HESEB Helmholtz-SESAME Soft X-Ray Beamline für SESAME

HESEB and the Twinning Programm

Webinar on March 30th, 2020

Dr. Annick Froideval, Annette Weißig, Dr. Barbara Schramm
HZDR

HESEB partners and soft X-ray beamlines in Germany

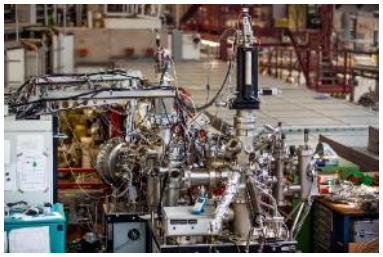
Instrumentation and Techniques

More than 270 Beamlines

More than 6000 beamtime campaigns

More than 30.000 users

More than 5000 publications



Techniques available

- **Photoelectron emission**
- **Imaging**
- **Scattering**
- **Emission or Reflection**
- **Absorption**
- **Diffraction**
- **Lithography**
- **Ion Spectroscopy**

- XPS
- Time-resolved studies
- Spin-resolved ARPES
- Photoelectron diffraction
- Angular Resolved PES
- PEEM

- XMCD
- Time-resolved studies
- NEXAFS
- EXAFS
- RIXS

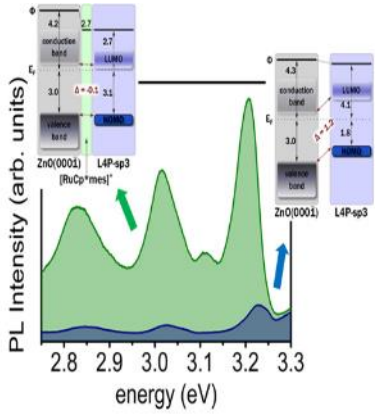
Adapted from CALIPSOplus twinning programme

BESSY II

BESSY II

- 48 beamlines
- 7 under construction or commissioning
- Wavelength: THz to hard X-Ray**, focus on soft X-Rays**
- Flexible pulse and time structures 1ps – 20ps
- Dedicated energy material science infrastructures

Organic Electronics: An efficiency boost for hybrid inorganic / organic semiconductors

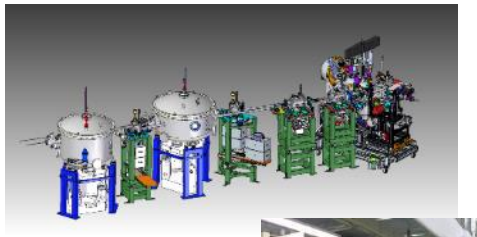


Overcoming the fundamental limits of inorganic semiconductors for electronic applications by hybrid organic/inorganic hetero structures

→ Understanding organic, molecular and hybrid electronics

Nature Communications 6, 6754 (2015)
doi:10.1038/ncomms7754

Solar Fuels and Catalysis; in system, in situ, operando



→ The full chain of energy conversion, energy storage and energy efficiency

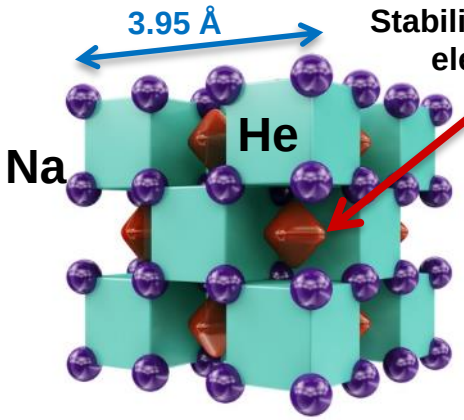
Nature Communications 6, 6187 (2015); doi: 10.1038/ncomms7187

PETRA III

PETRA III

- 18 beamlines in 3 halls
- particle energy 6 GeV
- energy range 25 eV – 200 keV

A stable compound of helium and sodium at high pressure



Usually, helium atoms do not form any chemical bonds!

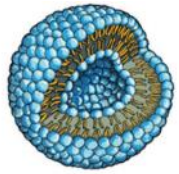
Identified at **beamline P02.2**: Na_2He electride

→ the first stable chemical compound containing Helium

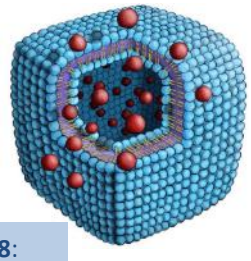
X. Dong et al., Nature Chemistry **9**, 440–445 (2017)

Vesicle Origami: Cuboid Phospholipid Vesicles Formed by Template-Free Self-Assembly

Vesicles are „bubbles“ made from lipid molecules


spherical vesicles

Usually spherical
Cannot break easily!
→ limited usage



Identified at **beamline P08**:
Cubic vesicles with edges being **predetermined breaking points**

→ new options for medical treatment: **targeted transport of drugs**

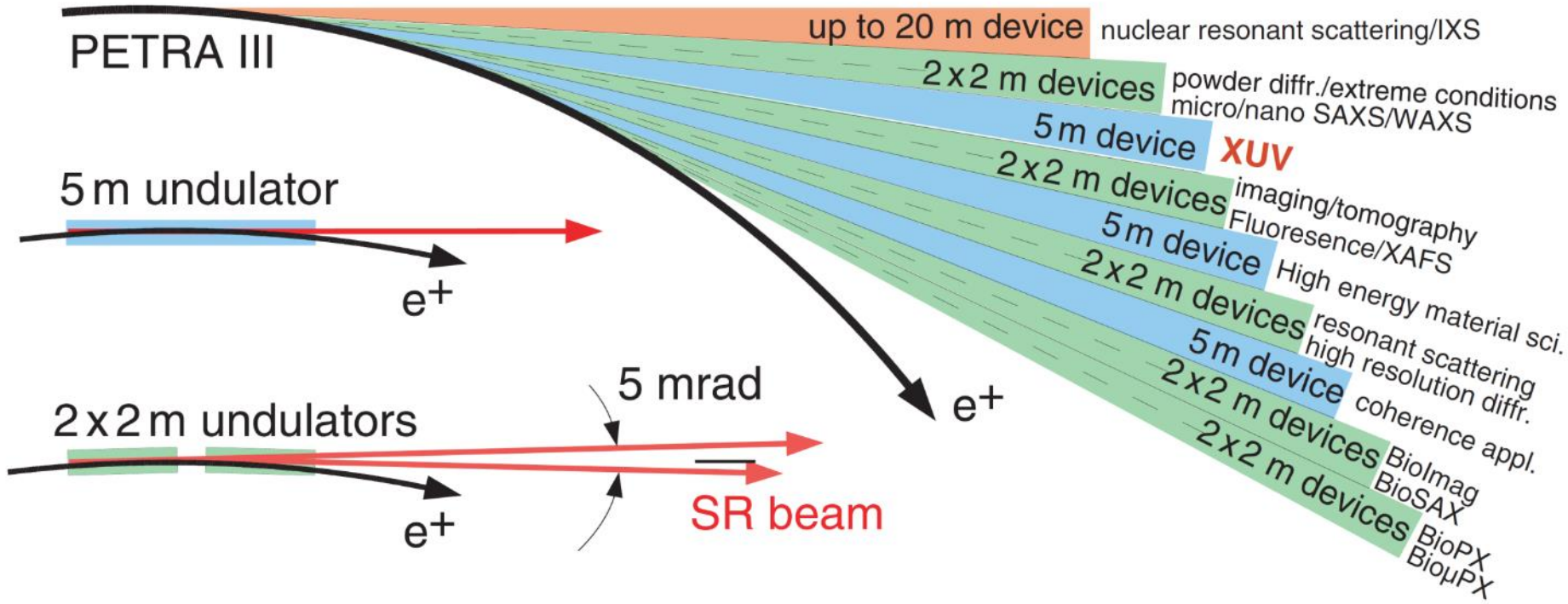
F. Neuhaus et al., Angewandte Chemie (Int. Ed.) **56**, 6515–6518 (2017)

PETRA III Parameters

- **Beam energy** **6 GeV**
- **Beam current (top-up)** **100 mA**
- **Circumference** **2304 m**
- **Revolution period** **7.685 µs**
- **Bunches** **960 / 40**
- **Bunch period** **8 / 192 ns**
- **Bunch length (FWHM)** **100 ps**
- **Emittance (horizontal)** **1.2 nm*rad**

PETRA III Beamlines (Max von Laue Hall)

- **9 straight sections – 14 undulator beamlines**



- **Up to 11 more beamlines in the two extension halls**

Schematic courtesy of Dr. Oliver Seeck

KARA

KIT

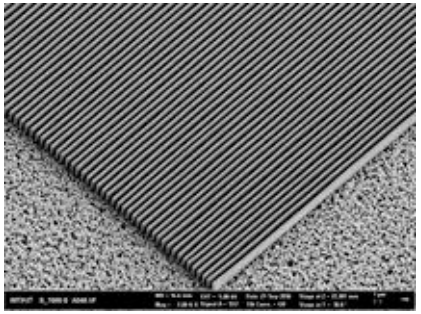
- Access for national and international academic research groups to state-of-the-art beamline facilities is provided by KIT via a cooperation-model.
- KIT supports Small and Medium-sized Enterprises (SMEs) in the development of new technologies, novel materials, and processes.
- KIT operates electron accelerators for the development of accelerator technology as well as for the provision of radiation from the THz regime to X-rays
- The "Karlsruhe Research Accelerator" KARA is operated by the Institute for Beam Physics and Technology. The Institute for Quantum Materials and Technologies (IQMT) at KIT is one of the external institutions owning and running a beamline of KARA: the **soft x-ray analytics facility WERA**.

Materials and processes for energy and transport technologies

Thin-film solar cells, batteries, catalytic materials, printable electronics, light emitting diodes, materials for electrochemistry

Materials and processes for energy:
http://www.ips.kit.edu/2728.php

Gratings for medical diagnostics

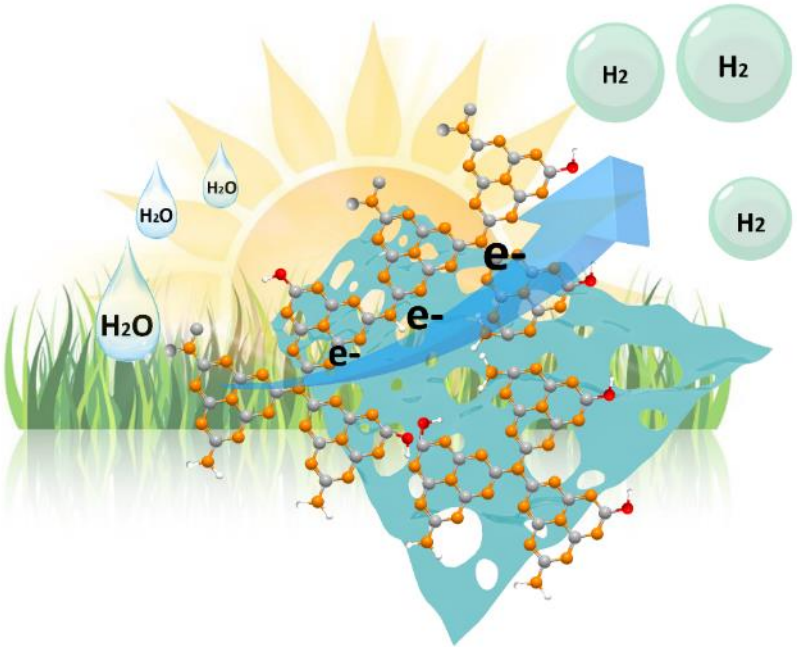


High quality, high performance X-ray gratings, for applications in medical diagnostics and materials analysis

X-ray gratings are developed with very high aspect ratio and smooth side surfaces (http://www.imt.kit.edu/x-rayoptics.php).

Application of soft X-rays at BESSY II

Solar–to-hydrogen conversion

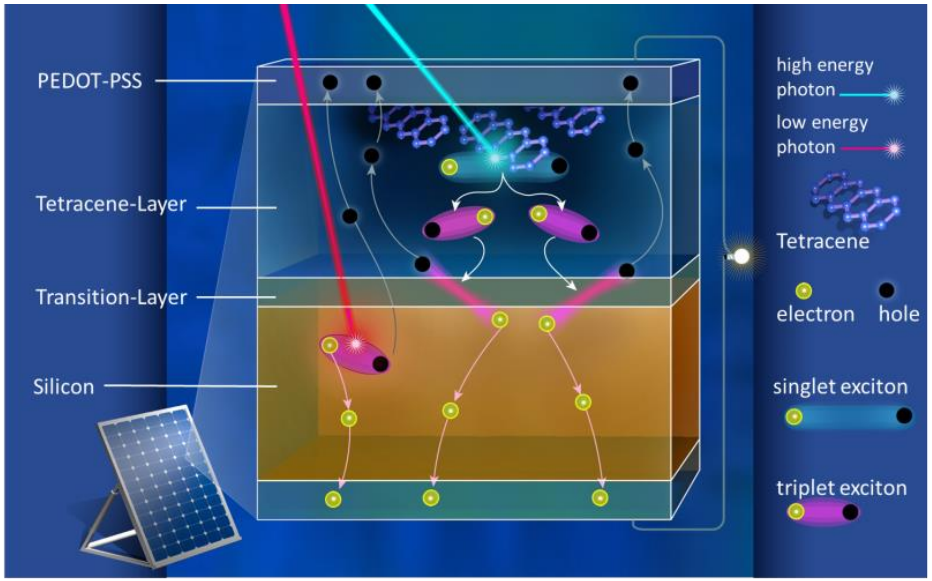


PCN nanolayers under sunlight can split water. © Nannan Meng /Tianjin University

Investigation of catalysts for splitting water to produce hydrogen using soft x-ray spectroscopy at BESSY II

Published in Energy&Environmental Science (2018), DOI: 10.1039/C7EE03592F

Silicon solar cells



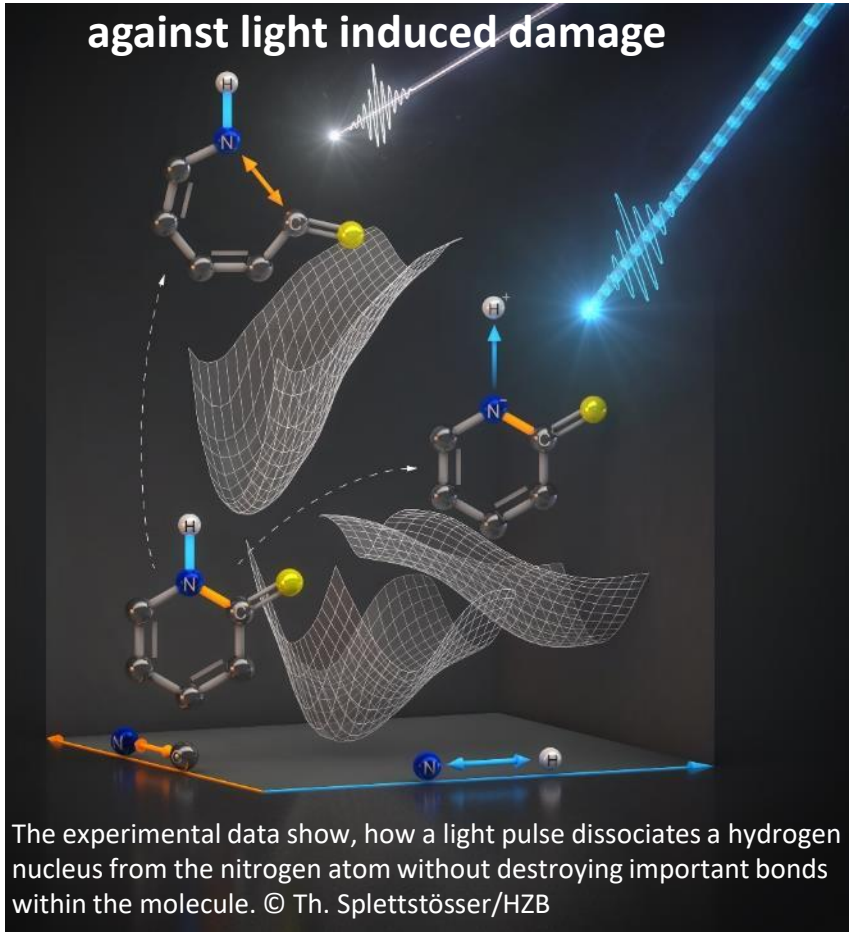
Principle of a silicon singlet fission solar cell with incorporated organic crystals © M. Künsting/HZB

Properties of the interfaces of organic layers in silicon solar cells that are crucial for boosting the efficiency where studied at BESSY II using soft X-rays.

Published in Materials Horizons (2018), DOI: 10.1039/c8mh00853aI

Application of soft X-rays at BESSY II

Mechanism to protect biomolecules against light induced damage



The experimental data show, how a light pulse dissociates a hydrogen nucleus from the nitrogen atom without destroying important bonds within the molecule. © Th. Splettstösser/HZB

Molecular changes could be observed by resonant inelastic X-ray scattering at BESSY II

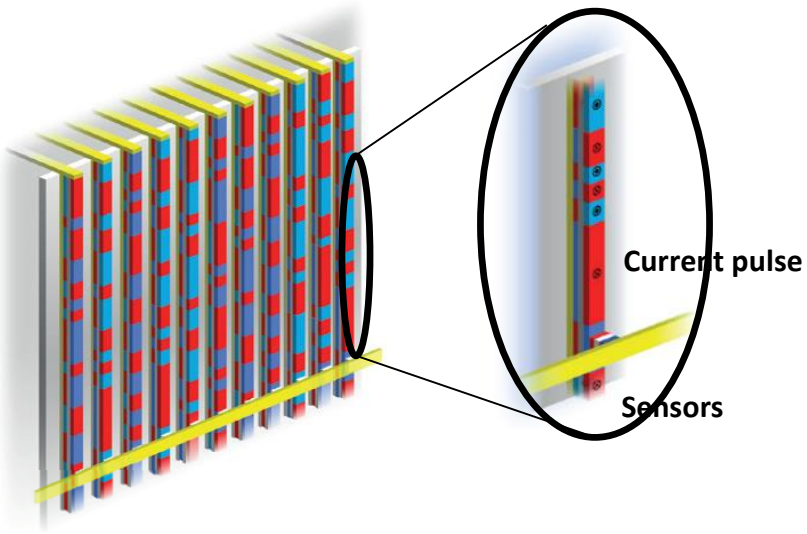
Published in Angewandte Chemie (2017), DOI:10.1002/anie.201700239

Application of soft X-rays at PETRA III

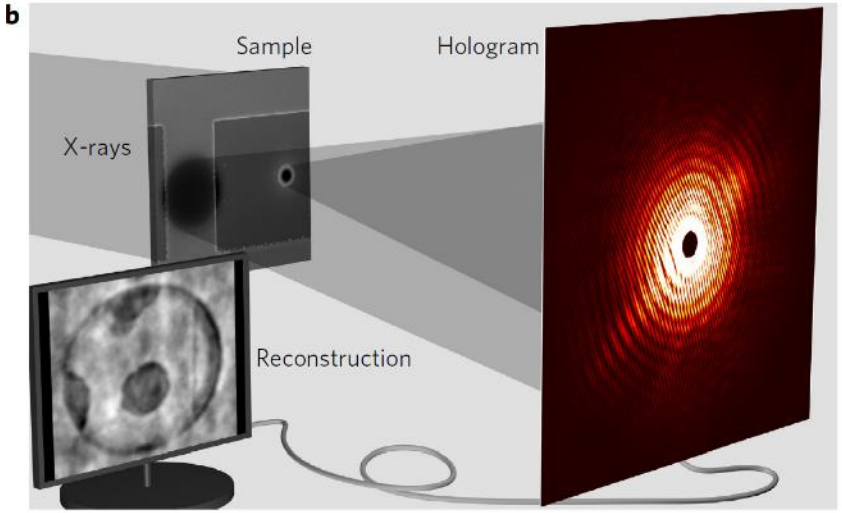
Magnetic nano-objects

Motivation: Skyrmion racetrack memory

3D racetrack memory



S. Parkin & S.-H. Yang, Nat. Nanotech. **10**, 195–198 (2015)

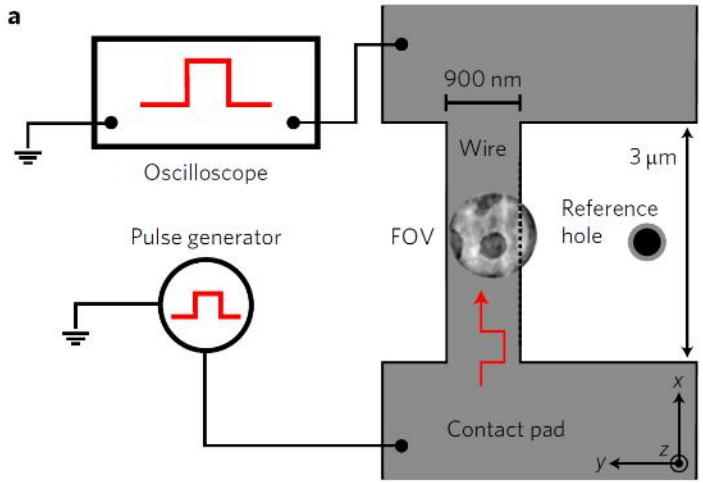


holographic imaging of Skyrmions in $Pt_{2.7nm}/Co_{60}Fe_{20}B_{20,0.8nm}/MgO_{1.5nm}$ (15 repeats)

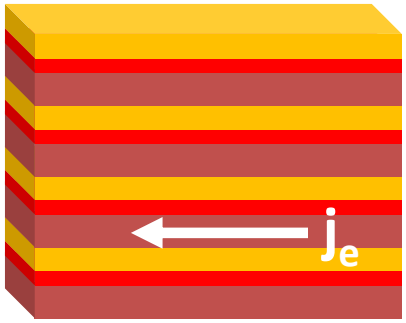
magnetization profile

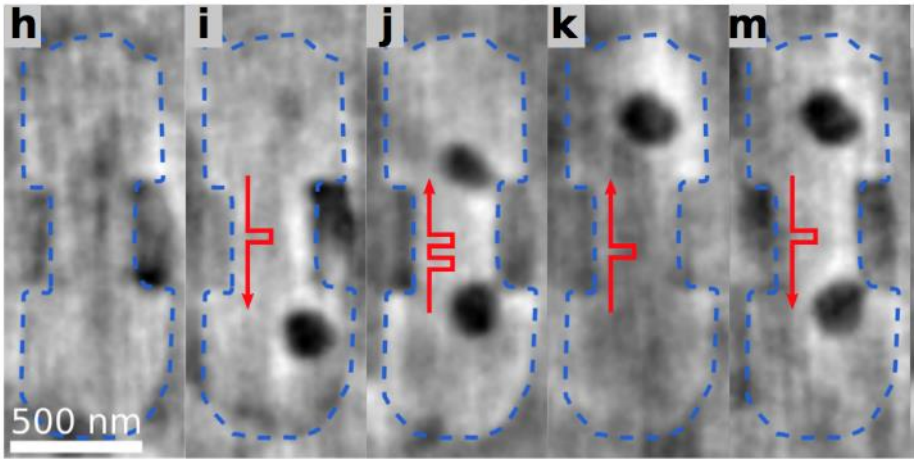
S. Eisebitt et al., Nature ***432****, 885 (2004), F. Büttner et al., Nat. Phys.* **11**, 225-228 (2015)

Manipulation of Skyrmions (PETRA III)



Sample: Stripline of Pt/CoFeB/MgO multilayer





1. Magnetically saturate the sample with external field
2. Send current pulse through multilayer
3. Image magnetization via Fourier-transform holography (XMCD contrast)

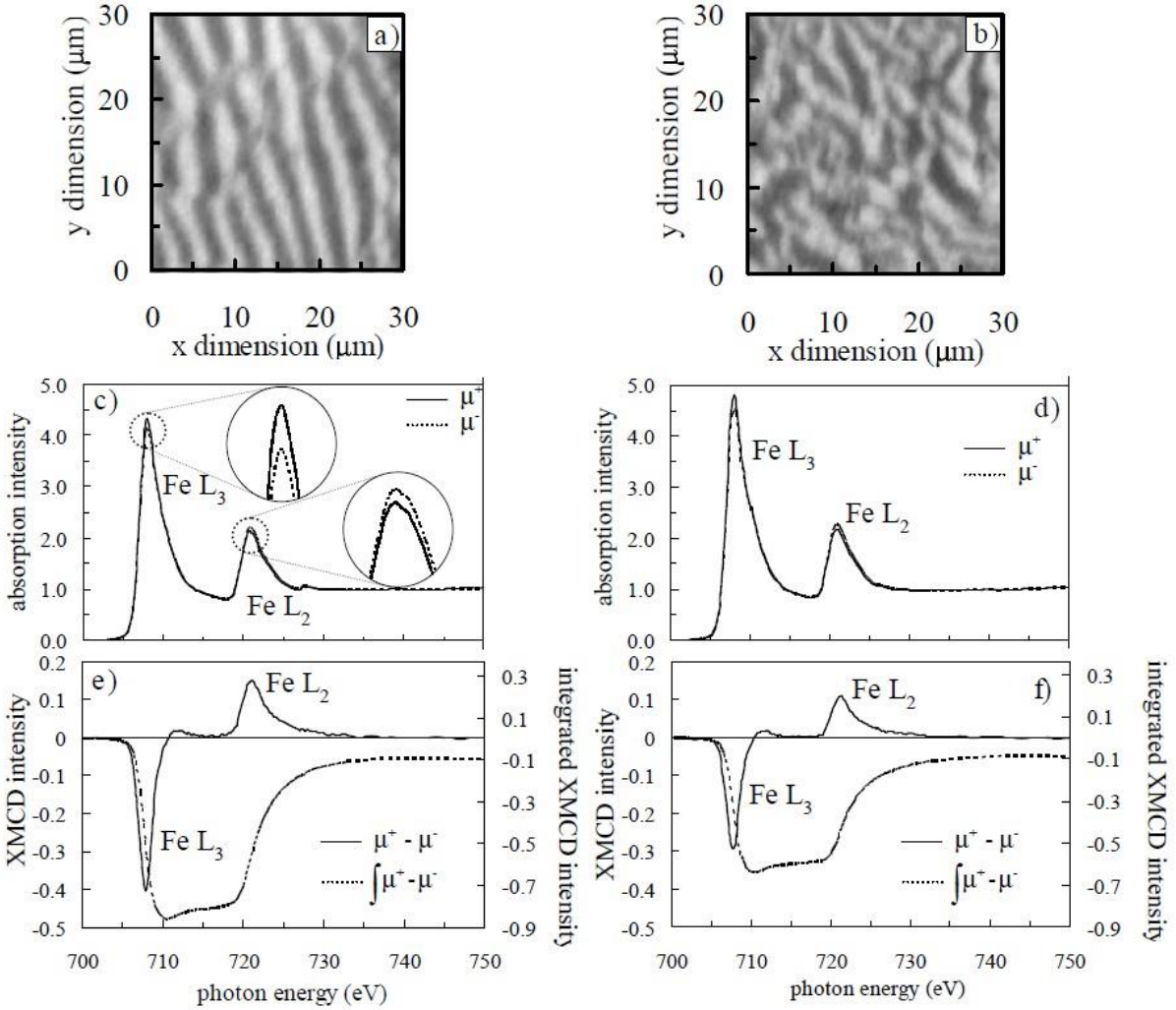
F. Büttner et al., Nat. Nanotech. 12, 1040 (2017).

Experimental observation of skyrmion nucleation, annihilation, and shifting of skyrmions at a notch in a nanotrack:

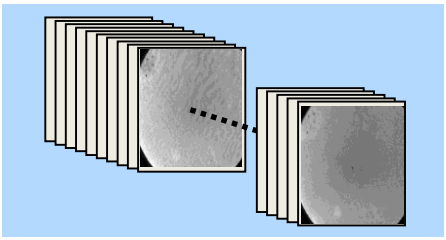
- (i, j) Single current pulse nucleates skyrmion at the exit of the constriction.
- (k) Nucleated Skyrmion can be detached from the constriction and then moved further away by current pulses.

Application of soft X-rays at KARA

Magnetic studies - PEEM images recorded at the Fe L_3 edge on two Fe-Cr alloys:



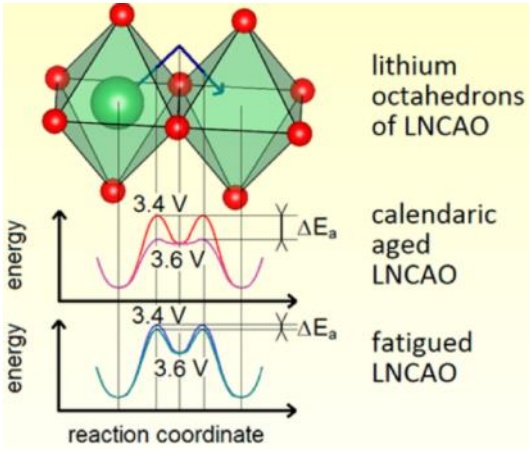
Stack of PEEM images collected at KARA - WERA beamline



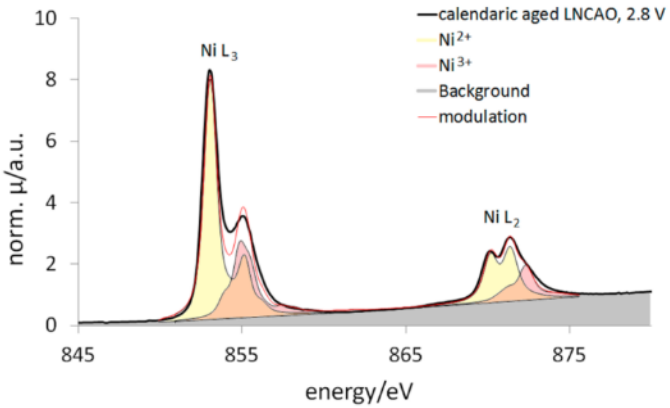
A. Froideval *et al.*, PRL **99,** 237201 (2007)

Application of soft X-rays at KARA

Origin of fatigue in Li-ion batteries – NEXAFS at the Ni L edge:

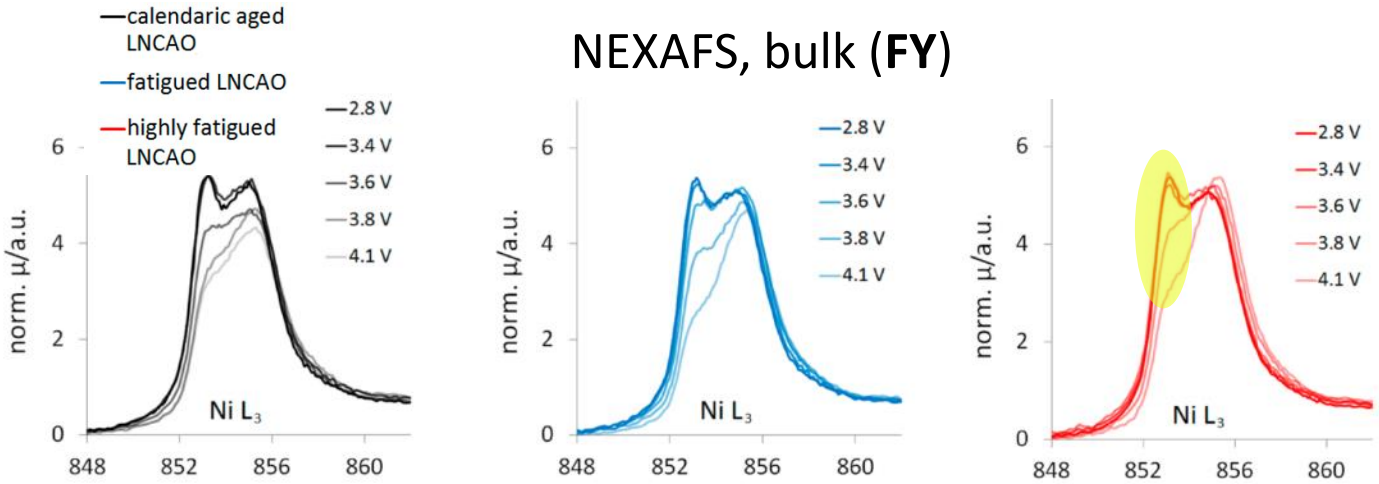


NEXAFS, surface region (**TEY**)



K. Kleiner *et al*., ACS Appl. Mater. Interfaces **7**, 19589 (2015)

NEXAFS, bulk (**FY**)

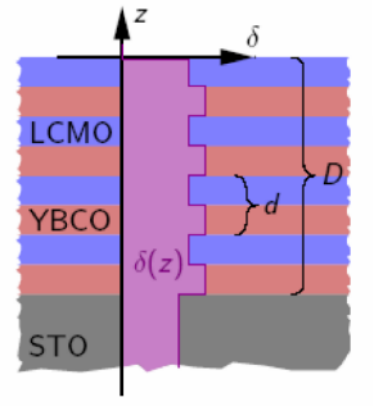


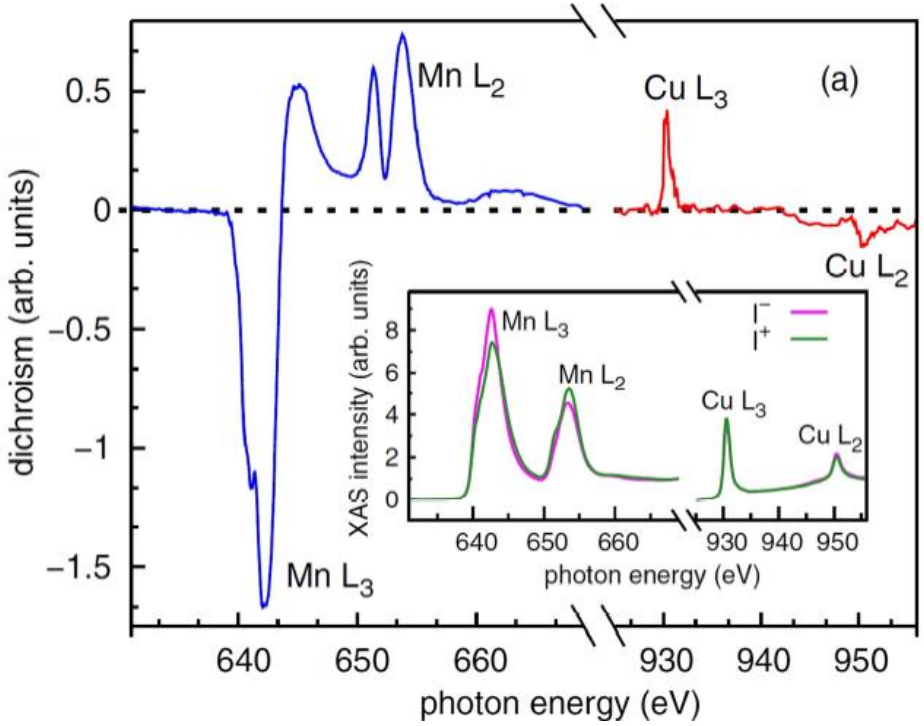
Monitor Ni valence *etc*. during aging / fatiguing process
Fatigue: increased NiO species even in bulk!

Application of soft X-rays at KARA

Magnetic thin-film systems – XMCD, magnetic coupling:

Multilayer SC/FM: $YBa_2Cu_3O_7$ – $(La,Ca)MnO_3$



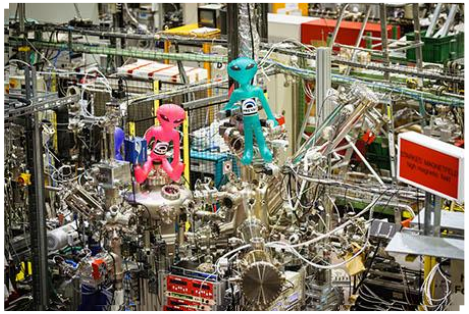


D. K. Satapathy *et al.*, PRL **108**, 197201 (2012)

XMCD: Induced magnetic moment at the Cu atoms at the interface!
Opposite sign at L_3 -> coupling *anti*parallel to manganite magnetization.
Cu XMCD detected from buried interface, about 10 nm deep.

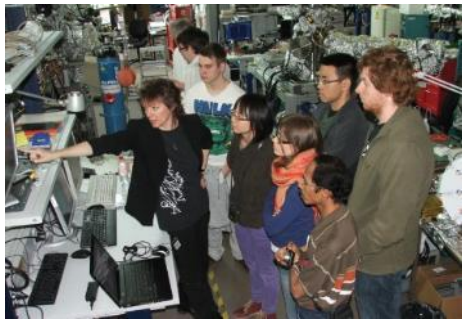
The Twinning Programme

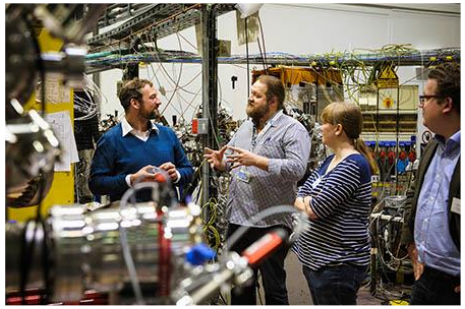
We like to invite you to paticipate in a beamtime of an experienced user group at a German soft X-ray beamline



We offer:

- Free access to the light source
- Full coverage of your travel and subsistence costs
- Tailor made twinning teams
- Training in how to use a soft x-ray beamline
- Experience in executing a beamtime
- Discussion and support in writing your proposals
- Contact to facilities and possible collaborators





The Twinning Programme

Your benefits:

- Experience
- Discussion
- Training
- Support
- Financial support
- Lower barriers
- Possible collaborations

Your duties and preparatory work:

- Apply to participate
- Describe your scientific interest
- Make the best use of the programme
- Disseminate the information and experience
- Enjoy and have fun
- Write your own proposals afterwards

Outcome

- Experience
- Knowledge on how to write proposals and execute beamtime
- Inclusion into the European light source landscape
- Dissemination
- Publication
- Own proposal

How does it work in practice?

HESEB - Helmholtz-SESAME Beamline in the soft X-ray regime

News: Start of Twinning Programme

As part of the HESEB Project, a **Twinning Programme** is offered, whose main aim is to support the user community from SESAME member countries in gaining knowledge and experience with soft X-ray synchrotron use during a joint beamtime with an experienced user group at a Helmholtz synchrotron.

You can register to the Programme:

As twinning guest:

- You are a researcher from a university or a research institution in a SESAME member country, i.e. in Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine and Turkey.
- You would like to use soft X-rays from a synchrotron in your research,but you are lacking the necessary experience.

We invite you to participate in a beamtime of an experienced user group in your research field at a soft X-ray beamline of a German synchrotron.

You will be involved in the experiment preparation, in the beamtime itself and in data analysis and interpretation. You will be able to discuss with the experienced user team, to ask questions and to learn a lot for your own projects.

When later applying for an own beamtime you may again contact your mentors, asking for support in proposal preparation. If beamtime will be granted, in some cases your twinning host might even join your beamtime.

As twinning guest, you will profit of free access to the facility at which the beamtime takes place and your travel and accommodation costs will be covered.

As twinning guest, please register here: (insert link)

As twinning host:

- You are an experienced soft X-ray user who is willing to offer mentoring and support for future soft X-ray users from SESAME countries by hosting this new user during one of your beamtimes at a German synchrotron.
- You are ready to share your experience and to offer consultancy for proposal drafting and, if applicable, for setting up a beamtime at a soft x-ray beamline, potentially at HESEB.

As twinning host, the cost for travel and accommodation related to the beamtime during which you host the guest will be covered for one of your team members. In some cases, a fruitful collaboration will arise from this joint beamtime and you will join your former guest during his or her beamtime. In this case again the costs for travel and accommodation will be covered for one of your team members.

Please register here as twinning host: (insert link)

Any questions regarding to the HESEB twinning programme should be addressed to: **heseb@hzdr.de**

How does it work in practice?

1. Go to the HESEB Twinning website: https://www.hzdr.de/db/Cms?pOid=58977&pNid=141
2. Select the program you would like to participate in
3. Complete the pre-registration form and submit
4. Wait for the email confirming the pre-registration
5. **Click the confirmation link in this email → the full registration online form will open**
6. Complete this form and submit again

What will happen next?

- Your profile will be compared with the profile of the registered host user groups
- If we have no experienced user group matching your profile in our "pool" we will pro-actively search for suitable host
- As soon as we will have identified a "mentor group" we will establish the contact with you!

Thank you for your attention

We would like to thank Dr. Antje Vollmer, head of the user office of BESSY II, for sharing her presentation prepared to promote the Twinning program in the framework of the EU project CALIPSOplus and various inputs on recent research achievements.