Electron Microscopy and Electron Microscope

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Convergent Beam Electron Diffraction (CBED)

In collaboration with Sarah J. Haigh[1,2] and Kostya S. Novoselov[1,3,4]

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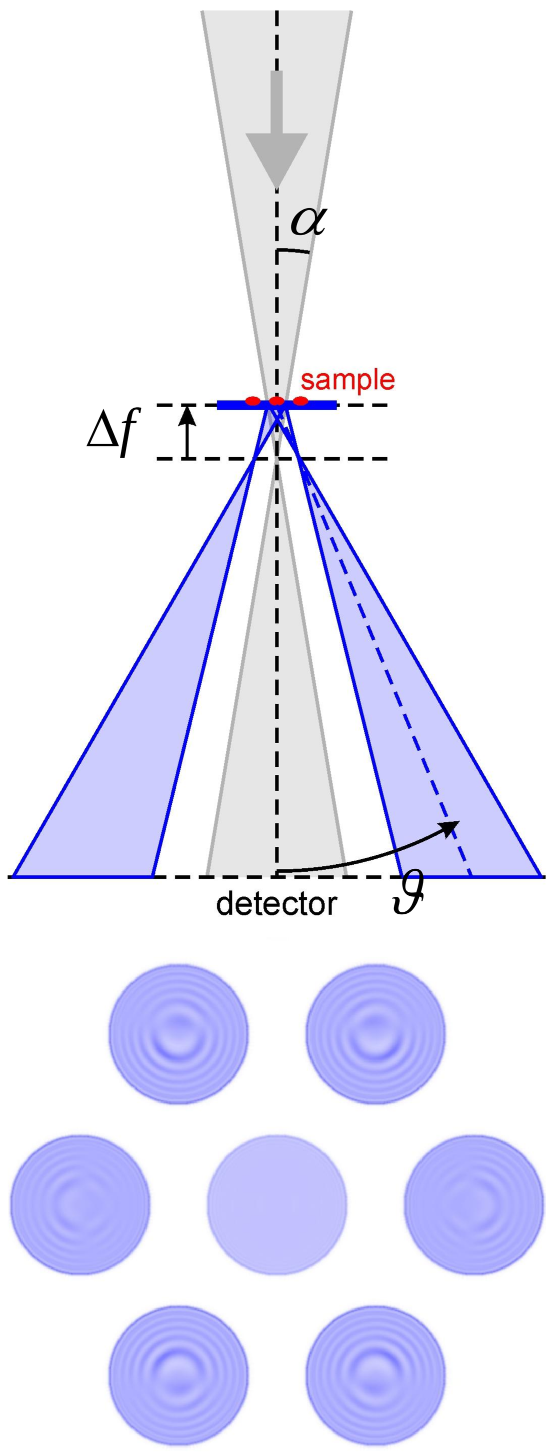
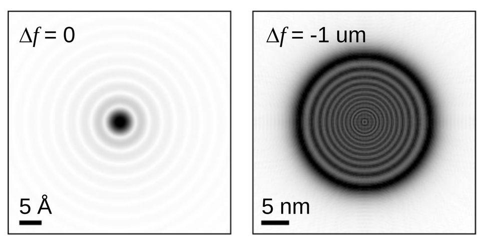
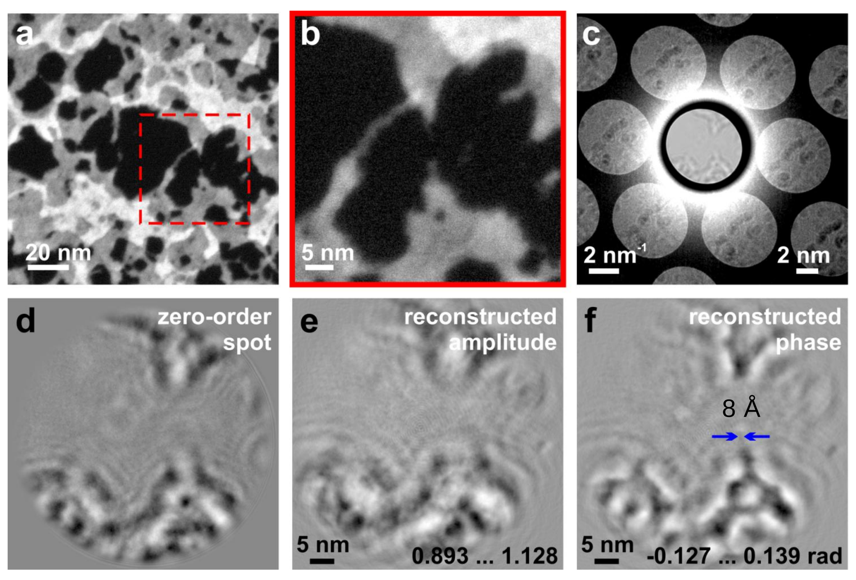


- Radiation dose is adjusted by choosing different defocus Δf as $\eta = I_0/A_0$, where I_0 is the intensity of the electron beam and A_0 is the probed area

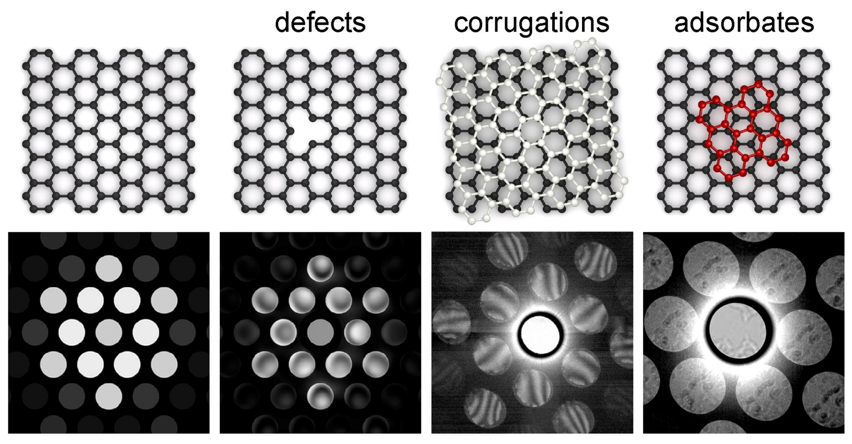


- Probing beam diameter: $D_0 = 2|\Delta f|\tan\alpha$
- Positions of the CBED disks: $\sin\vartheta = \frac{\lambda}{a}$

imaging adsorbates



imaging defects



PNAS 115 (29) 7473-7478 (2018);
Front. Phys. 14 (1), 13606 (2019);
Ultramicroscopy 212 112976 (2020);
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Soichiro Tsujino

Quantum materials field emission electron source ~ an ultimate spatially coherent cathode?

What has been done:

Normal metal field emission cathode is a basis of the state-of-the-art high-resolution electron microscope!

What's new?

P. A. M. Dirac said, "each photon then interfere only with itself. Interference between different photons never occurs", in *Quantum Mechanics* (Oxford 1958).

~ Turns out to be NOT true.

Is it true or not true for electrons: "each *Electron* then interfere only with itself" ?

A. Yes! All cathodes are *incoherent*. *Only* single-atom field emitter is *perfectly* soatially coherent electron source?!

B. Not necessarily! Make a field emitter with materials with a long scattering length!. A Quantum Material (2D materials such as graphene, Topological Insulator would do?

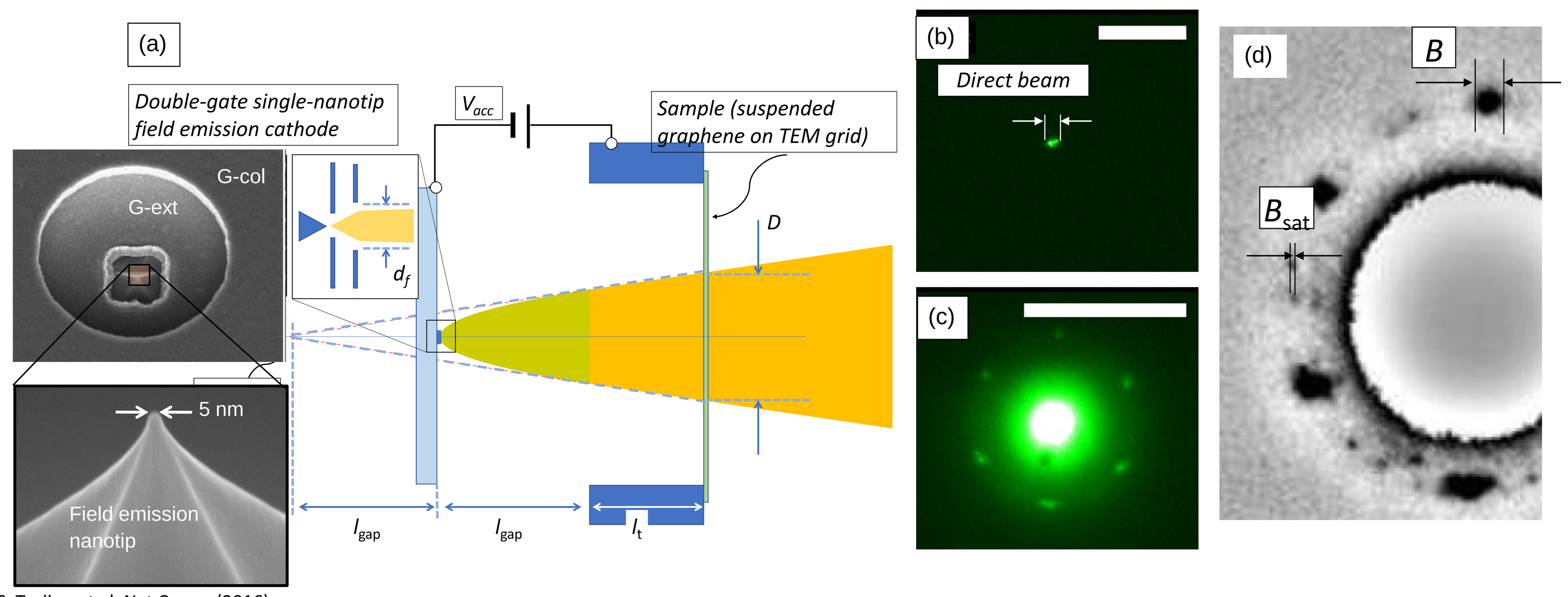
=> Let's find it out!

Why it matters:

It will enable *noble electron microscope* a. la. Gabor, a compact Three-Dimensional Holographic Microscope

Positions

available for a ***PhD thesis***, *Master thesis* & *BA project* via Uni ZH (Physics) in collaboration with *PD. Dr. Tatiana Latychevskaia*) and international collaborators from Uni Lyon (France), AIST (Japan), Uni Uppsala (Sweden), Uni Tartu (Estonia) ...



S. Tsujino et al. Nat Comm (2016).

References:

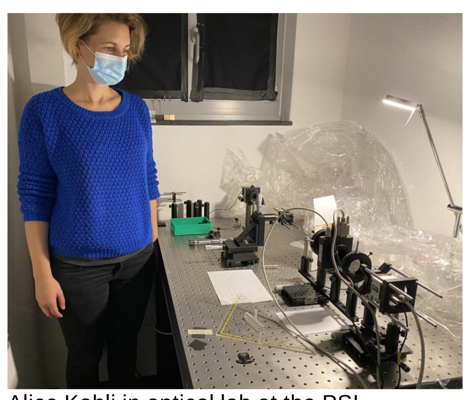
Tsujino, S.; Das Kanungo, P.; Monshipouri, M.; Lee, C.; Miller, R.J.D. Measurement of transverse emittance and coherence of double-gate field emitter array cathodes, Nature Communications (2016); DOI: 10.1038/ncomms13976

Lee, C.; Tsujino, S.; Miller, R.J.D., Transmission low-energy electron diffraction using double-gated single nanotip field emitter, Applied Physics Letters (2018); DOI: 10.1063/1.5030889

Tsujino, S.; Transverse structure of the wave function of field emission electron beam determined by intrinsic transverse energy, Journal of Applied Physics (2018); DOI: 10.1063/1.5035284

Tsujino, S.; (Review) On the brightness, transverse emittance, and transverse coherence of field emission beam, Journal of Vacuum Science & Technology B (2022); DOI: 10.1116/6.0001776

Light Beams with Orbital Angular Momentum



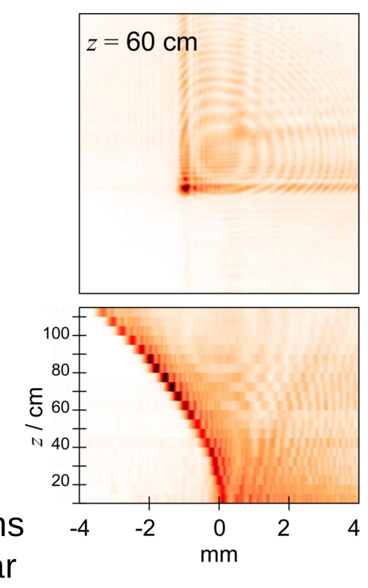
Alice Kohli in optical lab at the PSI

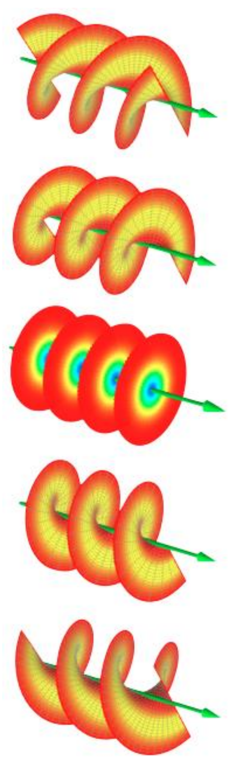
Experimental

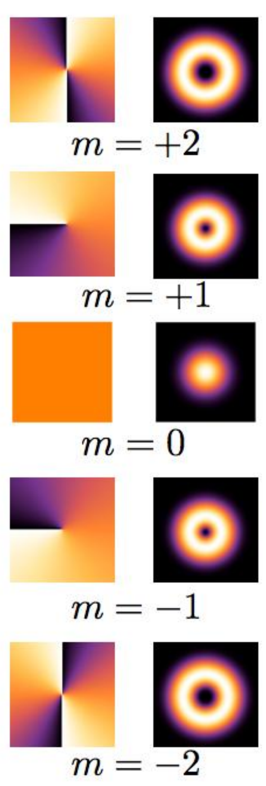
Creating of the bending light beams and Airy beams with orbital angular momentum (OAM)

Characterisation of the propagation and properties of the beams

Imaging with the beams





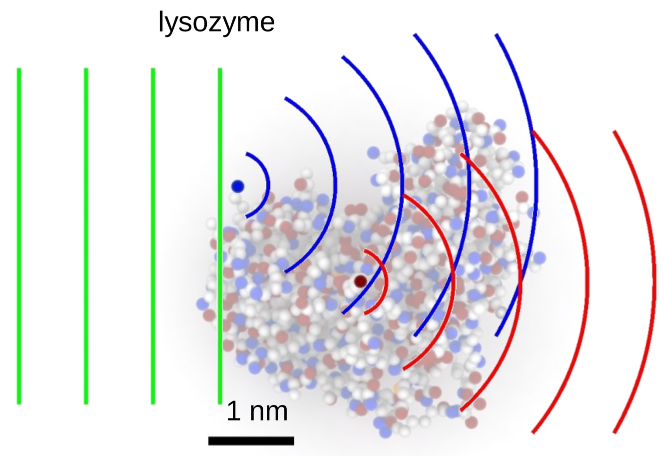


Sci. Rep. 6, 26312 (2016)
Appl. Opt. 55, 6095–6101 (2016)

Algorithms for Waves Scattering Propagation and Diffraction

for light, X-ray and electron waves

How do waves scatter?
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 reconstruction?
At what resolution?

Algorithms for
Ptychography
Tomography
Holography
Coherent Diffraction Imaging (CDI)

Holography with X-rays

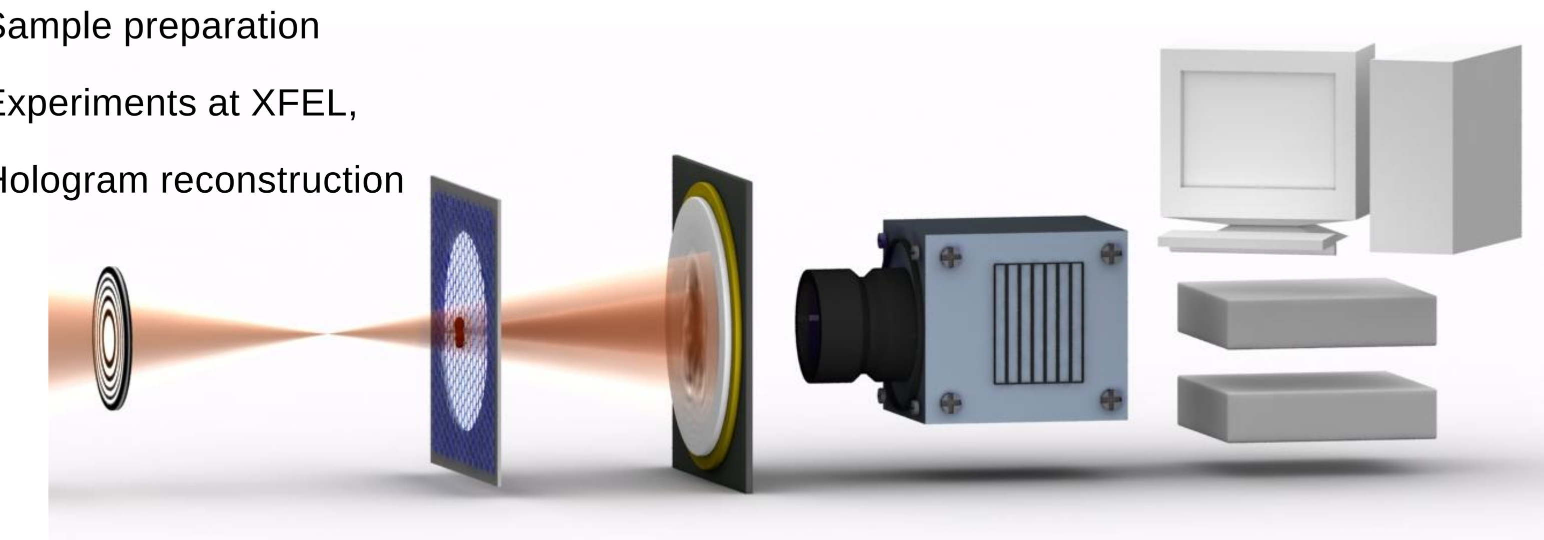
In collaboration with Kirsten Schnorr and Christoph Bostedt, Maloja X-FEL, PSI

Experimental

Sample preparation

Experiments at XFEL,

Hologram reconstruction



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