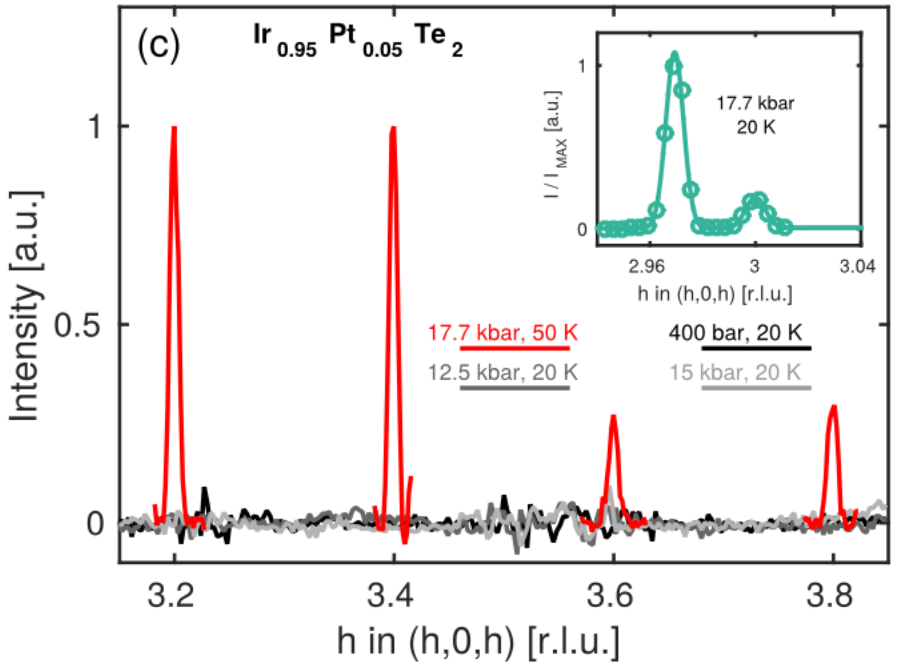
Terminology: CO example

Charge density wave order versus Charge order

Charge density wave

Charge order

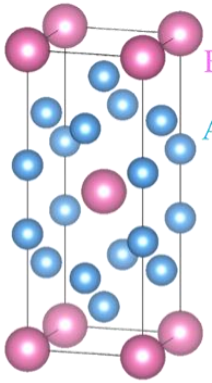




$EuAl_4$

Qisi Wang

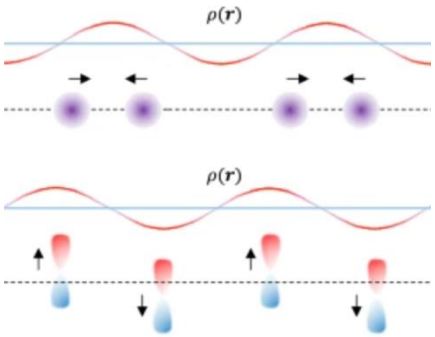
Lattice

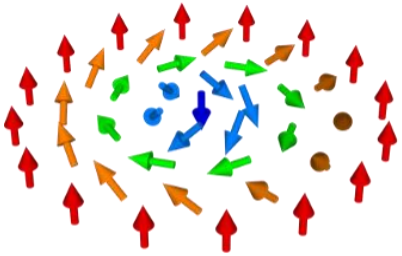


I4/mmm

Charge:

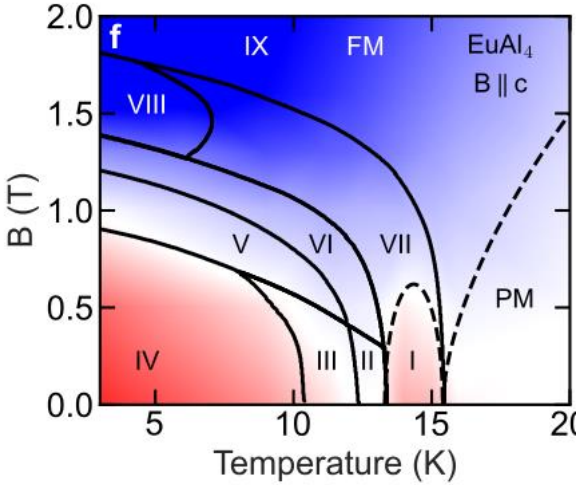
$q=(0,0,d)$, $T_{co}=130K$





Spin:

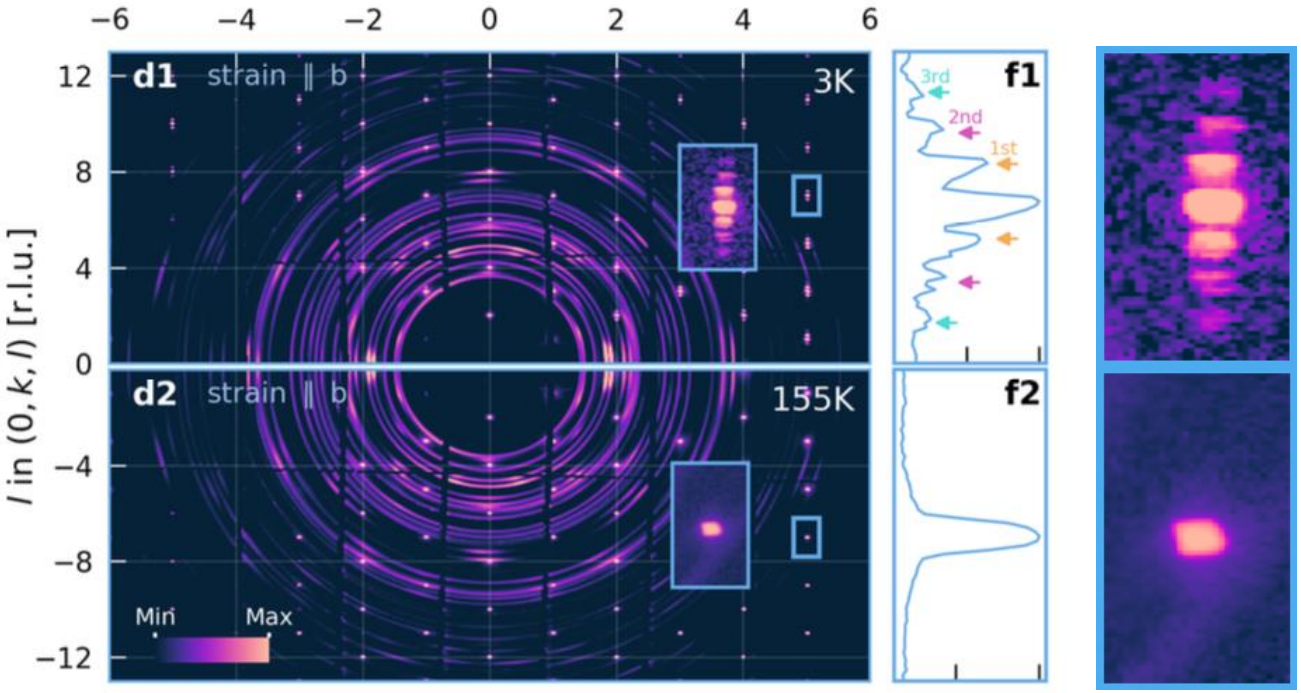
In-plane order, $T_N=15$ K



R. Takagi et al., Nat. Com. 13, 1472 (2022)

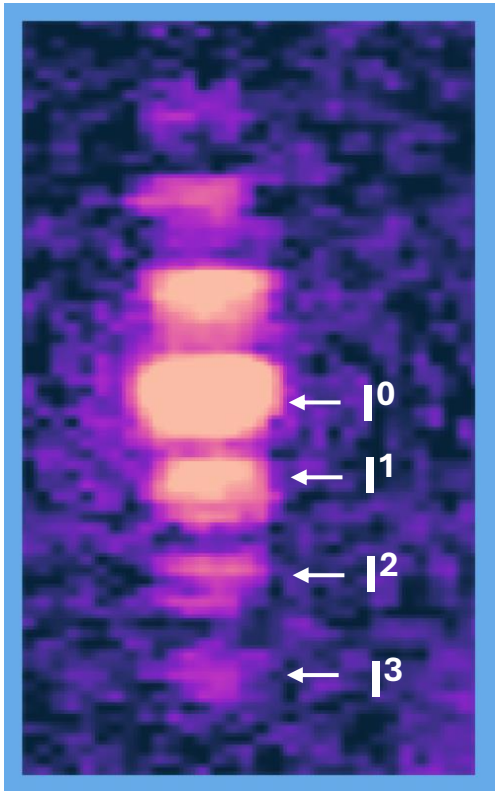
F. Z. Yang et al., Nat. Com. 16, 10401 (2025)

Charge order (CO) and charge localization in $EuAl_4$



- Strong CO peaks -> significant lattice distortion involving Eu atoms
- Weaker CO peaks with h=k=0 -> involving in-plane distortions

Charge order and charge localization in $EuAl_4$



Charge Order Parameter

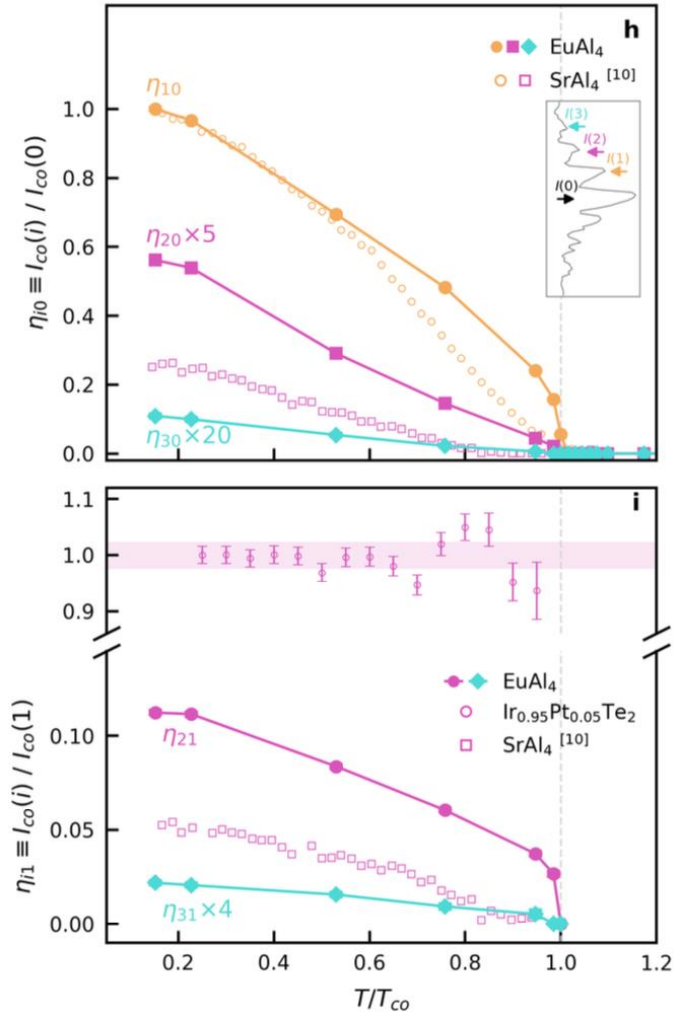
$$\frac{I^1}{I^0} = \eta_{10}$$

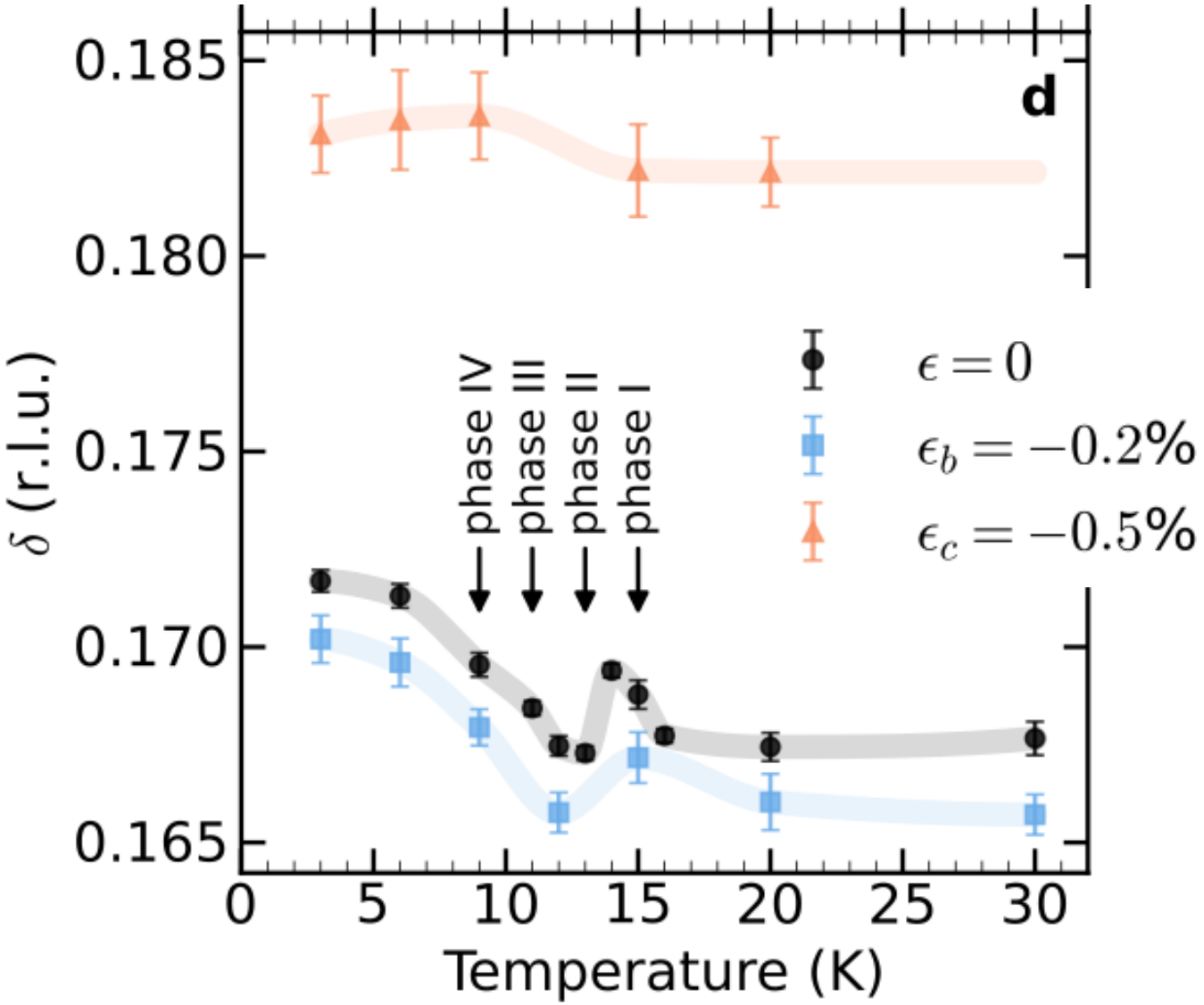
$$\frac{I^2}{I^0} = \eta_{20}$$

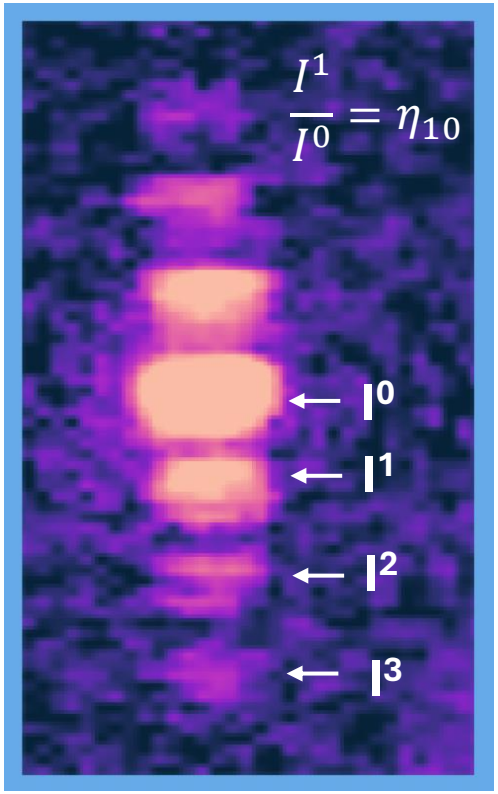
Charge Order Localization

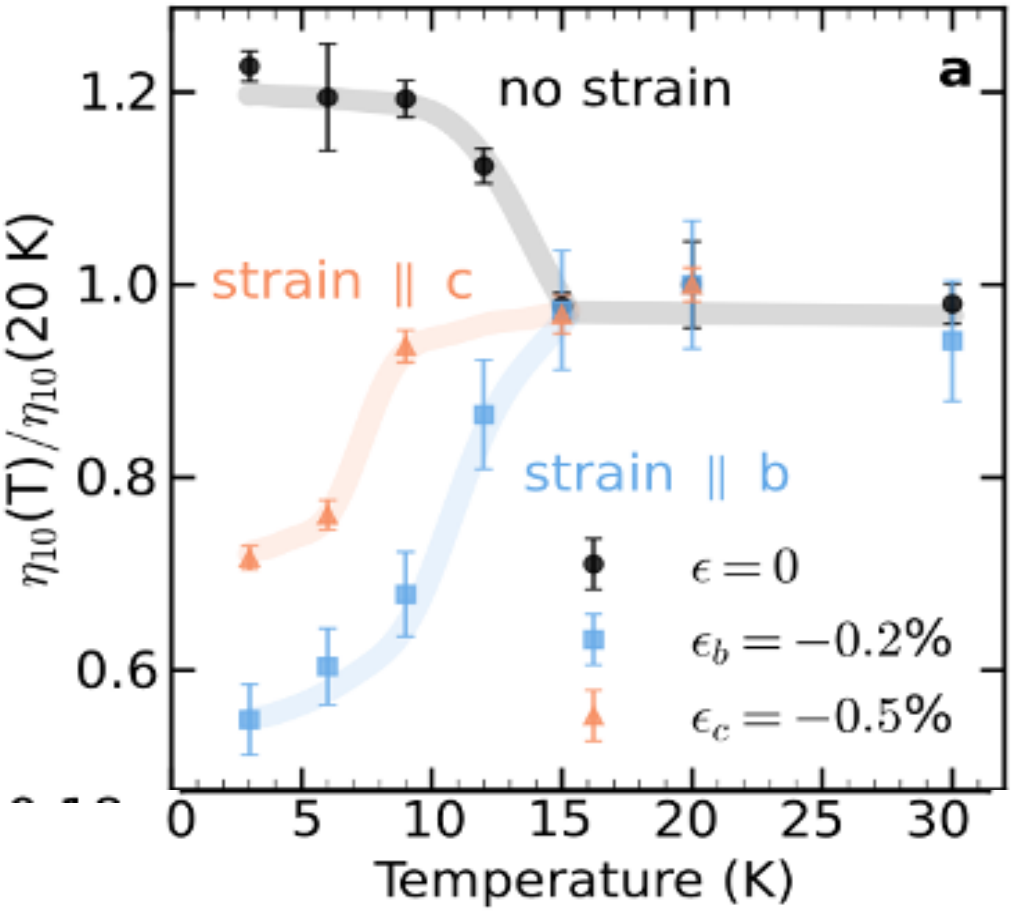
$$\frac{I^3}{I^0} = \eta_{30}$$

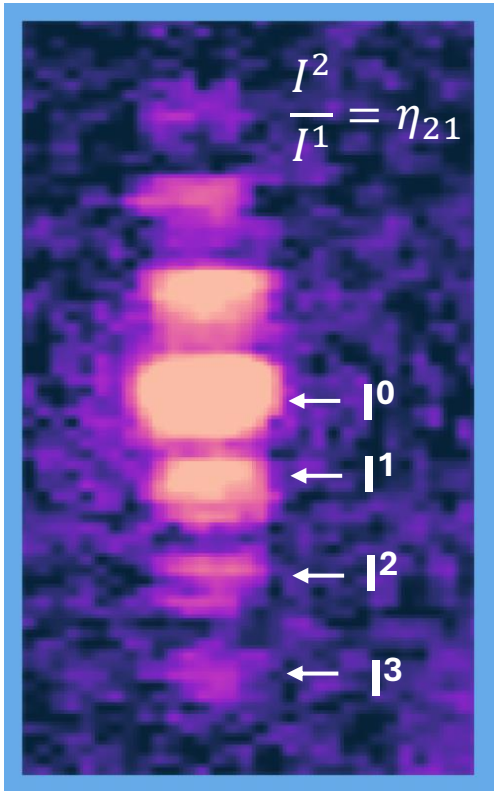
$$\frac{I^2}{I^1} = \eta_{21}$$

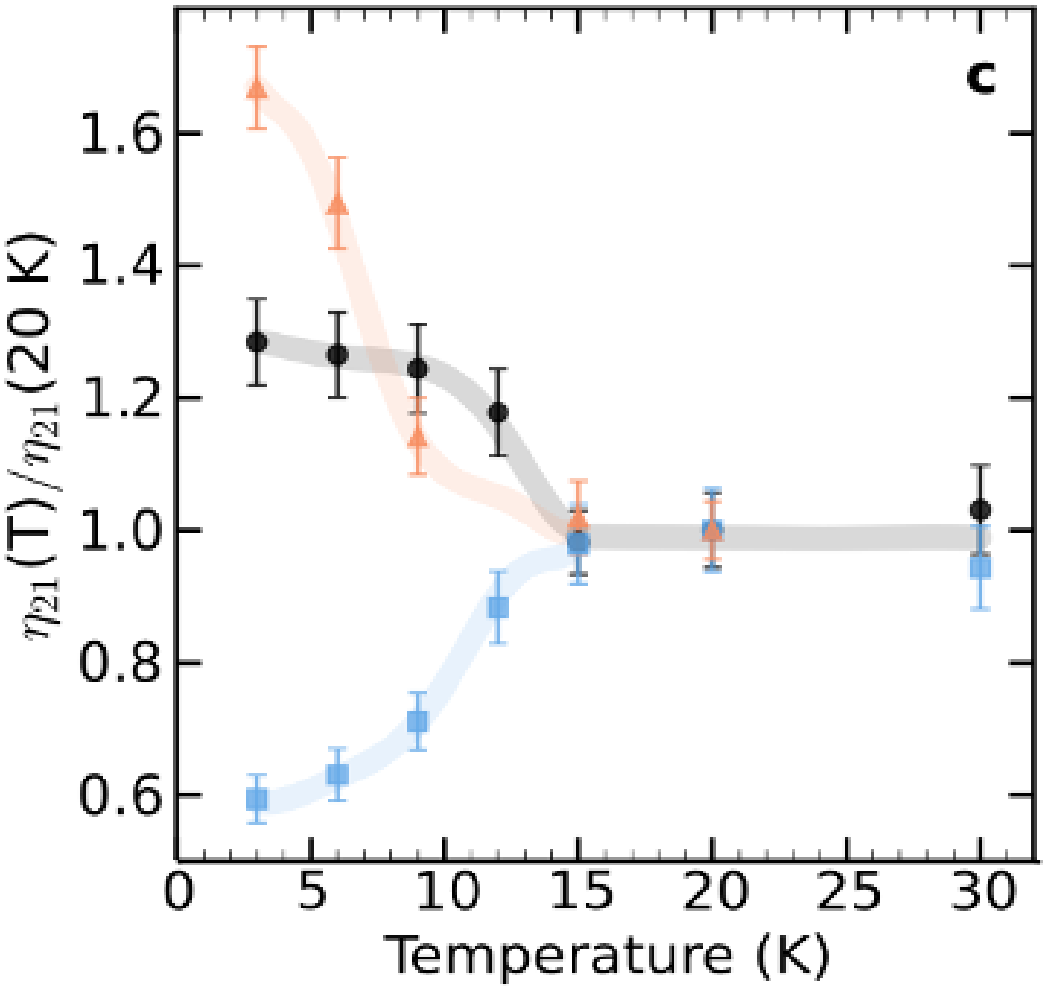


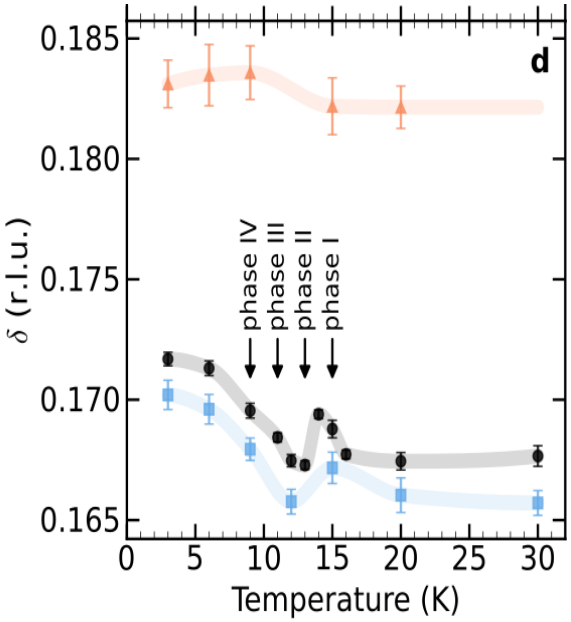

d
0.185
0.180
0.175
0.170
0.165
δ (r.l.u.)
0
5
10
15
20
25
30
Temperature (K)
phase IV
phase III
phase II
phase I
$\epsilon = 0$
$\epsilon_b = -0.2\%$
$\epsilon_c = -0.5\%$

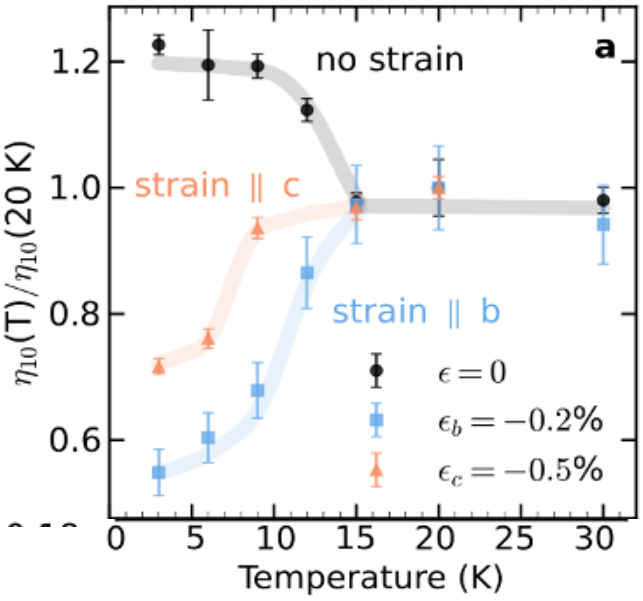

$\frac{I^1}{I^0} = \eta_{10}$
I0
I1
I2
I3

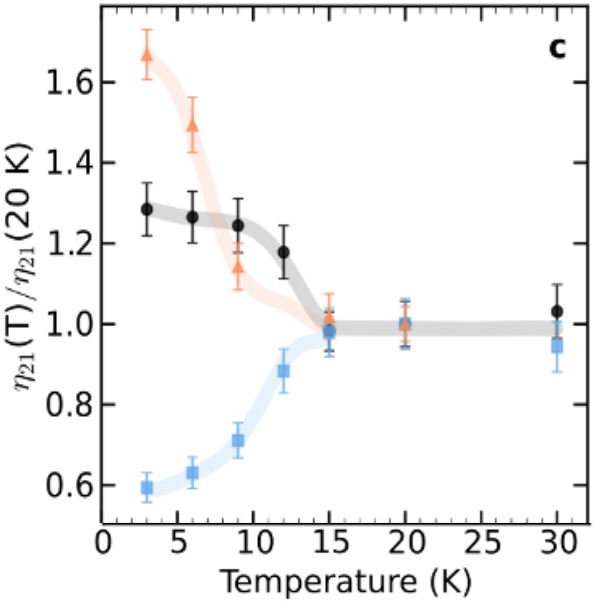

no strain
a
strain ∥ c
strain ∥ b
$\epsilon = 0$
$\epsilon_b = -0.2\%$
$\epsilon_c = -0.5\%$
$\eta_{10}(T)/\eta_{10}(20\ K)$
Temperature (K)
1.2
1.0
0.8
0.6
0
5
10
15
20
25
30


$\frac{I^2}{I^1} = \eta_{21}$
I0
I1
I2
I3


c
1.6
1.4
1.2
1.0
0.8
0.6
$\eta_{21}(T)/\eta_{21}(20\ K)$
0
5
10
15
20
25
30
Temperature (K)







$\epsilon = 0$

$\epsilon_b = -0.2\%$

$\epsilon_c = -0.5\%$

University Zurich

Johan Chang

High-magnetic-field experiments on cuprate superconductors

Content of Talk

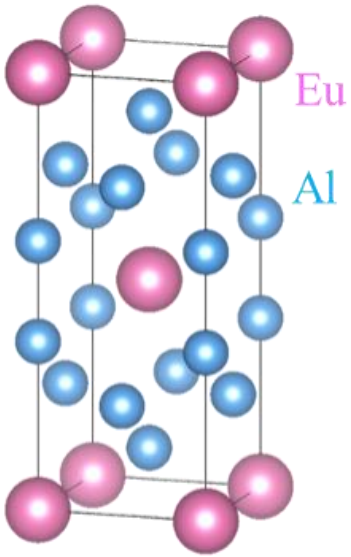
Charge localization & chiral magnetism in $EuAl_4$: arXiv:2607.07544

Novel field effects in cuprate superconductors: arXiv:2606.07349v1

Differentiation of site specific symmetry breaking: Nat. Comm. 17, 5837 (2026)

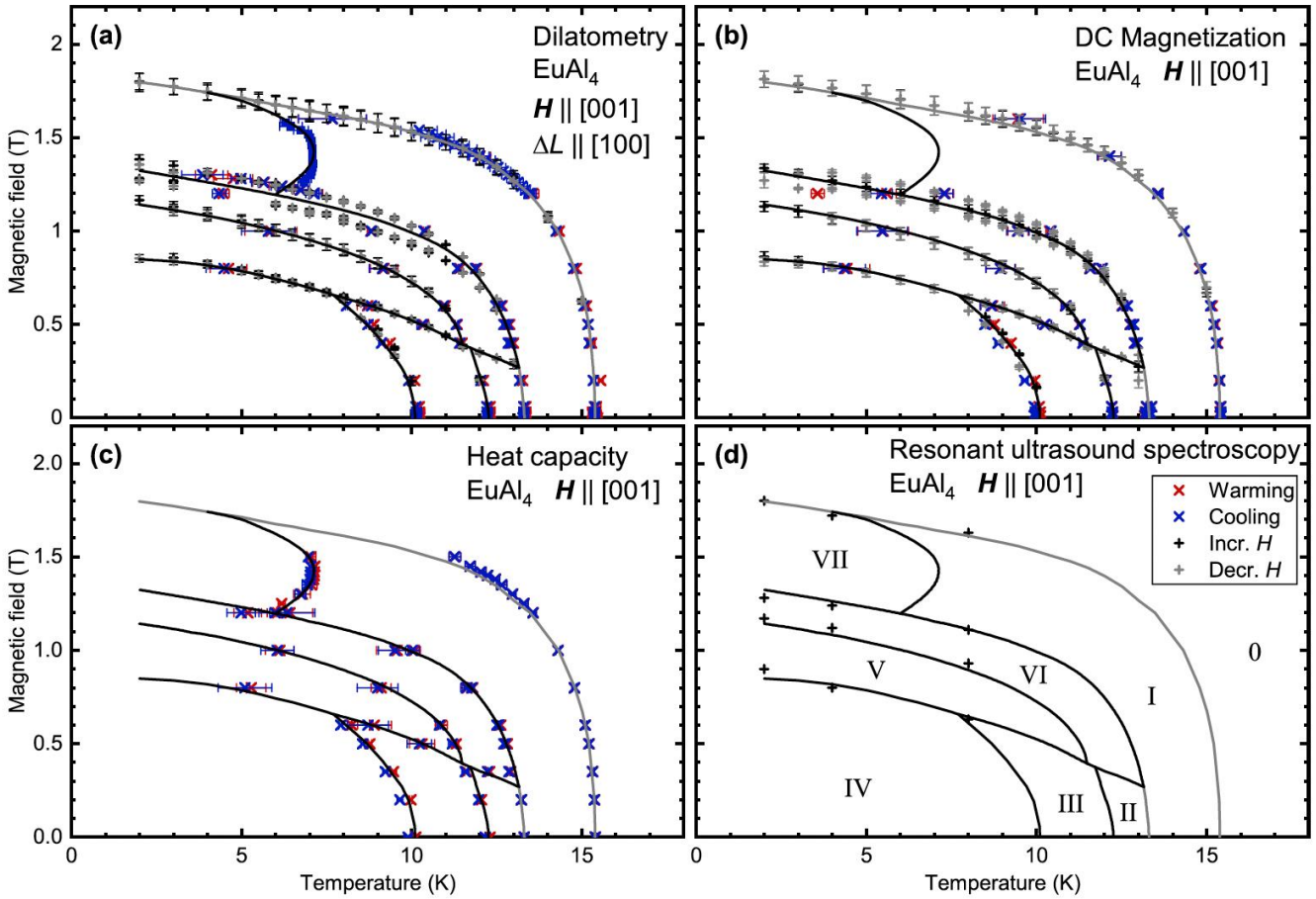
Reinforment learning for Laue diffraction: arXiv:2604.11773v1

$EuAl_4$: rich magnetic phases



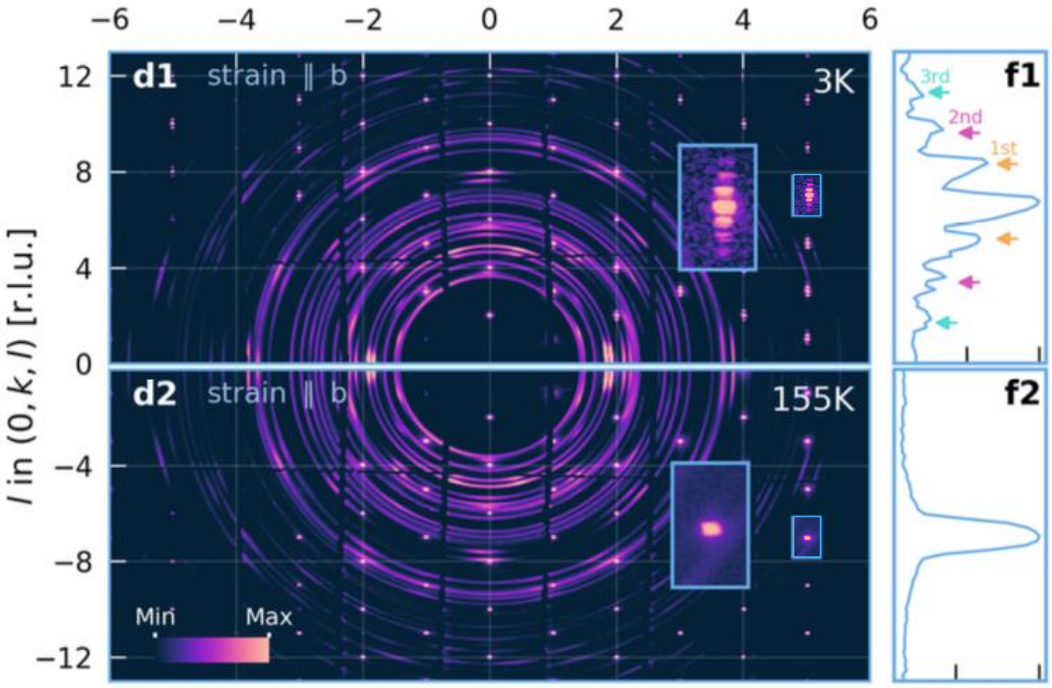
Eu^{2+} ($4f^7$) S = 7/2

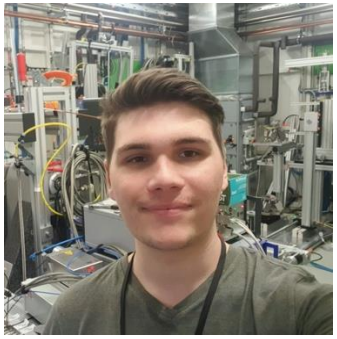
Magnetic phase diagram



W. R. Meier et al., PRB 106, 094421 (2022)

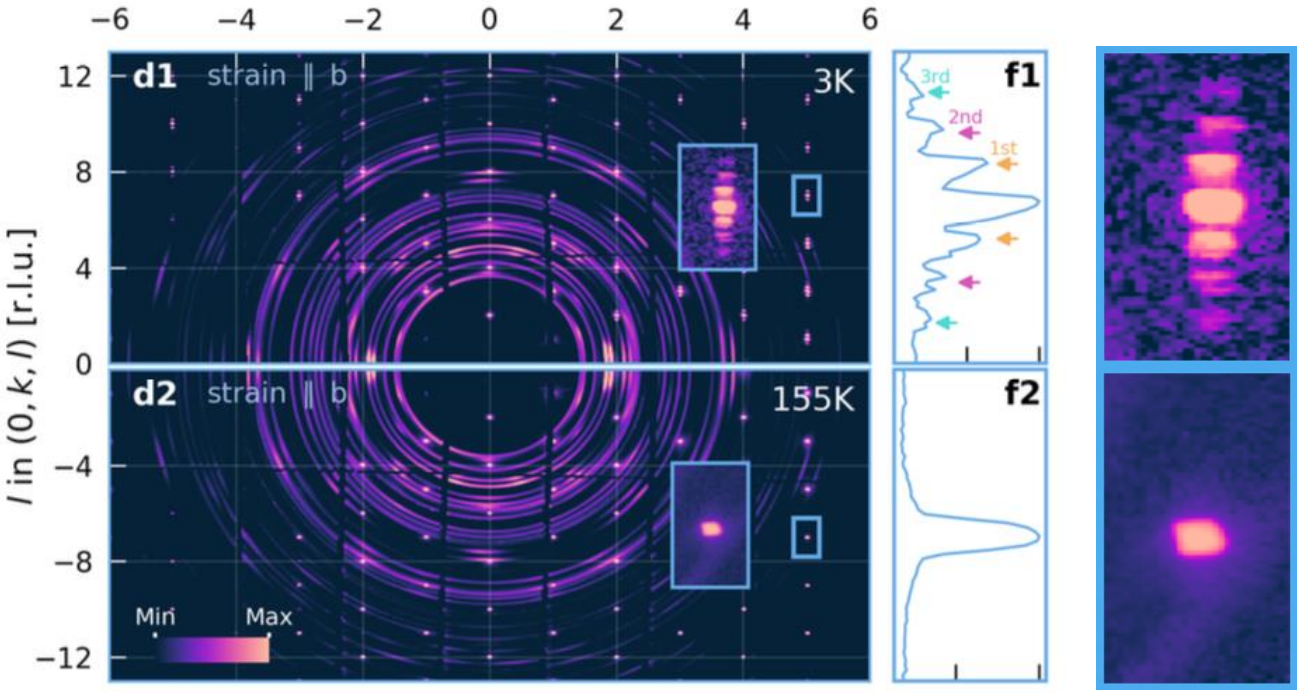
Charge order (CO) and charge localization in $EuAl_4$





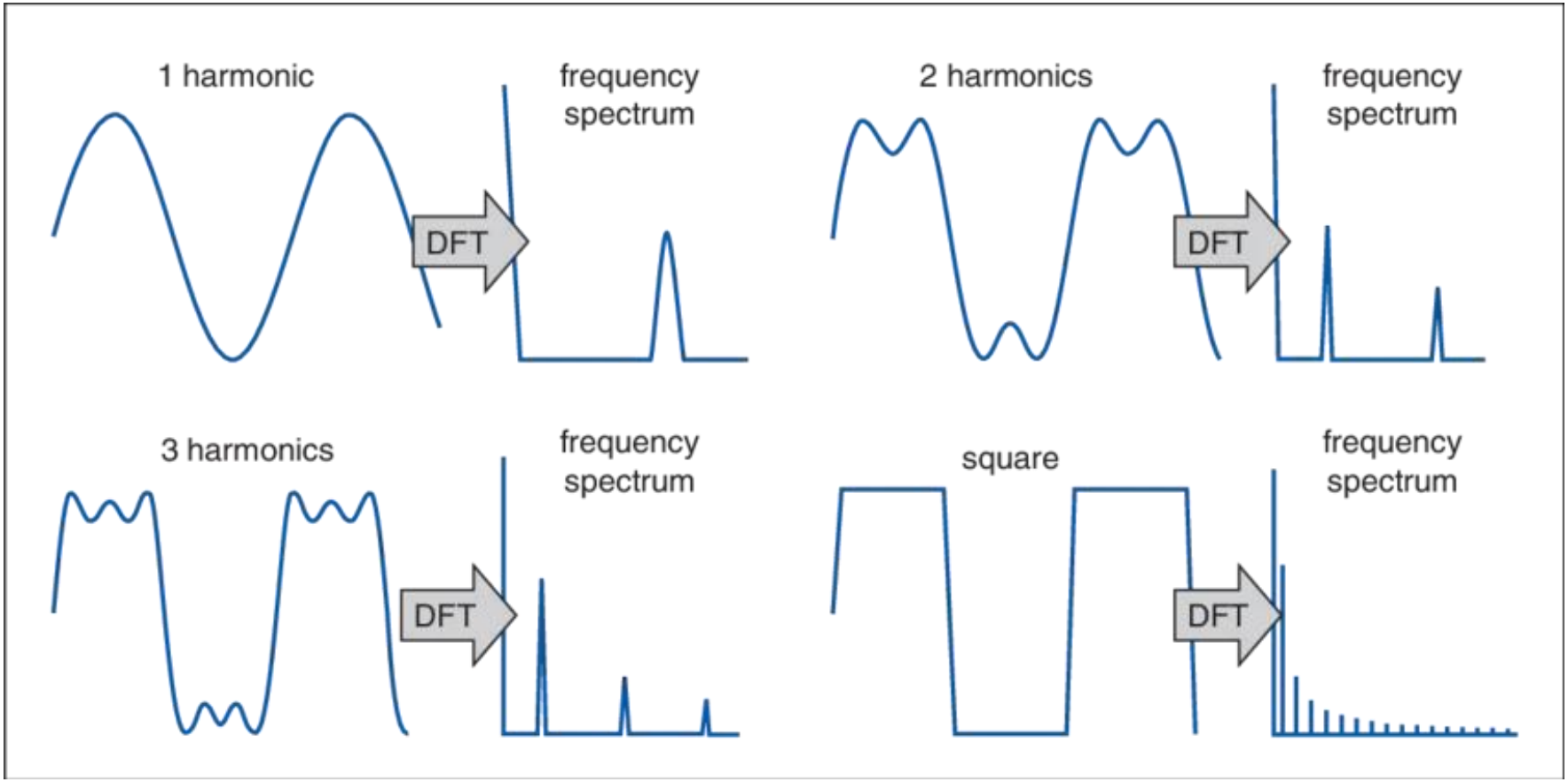
Mario Baumgartner

Charge order (CO) and charge localization in $EuAl_4$



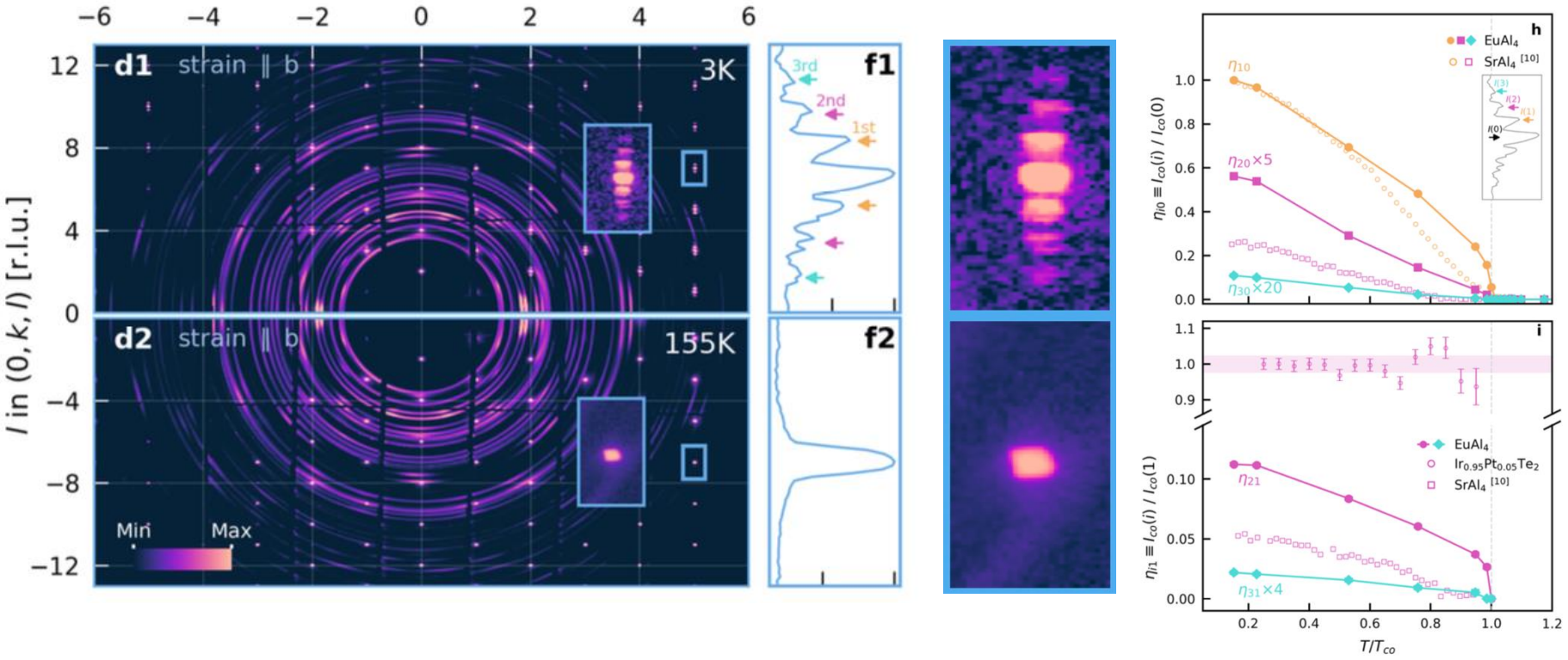
- Strong CO peaks -> significant lattice distortion involving Eu atoms
- Weaker CO peaks with h=k=0 -> involving in-plane distortions

Charge localitation explained



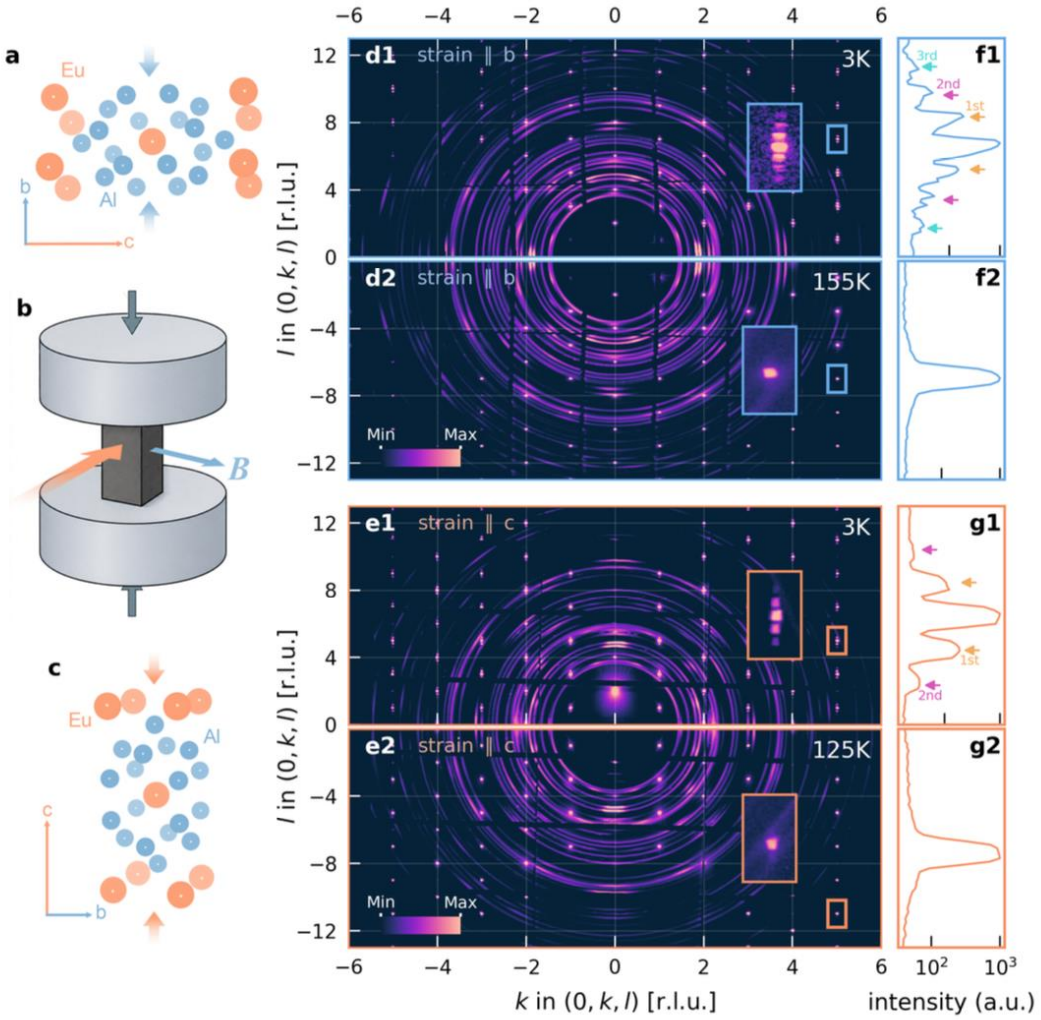
https://www.researchgate.net/figure/Graphical-representation-of-square-wave-modulation-coupled-with-Fourier-transform_fig4_268983947/actions#reference

Charge order (CO) and charge localization in $EuAl_4$



How charge localization evolve under pressure and magnetic field?

Charge order and charge localization in $EuAl_4$

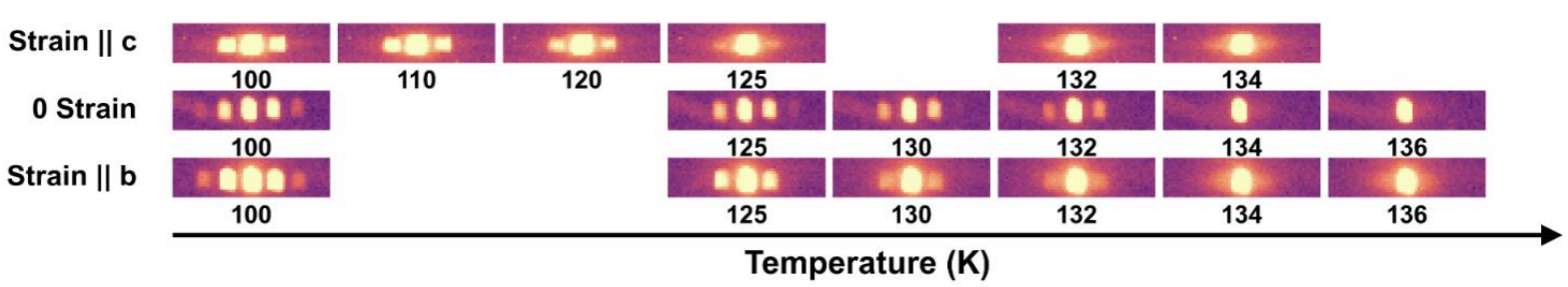


$$\frac{I^1}{I^0} = \eta_{10}$$ Charge Order Parameter

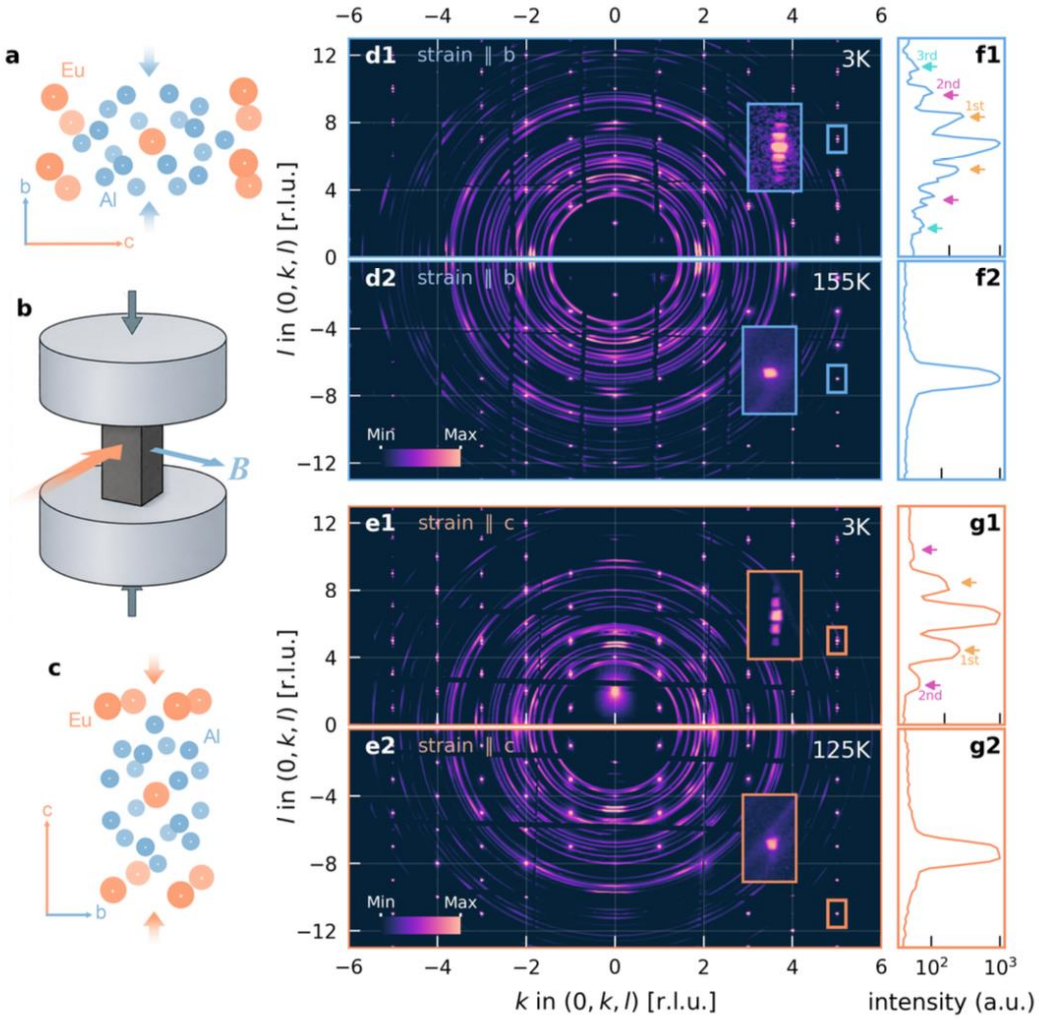
$$\frac{I^2}{I^0} = \eta_{20}$$

$$\frac{I^3}{I^0} = \eta_{30}$$ Charge Order Localization

$$\frac{I^2}{I^1} = \eta_{21}$$

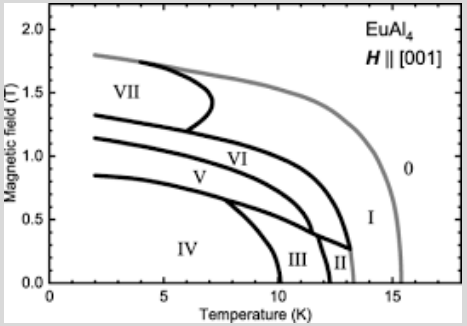


Al_4

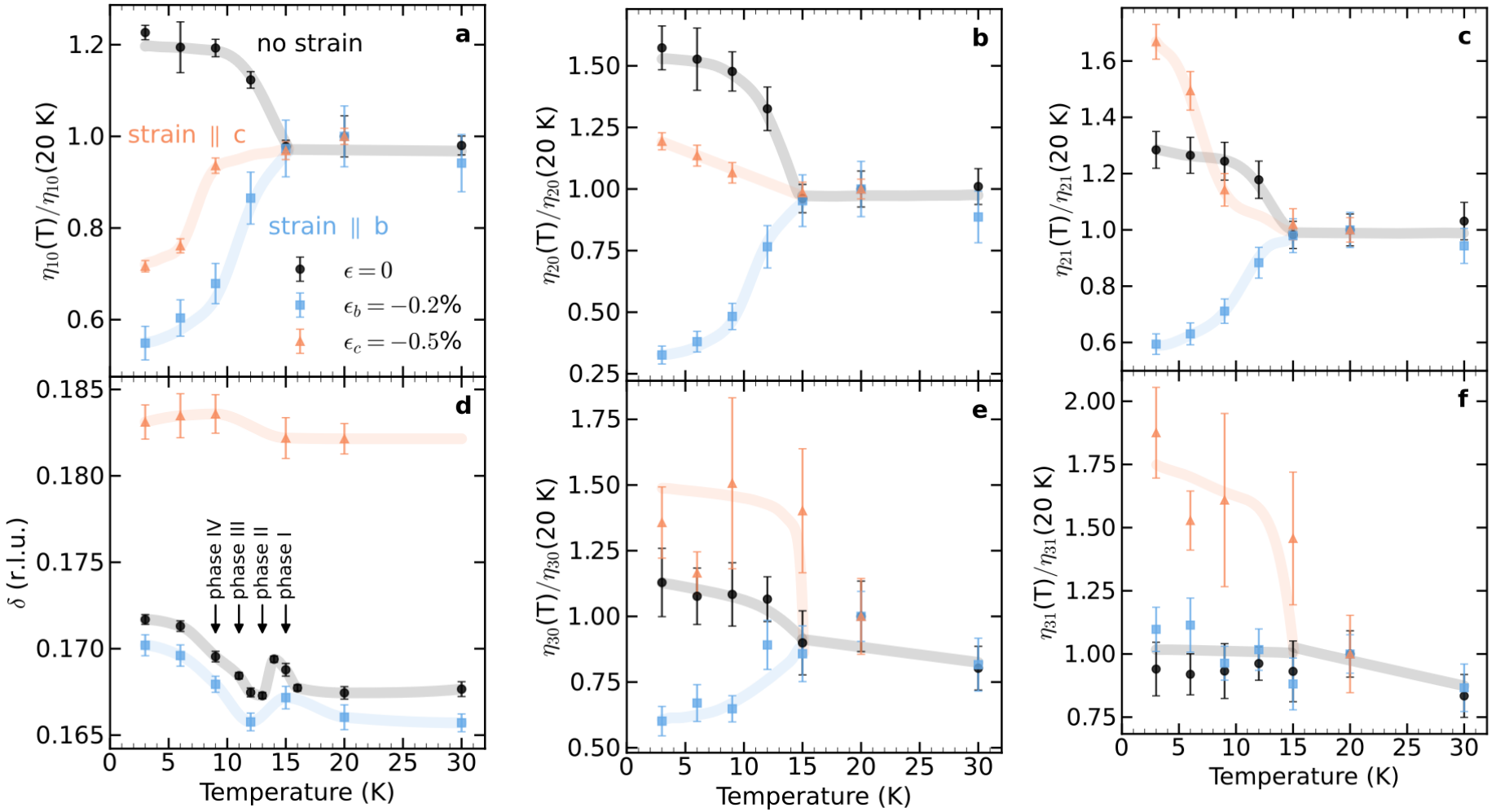


T_{co} suppressed under strain

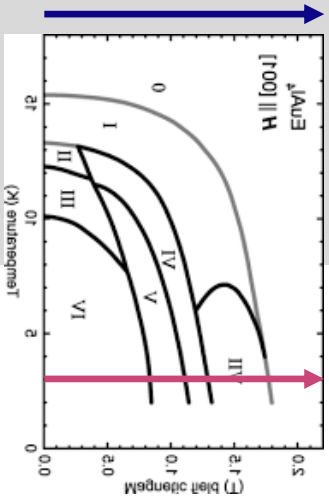
Charge localization and magnetism



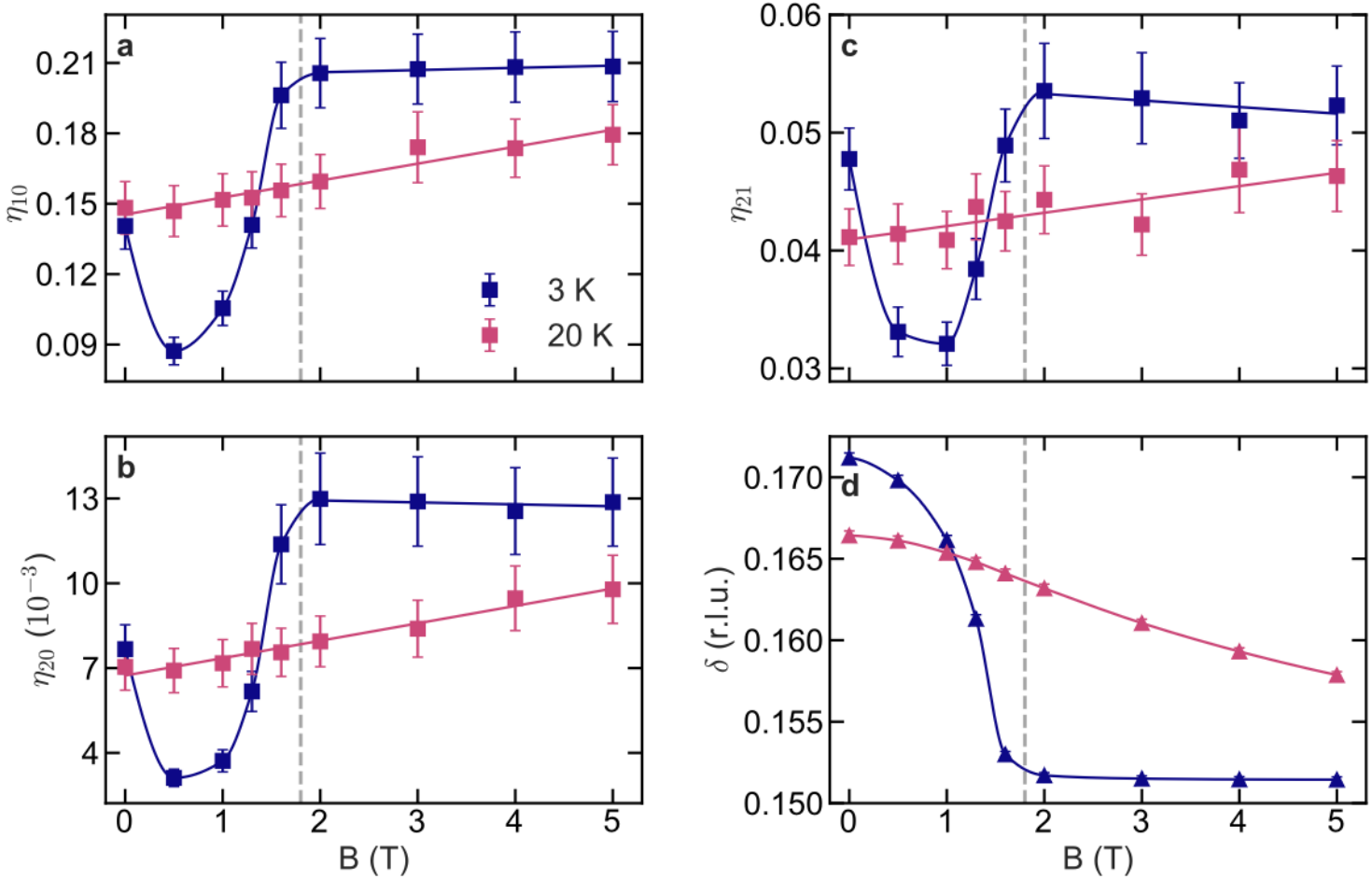
Meier et al., PRB **106**, 094421 2022



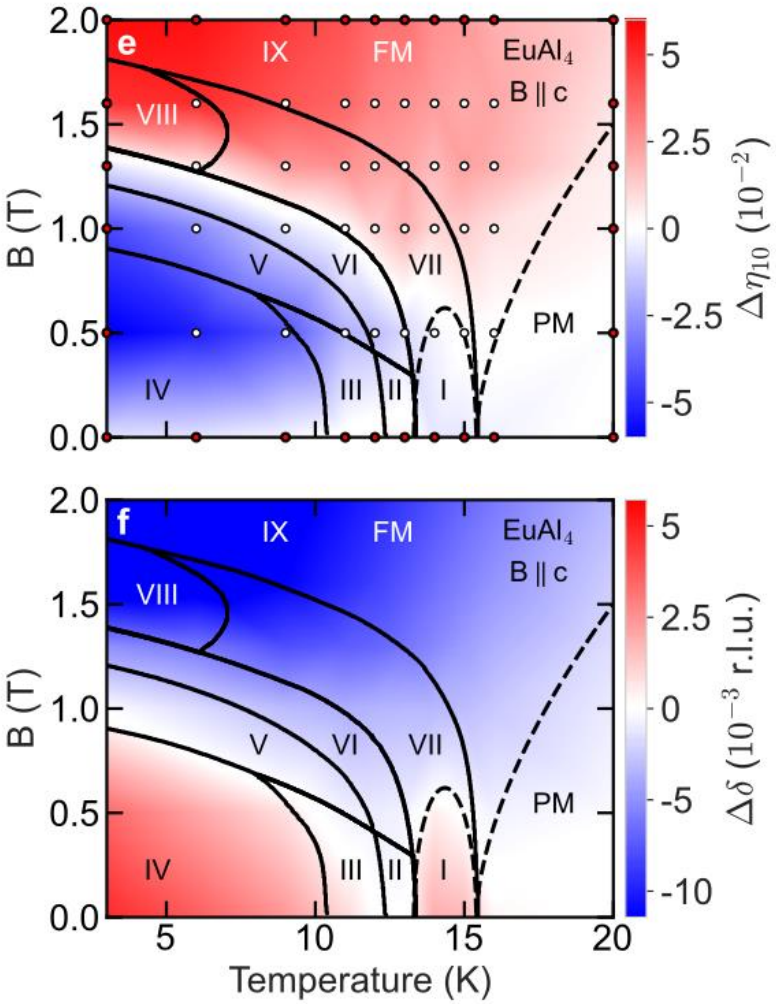
Magnetic field tuned charge localization



Meier et al., PRB **106**, 094421 2022



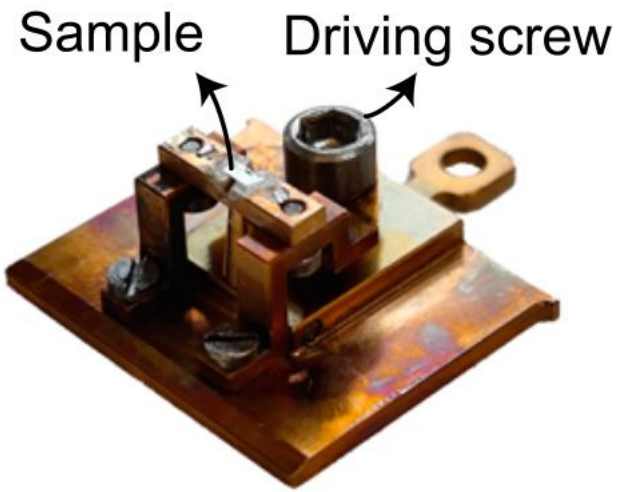
Magnetic field tuned charge localization



- Significant spin-charge order coupling
- Highly tunable
- Future neutron scattering study

Uniaxial pressure cells

Meeting point for collaboration



PPMS

Coming

Ruthenates

BiS_2-Supercon.

High-energy XRD

J. Choi et al.,
PRL (2022) $La_{2-x}Sr_xCuO_4$

J. Küspert et al.,
Comm. Phys. 7:225 (2024)

M. Baumgartner et al., $EuAl_4$
arXiv 2026

Neutron diffraction

G. Stimutis et al., $La_{2-x}Sr_xCuO_4$
Comm. Phys. 5:296 (2022)

ARPES

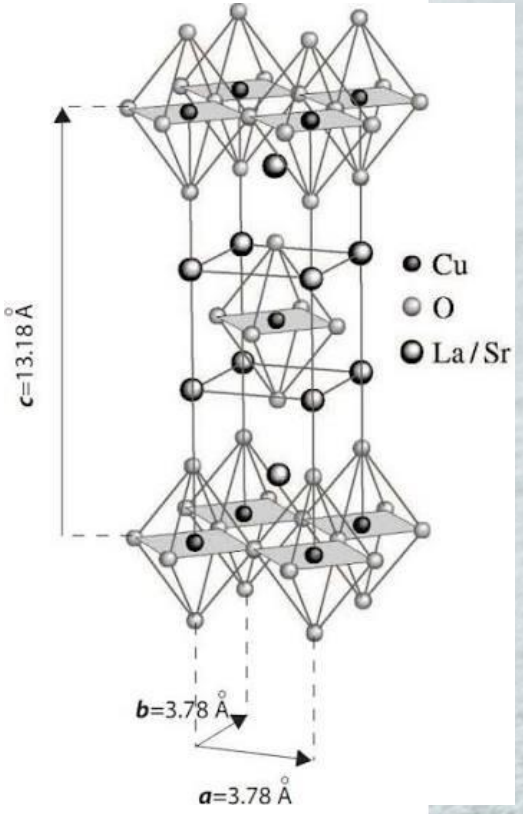
CsV_3Sb_5
C. Lin et al.
Nat. Comm. 15 10466 (2024)

CrSb
C. Li et al.,
arXiv: 2512.07683 (2025)

RIXS

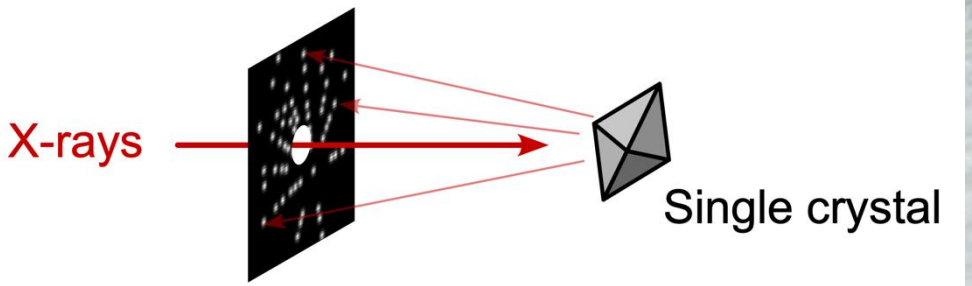
L. Martinelli et al.,
Phys. Rev. B 112, L041124 (2024)

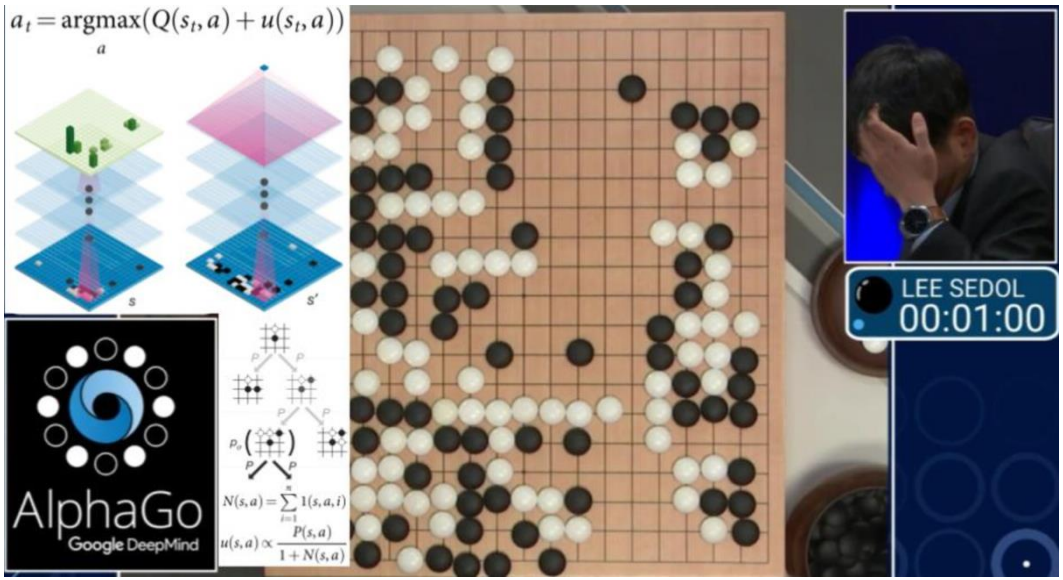
$La_{2-x}Sr_xCuO_4$
I. Biało et al,.
arXiv: 2601.01643 (2026)



https://2dsemiconductors.com/LaSrCuO4-crystal/

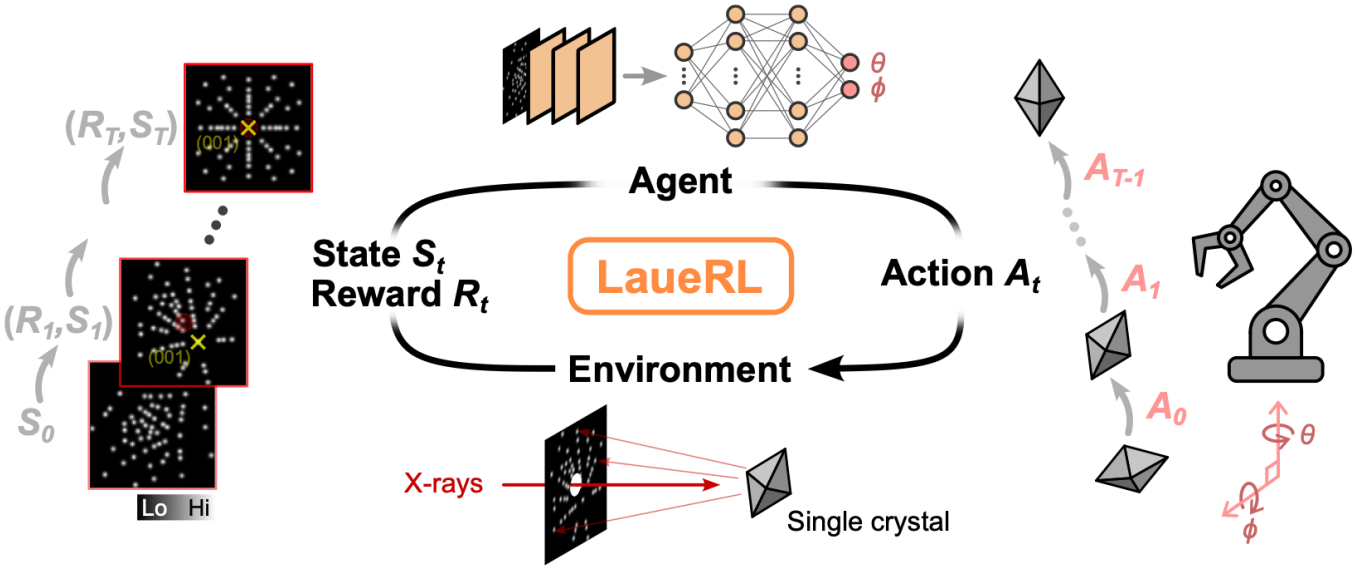
2D Semiconductors
THE LEADER IN UNCONVENTIONAL MATERIALS





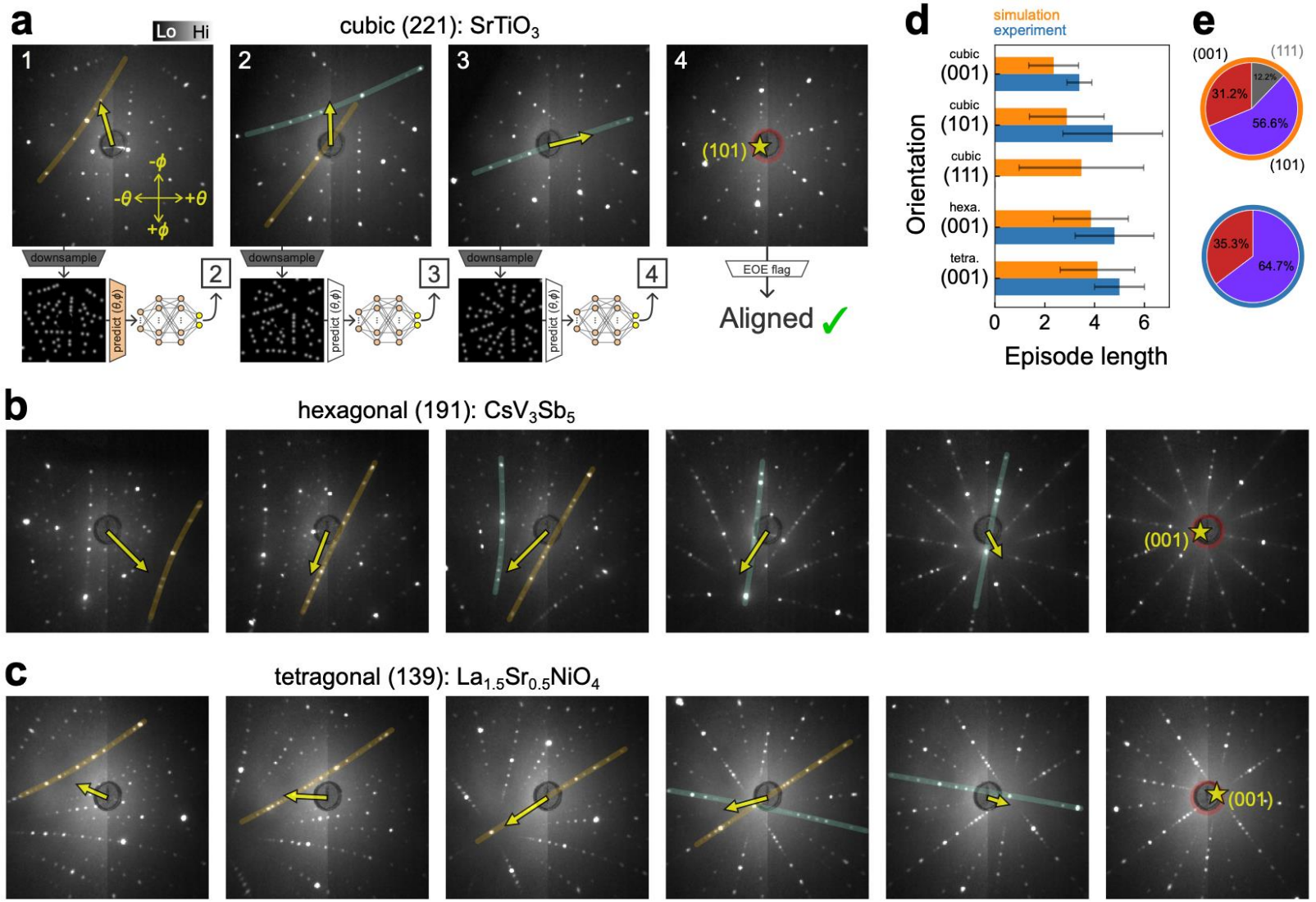
Nature, 529(7587), 484–489 (2016)

Jens Oppliger



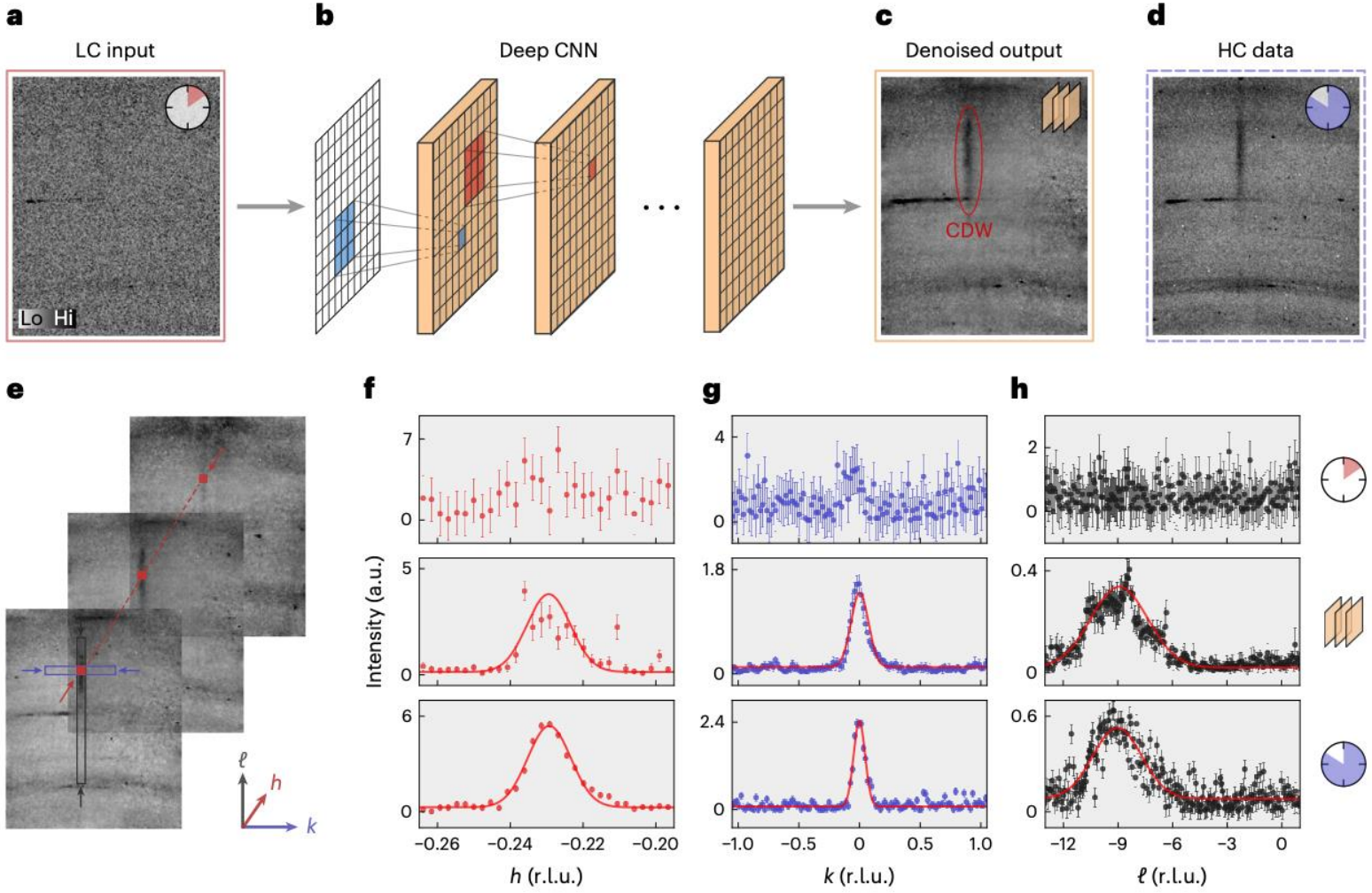
Reinforment learning for Laue diffraction: arXiv:2604.11773v1

Automated Laue



Reinforment learning for Laue diffraction: arXiv:2604.11773v1

Noise filtering: X-ray diffraction



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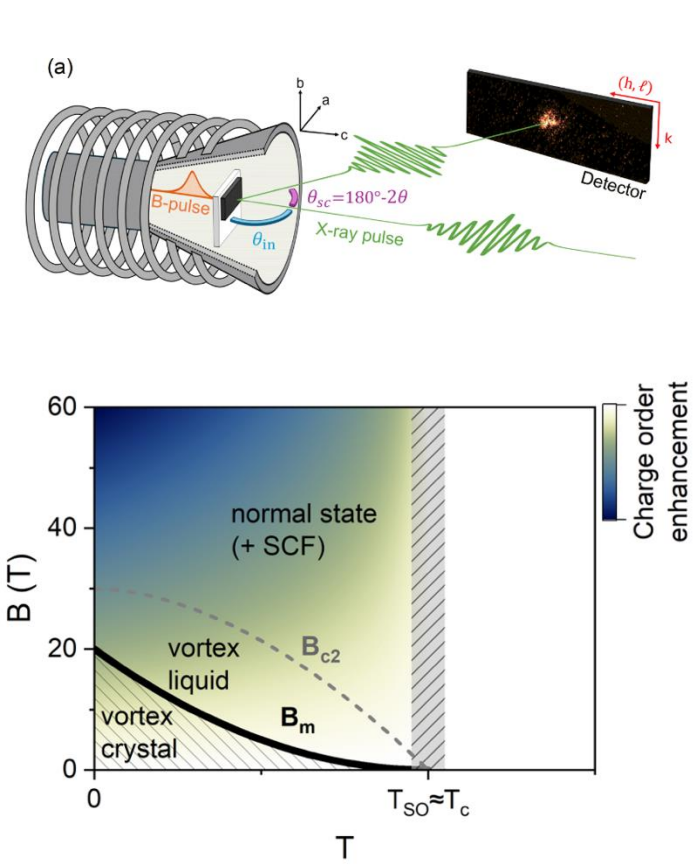
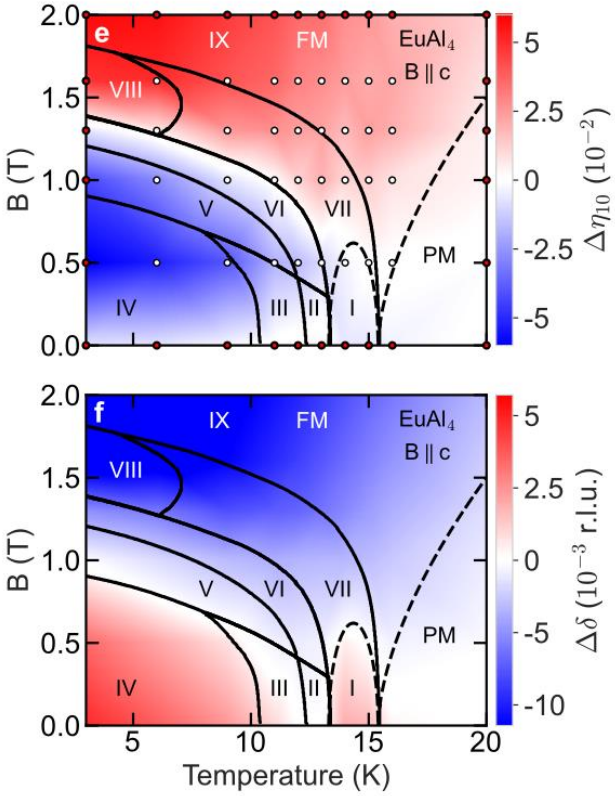
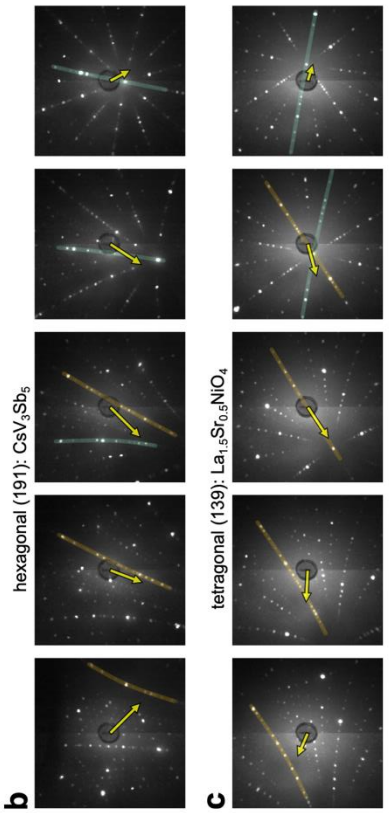
Summary



arXiv:2606.07349v1



arXiv:2607.07544



arXiv:2604.11773v1