PAUL SCHERRER INSTITUT

Coherent Diffraction Imaging and Holography

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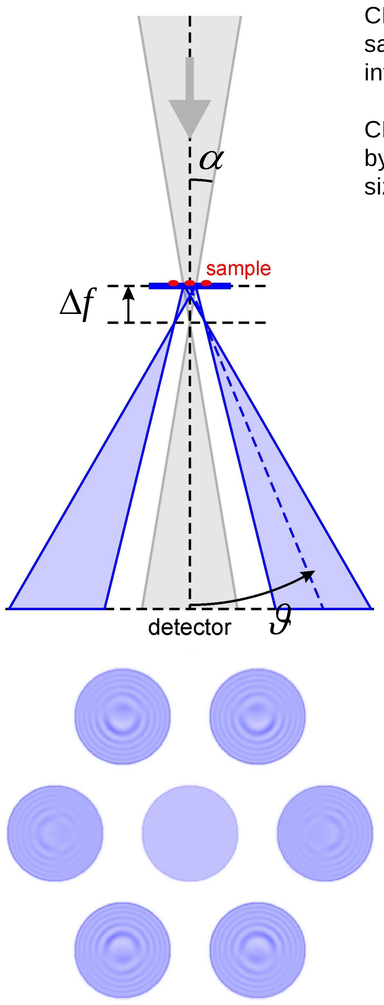
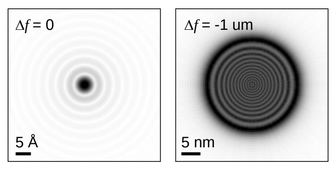
2D materials by Convergent Beam Electron Diffraction (CBED)

in collaboration with Sarah J. Haigh[1,2] and Kostya S. Novoselov[1,3,4]
[1]National Graphene Institute, [2]Department of Materials, University of Manchester, UK;
[3]Department of Materials Science and Engineering, [4]Centre for Advanced 2D Materials, National University of Singapore

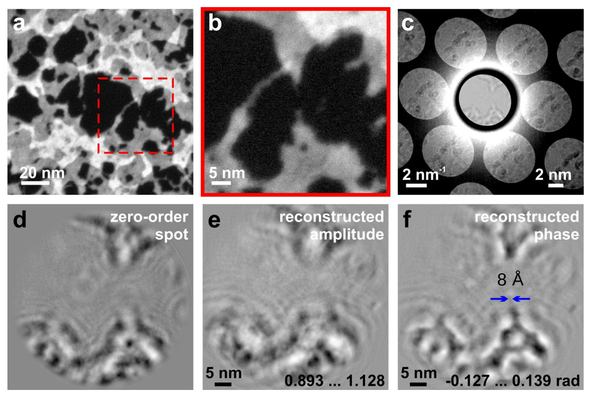


CBED patterns are real-space and diffraction patterns of the sample simultaneously. They contain plenty of structural information, the challenge is to reconstruct this information.

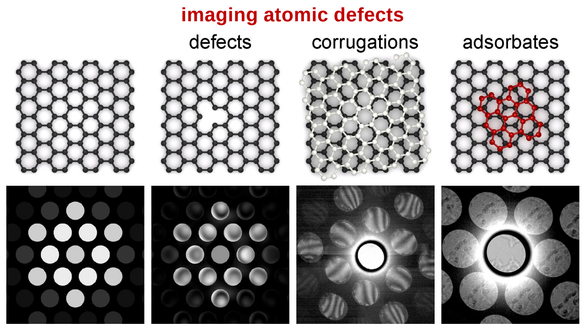
CBED is a **radiation dose** adjustable technique:
by choosing the sample position at different defocus Δf , the size of the probed area (and thus the dose) is regulated:



imaging adsorbates

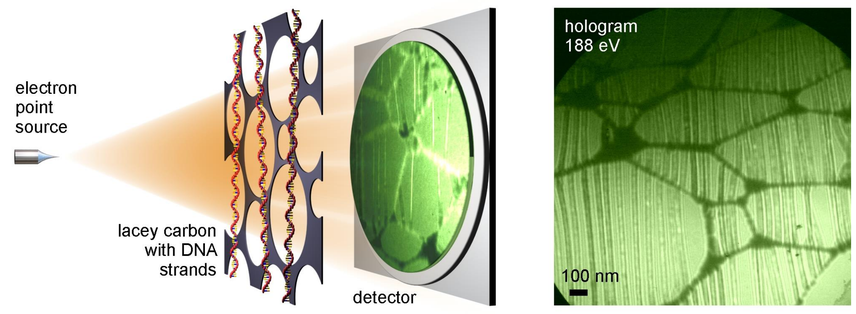


imaging atomic defects



PNAS 115 (29) 7473-7478 (2018);
Front. Phys. 14 (1), 13606 (2019);
Ultramicroscopy 212 112976 (2020);
Ultramicroscopy 219 113020 (2020);
Surf. Rev. Lett. 28 (8), 2140001 (2021)
Phys. Rev. B 105, 184113 (2022)
Carbon 201, 244–250 (2023)

Low-energy Electron Holography

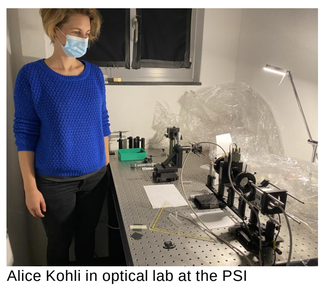


Imaging single-stranded DNA molecules by low-energy electron microscopy. Left: Schematics of the low-energy electron microscope where the sample can be imaged at different magnifications, the electron source-to-sample distance can be varied from tens of nanometers to a few microns. Right: An in-line hologram of ssDNA fibers; Sci.Rep. 9, 9989 (2019).

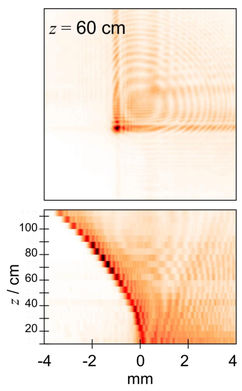
Experimental projects:
Installing and operating the low-energy electron microscope at PSI, sample preparation and hologram acquisition.

Theoretical and simulation projects:
Development of theoretical models of low-energy electron-matter interaction, analysis of low-energy electron holograms.

Airy Beams and Orbital Angular Momentum

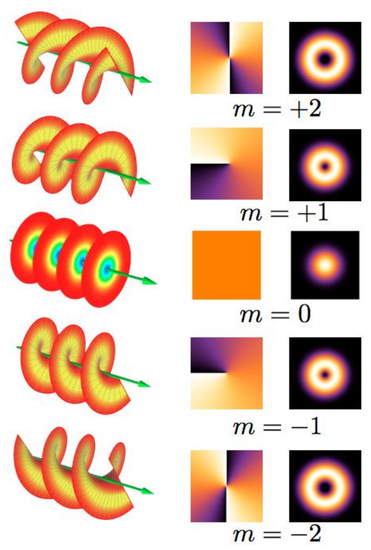


Alice Kohli in optical lab at the PSI

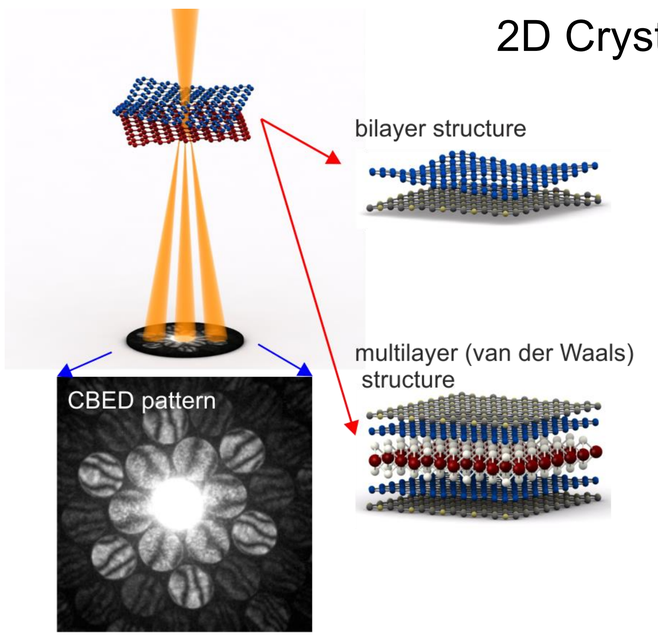


Experimental projects
• creating of the bending and Airy beams with orbital angular momentum (OAM),
• characterisation of the beams,
• imaging with the beams.

Sci. Rep. 6, 26312 (2016)
Appl. Opt. 55, 6095–6101 (2016)



2D Crystals' Atomic Structure by Ptychography



Ptychography and other iterative phase retrieval methods are explored for reconstruction of 3D atomic structure of 2D crystal systems (graphene, van der Waals structures).

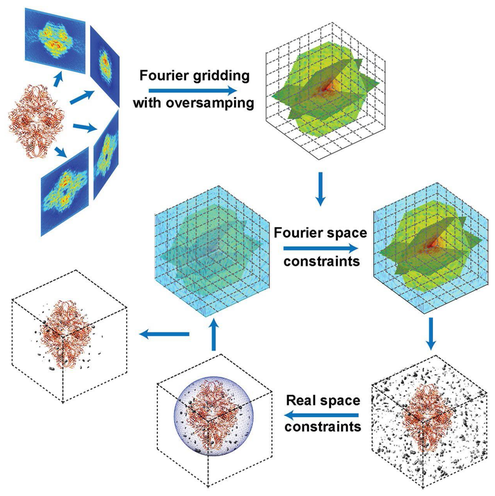
Tomography

in collaboration with Prof Ishikawa (ETH) and Prof Korkhov (ETH))

The puzzle of the resolution limit in electron tomography:

The resolution in electron tomography should be higher than obtained in a non-tomographic experiment, however it is typically lower.
What defines the resolution in electron tomography and whether it can be increased?

Project: Data analysis of experimental electron tomography data.

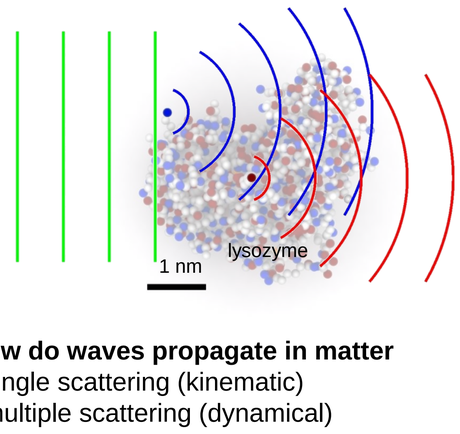


From Pryor et al, Sci Rep. 10409 (2017)

Theory and Simulations for Waves Propagation, Scattering and Diffraction

for light, X-ray and electron waves

Waves scattering
• elastic
• inelastic
• coherence



How do waves propagate in matter
• single scattering (kinematic)
• multiple scattering (dynamical)

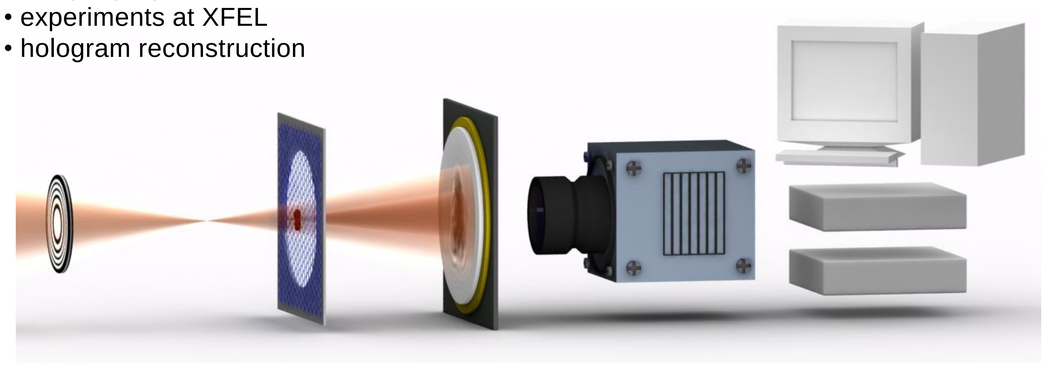
What can be reconstructed from intensity measurement
• sample 2D projection?
• 3D structure?
• atomic resolution?

Simulations for
• ptychography
• tomography
• holography
• coherent diffraction imaging (CDI)

X-ray Holography

in collaboration with Dr Kirsten Schnorr and Prof Christoph Bostedt, Maloja X-FEL, PSI

Experimental and simulations projects:
• sample preparation
• experiments at XFEL
• hologram reconstruction



FNSNF
Swiss National Science Foundation

The travel costs to PSI will be covered by PSI.
Theory and simulations projects can be done off PSI.

Universität Zürich[UZH]