ESRF - EBS

DRIVING EUROPEAN SCIENCE

ESRF-EBS: A DRIVER FOR EUROPEAN SCIENCE

In 2020, ESRF – The European Synchrotron launched a brand-new generation of high-energy synchrotron, the Extremely Brilliant Source (EBS), opening a new era for X-ray science.

The EBS enables scientists to study the structure of condensed and living matter at the atomic level in higher resolution, with greater image quality and much faster data collection. This revolutionary new source pushes the limits of possibility, bringing X-ray science into research domains and applications that were previously unimaginable.

The state-of-the-art capabilities of this world-leading synchrotron X-ray source have been recognised with the awarding of nine prestigious European Research Council grants to ESRF scientists and long-term users for high-impact, breakthrough research carried out with the EBS. Discover these exciting new projects at the forefront of science, each aiming to contribute to advancing knowledge and addressing global challenges.

A NEW X-RAY TECHNIQUE TO STUDY METALS IN DEEP-SEA MARINE DEPOSITS

ERC Advanced Grant

Fathoming sequestration and enrichment of metals in DEEP marine deposits with novel micro X-ray emission spectroscopy (DEEP-SEE)

Deep-sea marine deposits contain vast reserves of Rare Earth Elements (REEs) and transition metals that are widely used in modern technologies such as solar panels and mobile phones. Long-time ESRF user and now ESRF scientist Alain Manceau will use a new technique called X-ray emission spectroscopy at beamline ID24 to study deep-sea samples at micrometre-scale resolution to investigate the processes that lead to the formation and prevalence of REEs and strategic metals on the seafloor.

"Thanks to the EBS, we will gain unprecedented sensitivity and precision, thus establishing a world-leading research programme in geosciences that will benefit the European community and beyond."

Alain Manceau
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INVESTIGATING THE NANOSTRUCTURE OF CATALYSTS IN ACTION

ERC Consolidator Grant

Coherent diffraction for a look inside nanostructures towards atomic resolution: catalysis and interface (CARINE)

Catalysts play an important role in our lives, from speeding up chemical reactions to creating fertilizers or converting toxic gases to harmless ones. ESRF user Marie-Ingrid Richard will use Bragg coherent X-ray diffraction imaging at beamline ID01 to investigate how the chemical structure of catalysts change while in action, focusing on a single nanoparticle as small as 20 nanometres and studying the processes that take place.

"My ERC grant would not exist if it wasn't for the new Extremely Brilliant Source at the ESRF. The EBS, with its high energy, brilliance and coherence, is like opening a new window into the world of science."

Marie-Ingrid Richard
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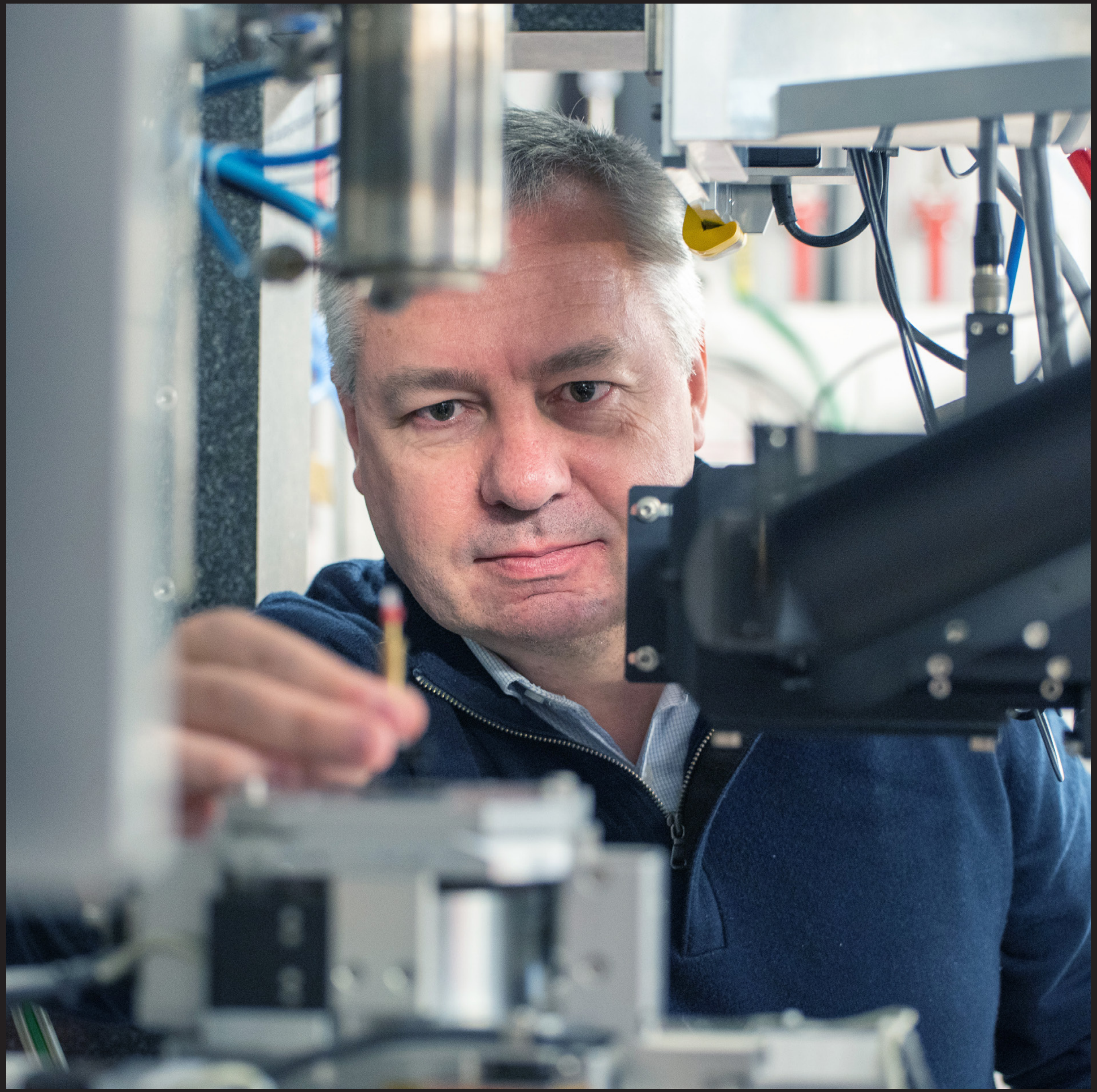

STUDYING THE ORIGINS OF EARTHQUAKES

ERC Advanced Grant

Break-Through Rocks (BREAK)

Earthquakes pose a huge risk for many people worldwide, but questions surrounding their origins and precursors make it difficult to predict how and when they may develop. ESRF user Francois Renard aims to use 3D X-ray diffraction, 4D X-ray microtomography and acoustic emissions at flagship beamline BM18 and beamlines ID11 and ID19 to study the mechanisms that lead to rapid seismic rupture in rock samples.

"With EBS, the ESRF has the world-leading capabilities needed to perform this experimental programme. New beamline BM18 provides the world's largest high-energy and high-coherence synchrotron beam for hierarchical imaging and high-throughput tomography."

François Renard
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MAPPING THE NEURONAL NETWORKS OF THE BRAIN

ERC Starting Grant

Bright, coherent and focused light to resolve neuronal circuits (BRILLIANCE)

To tackle neurological diseases such as Alzheimer's or Parkinson's, or to develop energy-saving computing architectures, an in-depth understanding of how neural circuits operate is needed. ESRF scientist Alexandra Pacureanu aims to develop a new approach in the field of brain imaging – developing X-ray nanotomography at nanoimaging beamline ID16A to achieve multiscale imaging of neural circuits.

"The EBS, along with beamline ID16A, a unique instrument for nanoimaging, is bringing about a revolution in the field of connectomics by pushing forward the frontiers of resolution and scalability."

Alexandra-Teodora Joita-Pacureanu
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PIONEERING METAL RESEARCH FOR NEW INDUSTRIAL APPLICATIONS

ERC Advanced Grant

The physics of metal plasticity (PMP)

The design of lighter, stronger metal components for the energy or aerospace industries requires detailed understanding of the strength of metals and how their ability to be shaped is affected during use. Long-time ESRF user Henning Poulsen will exploit the hard X-ray microscope he pioneered at beamlines ID06 and ID03 for high-resolution 3D studies that will lead to complex models to predict metal behaviour under stresses at all scales of structure.

"As a researcher, it's amazing to see our work embodied in an X-ray microscope that is immediately given the status of European flagship project."

Henning Friis Poulsen
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FOCUSING ON THE COMPLEX DYNAMICS OF GLASSES

ERC Starting Grant

A coherent view of Glasses: How coherent X-rays can elucidate the complex dynamics of glasses (CoherentGlasses)

Glasses, widely used in industry and technology, are disordered at the microscopic scale and their properties change with time; thus, a deep understanding of these complex materials at the atomic level remains elusive. ESRF user Beatrice Ruta will use coherent X-rays at beamlines ID10 and ID18 to investigate whether glasses at different pressures and temperatures have universal behaviours that can be predicted.

"Thanks to the EBS's coherent X-rays at high energies, I will be able to study the atomic motion in glasses at extreme conditions of temperature and pressure, opening totally new perspectives for my research."

Beatrice Ruta
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A NEW TECHNIQUE TO STUDY THE LINKS BETWEEN TENDON AND BONE

ERC Starting Grant

X-ray texture tomography as a tool to enable multiscale, in-situ imaging of the enthesis, a biological hinge between bone and tendon (TexTOM)

The enthesis is the biological interface between the tendon and the bone in our bodies, but, once damaged, it cannot be regenerated by the body. ESRF user Tilman Grünewald aims to develop a new technique called X-ray texture tomography, at beamlines ID13 and ID15A, to reveal the nanostructure and behaviour of the enthesis.

"With the ESRF's new EBS, being able to go to sub-100 nm X-ray beam sizes with high flux at beamline ID13, or having a sub-micron beam at 100 keV at beamline ID15A really is a game changer."

Tilman Grünewald
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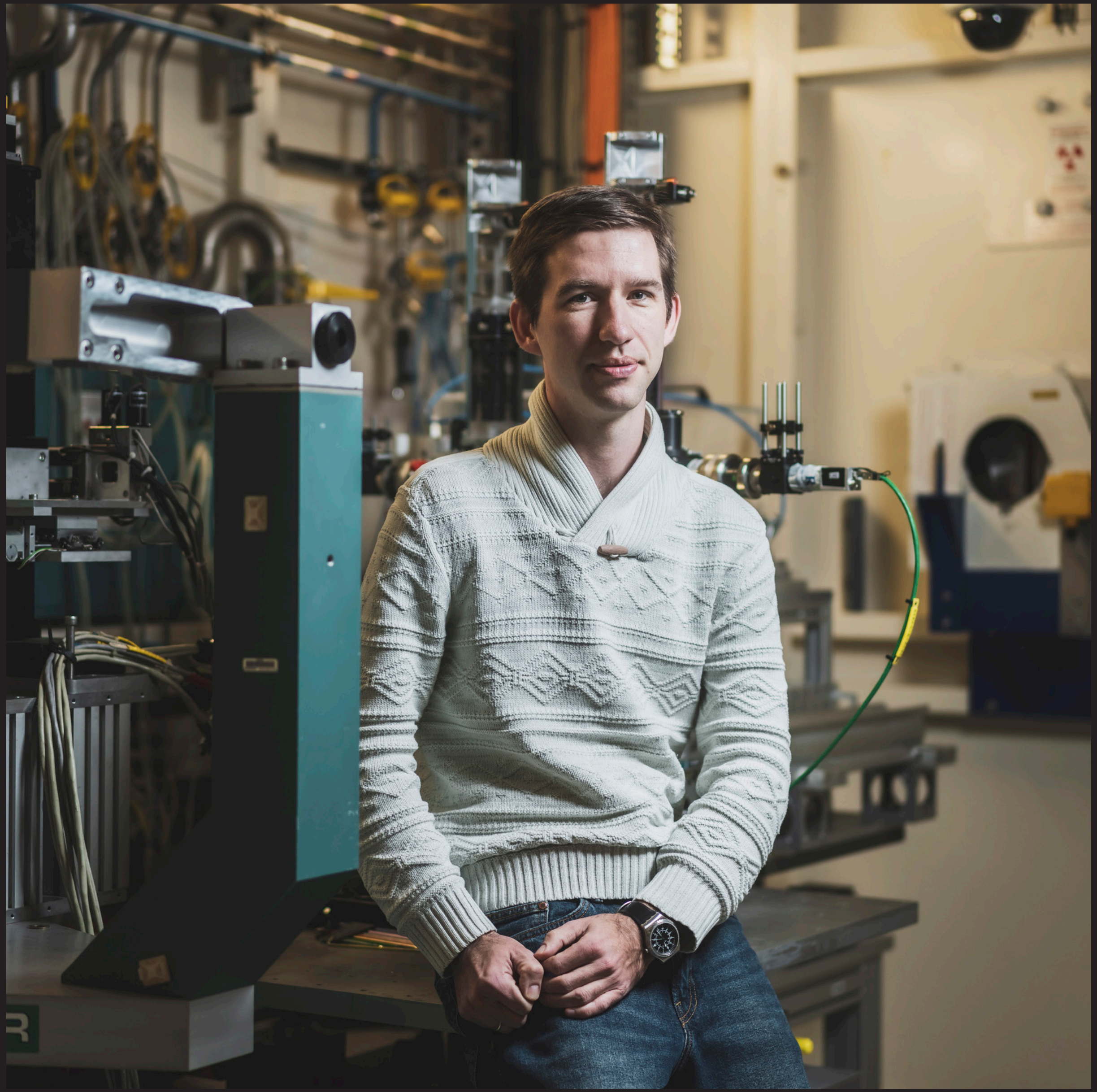

INVESTIGATING THE COMPOSITION OF THE EARTH'S CORE

ERC Starting Grant

Light elements in the core (LECOR)

The core of the Earth consists mostly of iron-nickel alloy but it should have additions of other, lighter elements that remain unknown today. ESRF scientist Ilya Kupenko will use a combination of X-ray techniques at beamlines ID14, ID28, ID27 and ID15B to study candidate compounds at extreme pressure–temperature conditions, with the aim of solving the fundamental question of the composition of the Earth's core.

"Thanks to the EBS's extremely small beam, I can study samples only a few microns in size. This makes the ESRF one of the few places – if not the only place – in the world where I can do my research."

Ilya Kupenko
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A NEW TOOL TO MAP DEFECTS IN ELECTRICALLY POLAR MATERIALS

ERC Starting Grant

3D piezoresponse X-ray microscopy (3D-PXM)

Electrically polar materials are key to essential technologies such as batteries and digital memory. ESRF user Hugh Simons will develop a new type of 'dark-field' X-ray microscopy at beamlines ID06 and ID03 to visualise electrical activity in materials in operation, with the aim to better understand how microscopic defects influence electrical activity in such materials, leading to higher-performance materials.

"The technique I am developing is based on the new capabilities of the EBS. It will allow us to investigate materials and examine their structures in a way completely different to what is available today."

Hugh Simons
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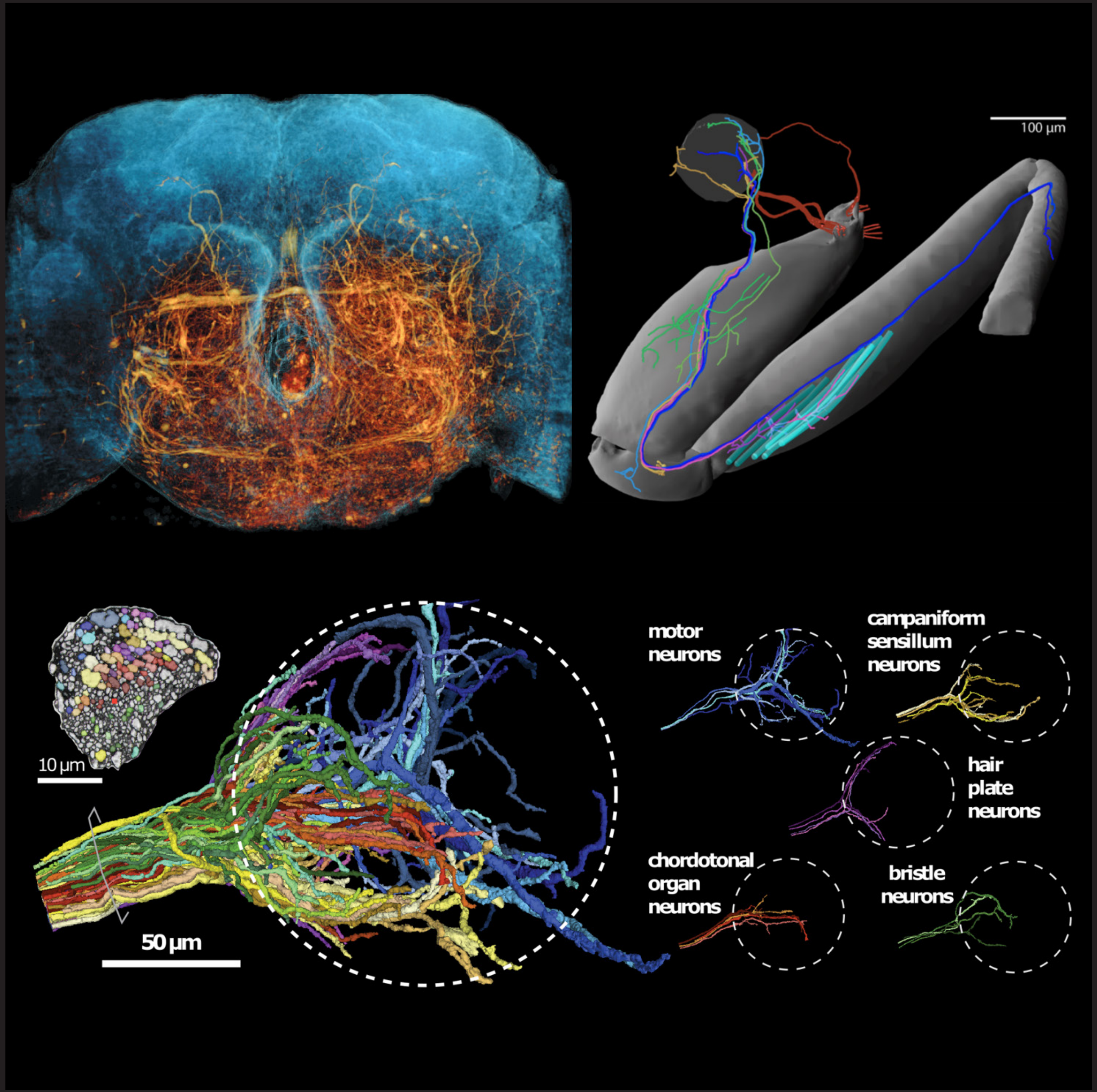
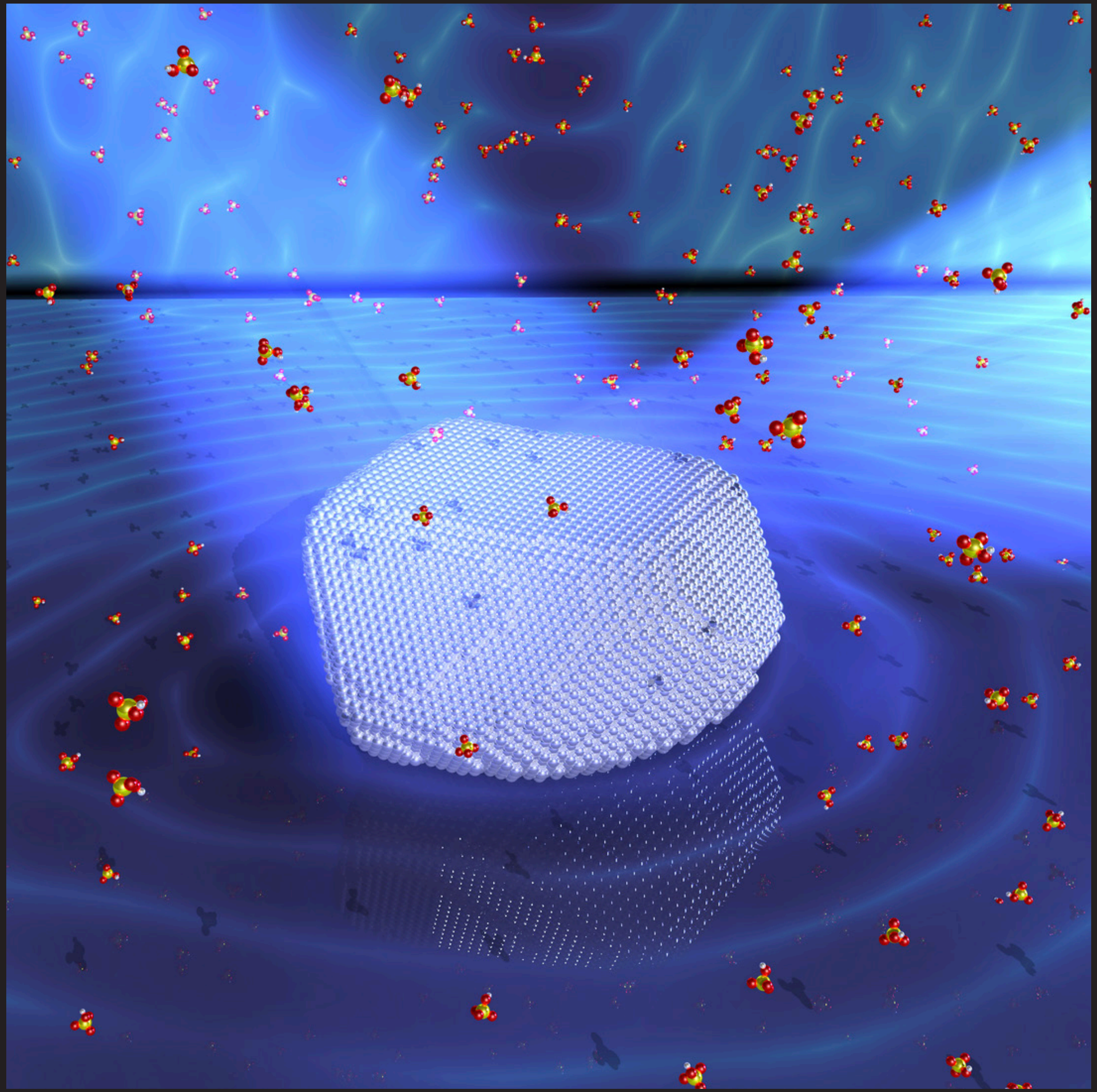


FIRST HIGHLIGHTS

- Dense neuronal reconstruction through X-ray holographic nano-tomography, A.T. Kuan *et al.*, *Nature Neuroscience* 23, 1637-1643 (2020); https://doi.org/10.1038/s41593-020-0704-9 (Left image)
- Functional and multiscale 3D structural investigation of brain tissue through correlative in vivo physiology, synchrotron microtomography and volume electron microscopy, C. Bosch *et al.*, *Nature Communications* 13, 2923 (2022); https://doi.org/10.1038/s41467-022-30199-6
- Four-dimensional X-ray micro-tomography imaging of dynamic processes in geosciences, C. Noiriel & F. Renard, *Comptes-Rendus Géosciences* 354, 255-280 (2022); https://doi.org/10.5802/crgeos.137
- Fate of Hydrocarbons in Iron-Bearing Mineral Environments during Subduction, A. Serovaiskii *et al.*, *Minerals* 9, 651 (2019); https://doi.org/10.3390/min9110651
- Probing nanoscale structure and strain by dark-field x-ray microscopy, C. Yildirim *et al.*, *MRS Bulletin* 45, 277-282 (2020); https://doi.org/10.1557/mrs.2020.89



- Imaging the strain evolution of a platinum nanoparticle under electrochemical control, C. Atlan *et al., Nature Materials* (2023); https://doi.org/10.1038/s41563-023-01528-x (Left image)

- Anomalous Glide Plane in Platinum Nano- and Microcrystals, M.-I. Richard *et al., ACS Nano* 17(6), 6113–6120 (2023); https://doi.org/10.1021/acsnano.3c01306

- Denser glasses relax faster: a competition between rejuvenation and aging during in-situ high pressure compression at the atomic scale, A. Cornet *et al., arxiv*; https://arxiv.org/ftp/arxiv/papers/2301/2301.02551.pdf

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- Bone mineral properties and 3D orientation of human lamellar bone around cement lines and the Haversian system, T.A. Grunewald *et al., IUCrJ* 10, 189-198 (2023); https://doi.org/10.1107/S2052252523000866

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