A LIGHT FOR SCIENCE

ESRF news

Number 51 September 2009

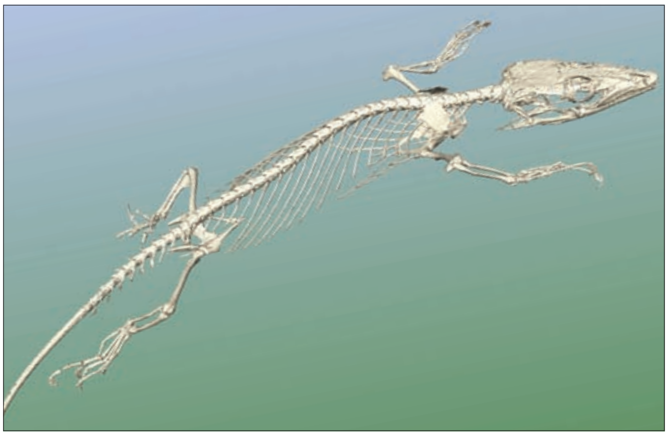
Extreme conditions

Take a trip to the centre of the Earth

Scientists look for the next best thing after diamonds

ESRF

A light for science



Scientists study the bones of the neon blue-tailed lizards. p6

Scientists attempt to create new materials similar to diamonds. p9

The directors of research evaluate their first months in office. p15

EUROPEAN SOUTHERN OBSERVATORY

On the cover: An artist's impression on extreme conditions in space. The image shows a stellar explosion.

ESRFnews Number 51 September 2009

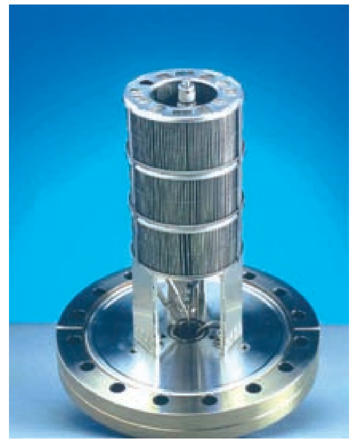
SAES® Getters' NEG Pump technology helps meet the vacuum requirements of XFEL (Spring-8) Japan.

The X-ray Free Electron Laser (XFEL) facility, adjacent to Spring-8 (Harima Science Garden City, Japan), is a joint project led by RIKEN and the Japanese Synchrotron Radiation Research Institute (JASRI) that is due for completion in 2010. The 8 GeV XFEL is a linear system approximately 700m in length incorporating a linear accelerator and in-vacuum undulators. Through the process of Self-Amplified Spontaneous Emission (SASE), coherent X-rays a billion times more intense than Synchrotron sources are emitted at femto second pulse rates. This significant advance in light source technology is expected to provide many improvements in, for example, the analysis of novel materials and atomic level imaging of fast moving systems. [1]

"SAES GP500 MK5 NEG pumps installed on the in-vacuum undulator (NEOMAX)"

The SAES Non-Evaporable Getter (NEG) pumps used at XFEL (Model: GP500 MK5 St707) are installed on the in-vacuum undulators manufactured by Hitachi Metal (NEOMAX). Each NEG pump provides pumping speeds of approximately 1900 ls^{-1} for H_2 and 650 ls^{-1} for CO in addition to high sorption rates of other active gases such as O_2, N_2, CO_2 etc. The St707 alloy (ZrVFe) effectively removes gas molecules through the process of chemisorption on the getters' active surface, and high sorption capacity is achievable through thermally driven diffusion of the sorbed gas into the getter bulk.

SAES Spectra Mat (Watsonville (CA), USA) is also providing its well tested Scandate Dispenser Cathode for the XFEL Accelerator Klystrons. These Cathodes provide moderate to high current densities at temperatures lower than other impregnant formulations, typical mean lifetime is documented at 65,000 hours.



"GP500 MK5 Getter Pump"

SAES Getters Group, the worldwide market leader in getter components for sealed-off devices and vacuum tubes, provides a wide range of Non Evaporable Getter (NEG) pumps and tailor-made NEG pump devices for supporting UHV XHV applications of all sizes.

Further details on SAES Getters products are available via the SAES Getters website and through local SAES Getters Group Sales Offices.

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[1] "Spring-8 Joint Project for XFEL" Pamphlet 2007 version – RIKEN website: www.riken.jp/XFEL

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Science under extreme conditions

During the last decades, we have witnessed an unprecedented surge in high-pressure high- and low-temperature research that has greatly improved our fundamental understanding of materials under extreme conditions. Many scientific breakthroughs have been achieved across fields ranging from Earth and planetary sciences to fundamental physics, chemistry and materials research, and extending into biophysics/biochemistry including questions concerning life and biological functions under extreme conditions. The fact that pressure can deeply modify chemical bonds and induce myriad changes in materials lies at the heart of the fundamental importance of high-pressure research. Pressure may induce order, but it can also create disorder, or transform a metal into an insulator and vice versa. Such transformations can be associated with major changes in electronic and magnetic states, including the formation of superconductors from originally insulating materials.

Another classical use of high pressure is in materials synthesis in the search for new materials with outstanding properties. Pressure can be applied to induce chemical reactions that do not occur under ambient conditions, but it can also accelerate or slow down such transformations. The materials synthesised at high pressure include new dense polymers, semiconductor phases and super-hard materials. The high-pressure transformation from graphite to diamond is the most famous example of such transformations but other super-hard materials based on light elements such as boron, carbon and nitrogen have been successfully synthesised. These new materials have great industrial potential and are promising alternatives to diamond. Pressure also plays a major role in Earth science due to its fundamental importance for the understanding of the constitution, structure and evolution of the Earth's interior under the high pressure–temperature conditions that prevail inside our planet.

"Extreme conditions science has a very bright future at the ESRF"

Research under extreme conditions (HP-HT) is being performed at many beamlines at the ESRF. These include ID27, ID9HP, ID16, ID18, ID24 and ID28, to name only the most important ones. The array of techniques that was initially restricted to structure determination using X-ray diffraction is now vastly extended to include many other X-ray techniques such as inelastic X-ray scattering, nuclear X-ray scattering and absorption spectroscopy. In this issue of *ESRFnews*, you will find highlighted recent examples of research conducted at different ESRF beamlines in the fields of physics (p9), materials science (p10) and Earth science (pp12–14).

Research on materials in extreme conditions has been identified as one of the main science drivers for the Upgrade Programme of the ESRF. Current planning for the Upgrade includes a significant increase in capacities for extreme conditions science. In this context, ESRF and ILL have taken the initiative for the creation of a Partnership for Extreme Condition Science (PECS), which is also introduced in this issue (p11). PECS is targeted at the next level of scientific and technical integration supplying not only improved beamlines but also an extended support structure for the benefit of the entire user community in extreme conditions science.

Extreme conditions science is a vibrant field being pushed around the globe in many institutions. Our efforts within the Upgrade Programme ensure that extreme conditions science has a very bright future at the ESRF.

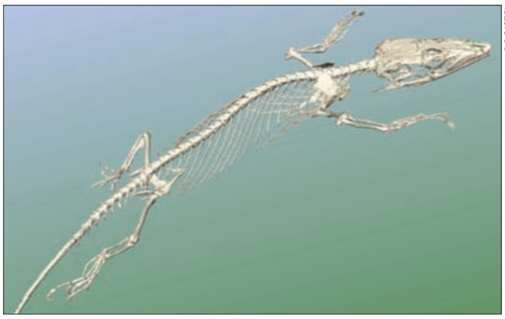
Harald Reichert, director of research and **Mohamed Mezouar**, scientist in charge of ID27

The ESRF shows how lizard descends

There are several species in the world that have evolved the ability to control their aerial descent by parachuting or gliding to the ground. These animals have developed a morphology that allows them to control their descent. This is not the case for the African neon blue-tailed tree lizard (*Holaspis guentheri*), which has nevertheless been seen "gliding" without having any external specialisations such as skin flaps or membranes.

Scientists from the University of Antwerp (Belgium) and the Musée National d'Histoire Naturelle (France) decided to find out whether these reptiles control their descent when jumping from tree to tree. Their first approach involved filming neon blue-tailed tree lizards, gliding geckos (*Ptychozoon kuhli*) and the common wall lizard (*Podarcis muralis*) as the animals leapt from a 2 m high platform. They then visited the ESRF to study the internal structure of the animals.

At first, the video clips did not show any obvious indications that the African lizard could control its descent any better than the common wall lizard. Both species were able to cover horizontal distances of 0.5 m after leaping from the platform, while the gliding gecko covered distances greater than 1 m, aided by its webbed feet and skin flaps. However, the tree lizard only weighs 1.5 grammes, only one-third of the larger common wall lizard's weight and one-tenth of the gliding gecko's mass. This indicated that the tiny lizard travelled 20 cm farther than the wall lizard, and was slowing down its descent considerably, demonstrating that it did show a controlled aerial descent. The team also realised that instead of increasing its surface area to generate lift, the tree lizard is able to control its descent because it is so light.



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Left: the bone structure of the neon blue-tailed lizard was analysed on ID17 and ID19 at the ESRF. Above: the neon blue-tailed tree lizard.

This is where the ESRF comes in. The team analysed the skeletons of the three species of animal on ID17 and ID19 to study their internal structure. Thanks to the X-rays, they could see that the tree lizard's bones were light, not strongly ossified and full of foramina, making its skeleton light for gliding. "I was fascinated that by using this non-destructive technique the skeletons of small organisms, like this lizard, can be visualised in such great detail. Without these images, we could only speculate about how the animals get so light. When Anthony Herrel told us about the possibility of getting this information in collaboration with the French group, I was thrilled," says Bieke Vanhooydonck, the main leader of the team.

The next step for the team is to investigate other gliding lizards and frogs to see whether they have evolved similar adaptations to control their descent when jumping out of trees.

Reference

B Vanhooydonck *et al.* 2009 *J. Exp. Biol.* **212** 2475–2482.

Users' corner

Following the 1 September deadline for proposal submission, the next Beam Time Allocation Panel meetings will take place on 22 and 23 October. Decisions will be communicated to proposers early in December.

The plenary session of the 20th ESRF Users' Meeting will take place on 10–11 February 2010. It will last one and a half days to include more oral presentations and a general discussion session. More details will be published in the next issue of ESRFnews.

News from the beamlines

- **The new structural biology small-angle scattering beamline ID14-3** was officially inaugurated in June 2009. Small-angle X-ray scattering (SAXS) allows the shapes of proteins in solution to be studied – particularly useful for studies of proteins that fail to crystallise, making normal crystallographic techniques impossible. For proteins that do crystallise, SAXS can provide complementary data to verify that their structure in crystal is representative of their structure in solution. The beamline is the fruit of a successful collaboration between the ESRF and the EMBL Grenoble outstation. The most recent addition to the beamline is a robotic sample changer, which will enable higher throughput and increased reliability.
- **A high-pressure gas system** will be installed on BM26A to enable high-pressure catalysis experiments under gas flow. This will be available early in 2010.
- **A Pilatus 300 k detector** for WAXS experiments will be available on BM26B from September 2009.
- **The Non-Crystalline Diffraction (NCD) station of BM16** is now equipped with a gas-filled detector, which has been designed and manufactured at the Spanish synchrotron source, ALBA. The large sensitive surface (200 × 200 mm^2), low background and high sensitivity make this detector ideal for SAXS studies of proteins in solution.
- ***In situ* measurements of electrical polarisation (P-E loops)** are now possible at XMaS, for example for the study of ferroelectric and multiferroics. The next XMaS Users' Meeting will take place on 17 November at Diamond. It will be held jointly with Diamond I16 and I07 beamlines.
- **A website presenting best practices to perform *in situ* electrical measurements** on multiferroics at X-ray or neutron facilities is now available online at www.npl.co.uk/advanced-materials/materials-areas/functional/x-ray-and-neutron-scattering-in-multiferroics-research. This website is based on the subjects tackled during the workshop on multiferroic materials co-organised by XMaS, the UK National Physical Laboratory and the Institute of Physics, which took place in June.
- **There is a new sample environment on ID01.** Recent developments of ID01 make micro and nanobeams available for the study of individual nano-structures by using local probe X-ray diffraction (XRD). A new component is available on the beamline and it allows scientists to carry out μ-XRD experiments in a controlled temperature environment. The sample holder incorporates a PELTIER element, which permits a temperature range of –20 to +80 °C and in a helium atmosphere. A Lakeshore 332 controller, associated with a Pt-100 sensor, guarantees a temperature control of ±0.001 °C. The system has been designed by Hamid Djazouli, from ID01, with Peter van der Linden, from the Sample Environment Support Group, for a user experiment to investigate the size dependence of a temperature-driven phase transition. For more information, contact id01@esrf.fr.

Theoreticians are awarded prizes

The theory group is celebrating prizes for two of its scientists. Head of the group, Patrick Bruno, has recently been laureate twice. The Czech Academy of Sciences has just awarded him the Ernst Mach Medal. At home, the French Physical Society presented him with its Grand Prix Jean Ricard for 2009. Another theoritician, Luigi Genovese, has just received the French national prize Bull-Joseph Fourier for developing a programme called Big Density Functional Theory (BigDFT), which can assemble the electron-density pattern for groups of thousands of atoms.

The ESRF films the birth of a molecule

When two molecules fuse together, the reaction takes place too fast to track at the molecular level with standard visualisation techniques. However, scientists from the Centre for Molecular Movies at the University of Copenhagen (Denmark) have used X-ray scattering to film the formation of a large platinum-containing molecule from smaller blocks that were activated by short flashes of light from a laser on ID9B. Each image in the film represents less than a millionth of a millisecond.

This achievement could help make more effective chemicals and enzymes for everything, from waste-water treatment plants to catalytic converters in cars.

Reference

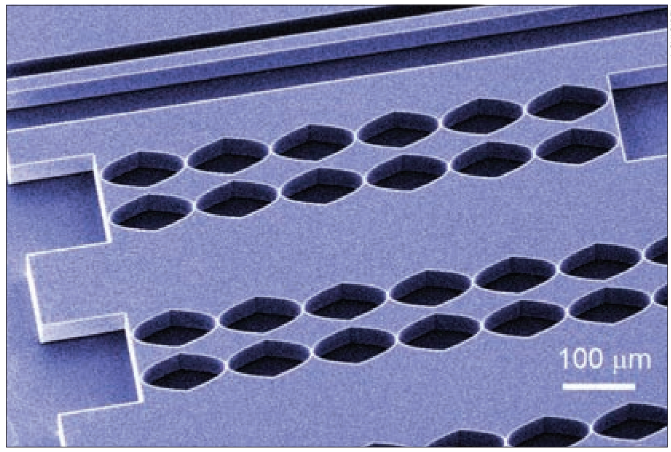
K Haldrup *et al.* 2009 *Angewandte Chemie International Edition* **48** 4180–4184.

Science groups receive new names

The aim of the new ESRF group names, which were announced at the Science Advisory Committee meeting last May, is to describe the science covered by them and to have coherence within the groups.

Group 1: Structure of Materials
Group 2: Electronic Structure and Magnetism
Group 3: Dynamics and Extreme Conditions
Group 4: X-ray Imaging
Group 5: Structure of Soft Matter
Group 6: Structural Biology

New nanointerferometer employs a bilens system



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Scanning electron microscope image of a single silicon bilens consisting of six parabolic lenses. The bilens was selected by the editors of *Physical Review Letters* to feature on the journal's cover.

It is 151 years since the French physicist Félix Billet proposed in his Physical Optics book to cut lenses into two parts to split beams and measure the coherence in the overlapping section of the two beams. Today, scientists from the ESRF, the Kurchatov Institute in Moscow and the IMT RAS in Russia, have developed a new X-ray interferometer using a bilens system. It consists of two parallel compound refractive lenses, each of which creates a diffraction-limited beam under coherent illumination.

Scientists study the region where the coherent beams overlap. Contrary to double slits, bilenses can be tunable to energies that are as high as necessary and they are fast. Furthermore, the bilens system could potentially be used to study samples down to 10 nm.

"Our idea is to apply these lenses to study mesoscopic materials: photonic or colloidal crystals or self-organised materials," explains Anatoly Snigirev, the driving force of the project. "In addition to conventional nanoprobes based on these lenses, nanointerferometers will surely play an important role in the Upgrade programme."

Reference

A Snigirev *et al.* 2009 *PRL* **103** 064801.

Study unravels the secrets of natural nanoparticle formation

Using the X-rays of the ESRF, scientists from the University of Leeds (UK) have shown for the first time how silica nanoparticles form in a solution, illuminating a process that is fundamental to understanding our natural environment.

Although silicon is perhaps best known for its use in industry – for example, in silicon chips – silica (SiO_2) nanoparticles are very abundant in the natural world: in the soil beneath our feet, the skeletons of microorganisms in the ocean, hot springs and geysers in Iceland and Yellowstone National Park, and even in the Earth's atmosphere.

Now scientists have been able to directly follow, *in situ* and in a time-resolved manner, the solution-based nucleation and growth of tiny silica nanoparticles – one of the building blocks of our environment, which are just 2–8 nm across. The experiments took place on the DUBBLE beamline at the ESRF.

Previously, scientists had characterised this process solely from the changes in the solution chemistry and it was not feasible to characterise this natural process due to the technical challenges of quantifying the initial stages of the formation of such tiny particles in solution.

The team from the University of Leeds was able to mimic the natural conditions in which these nanoparticles form, allowing them to observe the leap from individual dissolved ions to particles. The results show that these mineral particles form in a matter of minutes and they remain stable for several hours. However, unlike industrial nanoparticles, they are formed as part of a natural process happening every day on the Earth's surface.

"If we understand how the first atoms of silicon get together to form particles we can understand the fundamental first steps of the formation of silica-containing minerals and the skeletons of microorganisms," says Sam Shaw, one of the two team leaders of the study.

"Tonnes and tonnes of silica are produced for industrial applications, but we can now simulate and quantify exactly how nature forms silica nanoparticles, which are equally ubiquitous. This knowledge could have very far-reaching applications. For example, we have found silica deposits on Mars, so it's likely that this process may have happened there too," explains Liane Benning, also team leader of this research.

Reference

D J Tobler *et al.* 2009 *Geochim. Cosmochim. Acta.* **doi:10.1016/j.gca.2009.06.002.**

Photonic Science
Scientific Detector Systems

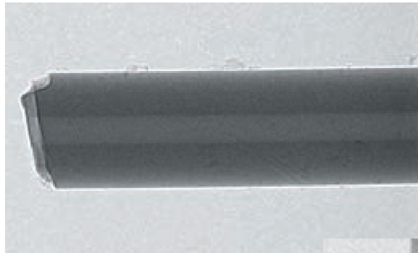
Very High Resolution VHR X-ray CCD offers 11 up to 32 Mega pixel resolution

Photonic Science delivers a new generation of complete X-ray CCD systems for home lab and synchrotron facilities.

These cameras are routinely used for highly demanding imaging applications such as Nano/Micro CT, Phase Contrast Diffraction, Enhanced and Coherent Diffraction.

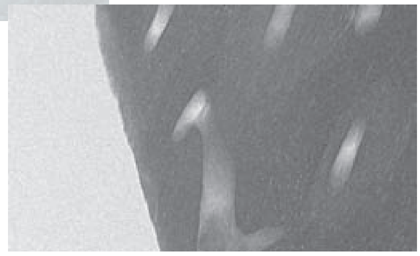
The VHR camera is available with input sizes ranging from 18 mm x 12 mm with 3.7 micron pixel size up to 132 mm x 104mm with 21.4 micron pixel size.
Single crystal and structured scintillator design allows to cope with both low and high energy operations without compromising on resolution.

GigE or Camera link interfaces will enable a fast data transfer to PC whilst maintaining 100% continuous duty cycle acquisition. Full software development kit/socket/SPEC drivers provided as standard.



Tungsten filament rod, phase contrast edge enhancement @ 500nm resolution, 30 sec exposure using 40 kV 50 μA nanofocus source.

Camera VHR 11M 1:1



Ostecocytes cells, 100 micron bone section, 500nm resolution, 30sec exposure using 40 kV 100 μA nanofocus source.

Camera VHR 11M 1:1

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Finding the next best thing after diamonds

New materials with better properties than diamond have come to light after testing them at the ESRF.

Apart from its use in jewellery, diamond is highly valued and widely used in industry.

Most people associate diamonds with jewellery, but these gemstones go beyond beauty. They are the hardest natural material known and are highly valued by industry for this property. Industrial uses include cutting, drilling, grinding and polishing. However, there are a few drawbacks: diamonds strongly resist heating and as soon as they are in contact with a metal, they ally with it. This is why researchers are in pursuit of substitutes for diamonds with a better conductivity and more resistance to temperature and corrosion.

To create new materials, scientists focus on the periodic table. Carbon, the source of diamonds, is not the only element that is linked to hardness. Boron and nitrogen also form strong, short chemical bonds. In 1956 scientists combined boron and nitrogen to create cubic boron nitride (cBN), which has been used as an alternative for synthetic diamonds. However, it only has half of the hardness of diamond.

A team from the Institute for Superhard Materials in Ukraine, together with scientists from the University of Paris, the University of Bayreuth (Germany) and the ESRF, managed to combine carbon, boron and nitrogen in one material in 2001. The result, cubic BC_2N, is a compound that is halfway between diamond and boron nitride in composition. The team applied a pressure of 18 GPa and temperatures above 2200 K, which triggered the appearance of a new phase. Although the new compound is not as hard as diamond, it is harder than its predecessor, cBN. Despite the fact that it was synthesised eight years ago, the paper on BC_2N is still in the limelight (Solozhenko *et al.* 2001). Proof of this are the 150 citations that it has had – 80 of which were in 2008.

A cheap, super-hard material

The financial cost of developing these new materials at a mass-production rate will determine whether they will be used in industry. A potentially cheap solution for an ultrahard material is the result of research done by the University of Bordeaux and the University of Clermont-Ferrand (France).

The team studied a carbon nitride under high pressure and temperature, but the first experiments failed. The scientists soon noticed that there was a small portion of the structure that was already surprisingly super-hard at ambient conditions. The team then decided to isolate the small particle, compress it and characterise it.

The results proved that, in accordance with previous theoretical predictions, crystalline carbon nitrides exhibit exceptional compressibility behaviour. In addition, despite the usual considerations, the team demonstrated that there is no need for severe and expensive pressure and temperature conditions to elaborate low-compressibility, covalent materials (Goglio *et al.* 2009).

The downside of this story, and most of the stories linked to creating new materials, is that their production is still at a very small scale. In most cases, when scientists try to increase the production, the material decomposes, which means that the phases are very fragile. However, the creation of new hard materials is progressing swiftly and researchers generally comment that it is only a question of time until new materials can be synthesised in large quantities.

Industrial interest

A team from the University of Bayreuth has already managed to raise the interest of industry in their patented Aggregated Diamond Nanorods (ADNRs), a new material synthesised in 2005 based on bulk samples of nanocrystalline diamond and identified at the ESRF as the densest form of carbon (Dubrovinskaia *et al.* 2005).

Results showed that the ADNRs' density is greater than that of diamond by 0.2–0.4% and is 11% less compressible. The combination of the hardness of the ADNRs and its chemical stability could make it a potential material for machining hard materials, grinding and polishing, as well as for use as anvils in scientific devices like diamond anvil cells and multi-anvil presses.

Another new material that is attracting the interest of industry is the super-hard aggregated boron nitride nanocomposite (ABNNC), synthesised by the same team and tested at the Swiss Norwegian Beamline at the ESRF (Dubrovinskaia *et al.* 2007). ABNNC is the first non-carbon-based bulk material with a value of hardness approaching that of single crystal and polycrystalline diamond and ADNRs. ABNNC also has unusually high fracture toughness and wear resistance, as well as high thermal stability (above 1600 K in air), making it an exceptional superabrasive.
M Capellas

References

N Dubrovinskaia *et al.* 2005 *Appl. Phys. Lett.* **87** 083106.
N Dubrovinskaia *et al.* 2007 *Appl. Phys. Lett.* **90** 101912.
G Goglio *et al.* 2009 *Diamond & Related Materials* **18** 627–631.
V L Solozhenko *et al.* 2001 *Appl. Phys. Lett.* **78** 1385–1387.

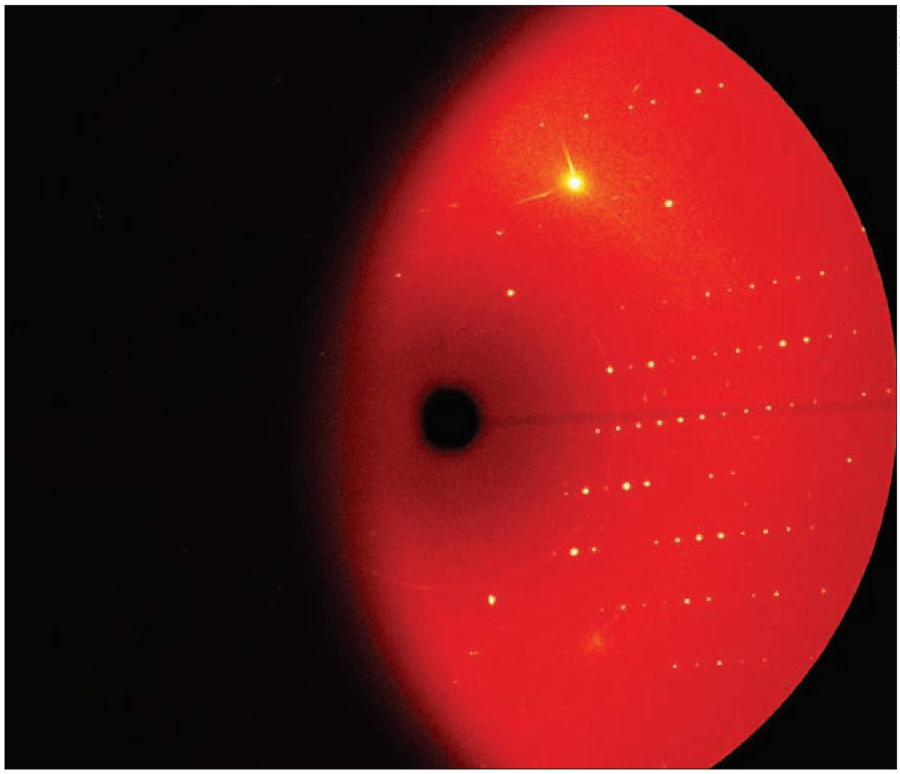
Elements change from insulator to conductor, and vice versa

Many elements, such as oxygen, are insulating at room temperature, but if you put them under pressure you get materials that don't have electrical resistance. The other way round, which is a more exotic event, takes place with elements such as lithium or sodium. Scientists are slowly managing to understand why and how these events happen.

Oxygen is the third most abundant element in the universe by mass, after hydrogen and helium. More than 20% of the volume of air consists of oxygen. Despite its predominance, its behaviour under pressure is still not clear to researchers. Above a pressure of 96 GPa (about a quarter of the pressure inside the Earth's core), oxygen has shown a metallic phase, but scientists have only recently determined the changes in its crystalline structure.

A team from the Commissariat à l'Energie Atomique (France), the University of Ottawa (Canada) and the ESRF, clarified a standing debate on the transition of the element from the insulator to the metallic phase (Weck *et al.* 2009). They used angle-dispersive X-ray diffraction on three single-crystal samples of oxygen embedded in helium at ID27 – the high-pressure beamline. The results showed the atomic displacements leading to the new structure. Metallisation takes place due to the closure of the band gap that occurs with an instability of the lattice, which evolves into a denser structure with the dissociation of molecular entities.

The metallic oxygen can transform even further. Above 250 GPa, theoreticians predict that it transitions to an atomic metal. "This is the next challenge for ID27, providing that the users grow good quality single crystals at these conditions," explains Mohamed Mezouar, the scientist in charge of the beamline.



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Composite diffraction image: data from the one of the phases of sodium with 90 atoms in unit cell.

Weird metals

The opposite effect from oxygen under pressure takes place when metals, such as sodium and lithium, become compressed. They both belong to the group of lighter elements classified as "simple metals", meaning that they have simple crystal and electronic structures. However, under pressure they adopt different physical states. Recently, two separate teams (Ma *et al.* 2009 and Matsuoka *et al.* 2009) discovered that sodium and lithium are actually insulating when under pressure and that sodium becomes transparent, using Raman spectrometry and the Advanced Photon Source in Chicago (US) (Ma *et al.* 2009).

The pioneering experimental work on lithium and sodium under high pressure was started at the ESRF on the beamline ID9A several years ago. It was known that under ordinary conditions sodium adopts a straightforward crystal structure, but under high pressure, and therefore high density of the metal, things change. For starters, the melting temperature of sodium is lower at high pressure (118 GPa) than at ambient conditions. Today, a team from the University of Edinburgh (Gregoryanz *et al.* 2008) and the ESRF found that seven different crystalline phases are reached in a very small region of pressure–temperature domain, in the vicinity of the sodium's melting curve minimum. Slight changes in pressure or temperature set off new transitions, some of which are very complex and had never been observed in any other element before. One of these structures contains more than 500 atoms in the unit cell.

"Sodium and lithium are actually insulating when under pressure"

The team carried out their experiments on ID27 using single-crystal diffraction. They identified the lattice parameters and the number of atoms of all seven phases. The results for sodium shed light on theoretical models that predict bizarre states for other materials, such as hydrogen.

M Capellas

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E Gregoryanz *et al.* 2008 *Science* **320** 1054.
Y Ma *et al.* 2009 *Nature* **458** 182–185.
T Matsuoka *et al.* 2009 *Nature* **458** 186–189.
G Weck *et al.* 2009 *PRL* **102** 255503.

ESRF and ILL plan to put extreme research forward

Experiments using high pressure and temperature represent a classic field of research at the ESRF and the ILL. A Partnership for Extreme Condition Science (PECS) could marry expertise and techniques from both labs, which could benefit the whole community.

The ESRF Upgrade's new possibilities

With the Upgrade of the ESRF, new research opportunities will open up, such as: ultrahigh-pressure and low-temperature experiments; multi-anvil press experiments with white and monochromatic beam; ultrahigh pressure and temperatures XRD experiments with a double-sided laser heating system and a Paris–Edinburgh large-volume cell; and XAS measurements at ultrahigh temperaturesand pressure.

Spot sizes will decrease as well, namely on ID28 and ID16 today (UPBL6): in the first one, the flux density will be enhanced by more than a factor 20 thanks to a focal spot size of 15 × 5 μm^2, in the latter, the aim is to obtain a spot size of a few microns, ideally 5 × 5 μm^2, to probe electronic excitations of highly compressed materials using IXS. Finally, *in situ* studies of the structure, dynamics and electronic and magnetic properties of highly compressed materials simultaneously will be possible on ID18 (UPBL3).

Seven beamlines are ordinarily carrying out experiments under extreme conditions at the ESRF. What used to be complicated experiments have become routine and the development of new techniques in synchrotron radiation has allowed the "high-pressure community" to advance by leaps and bounds throughout recent years in their race for more challenging experiments. From using mostly X-ray diffraction (XRD) for the structural analysis of the samples, the techniques for extreme-conditions research have extended to inelastic X-ray scattering (IXS), nuclear inelastic scattering (NIS), extended X-ray absorption fine structure (EXAFS), X-ray magnetic circular dichroism (XMCD), X-ray Compton scattering and X-ray magnetic scattering. The future looks equally promising.

Following on from the success of this domain, the Upgrade Programme will focus on dedicated beamlines to high pressure in order to reach pressures and temperatures that are still not attainable today. The beamlines involved will be ID15, ID27, ID6, ID28, ID16 (Upgrade Beamline 6), ID24 (UPBL11) and ID18 (UPBL3). Equally, the ILL is preparing a pioneering high-pressure programme in neutron research for the years to come. The favourable timing of these two projects, coupled with the need of strong support infrastructures to ensure the successful operation of the upgraded instruments, makes the creation of a Partnership for Extreme Condition Science very auspicious.

"The new partnership will facilitate collaborations with long-term users for developing new instruments"

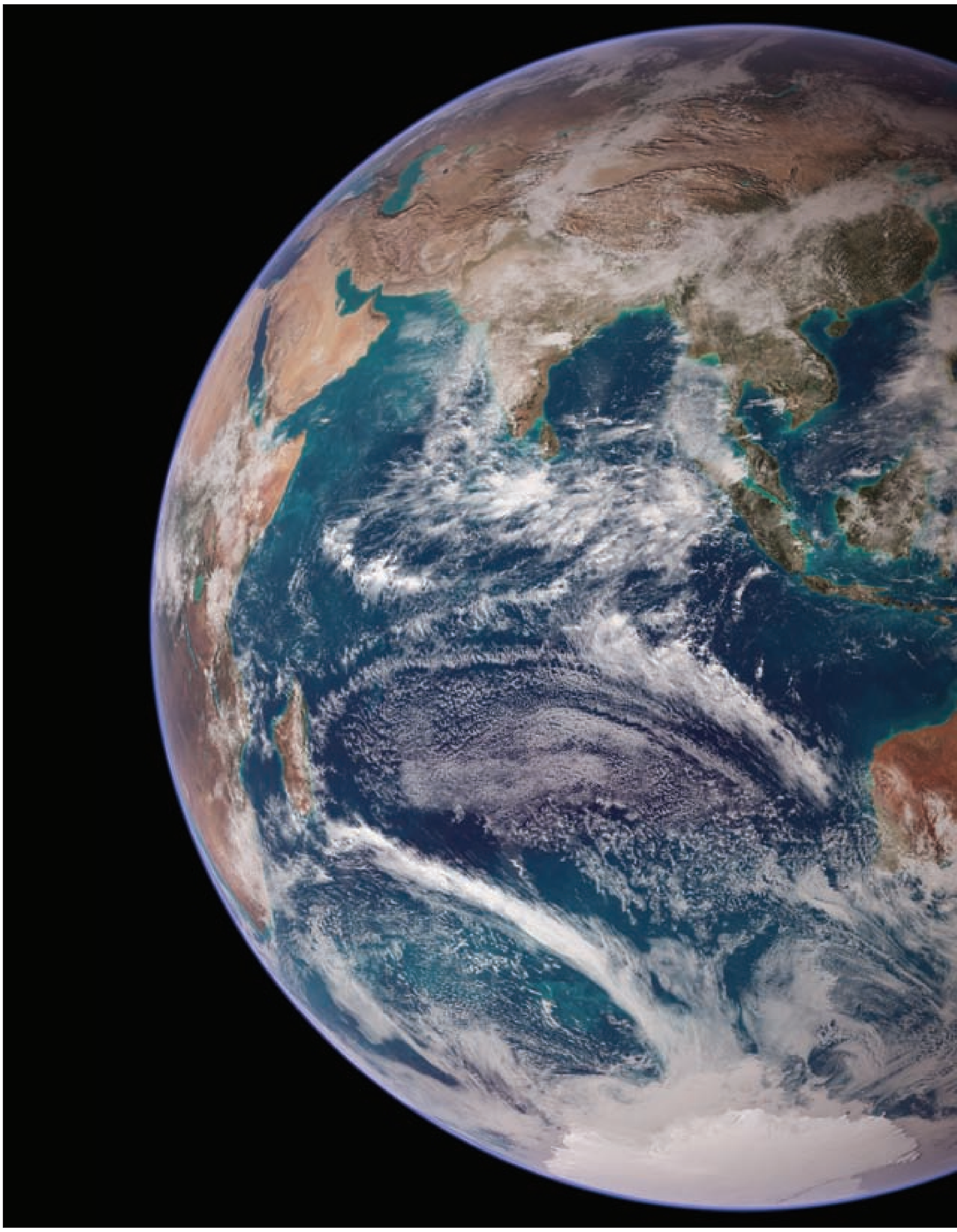
The new partnership intends to create and implement complex high-pressure and high- and low-temperature environments fully adapted to specific ESRF and ILL instrumentation. State-of-the-art sample manipulation and characterisation equipment for off-line testing will also be available. Another aim of this alliance will be to facilitate collaborations with long-term users for the development of new instruments that would benefit the whole community.

It is still early days for the partnership, but the ESRF and ILL are already actively consulting the high-pressure community. Harald Reichert, director of research at the ESRF, says: "We want to hear what our users have to say about this initiative and what their needs are. It is extremely important for us, and this is why we are having a session on this matter in the annual meeting of the European High Pressure Research Group in September."

M Capellas

Take a trip from the centre

The Earth is still an enigma. But the ESRF is helping to demystify our planet, its composition and inner activity.



The Earth as it is viewed from space. Earth ranks fifth in size among the nine planets that make up our solar sys

Geologists believe that Earth was struck by a planet the size of Mars about 4.5 billion years ago. The impact led to the formation of our satellite, the Moon and melted most of the planet's rocks, creating its core, as the metallic iron between the rocks sank towards the centre. Therefore, iron is of major interest in the scientific community. Despite it being physically impossible to access the Earth's core, high-pressure experiments at synchrotron sources can provide major clues about the role that iron and other materials play in the core.

The Earth's core is divided into two zones: the outer core, which is liquid, and the inner core, which is solid. The main component of the core is iron, which is crystallised in the inner core. Scientists know this because the speed of sound through the core (the velocity at which seismic waves travel across it) and the density of the core are similar to those seen in iron at high pressures and temperatures. On top of that, iron is sufficiently abundant in the universe to make up for approximately 35% of the mass of the planet present in the core.

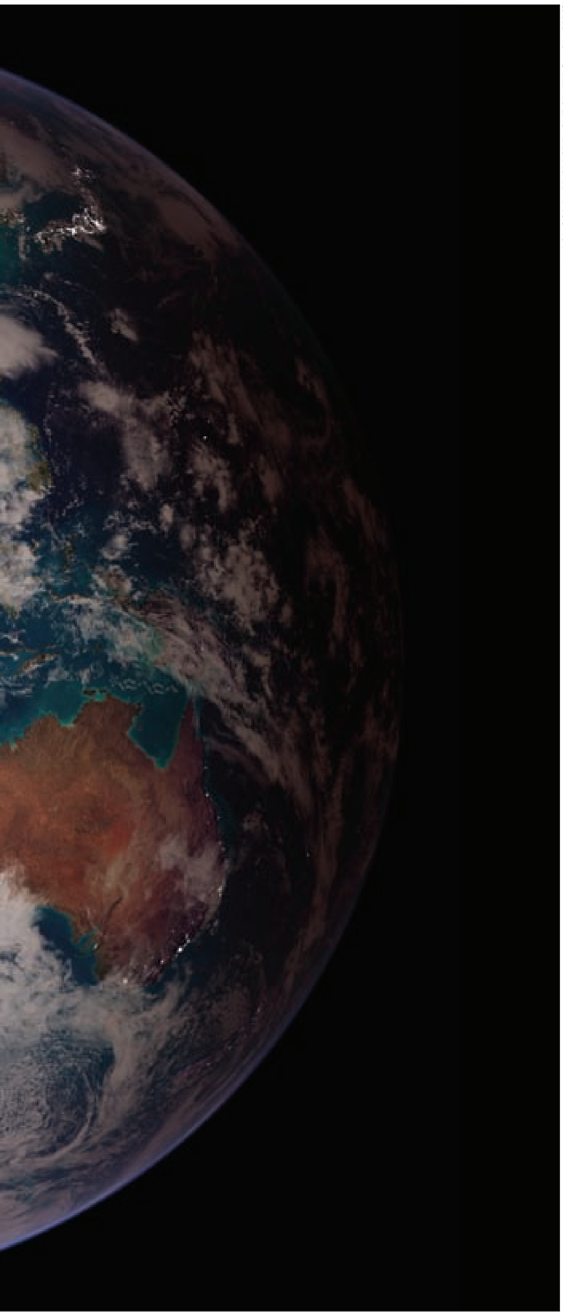
However, iron is not alone in the core. The core should contain ~10% wt of nickel and, more importantly, seismology shows that both parts of the core are too light to be pure, dense iron–nickel alloy. The outer core could have 6–10% wt of lighter elements, while the inner core would contain 2–3% wt. The candidates that could potentially mix with iron are sulphur, silicon, carbon and oxygen.

The case of sulphur

It is quite likely that sulphur is present in the deepest sector of the Earth because meteorites contain this element abundantly. A team from the University of Paris and the University of Clermont-Ferrand (France) is studying how sulphur fuses with iron at high pressure and temperature. It focuses on how it crystallises and what phases form when mixing it with iron. The team recently published the results of experiments on ID27 at the ESRF, where it studied the fusion temperature of an alloy of iron and sulphur (Fe-FeS) (Morard *et al.* 2008 and 2009). They discovered that when adding sulphur to iron the melting temperature decreases by almost 1000 K and at extreme pressures acts as an antifreeze. However, iron is not the first phase to crystallise below the melting temperature but Fe_3S, implying that sulphur gets trapped in the solid phase (for plausible sulphur contents). Researchers also point out that sulphur enters the structure of liquid iron as an impurity, without disturbing the local structure.

The results contest the hypothesis that the crystallisation of the inner core, which still happens at a rate of 800 tonnes per second, rejects enough sulphur to the outer core to match the 6–10% wt density deficit. At the same time, seismological measurements state that there is a big difference in density between the inner and outer cores, so there needs to be a rejection of elements. Those light elements, when rejected, facilitate the convection to the outer core and allow the magnetic fields to take place. A paper, mainly based on *ab initio* calculations (Alfe 2002), suggest that sulphur would become increasingly compatible with solid iron at increasing pressure and that sulphur would not be rejected to the outer core (so sulphur could not explain the density difference between the inner and outer cores). Chrystéle Sanloup, a scientist at the University of Paris, concludes

e of the Earth to its surface



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tem. It has a diameter of about 13 000 km.

The Earth's layers

Layer	Distance from surface (km)	Pressure (GPa)	Temperature (°C)
Crust	0–35	<1	200–600
Upper mantle	35–660	1–25	600–1600
Lower mantle	660–2890	25–136	1600–4000
Outer core	2890–5150	136–330	4400–6100
Inner core	5150–6360	330–360	6100K (±500K)

that "sulphur cannot be rejected in sufficient quantities to match the seismological data, so we have to look for other elements – silicon and oxygen being the best candidates".

Silicon and oxygen

Observing the speed at which seismic waves pass through the Earth allows geophysicists to determine the density and stiffness of rocks at inaccessible depths. If they can match those properties with those of known substances at elevated temperatures and pressures, they can subsequently infer what the conditions must be deep in the Earth.

At the ESRF, a team from the Institut de Minéralogie et de Physique des Milieux Condensés at the University of Paris studied the sound velocity in solid iron alloyed with light elements using high-resolution inelastic X-ray scattering on ID28 (Badro *et al.* 2007). It ruled out sulphur as a possible light element in the core and proposed that the inner core is made of iron, silicon (2.3% wt) and traces of oxygen. If extrapolated to the liquid state, the team suggests that the outer core could contain 2.8% wt silicon and 5.3% wt oxygen. Silicon and oxygen can be partly dissolved in iron, so the total amount of light elements in the inner core would be 2.5% wt, and 8% wt in the outer core.

More recently, the team studied silicon bearing iron–nickel alloys and compared them with pure iron. The results, which have been submitted for publication, show a model for the contribution of silicon and nickel to the Earth's inner core.

On the boundaries between the core and the mantle: the weird D'' layer

The core still has many surprises in store, as does the mantle surrounding it. At the boundary between the two zones there is the so-called D'' layer. This heterogeneous layer can have from no thickness to about 250 km.

The bizarreness of the D'' layer is the subject of debate among geologists. Some link it to the fact that supposedly there are expelled elements from the core that reach the mantle, where they will create hotspots, plumes, etc. Others blame the partial fusion of the material present, which mixes with other materials like water and the phase transition of silicate-perovskite (analogue to the calcium titanium oxide mineral found in the Earth's crust) to post-perovskites. Finally, there is another point of view that states that the culprit is the slabs in the subduction zone, which sink onto the D'' layer area, transforming it into a "slab graveyard".

The quest to decipher the strangeness of the D'' layer could provide the community with a lot of valuable information about the Earth's dynamics. The team from the University of Clermont-Ferrand has recently tried to determine the density and anisotropy of magnesium- and iron-containing silicate perovskites on ID24 and ID27. It also investigated post-perovskite of the same material, which occurs when pressure increases in the lower mantle. The idea was to determine whether the phase transitions in perovskite are at the origin of seismic discontinuities in the zone. The post-perovskite transition could also provide information about the temperature variations of the D'' layer. At the time of *ESRFnews* going to press, a very promising paper addressing these questions was in the submission process (Andrault *et al.* 2009).

It is crucial to study perovskites with iron, even if it is technically more complicated, because iron is a transition element that can change its electronic structure under pressure and, as a consequence, the way that the Earth's interior behaves. Researchers from the University of Bayreuth carried out nuclear resonance experiments on ID18 and ID27, as well as at the Advanced Photon Source, on lower-mantle perovskites. The goal was to measure the spin-state transitions of iron in the perovskite. Surprisingly, they found a stable intermediate spin state throughout the lower mantle (McCammon *et al.* 2008).

Closer to the surface: the subduction zone

The lower mantle might be the destination of ocean plates when they become too cold and sink. The plates are taken from the subduction zones, from where they are driven back to the mantle, beneath another continental or oceanic plate. The reactions happening in the subduction zone are directly linked to earthquake and volcanic activity. The materials in this area react with the water present and take it back to the surface or send it down to the mantle. Dehydration of the rocks of the subduction slabs could trigger earthquakes. Scientists from the University of Lyon are trying to confirm this model by studying the materials present in the subduction zone, such as talc (a mineral resulting from the metamorphism of magnesian minerals such as serpentine, pyroxene, amphibole, olivine, in the presence of carbon dioxide and water) or antigorite (the high-pressure variety of serpentine, containing 13% wt of water).

Talc commonly hydrates ultramafic rocks

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A collision from a Mars-sized object hitting the Earth would form our Moon from the debris.

(rocks with high magnesium and iron content and low silica content) and it contains about 4.7% wt of water. In silica-rich rocks and under pressure, talc dehydrates and could play a role in the seismic activity of young subducting slabs (Chollet *et al.* 2009).

The team applied high pressure to the talc on ID27 and found that the rate of water release by the dehydration of talc is faster than the relaxation of the rocks. This implies that the water can't escape the rock easily when it is under pressure, and this can induce hydraulic rock fracture and, consequently, cause earthquakes. These results are in accordance with previous experiments on antigorite, which showed similar rates of dehydration and of rock relaxation. Therefore, the dehydration of minerals containing water may eventually be fast enough to trigger unexplained deep earthquakes.

And then, there is us

From the Earth's core to the subduction zones, everything going on inside our planet could have consequences on the surface and a better understanding of the mechanisms and composition of the Earth can help to track the possibilities of earthquakes, tsunamis, etc. Thanks to measurements of seismic waves and studies in labs and synchrotron sources, we now have some knowledge (even if it is sometimes discrepant) about what goes on underneath our feet. Denis Andrault, a professor from the University of Clermont-Ferrand and a regular user at the ESRF, points out that: "In the last decade, the possibilities of studies in Earth sciences have multiplied thanks to technology advancements. This has made our research even more exciting and at the same time, there are more debates, which keep the field very healthy."

M Capellas

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An insight into the Moon

The same giant collision between the Earth and the Mars-sized planet 4.5 billion years ago triggered the formation of the Moon, which formed from the debris of the impact (see picture opposite). The impact's huge energy caused extensive melting of both the Earth and the newly forming Moon.

To understand this period of the Earth's earliest history, scientists need to constrain the constitution and evolution of the interior of the Moon. The dark volcanic rocks that cover part of the lunar surface are key to unlocking these interior secrets, because they were formed by melting in the interior.

A team led by Wim van Westrenen, from VU University Amsterdam (the Netherlands) and Christèle Sanloup, from the University of Paris have come to the ESRF to measure, for the first time *in situ*, the density and structure of primitive, high-titanium lunar magma at pressures and temperatures covering the entire interior of the Moon.

The scientists studied a sample of molten "Apollo black glass", a titanium-rich lunar silicate magma that has no terrestrial equivalent. Its density had been studied using traditional quench techniques, allowing the team to validate its *in situ* technique. To measure magma density, they used an X-ray absorption technique previously only used for much denser metals. Subsequently, they studied the density variations in a low-titanium lunar magma. The results show that titanium content has a huge effect on magma density. By accurately measuring lunar magma densities, new light is shed on the dynamics of lunar volcanic eruptions as well as on the evolution of the lunar interior through time.

Their next step is to study the viscosity variations in the two lunar-magma compositions (low-titanium versus high titanium). A full Moon model will then be synthesised by combining these experimental results with the latest compositional data from lunar space missions and computer simulations of the dynamics of the early lunar interior.

High pressure to tackle the origins of life on Earth

Most of the biosphere is under high pressure so living organisms thrive both in the depth of the earth and at the bottom of the sea. The study of biological molecules can help elucidate their functioning.

Pressure on molecules allows scientists to study the different conformations they can adopt, including unfolded states. Prion diseases, for example, are linked to a change of conformation of an ordinary protein (Prp). When the new conformer forms (Prp-sp), it shows a very different structure than Prp.

Pressure studies can also elucidate what happened in the first stages of the emergence of life on Earth. There is a hypothesis that states that RNA may have emerged from an earlier world under extreme conditions of pressure, temperature and pH. This hypothesis presents double-helix molecules as crucial building blocks. A team from the University of Paris, the Institut de Biologie Structurale, the synchrotron Soleil and the ESRF carried out experiments on nucleic acids under pressure at the ESRF. They studied the behaviour of a form of DNA from ambient pressure to 2 GPa. The team noticed that the molecule could resist the pressure while keeping almost the same geometry of base pairs carrying genetic information. The molecular spring shape of the DNA allows it to acclimatise to harsh conditions, such as the deepest sea trenches, the Earth's interior or the impact of a meteorite. Therefore, the scientists believe that this adaptation could have played a role in the early days of life on our planet.

Reference

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Harald Reichert (left) and Serge Pérez (right) have been the new directors of research at the ESRF for 100 days, and are looking forward to many more.

In sync: the first 100 days of the new directors of research

Harald Reichert and Serge Pérez, the new directors of research, discuss the challenges of the Upgrade Programme, their day-to-day work and how they lead the science of the ESRF.

ESRFnews meets Harald Reichert and Serge Pérez, directors of research at the ESRF, after their first 100 days in office. Reichert is in charge of physical sciences and Pérez is leading life sciences. It is a sunny afternoon and we gather at Reichert's office, where the two directors normally meet because Pérez still hasn't had time to arrange his office to his own liking (he only arrived in June). Both offices are facing each other, with an office in between for their two personal assistants to deal with the non-stop calls and their busy agendas. Because the meeting with them took place in the middle of summer, the phone didn't ring as much and the atmosphere was relaxed, although activity didn't stop.

How was your first encounter?
Serge Pérez (SP): We met for the first time when we signed the contract.
Harald Reichert (HR): It was unceremonious, it took place in one of the small seminar rooms in the central building of the ESRF.
SP: When we were appointed to the job separately, no one told us who was going to be our "partner". In a way, it is like being married to someone you don't know, like an arranged marriage…
HR: …which is not unusual for scientists, because you are used to starting a new job every now and then and having to integrate yourself in a new environment.
SP: As scientists, we share the same ethical

and working models, so that makes our relationship very easy.

Tell us about the first 100 days

SP: The Upgrade is really a driving force. We are also working on the definition of partnerships. At the moment we have the Partnership for Structural Biology and we use it as a model, but we need to define new partnerships, such as for soft condensed matter, extreme conditions, paleontology and maybe on magnetism in phase 2 of the Upgrade.

HR: Since our arrival, most of our tasks have been linked to the Upgrade programme. We have already worked heavily to prepare the autumn meetings (Science Advisory Committee, appoint beamline allocation panel). One of our major duties is the space audit, which is a big thing. It consists of assessing whether we need extra room during the construction work within the Upgrade and should spend money on this or whether we are better off sharing office and lab space temporarily while the works are under way and invest the money in science.

What are each other's strengths?

SP: We are very complementary, not only regarding science. Harald is very knowledgeable because he was a user at the ESRF for 11 years before he became director, so he knows the beamlines very well. My experience is more in management of science, which brings a new aspect into the team, as well as the knowledge of the local organisation of science in Grenoble.

HR: We don't try to invade each other's work, we have no territories here and we share the common aim of advancing the ESRF. I really appreciate Serge's large experience in running an institution, while I concentrate more on technical aspects, because I already know the people and the beamlines very well, and that helps a lot when setting things up.

What is a typical day like?

HR: I cycle to work and arrive between 6.00 and 8.30 a.m. From 9.00 a.m. I have meetings all day until 6.00 or 7.00 p.m. Sometimes I fit in meetings over lunch, because I normally skip it. I also have to write e-mails and papers, which you can only do after the meetings. I often leave between 8.30 and 9.00 p.m. when I start to get hungry, so I have to go home, usually with paperwork to read. If I need to prepare material for the next day's meetings, I also do it at home. So it is a full day.

SP: Mine is slightly different because I still have some involvement in the doctoral school of the University Joseph Fourier, where I was director before coming here. Usually I get to the university campus at 7.00 a.m. to prepare the work for the school and at 9.00 a.m. I arrive at the ESRF. So we are both early birds.

HR: It is the best time to get things done, in the morning.

SP: That is right. Then I also have meetings like Harald, all day, but not necessarily the same ones. We decide who is going where between ourselves and it works out very well. We are fully aware of what the other one is doing and we trust each other completely.

HR: At the moment we have a lot of meetings where we both have to be present, where the new beamlines for the Upgrade are being discussed. We both need to be really informed about what is going on in this matter. We also share the same philosophy regarding presence: we try to be there as much as possible. I have done almost no travelling since I arrived here.

SP: Me neither. My day finishes normally at 7.00 p.m., when I go home, but with work to do, like Harald. So we never disconnect, not even at the weekends.

HR: We can't!

SP: Work is following us. But we enjoy it a lot.

HR: Otherwise we wouldn't be doing it.

Do you have any disagreements?

SP: It hasn't happened yet, but if we didn't agree on something, we would discuss it to find a consensus. We might have arguments but we solve them behind closed doors and then we speak with one voice.

HR: We are both reasonable people.

SP: And we don't have a personal agenda; we don't try to push one group more than another. This is important.

HR: Neither of us came from inside the institute, so we can look at things with an unbiased view. Another thing is that we both have a similar education. If Serge doesn't agree with me, there must be a reason for that, so instead of going against him I'd like to know his perspective because it is as valuable as mine.

What has been the biggest challenge?

HR and SP: The Upgrade.

HR: We have to run the division and at the same time make many decisions for the Upgrade.

SP: At some point we will also face a change of culture at the ESRF, in our division.

HR: With the Upgrade, we have a plan for seven years, a frame on how to spend the budget that has already been allocated. This is why we asked scientists to come up with the 31 conceptual design reports (CDRs) for the entire portfolio of public beamlines at the ESRF. All of this means that if someone has a new idea that is not covered by the CDRs during the next seven years, we may pursue it, but we will have to cancel something else. We can't do everything that we plan to do in the next seven years plus any new ideas that come up along the way.

SP: So we need to help scientists to find financial resources from other external sources.

HR: Another crucial aspect is that we should not just add new techniques to the beamlines. At some point we have to redefine the mission of beamlines and give them an orientation to new directions. This is difficult for scientists.

SP: We are going to be facing this situation soon.

HR: In fact, we have already taken decisions in that direction. No beamline will be closed, but it can change its mission, and this need for change normally happens very naturally. The strength of the ESRF is the highly specialised and unique beamlines and we should keep it like this.

SP: We also want to avoid duplication with national light sources, which push us to have very specialised stations that they can't offer.

HR: We do as much as we can to supply the best conditions for users and, despite the new synchrotrons, the user community is not leaving us, which is a good sign.

How are your relationships with staff?

SP: I try to go to the beamlines and talk to the scientists for about one hour every day. It is a good way to get to know the staff. Harald doesn't need to do that as much, though, because he already knows many people here.

HR: I also go to the experimental hall about once a day and sometimes I can sort out issues just by chatting informally with researchers on their beamlines. Both Serge and myself try to be available for any scientist wanting to discuss an issue more formally. Usually they can set up a meeting within a day or two.

With the Upgrade we are starting to look at the staff plan, i.e. defining how many people will be on beamlines that merge or have new end stations and what expertise they will have, how we will cope with the peaks of work during the Upgrade implementation, etc. It is like a big puzzle of 250 people, where you have to shift around pieces to make it fit.

How are your relationships with users?

HR: I've been a very intense user, my last experiment was in November. I know quite a few users and I meet some of them to discuss science. Some of them are members of the Science Advisory Committee and we talk about different issues. Many of these scientists are also my friends, so it is a pleasure for me to meet with them.

SP: For me, because I only arrived recently, it is important to get to know the ESRF scientists and technicians and when I've done this, I will meet the users. When the Upgrade starts phase 2, we will have to travel to approach the scientific community to listen to their

> **"We have to redefine the mission of beamlines and give them an orientation to new directions"**

demands. We are both trying to favour a bottom-up communication principle with the community.

HR: If you have around 4000 users a year, you can't talk to everyone. However, we keep a close eye on the user community and if people walk away, we want to know why. If someone is unhappy with their beamtime, they will complain first to the beamline scientists, so only the serious problems arrive on our desk. Most users don't say anything…

SP: …and that means that they are happy, otherwise they would certainly complain. With our industrial users we carry out feedback surveys.

Can you explain the importance of psychology in management?

SP: There are managerial courses that give you more recipes than real advice, but then comes your personal appreciation and that really makes a difference.

HR: There are a lot of brilliant scientists out there and when you are chosen for this job it is not because you are the brightest scientist in the world but because you are expected to run a division with 250 people, motivate them and find out where the problems are.

SP: However, you still need to have scientific recognition from your colleagues; you can't impose yourself as just a manager or administrator.

M Capellas

ESRF's new directors of research in a nutshell

Harald Reichert

Born in 1963

Has a PhD in physics from the University of Munich.

Was a researcher at the University of Munich, Houston (US) and the University of Wuppertal (Germany).

1997 – project leader at the Max Planck Institute for Metals Research in Stuttgart (Germany). There he continued to work on binary metallic alloys and started to work on solid–liquid interfaces.

2002– research professor at Max Planck Institute for Metals Research. His group developed sophisticated new instrumentation for use at synchrotron light sources. These include a unique diffraction end station on the High Energy Scattering beamline ID15.

2009 – director of research at the ESRF.

Serge Pérez

Born in 1948

Has a PhD in crystallography from the University of Bordeaux (France).

Was a researcher at the University of Montreal (Canada), Oregon (US) and at Eastman Kodak research laboratory (US).

1987 – director of research at the Centre de Recherches Agro-Alimentaires in Nantes (France), where he started his research on the development of structural methods applied to glycoscience and with particular emphasis on renewable bioresources.

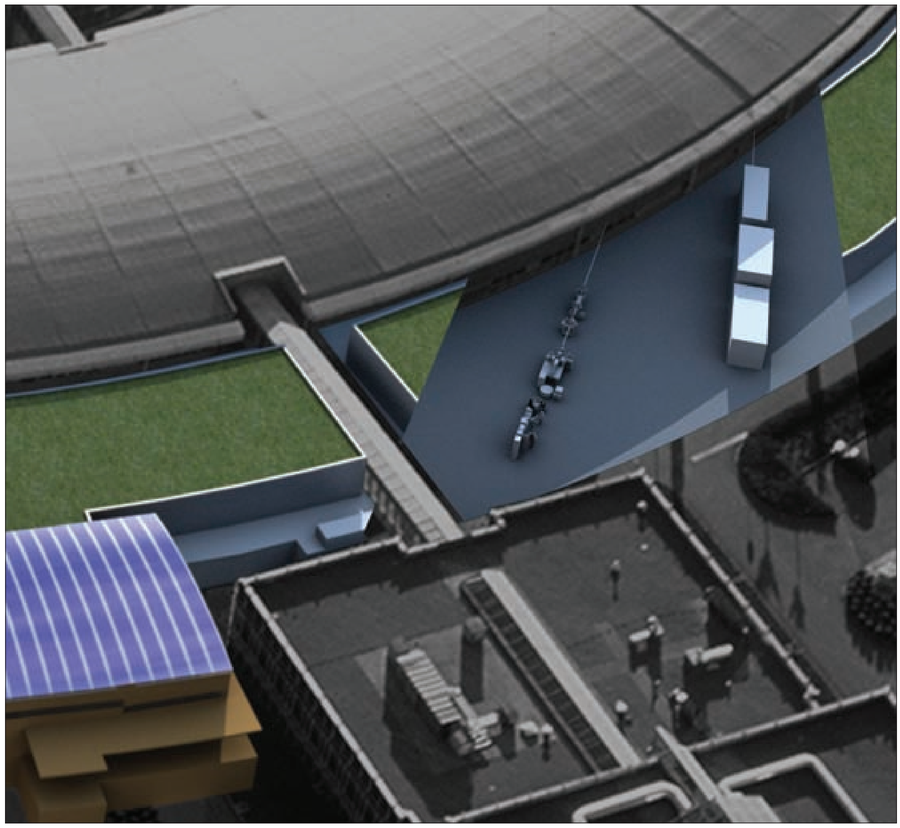
1996 – director of the Centre de Recherches sur les Macromolécules Végétales, Grenoble.

2007 – director of the Doctoral School of Chemistry and Life Sciences at the Université Joseph Fourier in Grenoble. He has been actively involved in the European research programmes led by the European Commission.

2009 – director of research at the ESRF.

Committee pieces together the Upgrade beamline puzzle

The Science Advisory Committee of the ESRF advises on what Upgrade beamlines should go forward in the first phase of the Upgrade Programme.



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An artist's impression of a section of the new beamlines in the ESRF's Upgrade Programme. In black and white, there is the ring (top left) and the central building (bottom right). Two of the new beamlines are visible, as well as one of the new office buildings (bottom left, in blue).

After several years of preparation for the Upgrade Programme, the Science Advisory Committee (SAC) of the ESRF delivered its advice on which beamlines should go ahead with the preparation of their technical design reports. The recommendations are based on the recently prepared conceptual design reports for the entire portfolio of public beamlines at the ESRF and are the fruit of thorough reflections that took into account the financial and spatial boundary conditions of the ESRF. At the first of the two SAC meetings of the year, in May, the committee recommended going ahead with the technical design reports for the following beamlines.

- High-energy beamline for buried interface structure and materials processing – UPBL2.
- Beamline for imaging, fluorescence and spectroscopy at the nanoscale – UPBL4.
- High-energy resolution inelastic scattering in the hard X-ray range with micro and nanofocus capabilities – UPBL6. The SAC recommended that there should be special efforts in the electronic excitations branch.
- Soft X-rays for nano-magnetic and electronic spectroscopy – UPBL7.
- Sub-microradian angular resolution small-angle scattering for probing the structure and nonequilibrium dynamics of self-assembling soft matter and biological systems – UPBL9.
- Structural dynamics of molecular assemblies – UPBL9. The SAC welcomed the move of the pump-probe branch of ID09 to a dedicated beamline, so that it can be fully exploited.
- Large-scale automated screening, selection and data collection for macromolecular crystallography – UPBL10.
- Pushing the limits of energy-dispersive X-ray absorption spectroscopy (XAS) towards the nanoscale in spatial and temporal resolution – UPBL11.
- The SAC also endorsed moving beamlines ID03, ID06, ID10A and ID15 (which will receive the high-pressure station from ID09A and the Large Volume Press).

The conceptual design report for UPBL1 – the future beamline on ID1 – should be further developed, as soon as the new scientist in charge settles down. The beamline will feature high-flux nanofocused hard X-rays and anomalous scattering, and the SAC encourages collaboration with the other beamlines exploiting coherence techniques, namely ID10 and ID22.

The conceptual design report of UPBL5 should be reconsidered due to the major consequences that its implementation would have for the beamlines involved. This project includes a dedicated high-energy imaging beamline for medical, materials science and paleontological applications. The SAC considered that the implementation of this new beamline (including a new building) might have a negative impact on ongoing programmes. The project of UPBL5 also proposed enhanced flux, high-resolution imaging and long propagation lengths for phase contrast imaging for ID19. The committee endorsed this part of the project with high priority.

"The SAC recommendations take into account financial and spatial boundaries of the ESRF"

The SAC acknowledged that Upgrade projects might be too early for some beamlines, such as ID13 (or UPBL8), because it is just beginning to use the newly commissioned nanobranch in the new hall extension. UPBL3, the nuclear resonance beamline for the study of nanoscale materials, has also been recommended for a later implementation with an emphasis on maintaining the current capacities.

M Capellas

R Paniago: boosting Brazilian science

Rogerio Paniago, a professor and former head of division at the Brazilian Synchrotron Source, has been a visiting scientist at the ESRF's ID1 beamline for the last year.

When you interview someone who has been working as a head of division at the Brazilian Synchrotron Source (LNLS), you expect to see quite a senior face. However, Rogerio Paniago is only 42 years old and a multifaceted scientist who feels equally at home commissioning an instrument as he does in his current position as professor at the university.

"It is normal in Brazil to find young people working at the synchrotron source because there is not a lot of history associated with these instruments. It started in the 1980s but the machine didn't come into operation until 1997, and then the user community grew," he explains.

Paniago returned to his homeland of Brazil in 1998 after accomplishing a PhD in Houston (US) on grazing incidence X-ray scattering from surfaces and a postdoctoral research position in the Ludwig-Maximillians Universität in Munich (Germany). He had seen the world, so the challenge of going back home and putting into practice all of the knowledge that he had acquired was very appealing. At that time he became an assistant professor at the Federal University of Minas Gerais. Later on, in 2002, he managed beamlines at the Brazilian Synchrotron.

In a second-generation source such as LNLS, and in a country like Brazil, which caters for the whole southern hemisphere (until recently, when the Australian Synchrotron became operational), the task of working in such a lab can seem daunting. But Paniago says that it is all about being multiskilled, continuing to learn and being able to teach others what you have learned.

"At the beginning of the operation the community was very artificial. We were asking scientists to carry out experiments even if they had never used such a source. In fact, this machine was built because it could potentially benefit many varied fields of science, so the government thought that it was a good investment, but the community had to be built from scratch," Paniago explains. Introducing the newcomers to the synchrotron world was a task that Paniago thoroughly enjoyed. However, he decided not to stay in the job. "At a light source such as LNLS you need to be versatile – you can't specialise – so your scientific research suffers a lot."

CLÁUDIA P SOUZA

Mountaineering is one of Rogerio Paniago's hobbies, which he has been able to practise to the fullest extent in Grenoble's mountains. Paniago (right) is pictured on top of Charmant Som with his wife Cláudia (left), sons Rafael and Bruno (front) and Till Metzger (middle), the scientist in charge of the ESRF's ID1 beamline.

His teaching ability is now put into practice at his university – which is about an hour's flight away from his former working place – where he is a full-time professor and pursues his own research programme.

Today Brazil is hoping to construct a new third-generation synchrotron source. "But I don't think that it will be finished in less than seven or eight years," he says. The financial situation of the country often determines the health of the technological investments, and, "in Brazil there are many fluctuations in the economy. To build these facilities you need a big initial investment, but you also require money to staff them and to keep them running, and this money is not easy to get," Paniago explains.

In view of this new project, Paniago, who has been a long-time associate of Till Metzger, the scientist who is in charge of ID1, agreed that he should become a visiting scientist on his beamline, which he has been doing for 11 months. "In Brazil there are few people who have the opportunity to go abroad and learn from the people who are at the forefront of synchrotron science, so if Brazil's source gets approval, I think that I could contribute a lot with all of the expertise that I have acquired," he says. "As a specialised scientist you can still make a difference in Brazil, whereas in Europe it is more difficult because there are many more experts."

Scientifically, he is amazed at the European team spirit and sees it as the only way to work with large, complicated and demanding projects, because they require expertise in different areas.

During his time at the ESRF he studied the elastic behaviour of single nanostructures using a combination of X-ray microdiffraction and atomic force microscopy, and also started a collaboration with the ID1 team to carry out 3D X-ray coherence diffraction imaging on highly strained nanostructures (Scheler *et al.* 2009).

On this side of the Atlantic, Paniago felt like he was in the Brazil that existed during his childhood. "Violence in Brazil is a relatively recent phenomenon. When I was young we lived like those who live in Grenoble, so it has been a very nice experience."

Moving continents with his wife and two children was not a daunting time because Cláudia "is used to living in different places and getting by" and his children "are so adapted that they now speak perfect French".

Despite thoroughly enjoying the family hikes in the mountains and defining Grenoble as "a wonderful place to live", Paniago is looking forward to going back to Brazil at the end of the summer and, hopefully, will be able to use his newly acquired knowledge at the new synchrotron.

M Capellas

Reference

T Scheler *et al.* 2009 *Applied Physics Letters* **94** 023109.

Start your scientific career at the ESRF

Students discuss the highlights and pitfalls of doing their PhD research at the ESRF facility.

The three years that all PhD students spend preparing their thesis constitutes a challenging period in their life, as it is the first time that they are in charge of a relatively large scientific project. The ESRF offers graduate students the chance to continue their academic career in a thriving and enriching environment.

The PhD students at this lightsource are still attached to a university, where their supervisor is normally based, although they need to spend at least 70% of their time at the ESRF. This system, far from being an inconvenience, has proved to be an advantage for many of the current PhD students. As Richard Van Rijn, who has been at the ESRF for two years, puts it: "It really pays off to discuss your research in two different environments on a regular basis. The discussions at the ESRF are usually more 'X-ray minded', whereas discussions at university focus more on scientific questions and not measurement techniques."

Another aspect that many students find to be an advantage is the access to beamtime, be it as in-house research or collaboration with users, and the networking possibilities. Tuomas Pylkkanen, who will finish his thesis at the end of this year, takes stock of his experience: "I get to do a lot of hands-on work at the synchrotron. Also, it is much easier to prepare experimental set-ups at beamline laboratories with their technical staff. I get to work with leading experts in the field and talk to many scientists. There is an immense amount to learn if you are open to it."

Independence

At the ESRF there are 44 PhD students scattered among the beamlines. This can make it more difficult for them to get together and interact than in a university.

According to some students, the atmosphere of a running

C ARGOUD

Pictured on the terrace of the Experimental Hall at the ESRF are some of the PhD students that were interviewed in August.

facility contributes to a certain isolation for students. "Often people in my group are really busy with users or beamline maintenance, so you have to develop a strong independence. This can be a problem if your thesis' subject is new to you, because you often need someone to explain concepts to you," says Erik Tancini, who started at the ESRF six months ago. Pylkkanen confirms this: "I interact less with other PhD students here than at university. Also, the work tends to be more independent and very focused on the (narrow) speciality of the beamline. University laboratories are usually working on many different things, exposing you to other subjects."

Economic and location appeal

Salary is a factor when graduate students ponder over whether they should move to another country to pursue their careers. Some of the Italian and German PhD students interviewed pointed out that the pay at the ESRF is better than in their countries.

The setting of Grenoble seems to be another attraction. "It is a beautiful city with mountains for hiking and skiing," says Christoph Schlueter, who is working on ID32. His colleague on the beamline, Frederik Golks, adds: "And the weather is much better than at Kiel, where my supervisor is!"

M Capellas

Movers and shakers

Scientist in charge of ID13
Manfred Burghammer

After the departure of Christian Riekel, the new scientist in charge of the microfocus beamline is Manfred Burghammer.

He is no stranger to the beamline, as he has worked there as beamline operations manager for several years.

His goals for the future of ID13 consist of keeping the beamline's leading role in micro- and nano-beam applications in crystallography, scanning diffraction and scattering and exploring new experimental possibilities for user and in-house research. He also hopes that the experience of the implementation of a nano-endstation on the beamline will contribute to the success of the Upgrade Programme.

Scientist in charge of ID21
Marine Cotte

Before leading ID21, Marine Cotte was a researcher at the Louvre Museum and visiting scientist at the ESRF.

Her wish list for the future of the beamline includes "pushing further its capacities in terms of lateral resolution, detection limit and chemical sensitivity, without breaking the equilibrium between these three poles. The combination X-ray/infrared needs also to be further exploited."

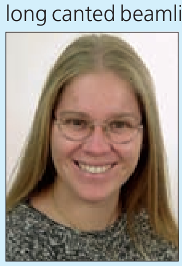
She would also like to continue her research, which is linked to ancient materials, such as paintings and glass.

ID21 has just got a new acronym: SMILE (spectro-micro-imaging at low energies), which "conveys rather well the working atmosphere on the beamline".

Scientist in charge of ID22
Gema Martínez Criado

Another beamline to get a new face at its head is ID22. Gema Martínez Criado, previously a beamline scientist on ID22, has been leading the beamline since spring of this year.

In terms of scientific output, she would like to encompass biomedical research, environmental and Earth sciences, nanotechnology and engineering. In the framework of the Upgrade Programme, Martínez Criado is looking forward to the implementation of the Nano-Imaging and Nano-Analysis (NINA) project. NINA is a long canted beamline, approved



to go ahead in phase 1 of the Upgrade, which "will greatly extend the scientific impact of ID22 beyond that achievable in the standard operation mode".

Beamline co-ordinator at BM28-XMaS
Laurence Bouchenoire

Laurence Bouchenoire is the new beamline co-ordinator of XMaS.

One of her main goals is "to find ways of attracting new users, especially with the ongoing developments in sample environment to reach lower/higher temperatures and to apply *in situ* electric and/or magnetic fields", she said.

"These cutting-edge implementations will help to keep the science done at XMaS at the forefront."

Bouchenoire has been a scientist at XMaS for more than six years and will continue her work on rare-Earth magnetism.

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DESY operates flexible work schemes. Handicapped persons will be given preference to other equally qualified applicants. DESY is an equal opportunity, affirmative action employer and encourages applications from women. There is an English-speaking Kindergarten on the DESY site.

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Human Resources Department | Code: 87/2009
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The Institute for Synchrotron Radiation (ISS) invites applications for a Scientist (f/m) position

You will be responsible for the establishment of the X-ray microscopy with hard X-rays at the synchrotron facility ANKA, especially for the instrumental development and the provision, implementation and scientific supervision of the X-ray microscopy measuring station.

Applicants should have a university degree in engineering or natural science, completed by a doctorate. Several years of professional experience in the field of synchrotron radiation, tomography and microscopic laboratory methods or their instrumentation are requested. Moreover, programming skills in IDL, Matlab, and C++ and/or Python are an advantage.

C++ as well as experience in the remote control of measurement setups is required. Experience in 3D-tomography imaging with hard X-rays is an advantage. Good command of the English language is indispensable.

Contract duration is limited to five years and its salary is group 13 (corresponding to VG II BAT), depending on your professional and personal qualification.

For technical information, please contact Dr. Bauer, **T: +49 (0) 7247-82-6489**

or visit: **http://ankaweb.fzk.de/website.php?page=about_jobs&id=51**

Please submit your application by Sept 30th 2009, (including curriculum vitae, certificates, training) stating ref: ESRF307/2009 to: Mrs. Mäurer, HPS, T: +49 (0)7247 82-5006 (Forschungszentrum Karlsruhe, ISS, Hermann-von-Helmholtz Platz 1, 76344 Eggenstein-Leopoldshafen, Germany).

Applications from qualified women are particularly encouraged.

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- Accelerator physics support with new photon beamlines.
- Insertion device modeling and control.
- Future development programs, including PEP-X.

The successful candidate will work in one or more of these areas in a collaborative group environment, participate in the experimental machine development program, and will publish critical analysis of storage ring performance and analysis of future machine upgrade scenarios.

Qualifications: A Ph.D. in accelerator physics or comparable experience. Demonstrated proficiency in the field of accelerator physics with preference for hands-on machine development, experience with particle beam optics and beam dynamics, demonstrated computer skills and experience with beam instrumentation. The candidate should be capable of developing and pursuing independent research.

The position is advertised as Associate Staff Scientist with an initial 3-year term, which could lead to a continuing appointment as a Staff Scientist. A more experienced candidate can contact me to discuss starting at the Staff Scientist level.

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Scientific Director

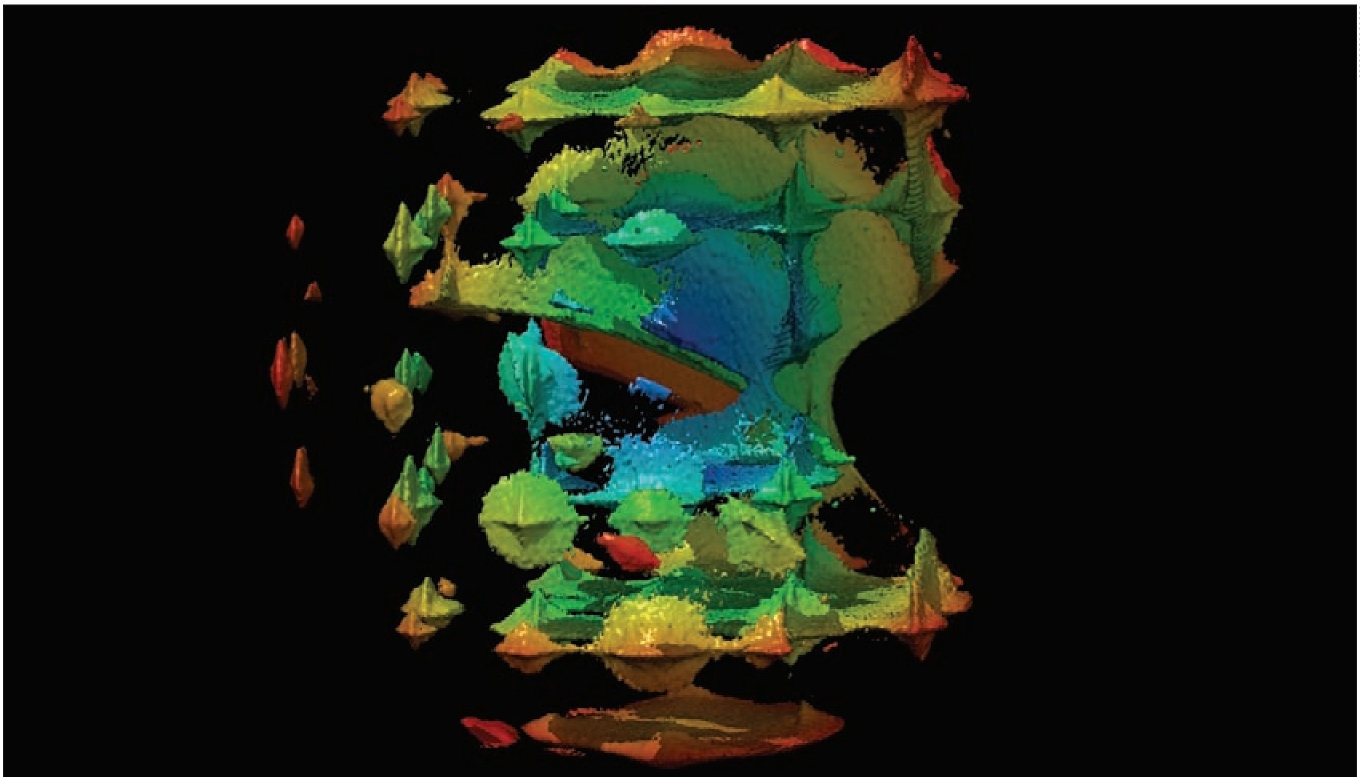
of a new start-up company that is being launched as a joint venture of private investors and CIC nanoGUNE Consolider. The company is located in San Sebastian, Basque Country (Spain), with the mission of developing graphene-based process and product technology as well as conducting related research activities.

The Scientific Director will be responsible for the design and management of the company's R&D strategy, the build-up and operation of its research laboratory and team, which will be based at the nanoGUNE facilities, as well as the development of a high-impact IP portfolio. The Scientific Director will also manage the coordination of the company's activities, which will utilize nanoGUNE´s state-of-the-art research infrastructure for nanoscience and nanotechnology.

Candidates should have an outstanding track record in research and technology or process development, with a preferred expertise in the field of thin-film or nano-materials growth and related areas of surface science, the ability to lead and manage a research team and build-up a world class research operation, as well as substantial experience with IP related issues. Proficency in spoken and written English is compulsory; knowledge of Spanish is not a requirement.

Applicants should forward their CV and a list of at least three references to director@nanogune.eu

Closing date: 30 September 2009



3D pattern of the diffuse scattering in $Li_x(K_{0.5}Na_{0.5})_{1-x}NbO_3$ (x = 0.02) cubic phase (450 °C). Recently, the efforts of specialists from all over the world were attracted to the development of environmental-friendly lead-free piezoelectrics with the electromechanical coupling close to that in lead zirconate-titanate and related compounds. The Li-doped mixed potassium-sodium niobates $Li_x(K_{0.5}Na_{0.5})_{1-x}NbO_3$ are now considered as the most prospective systems for practical applications. 3D mapping of the diffuse scattering, coupled with the inelastic X-ray scattering, gives important insights into the origins of the phase transitions in this system.

In the corridors

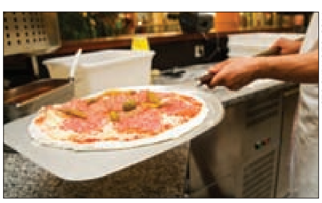
Pizza chefs inspire robotic movement

Engineers at Osaka University (Japan) have used the movements of pizza chefs to improve dexterity among robots.

The team focused on the pizza peel, the instrument used by chefs to manipulate pizzas in an oven. They designed a robotic hand that allows robots to move in a similar way. Despite the fact that the chef can only move the peel back and forth, and twist the pole, the two motions combined can rotate the pizza horizontally, which is what the robotic hand can achieve.

Reference

IEEE Transactions in Robotics, in press.



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Robots learn from pizza chefs.

A drop of rain creates a shower

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Raindrops create showers.

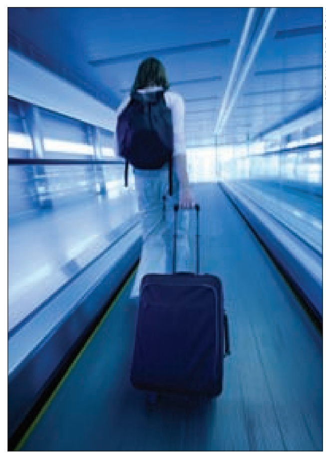
A single drop of water can produce a shower of droplets, French scientists have shown. Scientists had previously thought that the pattern of rainfall seen at ground level was created by drops of rain colliding as they fell.

The team, from the University of Aix-Marseille and the Institut Universitaire de France, filmed drops of water dripping from a tap and noticed that the air resistance increases as the drop falls, until it becomes bigger than the forces that keep the drop together. So the drop starts by flattening into a pancake, then deforms into a bowl shape before exploding into droplets. The scientists used their results to connect the bursting of a single drop to the distribution of raindrop sizes in showers.

Reference

E Villermaux and B Bossa 2009 *Nature Phys.* **doi:10.1038/ NPHYS1340.**

Travelators slow down the pace



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This may not be the fastest path.

Travellers often welcome moving walkways or travelators to move between an airport's multiple terminals. However, people on travelators tend to walk slower than normal, a new study based on mathematical models shows. According to the researchers, when stepping onto a travelator, people start walking at half the speed of the walkway. In addition to this, there is the conflict between visual cues and leg muscle signals (your eyes see that you are going faster than your legs are carrying you) and this adds to slowing down.

All in all, if you choose the travelator you will only go 11 s faster every 100 m than if you were not on the moving walkway.

Reference

M Srinivasan 2009 *Chaos* **19** 026112.

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731	8-4	-	2-1	500-1000	250/500	8	2-4	Ready	-	-	COMING SOON
740	64	32	-	65	30	12	0.19/1.5	Ready	NEW	NEW	-
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