EMFL Annual Report 2021

European Magnetic Field Laboratory

EMFL
European Magnetic Field Laboratory

Radboud University

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European Magnetic Field Laboratory

Annual report 2021

Contact

Council	Prof. Han van Krieken (RU/NWO-I, Chair until June 14, 2021) Dr. Sylvain Ravy (CNRS, Chair from June 14, 2021 onwards) Prof. Sebastian Schmidt (HZDR) Prof. Amalia Patanè (University of Nottingham) Prof. Adam Babiński (University of Warsaw) Dr. Pierre Védrine (CEA-IRFU)
Board of Directors	Prof. Peter Christianen (HFML, Chair from January 1, 2021 onwards) Prof. Jochen Wosnitza (HLD) Dr. Charles Simon (LNCMI)
Executive Manager	Dr. Martin van Breukelen

Postal Address	Helmholtz-Gemeinschaft Brussels Office Rue du Trône 98 1050 Ixelles, Brussels Belgium
Website	www.emfl.eu
Facilities	High Field Magnet Laboratory (HFML) Toernooiveld 7 6525 ED Nijmegen, The Netherlands Hochfeld-Magnetlabor Dresden (HLD) Bautzner Landstr. 400 01328 Dresden, Germany Laboratoire National de Champs Magnétiques Intenses at Grenoble (LNCMI-G) 25 rue des Martyrs, B.P. 166 38042 Grenoble cedex 9, France Laboratoire National de Champs Magnétiques Intenses at Toulouse (LNCMI-T) 143 avenue de Rangueil 31400 Toulouse, France

https://www.linkedin.com/company/emfl/

https://twitter.com/h2020isabel

Members

Radboud University
Houtlaan 4,
6525 XZ Nijmegen, The Netherlands
and
the Institutes Organisation of the Dutch Research Council (NWO)
Winthontlaan 2,
3526 KV Utrecht, The Netherlands
Parent organisation HFML

Centre National de la Recherche Scientifique
3 Rue Michel Ange, Paris, France
Parent organisation LNCMI Grenoble and Toulouse

Helmholtz-Zentrum Dresden-Rossendorf e. V.
Bautzner Landstr. 400
01328 Dresden, Germany
Parent organisation HLD

University of Nottingham
University Park
Nottingham, NG7 2RD, United Kingdom

University of Warsaw
Krakowskie Przedmieście 26/28
00-927 Warszawa, Poland

CEA-IRFU
Centre de Saclay,
91191 Gif-sur-Yvette Cedex, France

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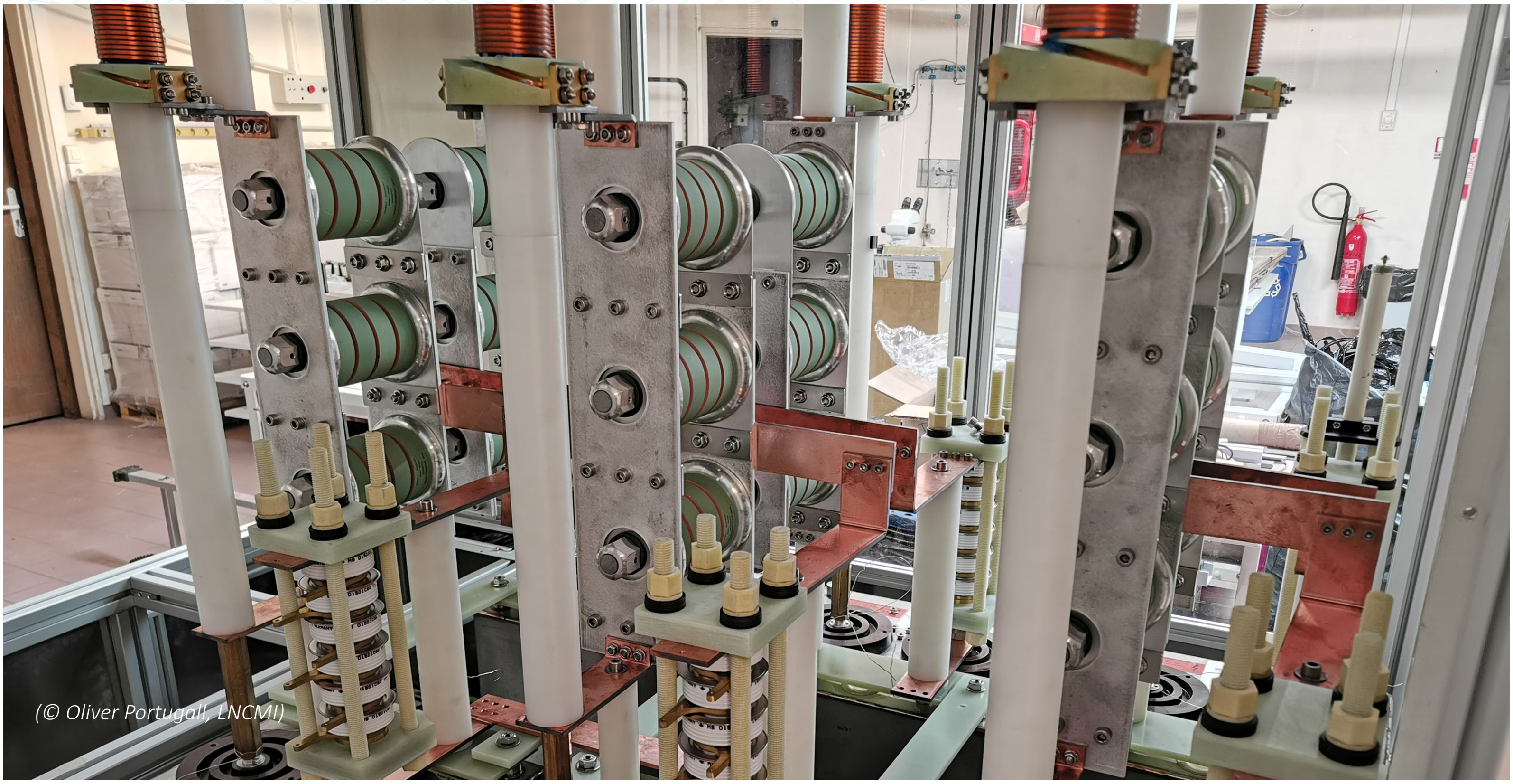
(© Oliver Portugall, LNCMI)

Foreword

Dear Reader,

It is a great pleasure to present to you the seventh annual report of the European Magnetic Field Laboratory, reporting many excellent scientific highlights and important developments.

In 2021, EMFL still had to deal with the impact of the Covid-19 pandemic, which affected different parts of our activities. Fortunately, the EMFL facilities did not need to close entirely, but our operational activities were still hampered by the Covid-19 restrictions and travel regulations. Effort was made to offer our external users mail-in and/or remote access to the facilities, but the whole situation inevitably caused a backlog of projects. Therefore, we are extremely happy that, despite these most difficult circumstances, we are able to report a large number of scientific highlights, important developments and new high field initiatives.

One of these initiatives is the start of the H2020-SuperEMFL project, which focuses on the development of all-superconducting user magnets at unprecedented field strengths of 40 T and beyond. SuperEMFL will produce a conceptual design report addressing all key questions concerning the realization and implementation of this type of user magnets in the European high field infrastructure.

2021 also marks significant progress within the H2020-ISABEL project. Together with our partners, both from academia and industry, a large number of initiatives are ongoing to strengthen the structure of EMFL and its coordinating role and socio-economic impact on an European and global scale.

Finally, I would like to thank all the staff and users of the EMFL facilities for their hard work, resilience and flexibility, to make 2021 such a successful year.

Peter Christianen

Chairman EMFL
Director HFML

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Mission

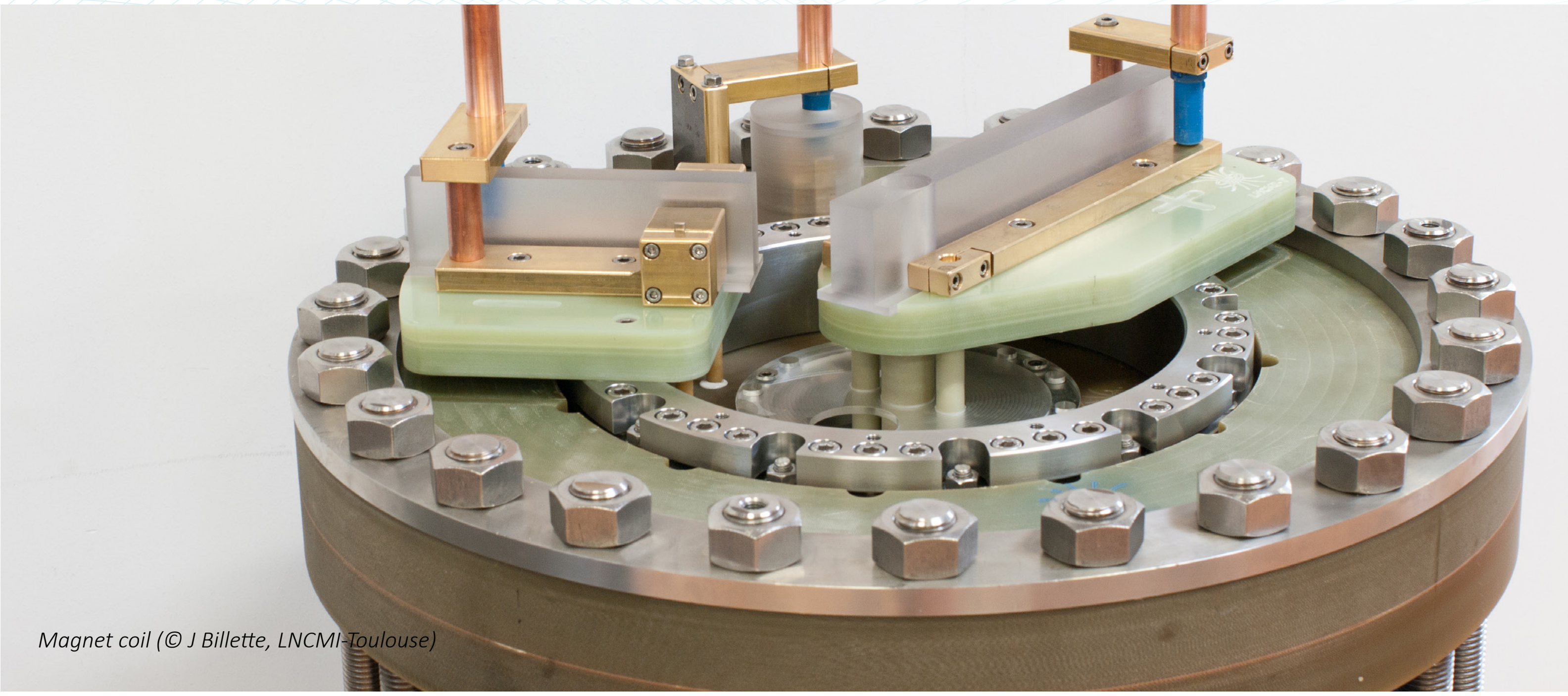
The EMFL develops and operates world class high magnetic field facilities, to use them for excellent research by in-house and external users

High magnetic fields are one of the most powerful tools available to scientists for the study, the modification and the control of the state of matter.

The European Magnetic Field Laboratory (EMFL) was founded in 2015 and awarded the Landmark status in March 2016 during the ESFRI Roadmap presentation in Amsterdam. EMFL provides the highest possible fields (both continuous and pulsed) for its researchers. The EMFL is dedicated to unite, coordinate and reinforce the four existing European high magnetic field facilities – the Dresden High Magnetic Field Laboratory (Germany), the Laboratoire National des Champs Magnétiques Intenses in Grenoble and Toulouse (France), and the High Field Magnet Laboratory in Nijmegen (The Netherlands) – within a single body as a world-leading infrastructure.

The missions of the EMFL are:

- to develop, construct and operate world-class high-field magnets
- to perform excellent research in very high magnetic fields
- to act as a European user facility for the scientists of the participating countries and for other scientists
- to act as the European centre of excellence for different magnetic-field-based material characterisation techniques in very high fields



Magnet coil (© J Billette, LNCMI-Toulouse)

Developments 2021

COVID-19

Also in 2021 EMFL, had to deal with the impact of the Covid-19 pandemic. The impact affected different parts of our activities and particularly our international guest programme.

In 2021 fortunately the EMFL facilities did not need to close entirely, but our operational activities were still hampered by the Covid-19 restrictions and travel regulations. National and local regulations still made it difficult for users from abroad to travel to one of the EMFL sites. Governmental rules, local policies, travel restrictions and insurances made that visits from abroad were very limited from the start of the pandemic and this continued in 2021. The awarded user projects that could not take place have been postponed and have been rescheduled, whenever possible, in mutual agreement with the respective user group. Consequently, the pandemic has caused a backlog of mainly external projects. Effort was made to offer mail-in and/or remote access enabling to perform external projects. In some cases this was indeed possible, but for a large number of the projects the external experimentalist is required on site.

Changes in the EMFL board of directors - Geert Rikken steps down as LNCMI director

Since January 1, 2021, there have been some changes in the composition of the EMFL Board of Directors (BoD). Geert Rikken has stepped down as director of LNCMI and is succeeded by Charles Simon, who will join the EMFL BoD. Peter Christianen, director of HFML, fills the BoD chair position. Changes in the EMFL board do occur more regularly, as the chair position rotates every 2 years, but with Geert Rikken stepping down, a period ends. Geert is one of the founders of EMFL and has been involved in the European collaboration of the high magnetic field facilities from the early start.

The first collaboration was the Integrated Infrastructure Initiative (I3) project EuroMagnet I (2004-2008), which was continued by EuroMagnet II (2009-2013, coordinated by Geert). The great success of these projects resulted in the EMFL –project (2011-2014), finally culminating in the foundation of the legal entity EMFL-AISBL on January 27, 2015. All that time, Geert has been present at the board meetings, the user meeting and schools and supported, wrote and coordinated many European projects. EMFL is in an excellent position and welcomed 3 external members, the University of Nottingham, representing the UK user community (2015), the University of Warsaw, representing the Polish user community (2019) and CEA-IRFU (2019) strengthening the collaboration on magnet technology. The EMFL-AISBL is also participating as partner in 2 European projects ISABEL and SuperEMFL.

Geert has actively managed many of those activities, being chair of the EMFL BoD for 2 periods and successfully paved the way for the expansion of EMFL. As Geert is the coordinator of the H2020 ISABEL project that stands for ‘Improving the Sustainability of the European Magnetic Field Laboratory’, he will be closely involved in the further development of EMFL. Fortunately, EMFL can continue profiting from his knowledge, new ideas, and determination to further advance the high magnetic field community.

The new EMFL Board of Directors

Peter Christianen (chair)
Director HFML - Nijmegen

Jochen Wosnitza
Director HLD - Dresden

Charles Simon
Director LNCMI - Grenoble & Toulouse

SuperEMFL: Towards all-superconducting user magnets beyond 40 Tesla

The primary objective of the EU funded design study SuperEMFL is to add an entirely new dimension to the EMFL through the development of all-superconducting user magnets at unprecedented field strengths of 40 T and beyond, granting the European high-field user community access to such high superconducting magnetic fields, more magnet time, and novel low-noise high-sensitivity capabilities, whilst at the same time reducing operating costs and the EMFL environmental impact.

SuperEMFL aims to develop a conceptual design report addressing all key questions concerning the technical and conceptual feasibility as well as the maturity of a major upgrade of the EMFL facilities based on the development of the high-temperature superconductor (HTS) technology. In this manner, SuperEMFL addresses both the scientific, organizational, and technical work to provide data, drafts, and plans for the construction, efficient implementation, and the conceptual work to fund and coherently integrate such magnets in the existing facilities.

The 48-months SuperEMFL design-study project contains several specific components:

- Define appropriate specifications such as homogeneity, stability and bore size according to the users' requirements with two targets: a 32+ as well as a 40+ T all-superconducting user magnet.
- Produce a complete design including a failure-mode analysis and a risk assessment of these all-superconducting user magnets.
- Develop the complete characterization and electrical, thermal and mechanical qualification of the HTS conductors and test coils. SuperEMFL will include characterizing industrial HTS conductors in an extensive manner giving a decisive advantage to the European companies involved in SuperEMFL.
- Demonstrate the feasibility concerning technological challenges through modelling and tests.
- Develop requirements for fabrication in an industrial environment.
- Prepare a funding roadmap to implement the magnets.

The EU Horizon 2020 program INFRADEV aims to support the development of world-class research infrastructures which will help Europe to tackle grand challenges in science, industry, and society. It facilitates and supports the implementation and long-term sustainability of the research infrastructures identified by the European Strategy Forum on Research Infrastructures (ESFRI) and of other world-class research infrastructures. In the SuperEMFL project, the following partners are involved:

- Centre National de la Recherche Scientifique (FR)
- Helmholtz-Zentrum Dresden-Rossendorf e.V. (DE)
- Radboud University (NL)
- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (FR)
- European Magnetic Field Laboratory AISBL (BE)
- Université de Genève (CH)
- Universiteit Twente (NL)
- Institute of Electrical Engineering, Slovak Academy of Sciences (SK)
- Theva Dünnschichttechnik GmbH (DE)
- Oxford Instruments Nanotechnology Tools Limited (UK)
- Bilfinger Noell GmbH (DE)

HTS insert magnet with its instrumentation wiring before mounting on the characterization probe.

The kick-off meeting was held on January 25th, 2021.

Novel access procedure to the EMFL: Dual Access

EMFL created for its users an extended and tailored range of new access procedures that will be implemented within the ISABEL project. For this purpose, there will be a survey addressed to the user community in the near future. In the course of 2021, novel access procedures, such as first-time, fast-track, long-term, and industrial-user access will be announced on the EMFL and ISABEL websites as well as integrated into the EMFL online proposal submission system.

A first start is made and within the ISABEL project a novel Dual Access procedure already started from the first call in 2021. This procedure will invite users at an early stage of their research projects and will lower the barrier for access as well. Within one experiment proposal, users will have the possibility to apply both for first-step access to research equipment dedicated to the moderate-field range accessible with superconducting magnets, and in a subsequent second step to the highest possible magnetic fields at the EMFL installations in Grenoble, Nijmegen, Toulouse, and Dresden. For performing experiments in the moderate-field range, thanks to the ISABEL project, EMFL has partnered with well equipped and experienced regional facilities distributed over Europe. In this way, the dual-access procedure will particularly support such users that, so far, have had inadequate access to superconducting magnets. In the next issues of the EMFLNEWS we will profile the regional facilities:

- Superconducting magnet laboratory, University of Nottingham (UNOT)
- Oxford Centre for Applied Superconductivity, University of Oxford (UOXF)
- Nicholas Kurti High Magnetic Field Laboratory, University of Oxford (UOXF)
- Laboratory of Low Temperatures and High Magnetic Fields, Universidad Autonoma de Madrid (UAM)
- Research Laboratories of the Faculty of Physics, University of Warsaw (UWAR)
- Materials Growth and Measurement Laboratory, Charles University, Prague (UCHA)
- Research Facilities of the National Institute of Chemical Physics and Biophysics, Tallinn (NICPB)
- Spintronics and Nanomagnetism Laboratory, University of Salento, Lecce (USAL)

How to apply for Dual Access

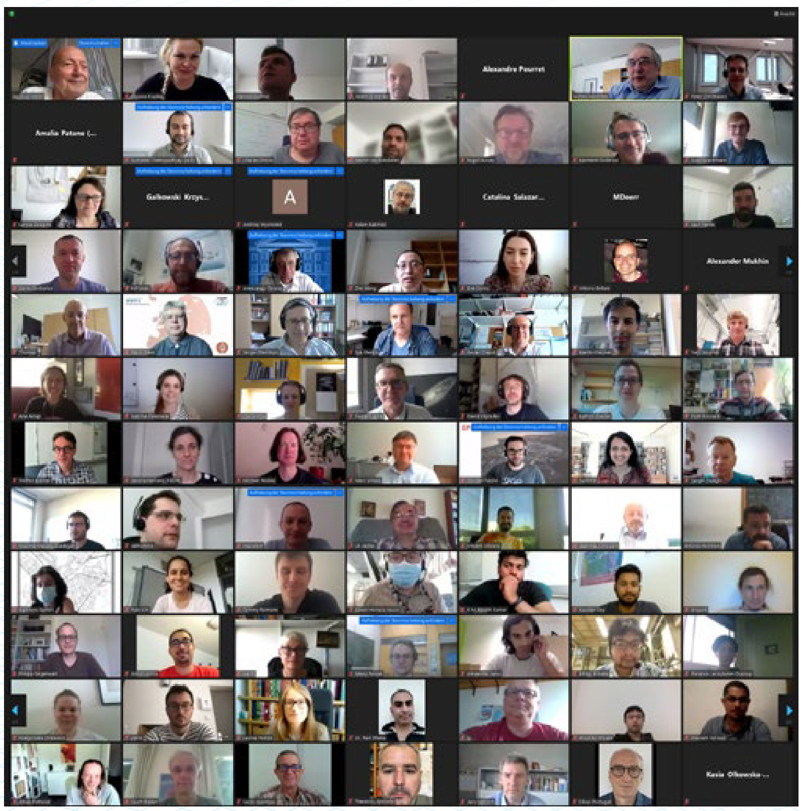
Proposals will be submitted within the periodic EMFL calls. The EMFL Selection Committee will judge the scientific pertinence of the proposed low-field experiments and high-field experiments together and will grant conditional access to the EMFL installations in one statement. It is foreseen that local-support experts at the EMFL facilities will finally decide on performing the subsequent experiments at the EMFL high-field facilities, depending on whether the scientific need to continue the project at very high magnetic fields has been proven.

ISABEL will provide limited financial support for experiments at regional and EMFL facilities that participate in the dual access trial. Inquiries for use of regional facilities should be directed in the first instance to the local contacts of the regional facilities.

User Meeting of the European Magnetic Field Laboratories

After the cancellation of the user meeting in 2020, the EMFL Board of Directors undertook a fresh start this year. Organized by HLD, the twelfth user meeting of the European magnetic field laboratories took place on June 15, 2021 in video format. With up to 140 participants of the high-field community logged in to join the virtual venue, it was exceptionally well attended.

The aim of the meeting was to exchange ideas and experiences, to present scientific results, and to discuss about possibilities for improving the facilities' attractiveness. The meeting started with a warm welcome by Peter Christianen, chair of the EMFL Board of Directors and director of the HFML. After the announcement of and presentation by the EMFL prize winner (see separate article on the next page) the



audience enjoyed eight excellent invited talks from selected users reporting on recent scientific highlights done at EMFL facilities.

Further, there were introductory talks on the EU-funded projects ISABEL by Geert Rikken and SuperEMFL by Xavier Chaud, important for the future development of EMFL. As usual, the EMFL User Committee met during the meeting. Raivo Stern (NICPB, Tallinn, Estonia) chaired this part and reported afterwards on the outcome of the meeting and on suggestions of the Committee back to the Board of Directors.

The virtual user meeting ran very smoothly and was well received by the participants. However, the common coffee breaks, chats with colleagues, tours through the lab, and direct interactions were missing. We very much hope that the next user meeting will take place in person in Grenoble next June. We plan to provide remote access to this meeting.

EMFL Prize Winner 2021: Denis Gorbunov

We are still in the middle of the Corona pandemic, but this year´s EMFL award ceremony took place already a little bit more festive than last year. This time, Dr. Denis Gorbunov, staff member and local contact at the Dresden High Magnetic Field Laboratory (HLD-EMFL), had the honour to receive the prize, at the occasion of the EMFL user meeting. Due to the unusual circumstances, given the virtual ambience of the event, Jochen Wosnitza, director of the HLD-EMFL, was forced to hand over the award directly through the screen.

The EMFL prize winner 2021, Dr. Denis Gorbunov.

Dr. Denis Gorbunov received the award for his pioneering work in the field of magnetism, in particular for his research on rare-earth transition-metal compounds using a broad suite of experimental techniques, including x-ray experiments at very high, pulsed magnetic fields. Since 2009, the EMFL members award annually the EMFL prize for exceptional achievements in science done in high magnetic fields.

Report of the annual EMFL User Committee meeting 2021

After the cancellation of the user meeting in 2020 due to the worldwide pandemic shutdown, the EMFL and its user community adopted to the “new reality” and gathered online for its annual user meeting for 2021. The high participation of up to 140 people showed the desire for a meeting to exchange on current developments and scientific progress. The user community recognizes this large attendance as a positive adjustment and encourages the EMFL Board of Directors (BoD) to consider hybrid meetings in the future, as well.

Currently, the EMFL User Committee (UC) consists of 9 members. With the user community of EMFL steadily growing, the new UC repeats their request for a renewed, much stronger mandate to better represent the interests of the high-field users. The UC wants to stress that the first priority should be the satisfaction of the users’ needs and the aim to carry out world-class research.

A key part of the UC’s work is to review prior feedbacks and how the EMFL BoD has incorporated it. A point of review this year was the availability of information for users on accessible magnets, cryogenic infrastructure, and experimental techniques. While the UC together with the attendees can see progress in this area, particularly on the new EMFL website, a number of users requested a more detailed description with available resolution and documentation.

Another example of continuous and steady progress is aimed at the users themselves. Without their feedback and clear communication of needs for their experiments, the UC cannot help. With the support of the EMFL BoD, a new feedback form was developed. It has not led to the expected outcome and the EMFL BoD decided to change to an immediate questionnaire as part of the user meetings. Many of the participants partook in this experiment. However, we still emphasize our call here to all users to give feedback via the EMFL website.

Further issues, which were discussed, include general data protection rules (GDPR), open data strategy, online safety trainings, and how to improve activities of dissemination. To get a better understanding of the most widely used magnets, the user community is encouraged to get in contact and name the magnet they would like to experiment with the most. The user committee will then combine this input and discuss strategies with the BoD on how to meet the needs of the community best.

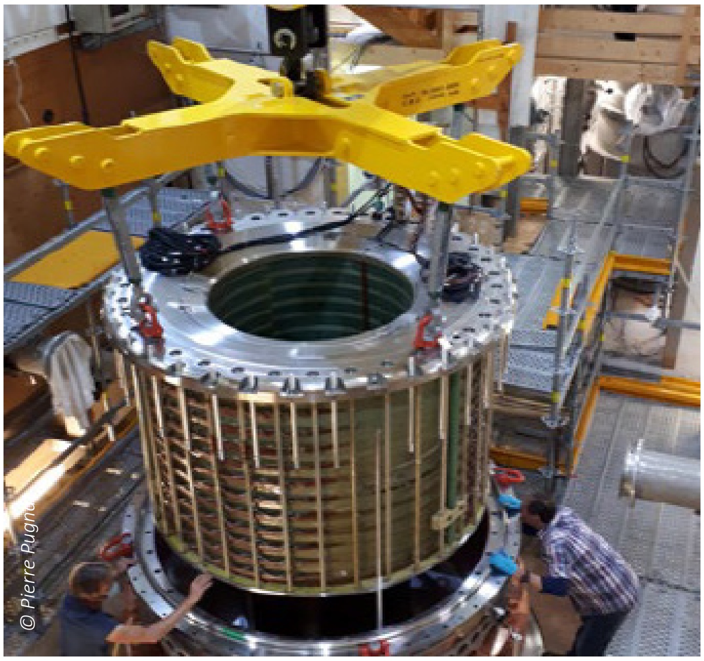
The UC welcomed two new initiatives at the EMFL. First, the new secondment activity allowing scientists and technicians to visit other laboratories and teams. Second, travel support for early-stage scientists from Europe and developing countries for attending the EMFL User Meeting and learning about the EMFL and experimental possibilities there.

Last but not least, the UC would like to thank the EMFL laboratories and their staff for the help during the past years in carrying out experiments on a remote basis. This new operational scheme has challenged both the users as well as their local contacts on finding new ways to communicate, long extra hours in the laboratory, as local contacts had to carry out experiments themselves, and logistics to get samples to the laboratories safely.

The 43+T Grenoble hybrid magnet: major achievements for final assembly

The hybrid magnet, combining resistive and superconducting technologies and that is under construction at LNCMI-Grenoble, has reached important milestones in 2021 despite the Covid-19 sanitary crisis. After a thorough preparation

Successful insertion of the superconducting coil in the He vessel. In the most constraint part, the radial clearance is 0.4 mm.



Closure welding of the He vessel with the superconducting coil inside requiring a strict control of the temperature to not damage the electrical insulation (contractor SDMS).

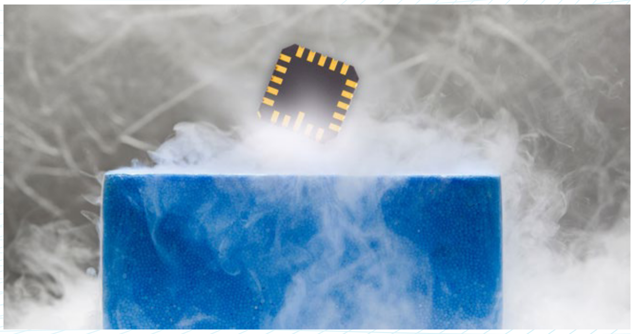
Trial assembly of the cryogenic line (contractor Cryo Diffusion) connecting the cryogenic satellite in the back to the superconducting magnet cryostat in the front.

phase, we successfully inserted the outsert superconducting coil of 1100 mm aperture into its He vessel (Figure 1). Supported by the company SDMS, we then realized the closure welds of the He vessel (Figure 2) following a strict procedure to not damage the coil, the instrumentation wires, and the ground electrical insulation. After a successful dye penetrant test of the welds, we will further perform pressure and leak tests. On June 30, Cryo Diffusion delivered the cryogenic line to LNCMI-Grenoble. We achieved an overall dummy assembly with the cryogenic line connecting the magnet cryostat to the cryogenic satellite that shall produce pressurized superfluid He (Figure 3). This step allowed us to ensure final mechanical adjustments prior to the final closure welds. We expect the superconducting magnet cooldown to start in the second quarter of 2022.

Paragraf graphene Hall sensors deliver high-accuracy operation in fields exceeding 30 Tesla and at cryogenic temperatures

Paragraf™ has leveraged its expertise in the manufacturing & implementation of graphene technology to make another major advance in Hall-sensor performance. The company has announced the availability of a new sensor range capable of unmatched sensitivity and linearity when placed in low-temperature environments and in strong magnetic fields.

Tested at the High Field Magnetic Laboratory (HFML) at Radboud University Nijmegen, the GHS-C sensors support operation in magnetic fields up to 30 T and at cryogenic temperatures (down to 1.5 K). The sensors deliver a degree of accuracy that has not previously been achievable under these conditions, sustaining non-linearity errors of significantly less than 1 % across the full measurement range.



The transformative magnetic-field measurement capabilities of the GHS-C devices are due to the graphene sensor elements. Graphene's inherent high electron mobility directly translates into high sensitivity capability, which is maintained across the entire magnetic-field range – making these devices far simpler to calibrate. The two-dimensional nature of graphene also means high quality, repeatable, and accurate data is provided by the GHS-C sensor, with no hysteresis and immunity to in-plane stray fields. This is a step beyond conventional Hall sensors which have demonstrated asymmetry, producing different measurements depending on field direction.

A further advantage of the GHS-C range is their very low power operation resulting in power dissipation in the below nW range, compared to µW or mW associated with non-graphene Hall sensors. Examples of suitable applications include low-temperature quantum computing, high-field magnet monitoring in next-generation MRI systems, fusion-energy field control, particle accelerators, and other scientific and medical instrumentation. The sensors can also be directly used in fundamental physics experiments, e.g., quantum physics research, superconductivity, and spintronics.

Visit of ISABEL and SuperEMFL partners at the LNCMI facility in Grenoble

Between 29 and 30 November 2021, ISABEL and SuperEMFL partners met for the first time in a face-to-face meeting at the LNCMI facility in Grenoble. This was a great opportunity to see each other in person, to review the projects progress with the executive board members, and to anticipate the coming actions and challenges with the ISABEL Council and SuperEMFL governing board. On the second day, the ISABEL and SuperEMFL coordination teams shared a joint meeting and discussed the synergy and implementation of their common actions.


© Eva Bezgousko

After the meetings, the participants had the opportunity to visit the infrastructure of the Grenoble facility. It was a moment of sharing experience and knowledge on large-scale magnet installations with the staff of Grenoble. The ISABEL and SuperEMFL partners thank the Grenoble staff for hosting the event and the participants for the fruitful discussions. We are all looking forward to new opportunities for more face-to-face meetings during the coming years.

Renewal of UK membership of EMFL approved by EPSRC

The renewal of the UK membership of the European Magnetic Field Laboratory (EMFL) has been approved, in principle, by the Engineering and Physical Sciences Research Council (EPSRC), the main funding body for engineering and physical sciences research in the UK. The renewal extends the current membership to 31 March 2027 and allows to continue and expand the well-established successful cooperation.

UKRI Engineering and Physical Sciences Research Council

The EMFL, consisting of the Laboratoire National des Champs Magnétiques Intenses (LNCMI) with sites in Grenoble and Toulouse, the High Field Magnet Laboratory (HFML- Nijmegen) and the Hochfeld- Magnetlabor (HLD - Dresden), provides access to the highest continuous and pulsed magnetic fields in Europe. The UK membership of the EMFL will enable the UK users the free access to these installations and of all available auxiliary equipment, expert support from the local staff, as well as funding for travel and subsistence.

Calls for proposals are launched by the EMFL twice a year (with deadlines in May and November) inviting proposals for research requiring access to one of the installations of the EMFL. Users may submit proposals for access to any of these installations by an on-line form, which can be found on the EMFL website (www.emfl.eu „apply for magnet time“). The proposals are evaluated by an international Selection Committee and are ranked based on scientific quality, justification of the need for high magnetic fields, and technical feasibility of the project.

Each year, the EMFL organizes a user meeting for those who have used or would like to use the EMFL. The purpose of this meeting is to bring users together to report on their experiments and exchange information about the opportunities offered by the EMFL. Also, UK as well as other users are invited to inform the EMFL on the specific needs in terms of new equipment or facility developments they may have in the future.

Magnetoforming coils with a long life-time: LNCMI to cement ties with Bmax

Since 2013, the LNCMI is collaborating with the Toulouse company Bmax / I Cube Research to design magnetoforming coils with long lifetime. Durability is a crucial issue for using electromagnets at an industrial scale, requiring the production of parts in large quantities with extreme precision and at controlled cost.

To generate very strong magnetic fields, it is necessary to use conductors that combine good electrical conductivity with very high mechanical strength. In addition to the magnet production, the LNCMI has its own wire-drawing workshop and is able to manufacture the conductors necessary for the fabrication of coils which can resist long-lasting magnetic fields (several tens of milliseconds) up to the 100 T range. It is this expertise that attracted Bmax / I Cube Research, a specialist in magnetoforming.

Magnetoforming is a technique that makes it possible to manufacture precise parts with shapes that cannot be obtained by other methods at reasonable costs. The pulsed electromagnets that are designed for this purpose generate very short and strong magnetic field pulses, which induce a current in the metal part to be molded. The part is then projected at very high speed onto a mold, which gives it the desired form. This technique is called direct, as opposed to indirect, magnetoforming where a punch is set in motion by magnetic forces, hits the material to be modeled and projects it to the mold. The operation takes place in a few tens of microseconds, and offers a level of precision in the shape of the parts that meets the expectations of very demanding sectors such as luxury, aeronautics, and automotive industry.

However, the pulsed electric currents that make this process possible impose enormous magnetic, mechanical, and thermal stresses on the electromagnet. The challenge is, therefore, to produce coils with conductive materials that are sufficiently resistant to sustain these stresses in order to use them on industrial production lines without the need of frequent replacement. Starting with a few hundred pulses realized a few years ago, the LNCMI, therefore, has optimized the electromagnets to withstand more than 30,000 pulses, which corresponds to a 50-times longer lifetime. Based on this success Bmax / I Cube Research is now in a position to extend its magnetoforming applications and to conquer new markets. Initially financed by funds of Bmax / I Cube Research, the partnership with the LNCMI was recognized institutionally and has been sponsored as part of local (NEXTMAG, LABEX NEXT), regional (MAG-IC, Région Occitanie), national (SIgMA, ANR), and European (ISABEL, H2020) projects.

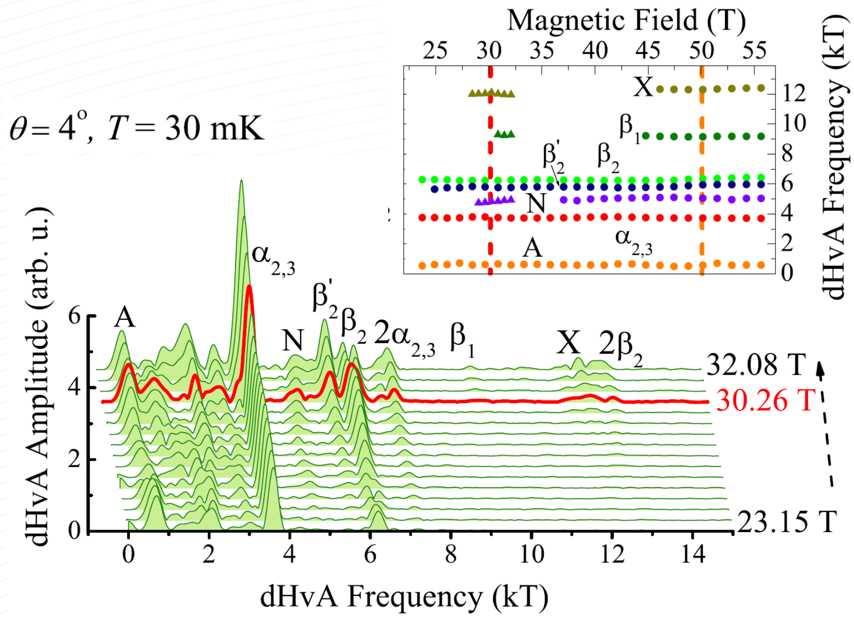
Magnetoforming coil

Scientific Highlights

Robust Fermi-surface topology of $CrRhIn_5$ in high magnetic fields

Rare-earth-based materials are now widely recognized as an ideal playground for exploration of the fascinating physics that develops around a quantum critical point (QCP). In Ce-based compounds, such a QCP typically separates an antiferromagnetic (AFM) state from a nonmagnetic ground state. In spite of numerous experimental investigations of such systems near a QCP, the details of what drives the QCP remain the subject of much theoretical debate.

$CeRhIn_5$ is one of the best-studied heavy-fermion materials. This AFM compound with TN = 3.8 K can be tuned to a QCP by pressure, chemical substitution, and magnetic field. Several de Haas–van Alphen (dHvA) experiments evidence localized f electrons of $CeRhIn_5$ at ambient pressure. As the critical pressure for the suppression of antiferromagnetism, P_c = 2.3 GPa, is reached, all dHvA frequencies observed below this pressure change discontinuously, signaling an abrupt Fermi-surface (FS) reconstruction as a consequence of f-electron delocalization. Recent results obtained at high magnetic fields suggested a unique behavior in CeRhIn5. A field-induced QCP was reported to occur at the critical field $B_c \approx 50$ T. An electronic-nematic phase transition was observed at B* ≈ 30 T and attributed to an inplane symmetry breaking. Finally, the emergence of additional dHvA frequencies was observed at B* and interpreted as a field-induced FS reconstruction associated with f-electron delocalization. This result is surprising given that magnetic fields are generally expected to localize the f electrons.



FFT spectra of the static-field dHvA oscillations in $CeRhIn_5$. The inset shows the evolution of the dHvA frequencies with field obtained from pulsed (circles) and static (triangles) field measurements.

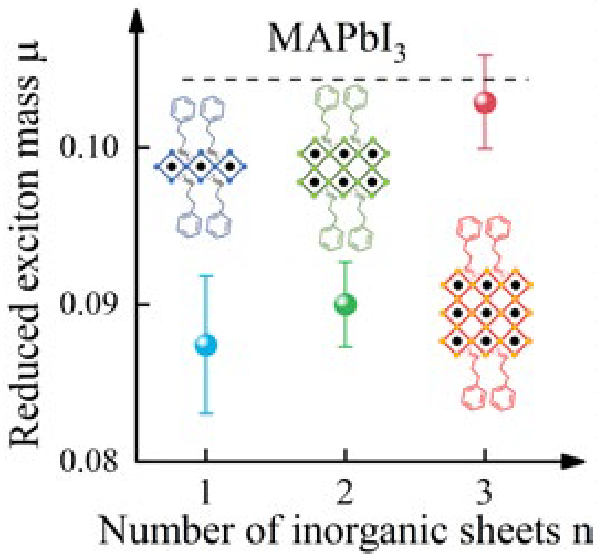
To resolve this controversial issue, researchers from the EMFL laboratories in Grenoble, Dresden, and Nijmegen, together with their Japanese colleagues, performed a comprehensive dHvA study of $CeRhIn_5$ using both static (up to 36 T) and pulsed (up to 70 T) magnetic fields. Several dHvA frequencies were found to gradually emerge at high fields as a result of magnetic breakdown (Figure). Among them is the theoretically predicted β_1 branch, not observed so far. Comparison of the angle-dependent dHvA spectra with those of the non-4f compound $LaRhIn_5$ and with band-structure calculations evidence that the Ce 4f electrons in $CeRhIn_5$ remain localized up to 70 T. This rules out any FS reconstruction, either at the suggested nematic phase transition at B* or at the putative QCP at B_c. These results demonstrate the robustness of the FS and the localized nature of the 4f electrons inside and outside of the AFM phase.

Reference

Mishra, S., J. Hornung, M. Raba, J. Klotz, T. Förster, H. Harima, D. Aoki, J. Wosnitza, A. McCollam and I. Sheikin (2021). "*Robust Fermi-Surface Morphology of $CeRhIn_5$ across the Putative Field-Induced Quantum Critical Point*". Physical Review Letters, 126: 016403.

Tuning the excitonic properties of a two-dimensional perovskite family via quantum confinement

Two-dimensional (2D) metal-halide perovskites constitute an important step in the evolution of low-cost organic-inorganic hybrid light absorbers and emitters. Similar to their 3D counterparts, layered perovskites show promising performance in photovoltaic and light emitting devices while preserving high environmental stability. The latter is of paramount importance for the industrialization of perovskite technology. In 2D perovskites the improved stability stems from the large hydrophobic organic cations L separating inorganic octahedral sheets. The general formula describing Ruddlesden-Popper (RP) 2D layered perovskites is $L_2A_{n-1}M_nX_{3n+1}$, where A is a small monovalent cation, M is a metal atom, X is a halide atom, and n denotes the number of octahedral layers. Despite their popularity and successfully deployment in various opto-electronic devices, some questions about their fundamental opto-electronic properties remain unanswered. For example, determining the effective mass of charge carriers in 2D perovskites is challenging, with most attempts so far limited to density functional theory (DFT) calculations. In principle, it is interesting to understand how the charge-carrier effective mass changes with increasing n, as the crystal structure evolves from that imposed by the large organic spacer L, to the crystal structure determined mostly by methylammonium (MA), i.e., in the bulk limit. Currently, the only report addressing this problem is limited to the case of butylamine (BA) [Blancon et al., Nat. Commun. 9, 2254 (2018)]. It was shown that the charge-carrier effective mass is enhanced in this 2D perovskite with respect to 3D $MAPbI_3$, and with an increasing number of inorganic sheets n, the effective mass μ decreases, reaching the bulk limit for high n values.



Evolution of the reduced effective mass μ with increasing number of inorganic sheets. Insets show the schematics of each sample (c axis pointing upwards): Black and open spheres stand for Pb and I atoms and build the inorganic framework; phenyl rings with attached ethylammonium groups form large organic spacers L (PEA, $C_6H_5C_2H_4NH_3^+$). For clarity, the small organic cation (MA, methylammonium) filling the octahedral voids is omitted.

We demonstrate that such an observation does not necessarily apply to all 2D perovskites. With the use of optical spectroscopy in high magnetic fields, we observe interband Landau-level transitions which provide direct access to the reduced effective mass μ of the charge carriers in 2D $(PEA)_2MA_{n-1}Pb_nI_{3n+1}$ perovskites, where n = 1, 2, 3 (see Figure for structure schematics). We demonstrate that μ increases with the number of inorganic layers n, reaching the same value as 3D $MAPbI_3$ already for n = 3. Our observations prove that an appropriate choice of organic spacer and inorganic layer thickness provide efficient methods to engineering the charge-carrier effective mass in 2D perovskites, which can be either lower or higher than in their 3D analogues. Having precisely determined μ, we also report on all important exciton parameters, such as binding energy, in-plane radius, and how these parameters evolve with increasing n. Our experimentally determined parameters can serve as a benchmark for first-principles calculations and exciton models.

Reference

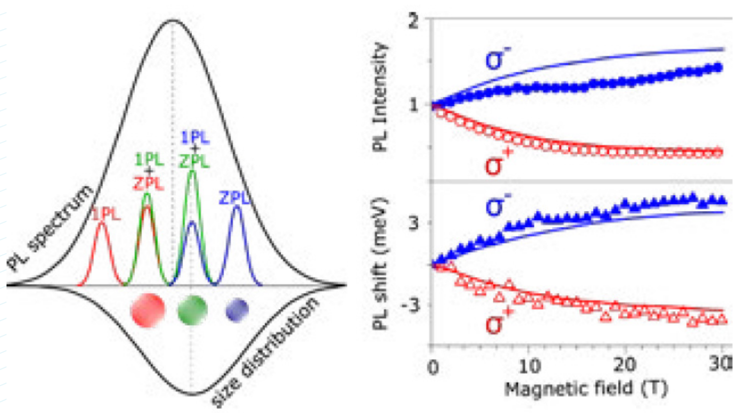
Dyksik, M., S. Wang, W. Paritmongkol, D.K. Maude, W.A. Tisdale, M. Baranowski and P. Plochocka (2021). "*Tuning the Excitonic Properties of the 2D $(PEA)_2(MA)_{n-1}Pb_nI_{3n+1}$ Perovskite Family via Quantum Confinement*". J. Phys. Chem. Lett., 12 (6): 1638-1643.

Polarised emission of CdSe nano-crystals in strong magnetic fields: the role of phonon-assisted recombination of the dark exciton

For a few decades, colloidal semiconductor nanocrystals have been the focus of intensive research. Due to the continuous progress in technology, nanocrystals with different sizes, shapes, compositions, and surface properties have been synthesized. Understanding their optical, electrical, and chemical properties has led to applications in various fields, such as light-emitting diodes, laser technology, field-effect transistors, solar cells, and biological labels. In these efforts, external magnetic fields have been used as a powerful tool not only to address magneto-optical properties and spin-dependent phenomena, but also to determine the basic optical properties of the nanocrystals, which are dominated by absorption and emission of coupled electron-hole pairs (excitons).

Usually, these experiments were performed on wet-chemically synthesized nanocrystals, showing a number of interesting magnetooptical effects: a field-induced shortening of the exciton lifetime, circular polarization of the photoluminescence emission, a finestructure splitting of the exciton energy levels, including the Zeeman effect in single nanocrystals, an anisotropic electron-hole exchange interaction, and electron-spin coherence. However, these previous photoluminescence experiments also revealed several unusual appearances: (i) a spectral dependence of the photoluminescence circular polarization degree, (ii) its low saturation value, and (iii) a stronger intensity of the Zeeman component which is higher in energy. The latter feature is the most surprising being in contradiction with the thermal population of the exciton-spin sublevels.

To resolve these open questions a team of researchers of the TU Dortmund, the Ioffe Institute and the ITMO University, both in Saint Petersburg, and the High Field Magnet Laboratory (HFML-EMFL) in Nijmegen performed experiments on CdSe nanocrystals embedded in a glass matrix, a system that had not been investigated before in high magnetic fields. They measured polarized photoluminescence in magnetic fields up to 30 T and observed the same puzzling behavior as the earlier reports described above. The team developed a model that takes into account the cumulative contribution of both zero-phonon and phonon-assisted recombination of dark excitons to the emission spectra of the nanocrystal ensemble. This model describes well all unusual experimental findings and can be readily extended to other colloidal nanocrystals, whose inhomogeneous broadening exceeds the optical phonon energy. These results demonstrate the promising role that colloidal nanocrystals could play for spintronics and quantuminformation applications based on spin-dependent phenomena.



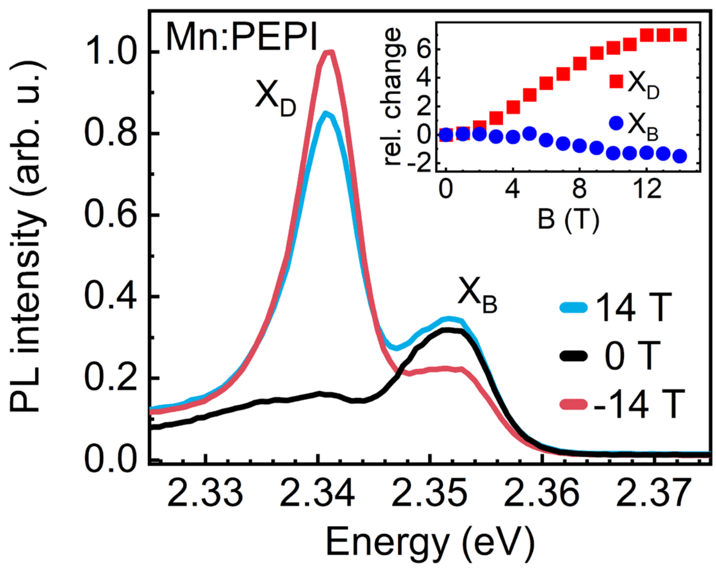
(Left panel) Photoluminescence spectrum of an ensemble of colloidal CdSe nanocrystals as a combination of zerophonon (ZPL) and phonon-assisted (1PL) emission of differently sized quantum dots. This results in a peculiar behavior of the circularly polarized photoluminescence emission in high magnetic fields: the higher energy, σ-polarized exciton level has a higher intensity (blue curves in right panel).

References

Qiang, G., A.A. Golovatenko, E. Shornikova, D.R. Yakovlev, A.V. Rodina, E.A. Zhukov, I.V. Kalitukha, V.F. Sapega, V.K. Kaibyshev, M.A. Prosnikov, P.C.M. Christianen, A.A. Onushchenko and M. Bayer (2021). “*Polarized emission of CdSe nanocrystals in magnetic field: the role of phonon-assisted recombination of the dark exciton*“. *Nanoscale*, 13: 790.

Enhanced opto-spintronic functionalities in layered hybrid metal-halide perovskites

Hybrid metal-halide perovskites offer the opportunity for a novel control of spins in a high-performance semiconductor due to their exceptional tolerance to structural defects and impurities, combined with their production as polycrystalline thin films and nanostructures from simple scalable solution-processing techniques. Introducing a small number of magnetic dopants into the nominally non-magnetic perovskite lattice produces a dilute magnetic semiconductor, holding a great potential for creating novel opto-spintronic functionalities for information and communication technologies. The development of materials which are simultaneously magnetic and semiconducting, while retaining excellent opto-electronic properties and high luminescence yields, is a scientific challenge. Thus, the ability of perovskites to accept dopants without deteriorating the structural quality is highly appreciated.



The circularly polarized PL spectra for Mn-doped PEPI [$(PEA)_2PbI_4$]. The inset shows the influence of magnetic field on the relative intensities of both dark (X_D) and bright (X_B) excitonic states.

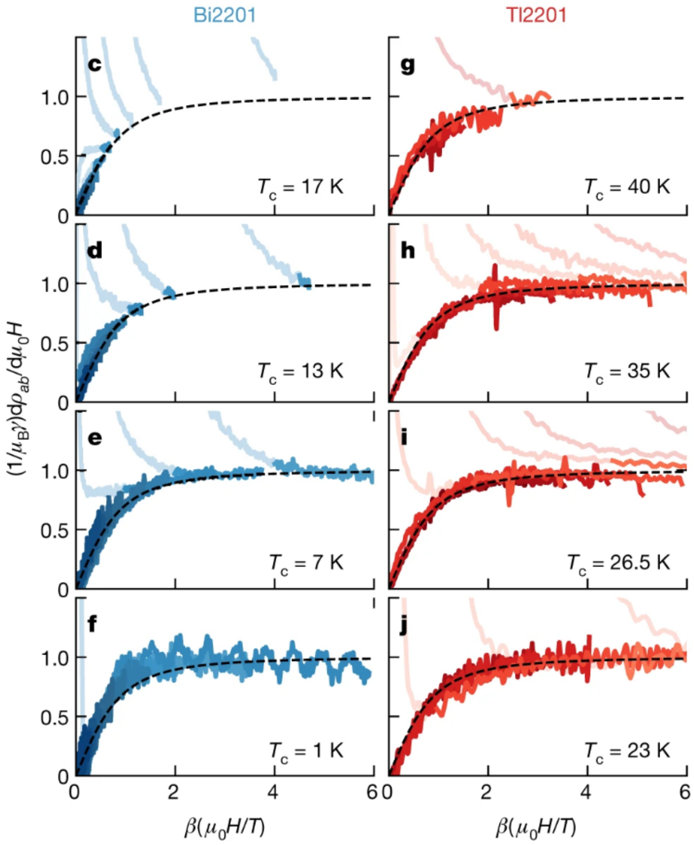
We report on the successful introduction of manganese dopants into the crystal lattice of the layered perovskite $(PEA)_2PbI_4$ inducing paramagnetism to the diamagnetic host material. This was accomplished by adding small amounts of manganese salts to the precursor solution. The measured magnetization while sweeping the magnetic field does not show hysteretic behavior and follows the Brillouin function for noninteracting J = 5/2 spin systems, corresponding to a spin alignment of the high-spin Mn d^5 configuration in magnetic field. Photoluminescence (PL) measurements in magnetic field show the emergence of a new signal located at the low-energy side of the bright excitonic peak (Figure). We attribute this emission to the dark state brightened by magnetic coupling to the bright exciton in presence of a strong magnetic field. In contrast to the nonmagnetic variant, this emission shows a nonzero degree of circular polarization, reaching a value of 13 %, which we find to be directly proportional to the material's magnetization. Our findings constitute the first demonstration of magnetization control of exciton spin physics in a transition-metal-doped lead-halide perovskite and provide a first step towards future opto-spintronic functionalities of these materials.

Reference

Neumann, T., S. Feldmann, P. Moser, A. Delhomme, J. Zerhoch, T. van de Goor, S. Wang, M. Dyksik, T. Winkler, J.J. Finley, P. Plochocka, M.S. Brandt, C. Faugeras, A.V. Stier and F. Deschler (2021). "*Manganese doping for enhanced magnetic brightening and circular polarization control of dark excitons in paramagnetic layered hybrid metal-halide perovskites*". *Nature Communications*, 12 (1): 3489.

Signatures of incoherent transport in the strange-metal regime of high-T_c cuprates

Researchers from HFML-EMFL, UK, Netherlands, and Japan studied the high-field magnetotransport properties of overdoped high-T_c cuprates and found behavior that is strikingly different from that of ordinary metals. For the latter, the resistivity increases quadratically with temperature and magnetic field. In cuprates, however, a novel 'strange-metal' phase exists in which the resistivity depends linearly on both temperature and field. Curiously, this behavior is found to persist over a large range of parameters. Combined linear-in-temperature and linear-in-field resistivity had only been observed previously at a singular quantum critical point where a second-order phase transition is suppressed to absolute zero. In the two cuprate families studied, however, this behavior was observed over an extended range of doping. Moreover, the strength of the magnetoresistance was found to be two orders of magnitude larger than expected from conventional orbital motion and insensitive to the level of disorder in the material as well as to the direction of the magnetic field relative to the electrical current. These features in the data, coupled with the temperature-field scaling properties, imply that the origin of this unusual magnetoresistance may not be the coherent orbital motion of conventional metallic charge carriers, but rather a non-orbital, incoherent motion from a different type of charge carrier whose energy is being dissipated at the maximal rate allowed by quantum mechanics. Taking into account earlier Hall-effect measurements, the team believes they have uncovered compelling evidence for two distinct charge-carrier types in cuprates- one coherent, the other incoherent. The key question to address now is which type is responsible for high-temperature superconductivity? Were it to be the latter, then this would signal an entirely new paradigm for superconductivity, one in which the strange metal takes center stage.



Scaled derivatives of the in-plane MR at different fixed temperatures between 4.2 and 60 K for various $Tl_2Ba_2CuO_{6+\delta}$ (Tl2201) and La/Pb-doped $Bi_2Sr_2CuO_{6+\delta}$ (Bi2201) single crystals with T_c values as indicated. To emphasize the similarity of the MR response of all the measured samples, both axes have been normalized. In this way, all the data collapse onto the same form given by the derivative of the function $y=\sqrt{(1+x^2)}$ as indicated by dashed lines. Note that the sections of individual curves that reside within the vortex state are here plotted faintly, since only in the normal state can the quadrature MR be probed.

Reference

Ayres, J., M. Berben, M. Culo, Y. Hsu, v.E. Heumen, Y. Huang, J. Zaanen, T. Kondo, T. Takeuchi, J.R. Cooper, C. Putzke, S. Friedemann, A. Carrington and N.E. Hussey (2021). "*Incoherent transport across the strange-metal regime of overdoped cuprates*". *Nature*, 595: 661-666.

Design of a pulsed magnetic dipole for magnetic linear birefringence measurements

We have designed a novel pulsed magnetic dipole, called foil coil, which can deliver a transverse magnetic field of more than 10 T along a 0.85 m optical access operating without cryogenic equipment. This magnet is dedicated to linear magnetic birefringence measurements in the framework of the Biréfringence Magnétique du Vide (BMV) apparatus installed at LNCMI-Toulouse.

The magnet is based on the winding of a 500 µm thick and 72 mm wide copper foil insulated with two layers of Kapton tape as shown in the figure. We wound about 100 meters of copper foil over a glass fiber/epoxy body with a racetrack shape, representing 50 layers of conductor. The 17 mm diameter optical access is provided by two holes in each turn in the insulated copper. Generating 10 T in about 6 ms allows us to operate the magnet at room temperature. This is the major difference to other pulsed magnets usually cooled in liquid nitrogen. Avoiding the need for a nitrogen cryostat, thus, the thermal insulation between the coil and the vacuum tube of the experiment permits to use the full access diameter of the magnet. This design offers a very good symmetry of the generated magnetic field thanks to the homogeneous current distribution and the very small effect of the layer transition compared to a wire wound coil.

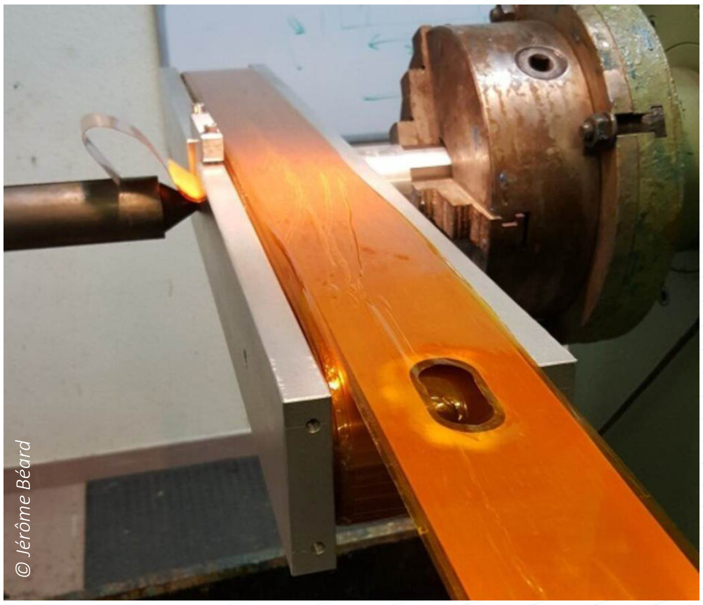


Photo of the foil coil during the winding showing one hole in the copper foil and in the Kapton tape. The holes have a racetrack shape to keep a circular access when the foil is wound over the cylindrical end of the magnet.

Once connected to one of the 3 MJ mobile banks of LNCMI, tests have been made up to 12.5 T. During scientific measurements, the maximum field is fixed to 11 T, providing a reasonable safety margin. The maximum field achievable by this magnet is limited by the buckling of the foil, mainly influenced by small faults in the winding, and is, therefore, hard to predict by a simulation.

We have proceeded to commission the magnet in the BMV apparatus. Some potential improvement in the design can be made to increase the efficiency or the ergonomics. First, an extra cooling to remove the heat from the magnet box can be installed. The repetition rate will be important to perform an experiment where hundreds of pulses will be necessary. Our first prototype does not have an optimized cooling because the main objective was to generate at least 10 T over about 0.8 m at room temperature and in air. Actual cooling is due to natural convection and can be increased with a forced flow of air inside the box containing the magnet. A second modification is to optimize the pulse duration, probably by shortening it, either by adapting the actual capacitor bank or using another one available at LNCMI, without lowering the maximum field. A next step could be a modification in the design itself. For example, it is possible to cut the copper foil to concentrate the current density closer to the laser beam path, increasing the efficiency of the coil.

We have taken preliminary scientific data in vacuum during commissioning and first results look encouraging. We installed the new magnet successfully and the absence of a cryostat simplifies the whole apparatus. The BMV team is currently working to optimize optics and to diminish the overall noise by acoustically insulating the apparatus from the coil before pushing the magnetic field to its maximum.

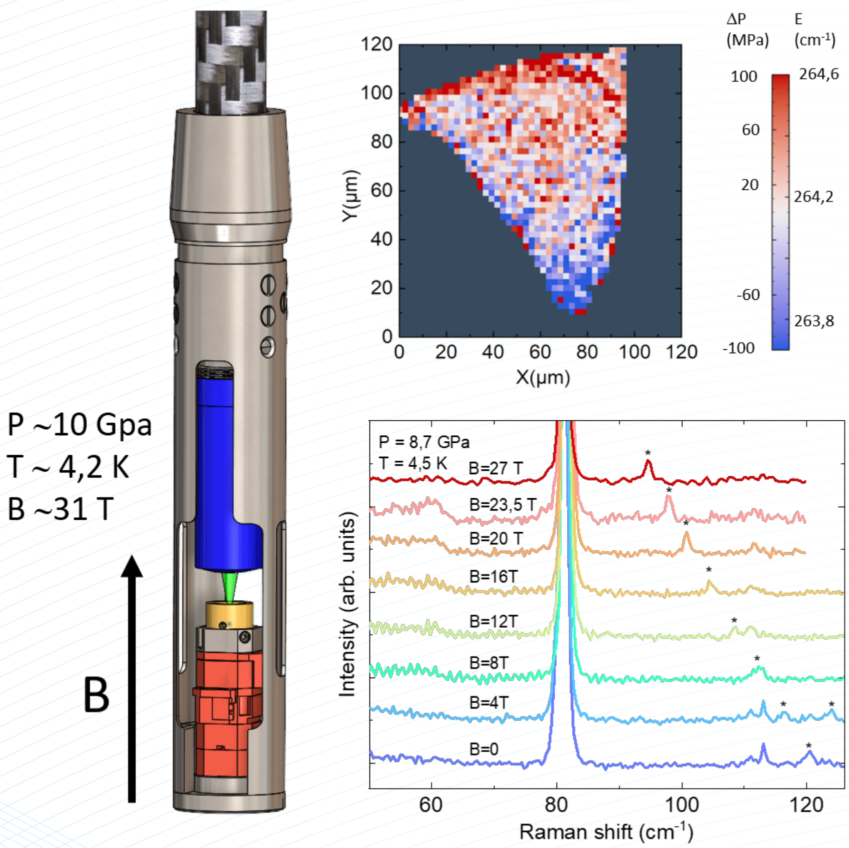
Reference

Béard, J., J. Agil, R. Battesti and C. Rizzo (2021). "A *novel pulsed magnet for magnetic linear birefringence measurements*". *Review of Scientific Instruments*, 92 (10): 104710.

Spatial resolved optical spectroscopy in an extreme environment of low temperature, high magnetic fields and high pressure

To flesh out the phase diagrams of novel material systems, researchers must examine these materials under extreme conditions. We have designed an experimental setup for optical spectroscopy that simultaneously offers three extremes: low temperature, a strong magnetic field, and high pressure imposed by using a diamond anvil cell. The setup provides these extreme conditions while maintaining micrometer scale spatial resolution for optical spectroscopy, which can be used to study exotic phases of microstructures.

We now have a powerful tool to investigate the electronic and magnetic properties of solids at hand, working in combined extreme conditions necessary for studying the occurrence of certain classes of exotic electronic phases. From its unique perspective, optical spectroscopy can shed special light on such electronic phases.



(Left) Schematic drawing of the optical probe including an optical objective (blue), a diamond anvil cell (orange), and piezo positioners (red). (Top right) spatial map of the Raman-scattering response of $FePS_3$ pressurized at 0.9 GPa. (Bottom right) Ramanscattering response of bulk $FePS_3$ at P = 8.7 GPa, including the magnon excitation, indicated by a star in the spectra, for different values of the magnetic field.

We have recently performed the first experiments in such environments with bulk layered iron phosphorus trisulfide. The results presented in the figure show that this setup permits independent tuning of the three thermodynamic parameters. Consequently, this setup can be used to investigate phase diagrams for different systems and probe their properties with optical spectroscopy. Thanks to the spatial resolution, tiny structures or specific locations on large samples can be investigated by optical spectroscopy (Raman scattering, photoluminescence, reflectivity). This setup will be particularly useful in the field of layered materials for which pressure allows for a tuning of the interlayer distance and the related interaction effects.

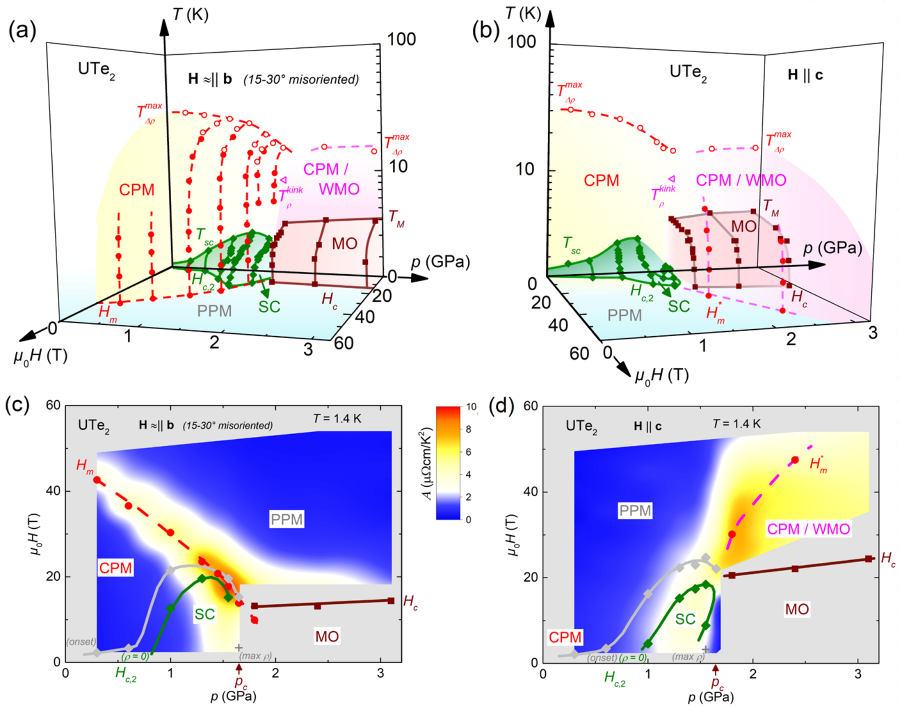
Reference

Breslavetz, I., A. Delhomme, T. Pelini, A. Pawbake, D. Vaclavkova, M. Orlita, M. Potemski, M.-A. Measson and C. Faugeras (2021). “*Spatially resolved optical spectroscopy in extreme environment of low temperature, high magnetic fields and high pressure*”. *Review of Scientific Instruments*, 92 (12): 123909.

Magnetic reshuffling and feedback on superconductivity in UTe_2 under pressure

The discovery of superconductivity in the heavy-fermion paramagnet UTe_2 has attracted a lot of attention, particularly due to the reinforcement of superconductivity near quantum phase transitions induced by magnetic field and/or pressure. In this system, hydrostatic pressure induces an enhancement of the superconducting transition temperature by a factor of two, reaching about 3 K. The effect of magnetic field on the ambient-pressure superconductivity is also very unusual, with the superconducting critical field exceeding 60 T for certain field directions.

Here, we investigated the electrical resistivity of UTe_2 under pressures up to 3 GPa and pulsed magnetic fields up to 58 T along the hard magnetic crystallographic b and c direction. We constructed three-dimensional phase diagrams (figure) and showed that the application of pressure and magnetic field leads to extremely complex phases in UTe_2 with a complete reshuffling of the magnetic anisotropy and associated strong effects on superconductivity. Near the critical pressure, a field enhancement of superconductivity coincides with a boost of the effective mass related to the collapse of metamagnetic and critical fields at the boundaries of the correlated paramagnetic regime and magnetically ordered phase, respectively. Beyond the critical pressure, field-induced transitions precede the destruction of the magnetically ordered phase, suggesting an antiferromagnetic nature. By providing new elements about the interplay between magnetism and superconductivity, our paper appeals for microscopic theories describing the anisotropic properties of UTe_2 under pressure and magnetic field.



Three-dimensional (p,H,T) phase diagrams and evolution of the Fermi-liquid coefficient A in the low-temperature (p,H) planes of UTe_2 in magnetic fields applied along b and c.

Reference

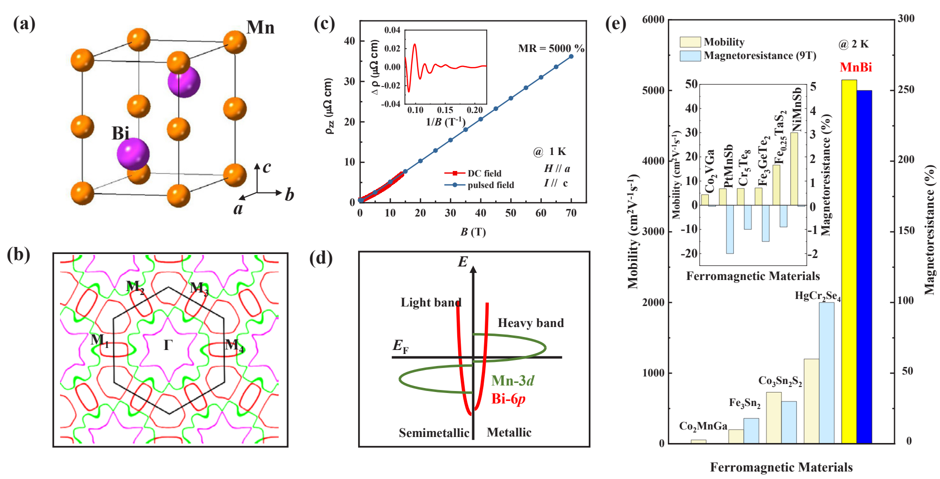
Vališka, M., W. Knafo, G. Knebel, G. Lapertot, D. Aoki and D. Braithwaite (2021). "*Magnetic reshuffling and feedback on superconductivity in UTe_2 under pressure*". *Phys. Rev. B*, 104: 214507.

Large linear non-saturating magnetoresistance and high mobility in ferromagnetic MnBi

Currently, a group of semimetals excites the physics community due to its intriguing properties derived from massless chiral particles— so-called Weyl fermions. As a consequence of linear band crossings at the Fermi energy and a high Fermi velocity, massless Weyl states can be the origin of a giant, non-saturating transverse magnetoresistance (MR) when exposed to an external magnetic field. In recent years, several groups reported nonmagnetic examples of topological Weyl semimetals, such as TaAs, NbP, and WTe_2, which show annenormous positive MR of more than 100,000 percent at low temperatures with a high charge-carrier mobility. However, ferromagnetic compounds rarely display a large MR because of localized electrons with a low Fermi velocity.

Nevertheless, scientists from the Max Planck Institute CPfS in Dresden, from USA, from Switzerland, and the HLD found a large, linear positive MR and high chargecarrier mobility in high-quality single crystals of the ferromagnet MnBi (crystal structure and calculated Fermi surfaces are shown in figures 1a and 1b). Our study shows that the MR of MnBi strongly depends on the field orientation and reaches a maximum of 5000 % at 70 T for field aligned along the a axis and perpendicular to the current (figure 1c). Shubnikov-de Haas oscillations with a frequency of only 23 T (inset in figure 1c) indicate a tiny Fermi surface with a light effective mass of the order of 0.4 times the free electron mass. We applied a two-band model to determine the chargecarrier mobilities. The large value of 5000 $cm^2V^{-1}s^{-1}$ at 2 K is almost the same for both, electron- and hole-like charge carriers, and is, thus, the highest mobility reported for ferromagnetic materials to date.

The behavior originates from a highly dispersive spin-polarized Bi band with a small effective mass. Figure 1d shows a schematic view of the density of states. Figure 1e provides a comparison of the highest reported mobilities and MR values for ferromagnets. Only a few examples with positive MR exist. The inset showcases selected FMs with the more usual negative MR and low mobilities.



a) Crystal structure of MnBi (NiAs-type). (b) Calculated Fermi surface at kz = 0. (c) Magnetoresistivity. (d) Schematic view of the density of states, showing light semimetallic bands in the spin-up channel and heavy metal bands in the spin-down channel. (e) Highest MR and charge-carrier mobility values for ferromagnetic materials. The inset exemplifies the low mobilities and negative MR for selected ordinary ferromagnetic materials.

This study demonstrates that also ferromagnets with a high Curie temperature can have high mobilities, which otentially is advantageous for the development of future spintronics applications.

Reference

He, Y., J. Gayles, M. Yao, T. Helm, T. Reimann, V.N. Strocov, W. Schnelle, M. Nicklas, Y. Sun, G.H. Fecher and C. Felser (2021). "Large linear non-saturating magnetoresistance and high mobility in ferromagnetic MnBi". *Nature Communications*, 12 (1): 4576.

Organisational structure

EMFL's objective, without profit aim, is to unite world-class high magnetic field facilities and to make them available for excellent research by users. More specifically, EMFL is responsible for the management of access, networking and coordination activities of the high-field facilities in Europe.

Council

The Council is the highest governing body of EMFL and consists of the EMFL Member representatives. The council does:

- appoint and dismiss the Directors and approve the candidacy of the executive manager,
- admit and dismiss EMFL Members,
- approve the progress report, annual accounts and the budget presented by the Board of Directors,
- amend the Statutes and approve the vision, mission and definition of values of the Association,
- discuss and develop strategic, scientific and technical plans of the EMFL.

The Council exists of:

Prof. Han van Krieken (RU/NWO, Chair until June 14, 2021)
Prof. Sebastian Schmidt (HZDR)
Dr. Sylvain Ravy (CNRS, Chair from June 14, 2021 onwards)
Prof. Amalia Patanè (University of Nottingham)
Prof. Adam Babiński (University of Warsaw)
Dr. Pierre Védrine (CEA-IRFU)

Board of Directors

The board of directors, composed of the laboratory directors, where needed seconded by an executive manager has the following tasks:

- define the vision and mission,
- execute the strategic operation,
- prepare the budget, the annual accounts and the progress report.

The Board of Directors exists of:

Prof. Peter Christianen (HFML, Chair 1/1/2021)
Prof. Jochen Wosnitza (HLD)
Dr. Charles Simon (LCNMI)

Strategic Advisory Committee

The Strategic Advisory Committee will evaluate the research activities of the high magnetic field facilities operated by the Host Members of the EMFL and advice on future research or technological activities.

To achieve this, the Strategic Advisory Committee will:

- Evaluate the research activities of the high magnetic field facilities operated by the host members of the EMFL.
- Evaluate the strategic plans of EMFL.
- Report its advice to the Board of Directors.

The Strategic Advisory Committee members are:

Dr. Massimo Altarelli (Chair), MPI for the Structure and Dynamics of Matter, Hamburg, Germany
Dr. Ziad Melham, Oxford Quantum Solutions, UK
Prof. Claudia Felser, MPI for chemical physics of solids, Dresden, Germany
Prof. Ingrid Mertig, Martin-Luther-Universität Halle-Wittenberg, Germany
Prof. Georg Maret, SciKon, University of Konstanz, Germany
Prof. Andrew Harrison, Diamond Light Source, UK
Prof. Andzrej Wysmolek, University of Warsaw, PL
Dr. Gabriel Chardin, APC Laboratory (Astroparticles and Cosmology), University of Paris

Selection Committee

The task of the EMFL selection committee is to ensure that from the proposed experiments only those that are of excellent scientific quality and clearly benefit from the access to a high-field facility are performed in the EMFL facilities.

The Selection Committee evaluates the scientific proposals on the following three criteria:

- scientific quality and originality of the proposal;
- necessity for the use of the infrastructure;
- track record and past performance of the user group.

Xavier Chaud	LNCMI-G	Applied Superconductors
Jens Hänisch	KIT	Applied Superconductors
Andries den Ouden	HFML	Applied Superconductors
Toomas Rõõm	NICPB	Magnetism
Mathias Doerr	IFP	Magnetism
Yuri Skourski	HLD	Magnetism
Uli Zeitler	HFML	Magnetism
Tony Carrington	Univ. Bristol	Metals and Superconductors
Mark Kartsovnik	WMI	Metals and Superconductors
Alix McCollam	HFML	Metals and Superconductors
Ilya Sheikin	LNCMI-G	Metals and Superconductors
Duncan Maude	LNCMI-T	Semiconductors
Amalia Patanè	Univ. Nottingham	Semiconductors
Marek Potemski	LNCMI-G	Semiconductors
Steffen Wiedmann	HFML	Semiconductors
Alban Potherat	Coventry University	Soft Matter and Magnetoscience
Hans Engelkamp	HFML	Soft Matter and Magnetoscience
Anne-Lise Daltin	Univ. Reims	Soft Matter and Magnetoscience

User Committee

In order to represent the interests of the high-field user community, members (all external to the infrastructures) are elected for a period of three years by the user community during the annual User Meeting. The chairman of the User Committee will report to the Board of Directors on behalf of the users. During the User Meetings the User Committee will report to the users and collect the feedback.

Raivo Stern (Chair)	NICPB, Tallinn	NMR/ESR
Ashish Arora	University of Münster	(Magneto)-optics of 2D semiconductors
Mathias Dörr	TU Dresden	Magnetism
Karel Prokes	Helmholtz-Zentrum Berlin	Magnetism
Carsten Putzke	EPFL	Metals/Superconductors
Antonio Polimeni	Sapienza Università di Roma	Optics/Semiconductors
Alexandre Pourret	IMAPEC-PHELIQS-INAC CEA	Magnetism/Superconductivity
Vassil Skumryev	ICREA, Barcelona	Magnetism/Magnetic materials
Stan Tozer	NHMFL	Magnetism/Superconductivity

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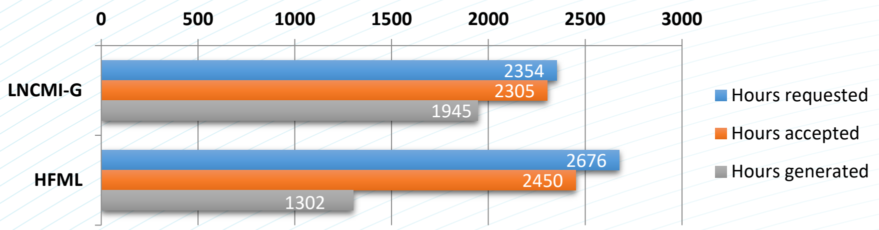
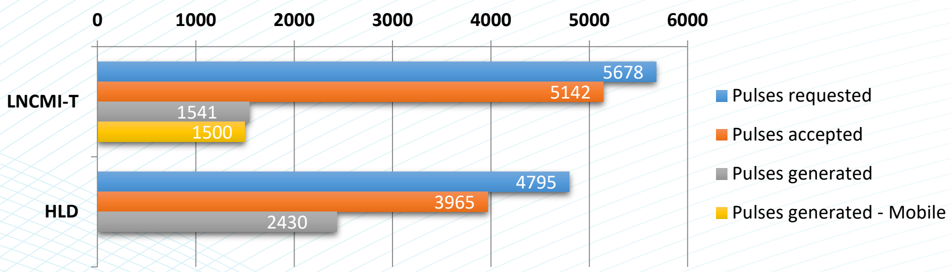
User Access

The 25th and 26th call for proposals closed in May and November 2021, resulting in 286 applications from 16 different countries in total. The Selection Committee (see page 26) has evaluated the proposals, covering the five types of scientific topics:

- Metals and Superconductors
- Magnetism
- Semiconductors
- Soft Matter and Magnetoscience
- Applied Superconductivity



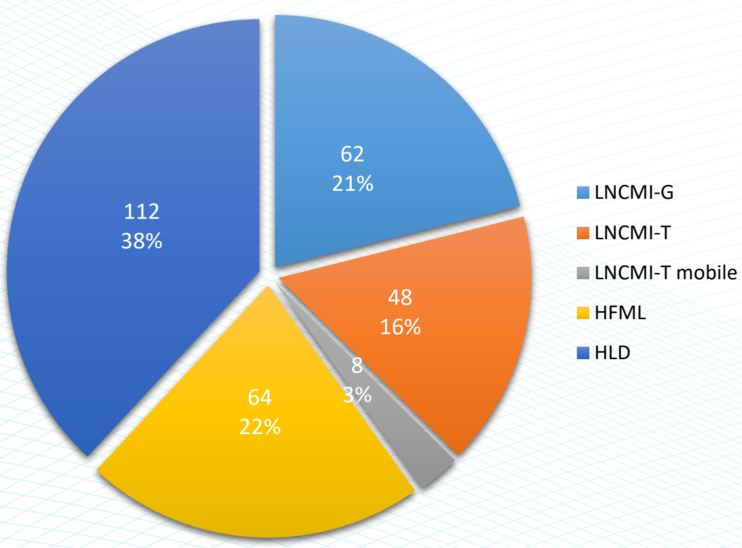
DC facilities



Pulsed facilities

The mobile pulses requested at LNCMI via EMFL at other large scale research infrastructures (ESRF, ILL, ...) are included as well. Access to this can be gained also via the proposal submission procedure of ILL, ESRF etc.

Distribution by facilities
Number of applications



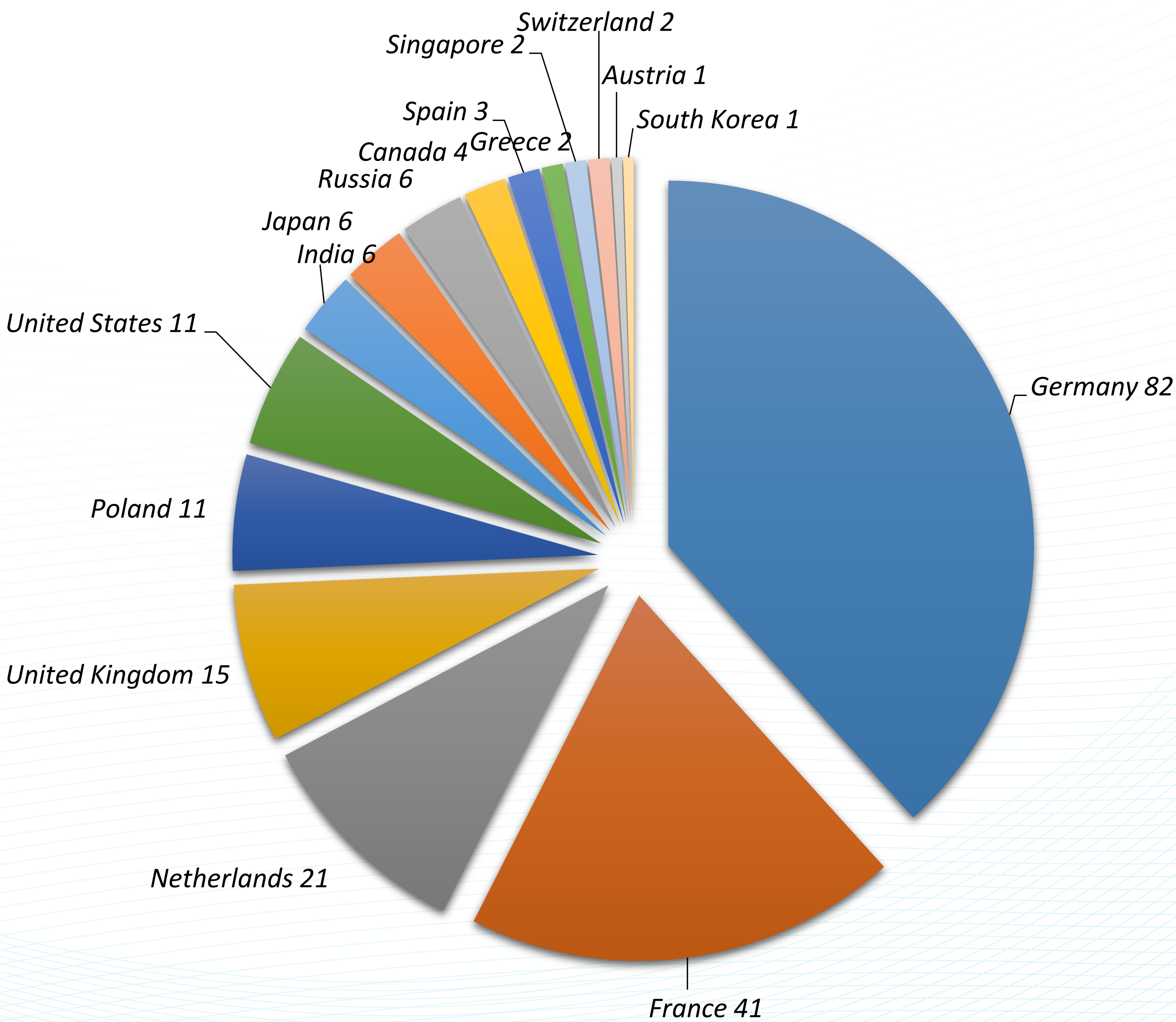
Evaluation of applications

Projects are classified in three categories:
A (excellent proposal to be performed),
B (should be carried out, but each facility has some freedom considering other constraints),
C (inadequate proposal or one that does not need any of the four unique high magnetic field laboratories).

In the B category, the ranking + or- serves as a recommendation to the facility. This freedom within the B category is necessary to allow the facilities to consider other aspects such as, for instance, available capacity and equipment necessary for a successful project. Besides of ranking the proposals the Selection Committee recommends on the number of accepted magnet hours or number of pulses.

Information about the proposal application procedure can be found at
https://emfl.eu/apply-for-magnet-time/

Distribution by countries
Number of proposals (counting the affiliation of the main applicant)



Publications

Articles 2021

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Thesis defences 2021

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Contact details

EMFL
Helmholtz-Gemeinschaft Brussels Office,
Rue du Trône 98
1050, Elsene, Brussels
Belgium

Tel +31-24-3653005
Fax +31-24-3652440
e-mail: emfl@science.ru.nl
www.emfl.eu

High Field Magnet Laboratory (HFML)
Toernooiveld 7
6525 ED Nijmegen, The Netherlands

Laboratoire National de Champs Magnétiques Intenses at Grenoble (LNCMI-G)
25 rue des Martyrs, B.P. 166
38042 Grenoble cedex 9, France

Laboratoire National de Champs Magnétiques Intenses at Toulouse (LNCMI-T)
143 avenue de Rangueil
31400 Toulouse, France

Hochfeld-Magnetlabor Dresden (HLD)
Bautzner Landstr. 400
01328 Dresden, Germany

https://www.linkedin.com/company/emfl/
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Responsible for the content:
Jochen Wosnitza (j.wosnitza@hzdr.de),
Charles Simon (charles.simon@lncmi.cnrs.fr),
Peter Christianen (peter.christianen@ru.nl),
Martin van Breukelen (martin.vanbreukelen@ru.nl)

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Martin van Breukelen

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G. Laureijs, J. Billette, O. Portugall, V. Moncorgé, HLD, LNCMI, HFML

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