

**SNX**

**Swiss-Norwegian Foundation for Research with X-Rays**

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*Report 2021*



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## General Remarks

The year 2021 is the eighteenth year of the SNX Foundation.

The accounting is supervised by OPTIMA COMPTA, in Seyssinet-Pariset, in Isère, for the two French associations, and by BfB Fidam Fiduciaire in Renens VD for the SNX Foundation. AUDICT FIDUCIAIRE in Lausanne audits the accounts.

These legal frameworks contribute to the smooth running of the collaborations and to the successful scientific work done at the Swiss Norwegian Beam Lines at ESRF.

The activities of the SNX Foundation are carried out at the European Synchrotron Radiation Facility (ESRF) in Grenoble and comprise the operation and up-grade of two beam line branches, called the Swiss-Norwegian Beam Lines (SNBL).

## Introduction

This report covers the year 2021 but first some recent history. Despite the global pandemic the ESRF managed to startup of the new ESRF-EBS source on time and a, albeit severely disrupted, successful restart of the user service in spring 2020 with mostly remote experiments. The SNBL objectives for this period were part of a long-term plan developed in 2017 and presented in the “SNBL 2019-2020 and beyond” document. This document was supported by the Swiss- and Norwegian users, their respective steering committees and approved by the SNX Council. The document was also handed over in 2018 to the funding agencies in both Norway and Switzerland (Research Council of Norway (RCN) and the State Secretariat for Education research and Innovation (SERI)) at that time. For 2020 this plan was successfully executed and incorporates the completion of the phase 1 installation works, the commissioning with EBS and the restart of the user program. Moreover 2020 was a record year in terms of publication output for SNBL with a total of 140 publications including one in the main Science and one in the main Nature journal.

The new 4-year contract (2021-2024) period has now successfully started with a new Swiss partner, the École Polytechnique Fédérale de Lausanne (EPFL) and for Norway the Norwegian University of Science and Technology (NTNU). Obviously, the user program continued in 2021, moreover the phase 2 major upgrade program for SNBL has started and will span over 4 years. This plan foresees that on BM01, Bragg diffraction, diffuse and small angle scattering, for single crystal, thin films and powder samples will become available. On BM31 it is planned that the combined diffraction and X-ray absorption experiments setup will be completed with Total Scattering and improvements in time and space resolution for all techniques. Improvements in beamline controls and online data analysis tools are also in the pipeline. The BM01 phase 2 upgrade has moderate cost. The BM31 phase 2 project however has a total investment budget of ~2 Million Euro's. Hence external funding was already applied by the Swiss and Norwegian user communities in the years prior and approved. This budget became available immediately with the new contract in place hence all conditions were united for a fresh restart. 2021 has therefore very much been a development and investment year and the works can be summarized as follows:

- 1)** A full user program was successfully and reliably executed on both beamlines, with a big portion of the experiments in the fall and spring of 2021 still in remote.
- 2)** 73 publications using SNBL data appeared in peer review journals, 13% of SNBL publications has an impact factor above 10 and 54% above impact factor 4.
- 3)** Major design, acquisition, assembly and project planning work has been performed for the phase 2 upgrades on both BM01 and BM31.
- 4)** Outside budget investments comprises a total of 2 million Euros.

## Scientific highlights



# ESRF HIGHLIGHTS 2021

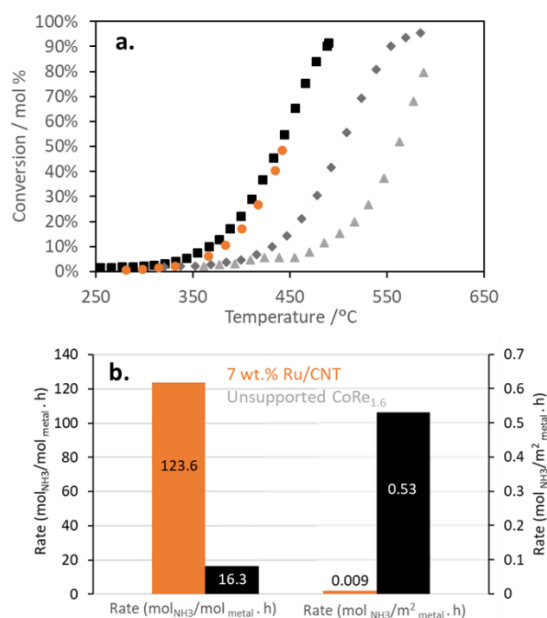


## New information from XANES/EXAFS for the development of novel ammonia decomposition catalysts

**On-demand production of hydrogen from ammonia can be accomplished by combining cobalt and rhenium, resulting in comparable activity to ruthenium, the best catalyst. *In-situ* EXAFS/XANES analyses demonstrate that bimetallic Co-Re species are responsible for the activity. The re-reduction of Co partially oxidised by  $\text{NH}_3$  in the presence of Re coincides with the on-set of activity.**

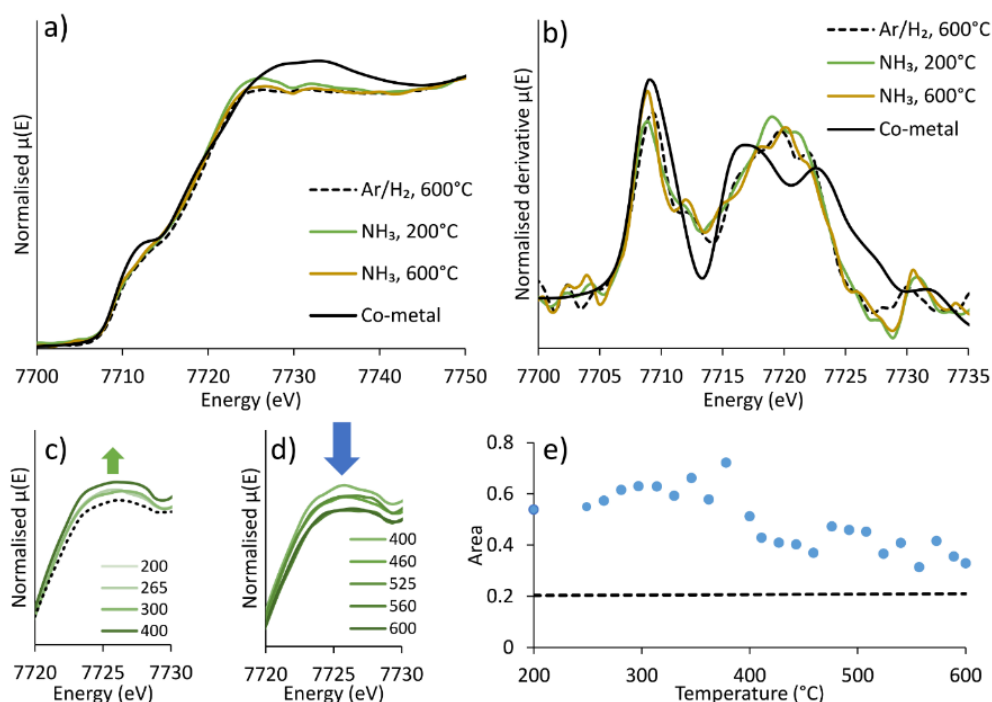
Ammonia is an attractive sustainable energy carrier due to its high hydrogen content and narrow flammability range [1] enabling the long-term energy storage in chemical bonds versus the short-term storage offered by electrochemical storage. Despite its potential, the implementation of ammonia in the energy landscape relies on the capability of releasing hydrogen on demand, preferably at temperatures aligned to those of fuel cells. Considerable scientific effort is currently focused on developing catalysts to attain this goal. The strategy employed here was the development of bi-metallic ammonia decomposition catalysts combining metals possessing different N-atom adsorption energies following the DFT simulations by Hansgen *et al.* [2] to achieve an optimum binding energy for catalytic performance mimicking the N-adsorption energy of ruthenium, the benchmark catalyst in this process.

$\text{CoRe}_{1.6}$  had comparable hydrogen production to 7 wt.% Ru/CNT (Figure 1a) [3]. While 3-5 nm supported Ru nanoparticles (7 wt.% Ru/CNT) present a considerably higher activity than the unsupported  $\text{CoRe}_{1.6}$  per mol of metal (Figure 1b), a rate orders of magnitude higher is shown by the  $\text{CoRe}_{1.6}$  based upon metallic surface area. Therefore, the active sites in Co-Re might be considerably more active than those in Ru. The low temperature activity is directly related to the intimate Co-Re interaction (Figure 2a and b) with the activity onset related to the contraction of the Re-Co bond distance.



**Fig. 1: a)** Activity of ■  $\text{CoRe}_{1.6}$  ▲  $\text{Ni}_2\text{Mo}_3\text{N}$  ◆  $\text{Co}_3\text{Mo}_3\text{N}$  ● 7% Ru/CNT. **b)** Reaction rate of 7 wt.% Ru/CNT (orange) and  $\text{CoRe}_{1.6}$  (black).

*In-situ* XAS undertaken at **BM31** revealed reduction of the cobalt precursor to  $\text{Co}^0$  occurred over a narrow temperature range from 350°C - 400 °C. Reduction of Re occurred in a single step from 300°C. XANES upon  $\text{NH}_3$  treatment show partial oxidation of cobalt, evident by the increased white line intensity [4] (**Figure 2c**). Although changes were observed in the Co XANES, EXAFS revealed no light atom scattering pairs (i.e., Co-N) were formed during low-temperature  $\text{NH}_3$  treatment. The white line intensity decreased from 400°C during  $\text{NH}_3$  treatment (**Figure 2d** and **e**) and reached a similar intensity to  $\text{CoRe}_{1.6}$  during pre-treatment at 600°C, corresponding to a partial reduction of Co coinciding with the onset of  $\text{NH}_3$  decomposition activity for  $\text{CoRe}_{1.6}$ .



**Fig. 2:** **a)** Co K-edge XANES of  $\text{CoRe}_{1.6}$ . **b)** First derivative of the Co K-edge XANES of  $\text{CoRe}_{1.6}$ . Beginning of 5%  $\text{NH}_3$  treatment (green), end of  $\text{NH}_3$ -decomposition (yellow) and reduced  $\text{CoRe}_{1.6}$  (...). **c)** Co K-edge white line intensity changes during  $\text{NH}_3$ -treatment between 200-400°C (reduced  $\text{CoRe}_{1.6}$  (...)). **d)** Re-reduction of Co between 400-600°C at the Co K-edge. **e)** Area for the Co K-edge white line intensity in  $\text{CoRe}_{1.6}$ .

Despite the changes observed, the Co-Co backscattering pair was stable when the temperature was increased from 300°C to 600 °C under  $\text{NH}_3$ . The average Co-Co multiplicity remained at 4 with a bond distance of 2.45 Å. The Re-Re backscattering pair elongated from 2.65 Å to 2.73 Å during the pre-treatment while a contraction of the bond distance to 2.65 Å occurred after switching from pre-treatment conditions to  $\text{NH}_3$  at 200°C. During  $\text{NH}_3$  decomposition, these distances changed: Re-Re increased to 2.73 Å, while Re-Co was shortened (2.56 Å) coinciding with activity onset. While the change in bond distance of Re-Re approached that of Re-foil (2.74 Å), it did not seem to be associated with sintering of a pure Re-Re phase as the average multiplicity was not changed.

These observations indicate local restructuring of both monometallic and bimetallic particles occurs between 400-600 °C, after  $\text{CoRe}_{1.6}$  is fully reduced. The major contributing species were Co-Co and Re-Re with only ~20% of the bimetallic Re-Co pair. Co-Re is clearly a complex system with interesting  $\text{NH}_3$  decomposition activity, where XANES/EXAFS-derived information is critical for enhanced understanding and further development.

## Principal publication and authors

CO<sub>x</sub>-free hydrogen production from ammonia - mimicking the activity of Ru catalysts with unsupported Co-Re alloys, K. Kirste (a), K.McAulay (b), T.E. Bell (c), D. Stoian (d), S. Laassiri (b,e), A. Daisley (b), J.S.J. Hargreaves (b), K. Mathisen (a), L. Torrente-Murciano (c), *Appl. Catal. B: Environ.* **280**, 119405 (2021); <https://doi.org/10.1016/j.apcatb.2020.119405>.

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(d) ESRF

(e) Mohamed VI Polytechnic University (Morocco)

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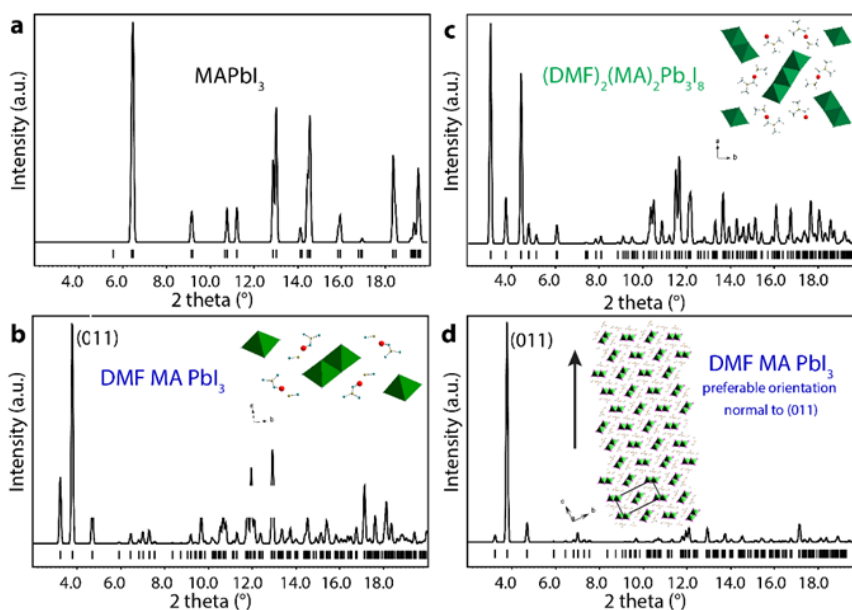
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## Intermediate phases of $\text{CH}_3\text{NH}_3\text{PbI}_3$ and their application in X-ray photodetectors

The intermediate phases of the organic-inorganic perovskite crystallisation process and their use in aerosol jet printing (AJP) allows the creation of 3D perovskite structures. Heterostructures based on  $\text{CH}_3\text{NH}_3\text{PbI}_3$  and graphene were successfully manufactured using AJP. X-ray detectors based on such heterostructures demonstrate record-high sensitivity values of  $2.2 \times 10^8 \mu\text{CGy}^{-1}\text{cm}^{-2}$ .

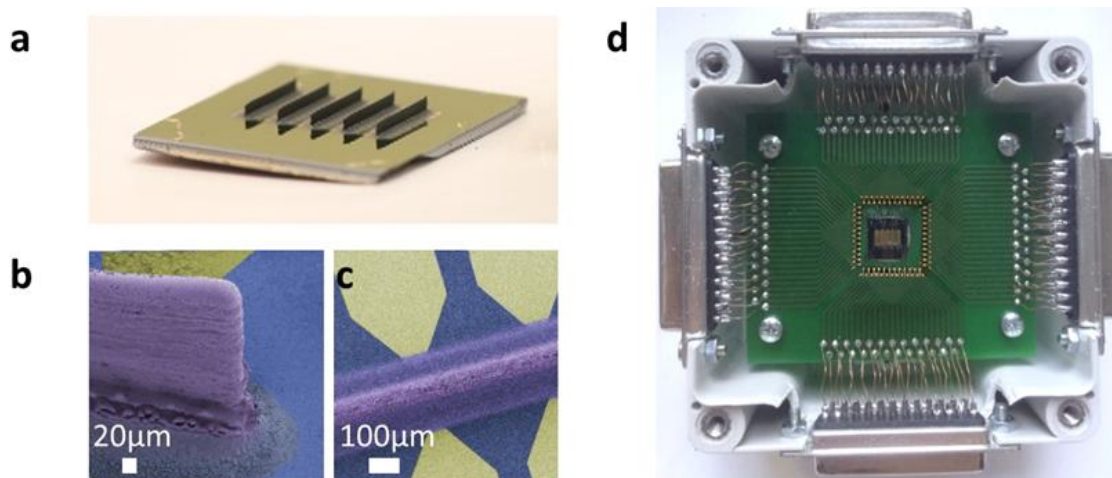
Hybrid organometallic halide perovskites have been intensively investigated in recent years as highly efficient light harvesters for various optoelectronic applications. Nevertheless, there are many open questions remaining regarding their crystallisation process [1]. It is well-known that organic-inorganic perovskite properties are highly affected by external factors such as temperature, pressure, humidity, etc. [2-4]. Therefore, it is crucial to understand the crystallisation process under specific conditions in manufacturing of the devices. Rapid crystallisation of  $\text{CH}_3\text{NH}_3\text{PbI}_3$  ( $\text{MAPbI}_3$ ) is of particular interest, as it is one of the most efficient photovoltaic materials and is in demand for integration into electric circuits. Upon the fast solvent evaporation of saturated  $(\text{DMF}) \cdot (\text{MAPbI}_3)$  solution, yellow micron-long wires appear and then convert to black  $\text{MAPbI}_3$  upon further DMF evaporation.

X-ray diffraction (XRD) data were recorded at beamline **BM01** during the crystallisation process of the wire-shaped  $\text{MAPbI}_3$ . To this end,  $(\text{DMF}) \cdot (\text{MAPbI}_3)$  solution was applied on a glass capillary and XRD data were recorded during evaporation of the solvent. **Figure 1** presents the XRD profiles of the structures that the solution undergoes upon crystallisation. This study shows that, from a soft framework of the inorganic species in solution, the mixture of two intermediate phases appears, and presents a possible transformation process for  $(\text{MA})(\text{DMF})\text{PbI}_3$  into  $\text{MAPbI}_3$ . Such fast-anisotropic crystallisation is important for the printing of  $\text{MAPbI}_3$  for both sensing and emitting light applications.



**Fig. 1:** XRD profiles of  $\text{MAPbI}_3$  and intermediate phases. **a-c)** Calculated XRD profiles of  $\text{MAPbI}_3$ ,  $(\text{MA})(\text{DMF})\text{PbI}_3$  and  $(\text{MA})_2(\text{DMF})_2\text{Pb}_3\text{I}_8$  intermediate phases. **d)** XRD profile of  $(\text{MA})(\text{DMF})\text{PbI}_3$  calculated with the preferable grain orientation normal to the (011) planes. *Reproduced from principal publication.*

Aerosol jet printing (AJP) enables the creation of high aspect-ratio crystalline 3D-structures. Devices based on aerosol-jet-printed MAPbI<sub>3</sub> are excellent candidates for X-ray detection, as MAPbI<sub>3</sub> demonstrates strong X-ray-stopping power. The AJP technique also opens the way for the creation of heterostructures of MAPbI<sub>3</sub> with various materials. An X-ray detector unit based on MAPbI<sub>3</sub> on graphene was made, as shown in **Figure 2**.



**Fig. 2:** **a)** 1 cm<sup>2</sup> sensing chip with 3D-printed MAPbI<sub>3</sub> walls. **b-c)** False-coloured SEM images of the 3D-printed MAPbI<sub>3</sub> wall on the gold electrodes (graphene in blue, MAPbI<sub>3</sub> in purple and metal electrodes in yellow). **d)** Photograph of the fully integrated X-ray detector unit. *Reproduced from principal publication.*

It was observed that these heterostructures are very promising photoconductors, and the X-ray detector unit demonstrated record sensitivity values of  $2.2 \times 10^8 \mu\text{CGy}^{-1}\text{cm}^{-2}$ . Therefore, such heterostructure-based X-ray detectors could allow for significant lowering of the radiation doses required for X-ray imaging, resulting in safer and more affordable CT imaging systems. With the AJP technique, along with better understanding of the crystallisation processes of complex materials, a new playground for material engineering is opening and new intriguing systems can be created in the future.

### Principal publication and authors

Ultrasensitive 3D Aerosol-Jet-Printed Perovskite X-ray Photodetector, A. Glushkova (a,c), P. Andričević (a), R. Smajda (b), B. Náfrádi (a), M. Kollár (a), V. Djokić (a), A. Arakcheeva (a), L. Forró (a), R. Pugin (b), E. Horváth (a,b), *ACS Nano* **15**, 4077-4084 (2021); <https://doi.org/10.1021/acsnano.0c07993>

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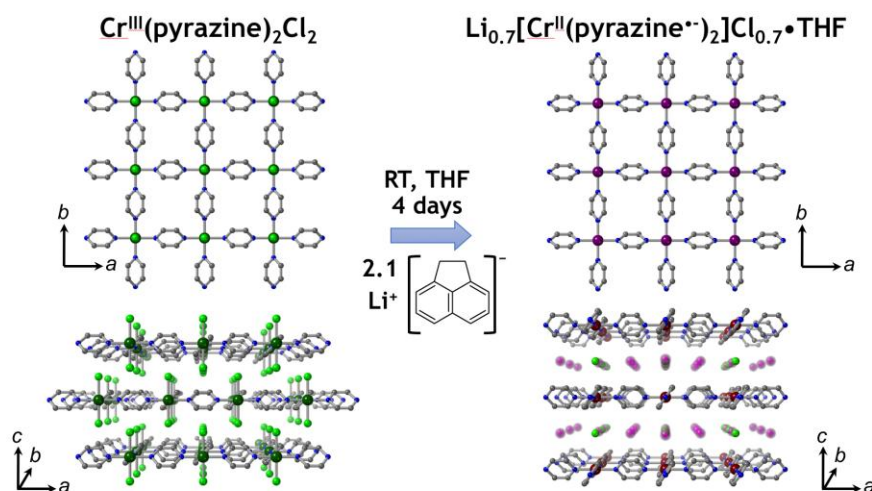
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## Unlocking the potential of molecule-based magnets above room temperature

**The thoughtful synthesis of high-performance molecule-based magnets is an ongoing challenge for the scientific community. This work develops a post-synthetic modification strategy, which allows to increase the exchange interactions between the metallic and organic radical spins of pre-formed coordination networks and results in magnets with unprecedented ordering temperatures and coercivity.**

Conventional magnets exhibit several drawbacks due to their purely inorganic origin, such as high energy consumption at fabrication level (e.g., SmCo and AlNiCo) and limited availability of key constituents (e.g., NdFeB and SmCo). While many such drawbacks could, in principle, be solved by using metal-organic magnets, the low operating temperatures of these materials (usually < 77 K) and the lack of generalised synthetic strategies have precluded their use in real-world applications.

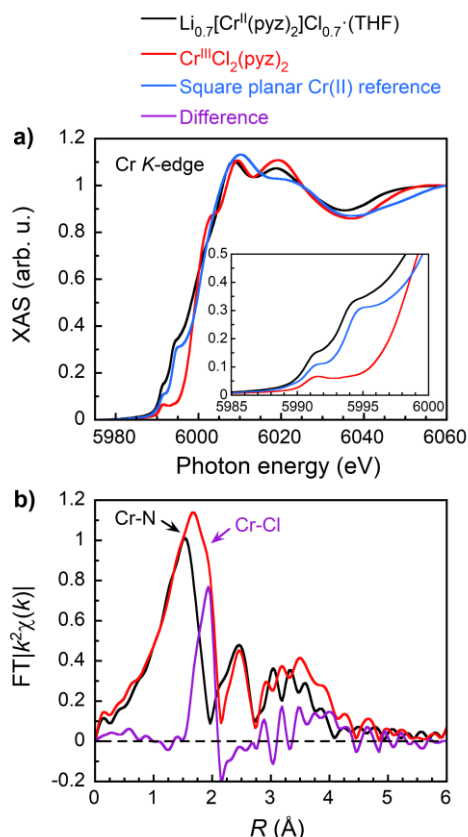
With this in mind, this work illustrates the post-synthetic modification of a couple of pre-formed two-dimensional (2D) coordination networks,  $\text{Cr}^{\text{III}}(\text{pyz})_2\text{Cl}_2$  (pyz = pyrazine, ferrimagnet below 55 K) and  $\text{Cr}^{\text{II}}(\text{pyz})_2(\text{OSO}_2\text{CH}_3)_2$  (antiferromagnet below 10 K;  $\text{OSO}_2\text{CH}_3^-$  = methylsulfonate anion) **[1,2]**. The reduction of the organic pyrazine moieties by lithium 1,2-dihydroacenaphthylene ( $\text{Li}^+[\text{C}_{12}\text{H}_{10}^{\bullet-}]$ ) leads to an increase in the number of spins and to strong magnetic interactions between the constituents, resulting in magnets that operate up to 515 K (**Figure 1**). Apart from exceeding the previous record working temperature observed for metal-organic magnets by more than 100 K, these new materials display unprecedented hard magnet properties at room temperature (RT), with coercive fields comparable to those of inorganic magnets.



**Fig. 1:** Scheme illustrating the post-synthetic reduction of the pre-formed  $\text{Cr}^{\text{III}}(\text{pyz})_2\text{Cl}_2$  pyrazine-based coordination network. Colour code: C, grey; N, blue;  $\text{Cr}^{\text{III}}$ , dark green;  $\text{Cr}^{\text{II}}$ , dark purple; Cl, light green; Li, purple.

In order to gain insights into these new systems, X-ray absorption spectroscopy (XAS), X-ray magnetic circular dichroism (XMCD) and powder X-ray diffraction (PXRD) experiments were performed at the **ID12** and **BM01** beamlines. X-ray absorption near-edge structure (XANES) spectra collected at the Cr K-edge for the RT magnets and reference compounds revealed the presence of square planar  $\{\text{CrN}_4\}$  environments in the RT magnets (**Figure 2a**), implying the reduction of Cr(III) ions into Cr(II) in the case of  $\text{Cr}^{\text{III}}(\text{pyz})_2\text{Cl}_2$  and the de-coordination of the axial ligands ( $\text{Cl}^-$  and  $^-\text{OSO}_2\text{CH}_3$ ) from the Cr ions. Such findings were further supported by Cr K-edge

extended X-ray absorption fine structure (EXAFS) spectra collected for the chlorine-based RT magnet and, more specifically, by the absence of the characteristic signature of the Cr-Cl bond that appears at  $R \sim 1.9 \text{ \AA}$  in the parent compound (**Figure 2b**).



**Fig. 2:** Experimental (a) XANES and (b) FT-EXAFS spectra of  $\text{Li}_{0.7}[\text{Cr}^{\text{II}}(\text{pyz})_2]\text{Cl}_{0.7}\cdot(\text{THF})$  (obtained after post-synthetic reduction of  $\text{Cr}^{\text{III}}(\text{pyz})_2\text{Cl}_2$ ,  $\text{Cr}^{\text{III}}(\text{pyz})_2\text{Cl}_2$  and a square planar Cr(II) model compound at the Cr K-edge at RT.

While structure determination was not possible in the case of the methylsulfonate-based RT magnet due to the co-precipitation of the  $\text{LiOSO}_2\text{CH}_3$  salt, synchrotron X-ray techniques, together with several spectroscopic, thermogravimetric and analytical techniques, revealed that the chlorine-based RT magnet was best described with the  $\text{Li}_{0.7}[\text{Cr}^{\text{II}}(\text{pyz})_2]\text{Cl}_{0.7}\cdot x(\text{THF})$  ( $0.25 \leq x \leq 1$ ) chemical formula, and enabled a good structural model that fit with the experimental PXRD data to be found. Thus,  $\text{Li}_{0.7}[\text{Cr}^{\text{II}}(\text{pyz})_2]\text{Cl}_{0.7}\cdot x(\text{THF})$  consists of quadratic 2D layers composed of  $\text{Cr}^{\text{II}}$  metal ions and radical pyrazine ligands. In addition, 0.7  $\text{Li}^+$ , 0.7  $\text{Cl}^-$  and  $x$  THF molecules per formula unit are located between the layers (**Figure 1**). Interestingly, the unusually strong coercive field of this compound can be modulated from 5300 Oe ( $d_{\text{layers}} = 8.5 \text{ \AA}$ ,  $x = 1$ ) to 7500 Oe ( $d_{\text{layers}} = 7.2 \text{ \AA}$ ,  $x = 0.25$ ) by the amount of THF molecules in the structure, or in other words, by the distance between the layers. Cr K-edge XMCD measurements further support the remarkable magnetic properties of these systems.

In conclusion, this work reports an original methodology to convert pre-formed coordination networks into high-performance magnets. These RT molecule-based magnets are much lighter than the conventional magnets and, therefore, of great relevance to aeronautics and spatial, mobile and wearable technologies.

## Principal publication and authors

Metal-organic magnets with large coercivity and ordering temperatures up to 242°C, P. Perlepe (a,b), I. Oyarzabal (a,c), A. Mailman (d), M. Yquel (a,b), M. Platonov (e), I. Dovgaliuk (e), M. Rouzières (a), P. Négrier (f), D. Mondieig (f), E.A. Suturina (g), M.-A. Dourges (h), S. Bonhommeau (i), R.A. Musgrave (a), K.S. Pedersen (a,i), D. Chernyshov (e), F. Wilhelm (e), A. Rogalev (e), C. Mathonière (b), R. Clérac (a), *Science* **370**, 587-592 (2020); <https://doi.org/10.1126/science.abb3861>

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(h) Univ. Bordeaux, CNRS, Bordeaux INP, ISM, UMR 5255, Talence (France)

(i) Department of Chemistry, Technical University of Denmark (Denmark)

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## Scientific output Impact Factors

73 peer reviewed papers were published in 2021 containing data from SNBL. >13% of the SNBL publications are published in journals with an impact factor above 10 and % above impact factor 4. See below the full distribution of papers per journal in 2021 and their impact factor.

Journal	Impact Factor	Publications in 2021
ADVANCED MATERIALS	30.849	1
NATURE CHEMISTRY	24.427	1
APPLIED CATALYSIS B-ENVIRONMENTAL	19.503	1
ACS NANO	15.881	1
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	15.419	1
ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	15.336	1
NATURE COMMUNICATIONS	14.919	1
CHEMICAL ENGINEERING JOURNAL	13.273	1
ACS CATALYSIS	13.084	2
CHEMICAL SCIENCE	9.825	3
ACS APPLIED MATERIALS & INTERFACES	9.229	2
PHYSICAL REVIEW LETTERS	9.161	1
CHEMSUSCHEM	8.928	1
NANO RESEARCH	8.897	1
BATTERIES & SUPERCAPS	7.093	1
CATALYSIS TODAY	6.766	1
CATALYSIS SCIENCE & TECHNOLOGY	6.119	1
INTERNATIONAL JOURNAL OF HYDROGEN ENERGY	5.816	1
JOURNAL OF ALLOYS AND COMPOUNDS	5.316	3
INORGANIC CHEMISTRY	5.165	5
NANOMATERIALS	5.076	1
DALTON TRANSACTIONS	4.39	1
CATALYSTS	4.146	1
JOURNAL OF PHYSICAL CHEMISTRY C	4.126	2
MATERIALS CHEMISTRY AND PHYSICS	4.094	1
CRYSTAL GROWTH & DESIGN	4.076	1
PHYSICAL REVIEW B	4.036	2
FARADAY DISCUSSIONS	4.008	1
PHYSICAL REVIEW MATERIALS	3.989	1
INTERMETALLICS	3.758	1
PHYSICAL CHEMISTRY CHEMICAL PHYSICS	3.676	2
MATERIALS	3.623	1
JOURNAL OF SOLID STATE CHEMISTRY	3.498	3
ACS APPLIED ELECTRONIC MATERIALS	3.314	1
JOURNAL OF SYNCHROTRON RADIATION	2.616	1
CRYSTALS	2.589	2

INORGANICA CHIMICA ACTA	2.545	1
METEORITICS & PLANETARY SCIENCE	2.487	1
ACTA CRYSTALLOGRAPHICA A-FOUNDATION AND ADVANCES	2.29	1
ACTA CRYSTALLOGRAPHICA SECTION B-STRUCTURAL SCIENCE CRYSTAL ENGINEERING AND MATERIALS	2.266	2
ARCHAEOLOGY	1.886	1
MENDELEEV COMMUNICATIONS	1.786	1
HIGH PRESSURE RESEARCH	1.431	1

## Scientific output Research Areas

All the SNBL papers in 2021 were also classified by research area. As the earlier years it's clear SNBL has a strong portfolio in chemistry and materials science followed by physics and crystallography. See below the full distribution per Research Area.

Research Area	Number of Publications
CHEMISTRY, PHYSICAL	23
MATERIALS SCIENCE, MULTIDISCIPLINARY	22
CHEMISTRY, MULTIDISCIPLINARY	15
CHEMISTRY, INORGANIC & NUCLEAR	11
NANOSCIENCE & NANOTECHNOLOGY	8
PHYSICS, APPLIED	7
CRYSTALLOGRAPHY	6
METALLURGY & METALLURGICAL ENGINEERING	5
PHYSICS, CONDENSED MATTER	4
ENGINEERING, CHEMICAL	3
PHYSICS, MULTIDISCIPLINARY	3
ELECTROCHEMISTRY	2
ENGINEERING, ENVIRONMENTAL	2
PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	2
ARCHAEOLOGY	1
CHEMISTRY, ANALYTICAL	1
CHEMISTRY, APPLIED	1
ENERGY & FUELS	1
ENGINEERING, ELECTRICAL & ELECTRONIC	1
GEOCHEMISTRY & GEOPHYSICS	1
GEOSCIENCES, MULTIDISCIPLINARY	1
GREEN & SUSTAINABLE SCIENCE & TECHNOLOGY	1
INSTRUMENTS & INSTRUMENTATION	1
OPTICS	1

## Publication list 2021

1. Arakcheeva, A., Pattison, P., Chapuis, G., Berger, H., Barisic, N., Forro, L. One-dimensional composite host-guest structure in BaVS<sub>3</sub> *Acta Cryst. section B*, 77, 115-122, 2021
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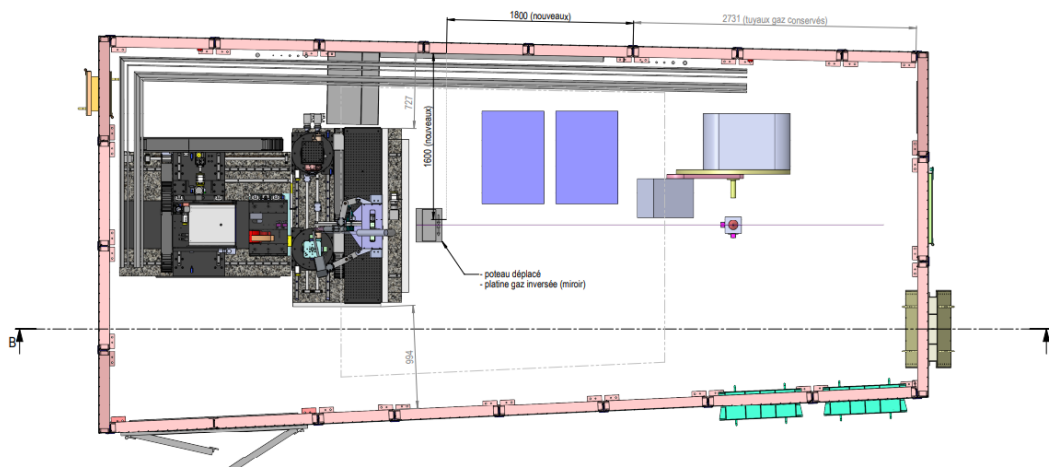
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## Summary of the works

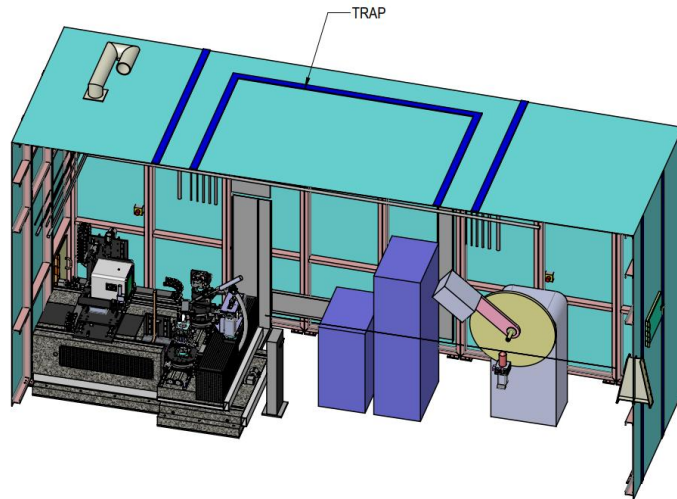
The ESRF has started to operate its beamlines with the new Extremely Brilliant Source in 2020. The SNBL has been preparing since 2017 for this event following a plan outlined in the “SNBL 2019-2020 and beyond” document. This document was supported by the Swiss- and Norwegian users, their respective steering committees and approved by the SNX Council. This document was also sent out by PSI for international review and received excellent evaluations. The SNBL international beamline review panel in 2019 also strongly endorsed the project.

In brief, the new EBS source provides excellent opportunities for SNBL users. In order to materialize these opportunities, a 2-phase plan for SNBL was therefore developed and consequently approved to adapt and upgrade both beamlines to the new EBS source. *Phase 1 covers investments in beamline equipment that are directly induced by the new source characteristics of the ESRF-EBS upgrade (i.e. higher heat load on the optical components).* Phase 2 provides an evolving scientific case for both BM01 and BM31 and their proof of concept. Obviously, the equipment installed now for Phase 1 is already compatible with the future scientific goals of the Phase 2 upgrade.

Phase 1 being completely finished, the new contract period between the NTNU and EPFL started and 2 Million Euro’s external funding available Phase 2 was ready was start. Major design works have hence been undertaken for the development of the new BM31 end station. The prior conceptual work was transformed in a full technical design (Figure 1 and 2) and all parts were ordered and machined by external companies. The assembly has started in 2021 and will continue in 2022. The new detector for PDF was also acquired and will be integrated in the new setup.

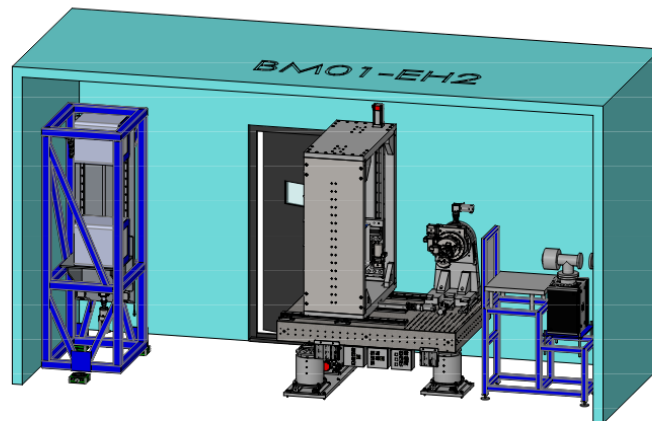


**Fig. 1:** Top view illustrating the layout of the upgraded experimental hutch of BM31. At the left side the new designed end-station XAFS-PDF-XRD.



**Fig. 2:** Isometric view illustrating the layout of the upgraded experimental hutch of BM31. At the left side the new designed end-station.

On BM01 the major job to be done was the implementation of a second detector for SAXS. The detector has been acquired and a new frame was designed and orders for construction were placed. See figure 3.



**Fig. 3:** Isometric view illustrating the layout of the upgraded experimental hutch of BM01. At the left side the new designed end-station for SAXS in the middle the existing end-station for XRD.