<u>OSIRIS</u>

in-<u>O</u>perando <u>S</u>pectroscopy and <u>R</u>esonant <u>I</u>nelastic <u>S</u>cattering beamline at ALBA

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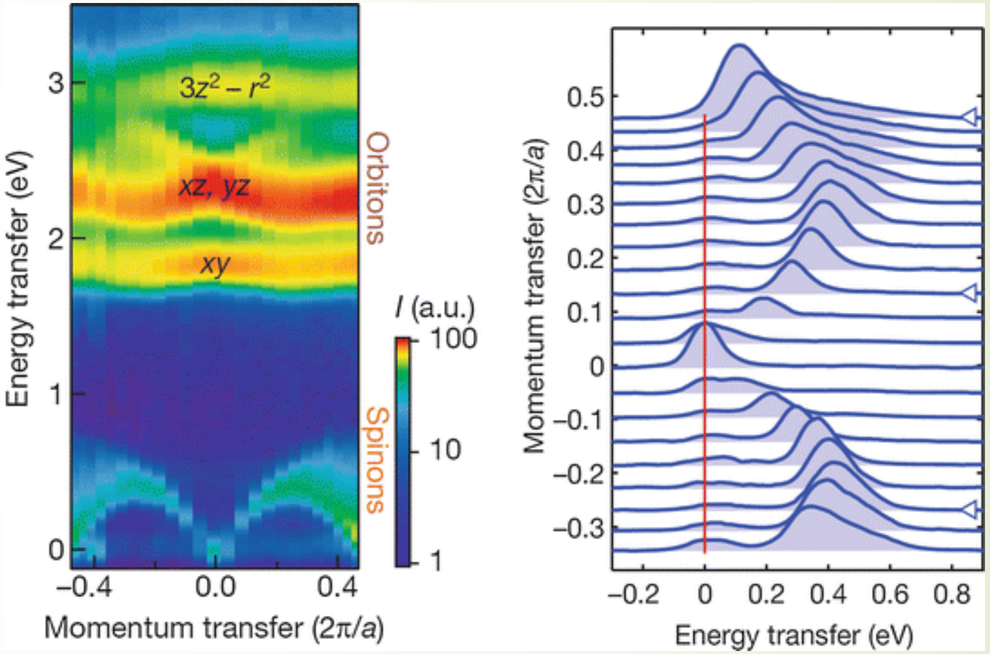
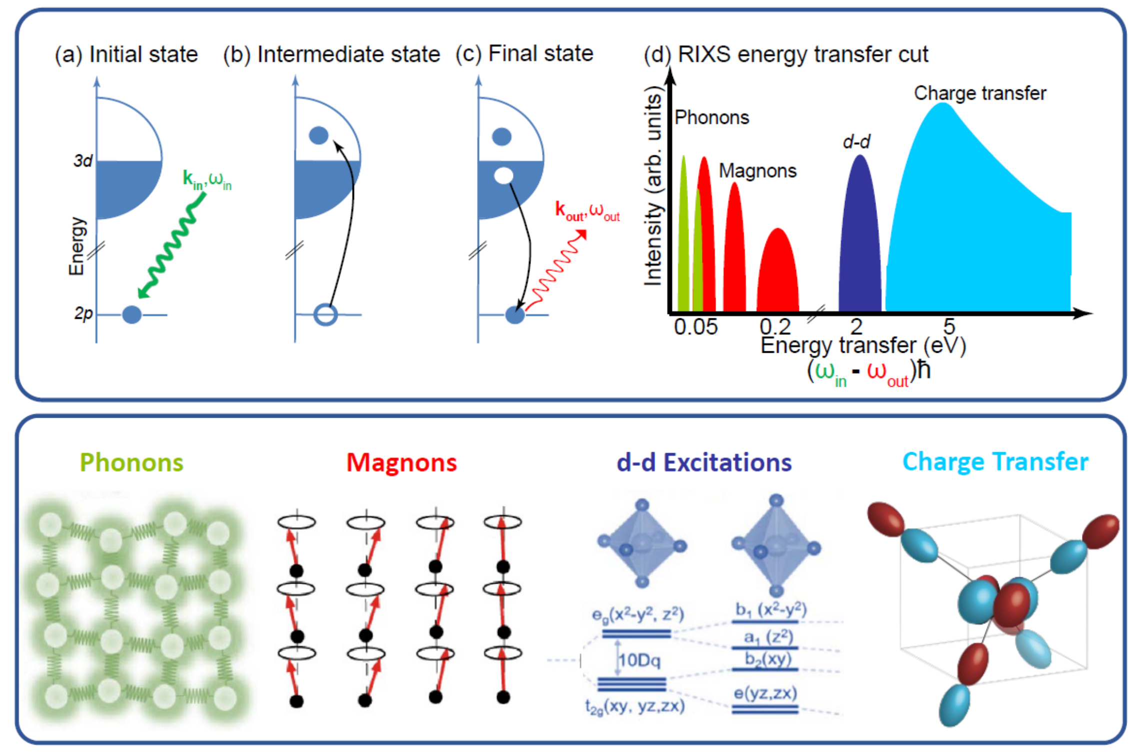
Outline

- What is Resonant Inelastic X-ray Scattering (RIXS)
- Science highlight
- Why a new RIXS line is required
- Why a long beamline for RIXS is needed
- Possibilities for the Spanish community



J Schlappa Nature 2012

RIXS: Resonant Inelastic x-ray Scattering



L Ament Review of Modern Physics 2011

Resonant: ω_i at an absorption edge

- element specific

(In)elastic: energy loss spectroscopy

- Probed excited states (0.01-10 eV)
- … and ground states
- Complementary to Raman and Neutrons

X-ray scattering: photon in/photon out

- neutral excitations
- momentum resolution

- **The best way to look at electrons and their dynamics**
- **RIXS is helping to solve many questions in physics and chemistry**

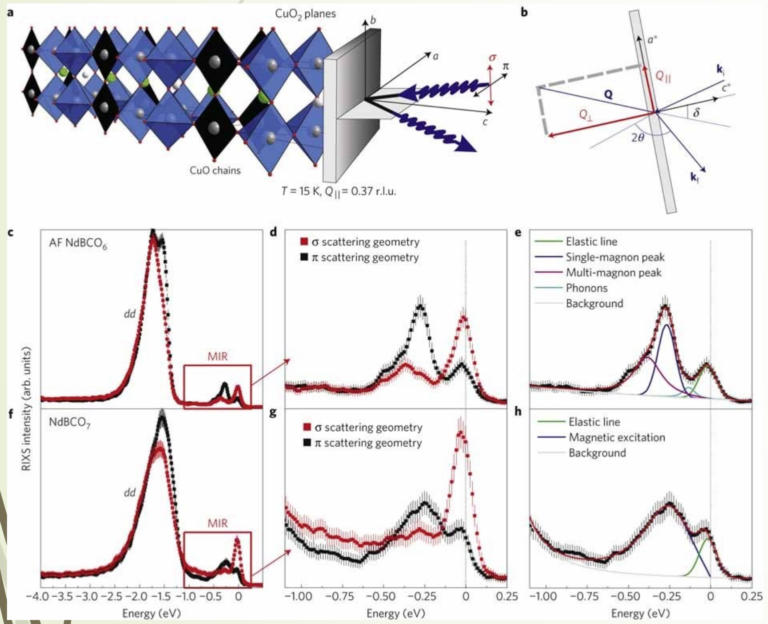
Excitations in quantum materials

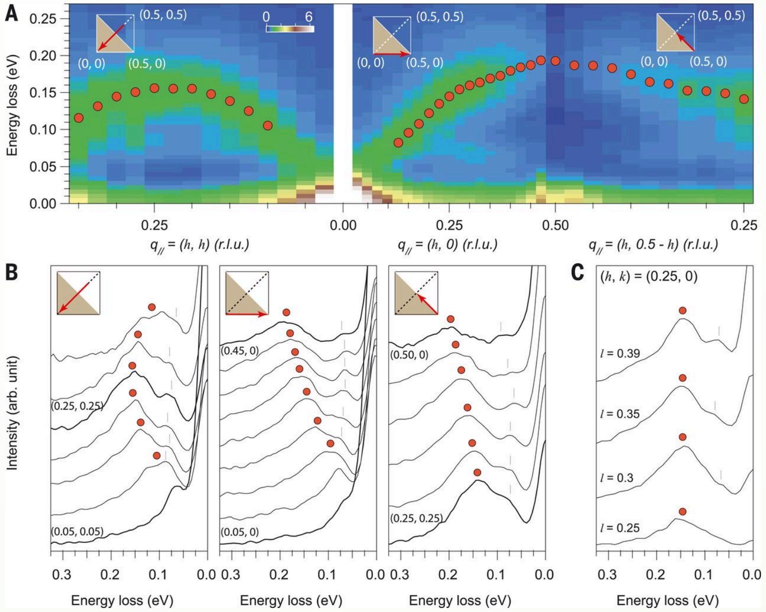
Dispersive magnetic excitations in superconductors

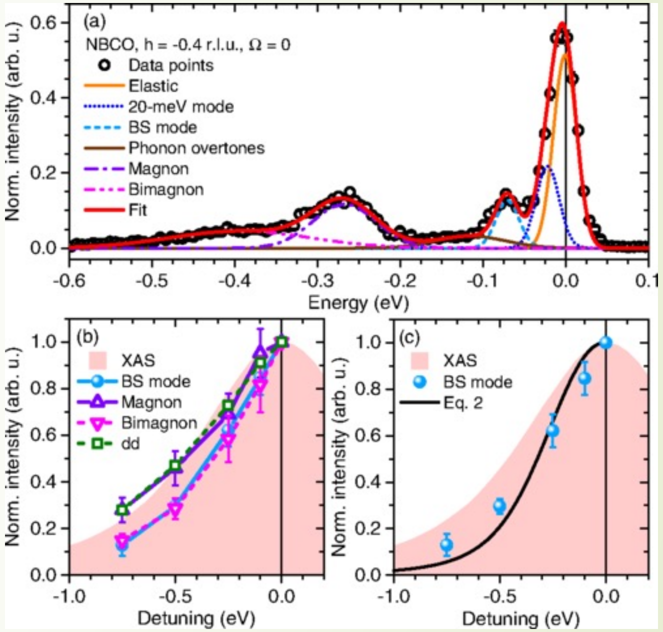
Electron phonon interaction

Cuprates

Nickelates



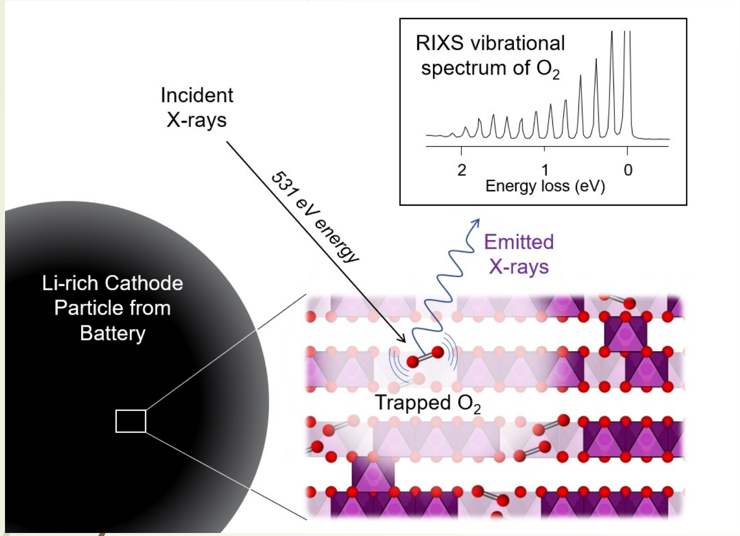


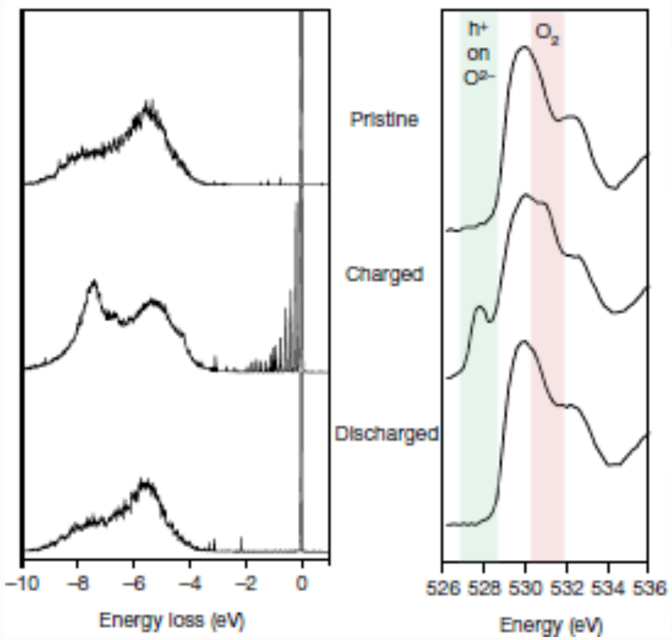


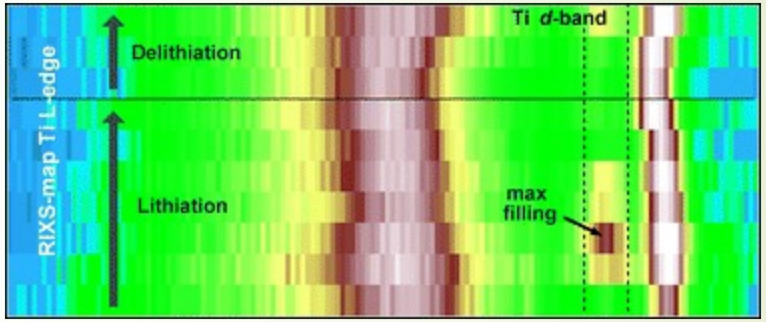
L. Chaix et al Physical Review B 2018
M. LeTacon et al., Nature Physics 2011
WS Lee Nature Physics 2014
MPM Dean Nature Materials 2013
MPM Dean Physical Review Letters 2013
L Chaix Physical Review B 2018

EPI in QM, thermoelectrics, solar cells

Batteries



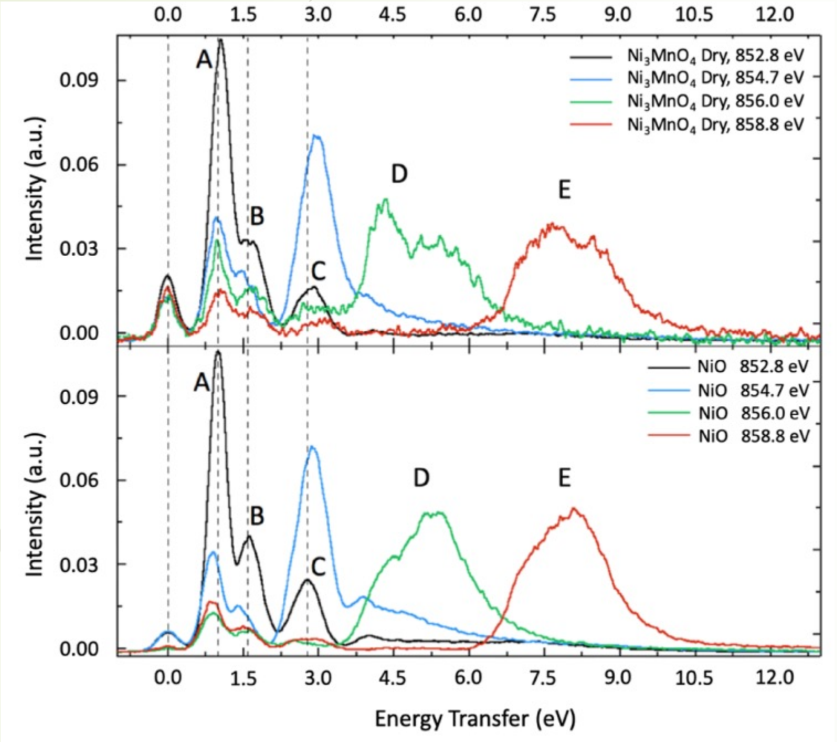


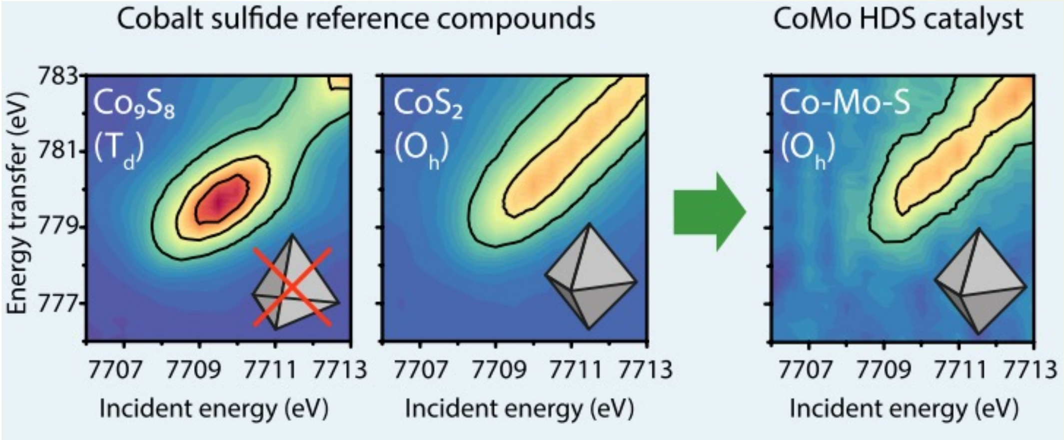


Robert A House Nature 2020
Robert A House Nature Energy 2021
J Wu Dalton Transactions 2020

RIXS unveiled the formation of O superstructures and lithiation process during the charging- discharging cycles of Li batteries

Catalysis





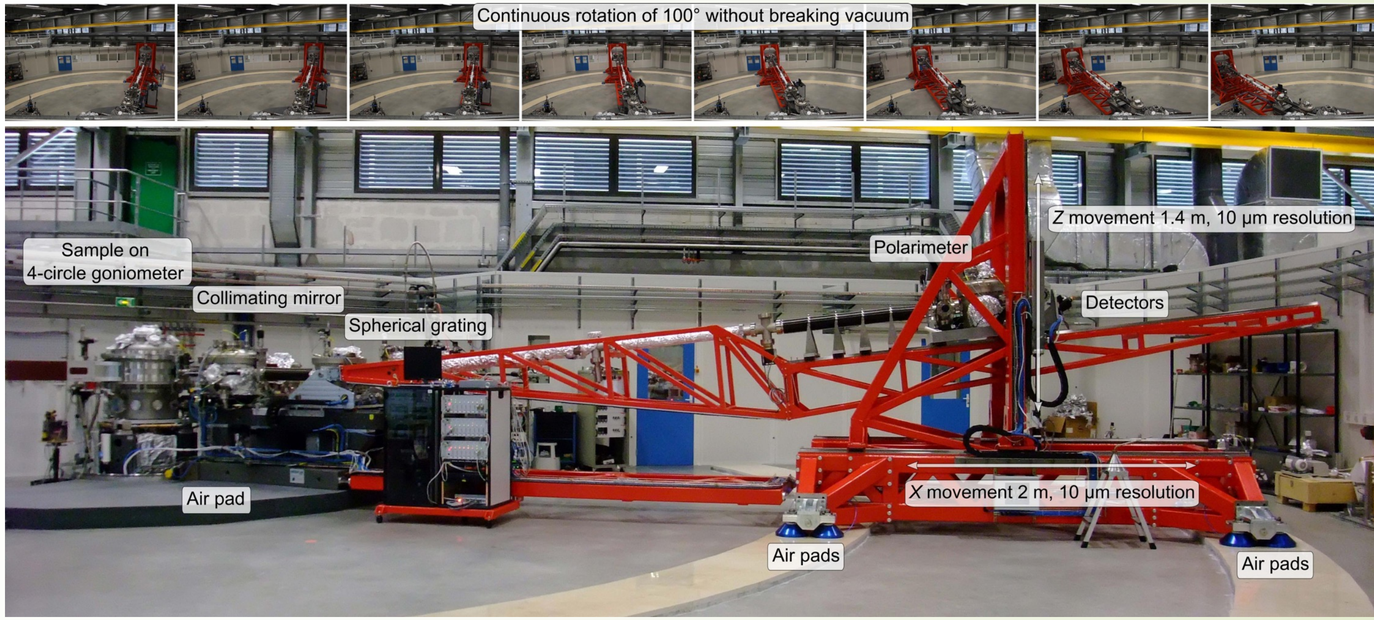
- Oxygen evolution for a graphene supported Ni_3MnO_4 catalyst.
- Nature of the active cobalt sites for hydrogenolysis

YS Liu Journal of Electron Spectroscopy and Related Phenomena 2015
M Al Samarai Applied Materials and Interfaces 2019
L van Haandel ACS Catalysis 2020

Physics/chemistry of materials fuels the progress of humanity→ RIXS ideal tool to study those materials

RIXS spectrometer

- Energy range: 300-2500 eV
- Beamline polarization: LH, LV, C+/C-
- Resolving power: 40.000. Total energy resolution: 25 meV at 930 eV, 14 meV at 530 eV.
- Focal beam: 50 (H) x 3 (V) um^2.
- Sample enviroment: solid state, liquids,
6-axis manipulator
- Temperature: 10-400 K
- Scattering angle: 40 < 2th < 150°
- Polarization analysis.

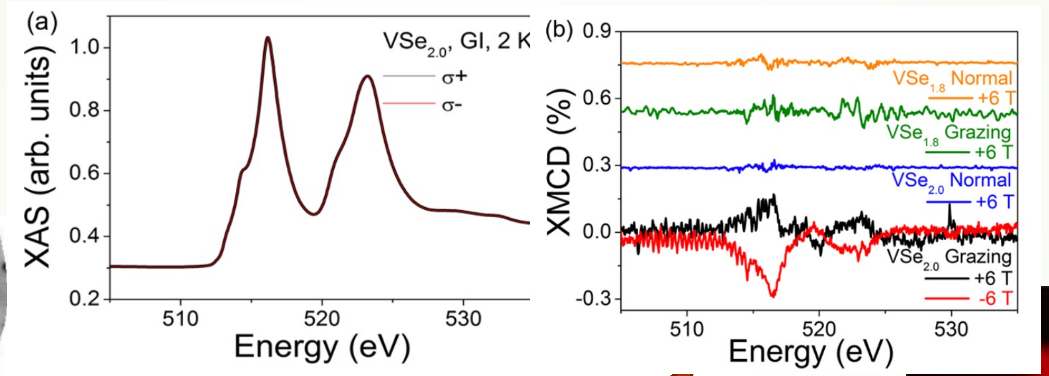


ID32 at ESRF

Why a new RIXS beamline is required

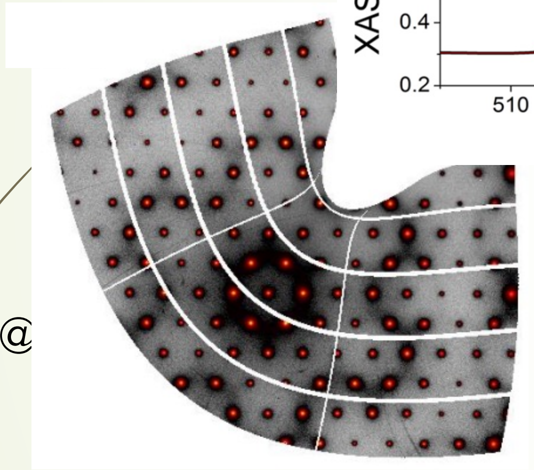
- RIXS users increase continuously
- Only few high resolution beamlines (ESRF, DIAMOND, NSLS)
- Highly demanding technique (beamlines are over subscribed by a factor of 4-5). Highly competitive!!!
- All producing very high impact papers
- Address the challenges of the Spanish (and international) research community (50 groups)
- RIXS instrument will enhance the strength of a multi-modal program together with ARPES, XMCD, TEM-EELS at ALBA

Why a new RIXS beamline is required

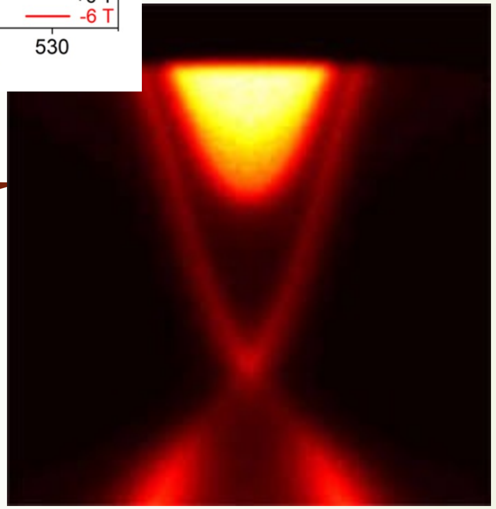


XAS/XMCD @
BOREAS & NOTOS

Structure @
MSPD

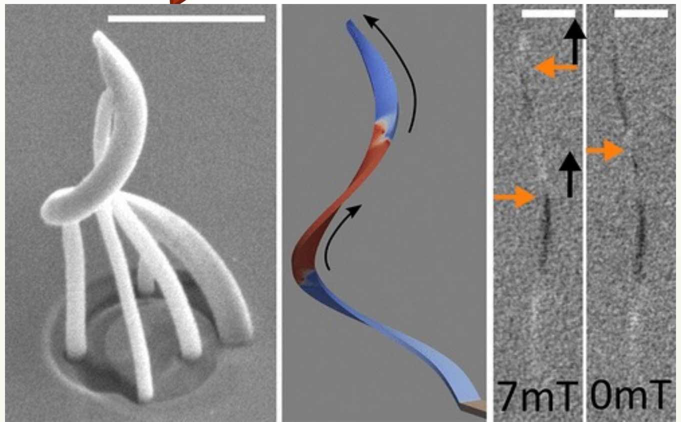


RIXS



ARPES @
LOREA

PEEM @
CIRCE



Why a long beamline for RIXS is needed

Key driving force of RIXS – energy resolving power, ***E/ΔE***

High resolution – small bandwidth

High photon flux (10^{14}-10^{15} ph/s)

↓

Long undulator: for instance 5 m APPLE II at ID21

↓

Minimized number of optics

Long beamline (80 m)
Long spectrometer (15 m)
Very high quality optics

↓

Extremely stable mechanics
(Vibrational stability)

↓

Good termal and floor stability

Possibilities for the Spanish community

- In operando conditions for materials for energy conversión/storage
- By enabling the electric and magnetic field RIXS could uncover new physics in many exotic systems
- RIXS can be combined with microscopy for studying electronic inhomogeneities (micro beam size)
- Study of surfaces, interfaces, and bulk electronic structure of novel inorganic and organic systems

Possibilities for the Spanish community

- Quantum materials (DIPC, ICMAB, IFIMAC, IMDEA)
- Functional materials: thin films and superlattices (UCM, USC, UNIZAR, ICMAB), micro/nanodevices (Nanogune, ICMOL)
- Energy: batteries (UAM, ICMAB), catalysis (CFM), fuel cells, solar cells, electro(baro)caloric materials (INMA)
- Chemistry: catalysis (ITQ, CFM, ICP) and reactivity

Thank you!