EMFL Annual Report 2023

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European Magnetic Field Laboratory

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HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

NWO

HLD.

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Science in High Magnetic Fields

FELIX
Free Electron Lasers for Infrared eXperiments

LNCMI

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European Magnetic Field Laboratory
Annual report 2023

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Foreword

Dear Reader,

It is with great pleasure that we present to you the ninth annual report of the European Magnetic Field Laboratory (EMFL), highlighting numerous scientific achievements and recent developments.

Thanks to the Isabel European project, we have introduced a range of innovative ways for accessing our facilities. As we progress in the program, we are tasked with evaluating the value added by these new modes and determining whether to integrate them permanently into the proposal submission process at EMFL. The year 2023 also witnessed significant advancements within the H2020-ISABEL project. Collaborating closely with our partners from academia and industry, we have initiated numerous initiatives aimed at fortifying EMFL's structure, enhancing its coordinating capacity, and amplifying its socio-economic impact on both European and global scales.

After the challenges posed by the COVID-19 pandemic, we successfully convened in 2023 a multitude of meetings and workshops to chart the future European roadmap for high magnetic fields. Notably, our annual user meeting in Nijmegen proved to be highly fruitful, including in the publication of the traditional user committee's report and the awarding of the EMFL Prize.

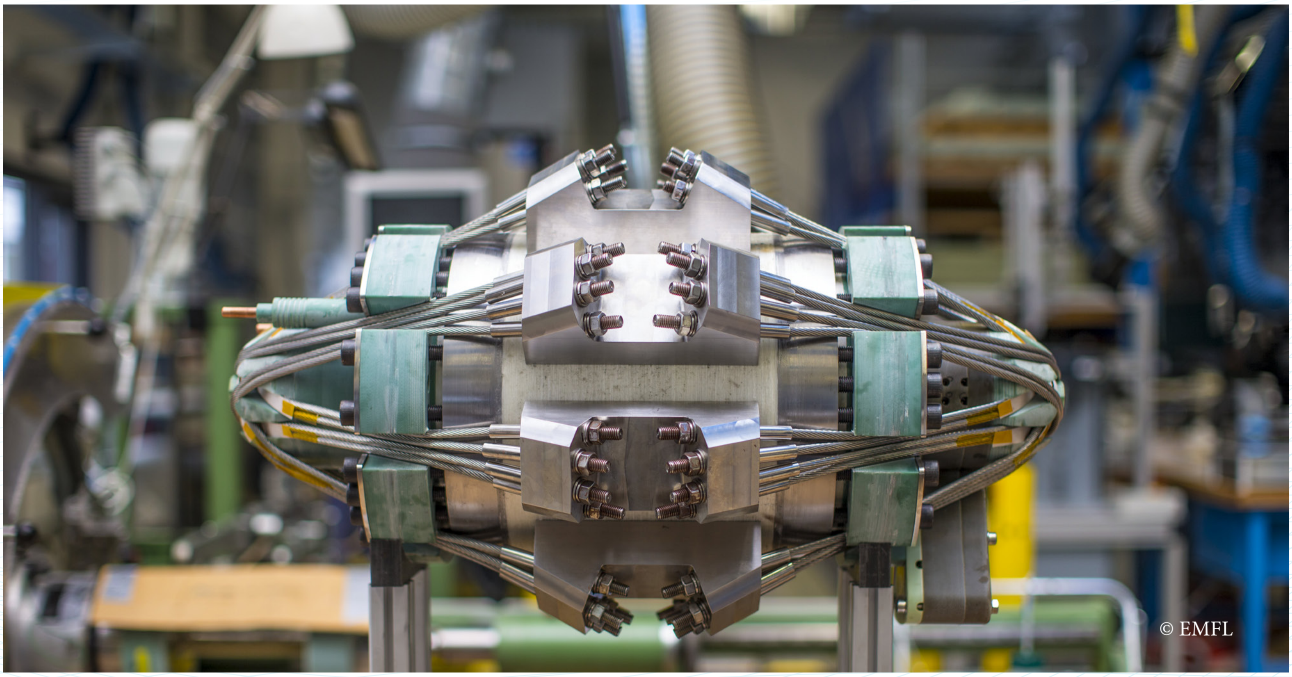
Despite enduring challenges in our continuous field facilities in Grenoble and Nijmegen related to electric energy, our stakeholders have generously allocated sufficient resources to sustain high magnetic field research at a "normal" pace. This reassurance is indeed heartening for our user community. Furthermore, we are actively engaged in robust initiatives aimed at enhancing energy efficiency within our laboratories.

One such initiative is the launch of the H2020-SuperEMFL project, which focuses on advancing the development of superconducting user magnets capable of reaching unprecedented field strengths of 40 T and beyond. SuperEMFL will produce a comprehensive conceptual design report addressing key considerations regarding the realization and integration of these user magnets within the European high-field infrastructure.

In closing, I extend my sincere gratitude to all the dedicated staff and users of EMFL facilities for their unwavering commitment, resilience, and adaptability, which collectively contributed to making 2023 an exceptionally successful year.

Warm regards,

Charles Simon
Chairman EMFL
Director LNCMI/CNRS



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 top-level 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 center of excellence for a multitude of magnetic-field-based material-characterization techniques in very high fields

European Magnetic Field Laboratory

Developments 2023

NEW ACCESS MODES

In the frame of the ISABEL project, we have designed and implemented novel access procedures to the EMFL facilities, aiming at addressing the needs of current and potential users of EMFL. Six novel access modes are now running and the long-term access mode has been prepared and will be proposed soon.

DUAL-ACCESS MODE As reported already last year, EMFL trials a novel dual-access procedure wich invites users at an early stage of their research projects and lower the barrier for access. Within one experiment proposal, users 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 possble magnetic fields at the EMFL installations in Grenoble, Nijmegen, Toulouse, and Dresden. This dual-access mode started from the first call in 2021 and has attracted already quite a number of new users. For performing experiments in the moderate-field range, thanks to the ISABEL project, EMFL has partnered with wellequipped and experienced regional facilities distributed over Europe.

LONG-TERM ACCESS MODE In order to meet the demand for long-term access schemes such as complex high-level science cases which require a sequel of high-field experiments, we have developed a tailored long-term access mode. Long-term proposals have started to be evaluated in fall 2022 by the EMFL BoD as a special category, and if positively evaluated, the applicants can obtain an extended amount of access over a two to three-year period.

FIRST-TIME ACCESS MODE As a further trial access mode, EMFL has set up a novel access scheme with the aim of lowering the threshold for researchers who want to use the EMFL facilities for the first time. Prospective users are encouraged to contact a staff member at one of the EMFL labs who will offer support in preparing a proposal. Additionally, EMFL will offer reinforced on-site support and reimbursement of travel and accommodation expenses. The first-access proposals will be evaluated by the EMFL Selection Committee, who will facilitate access for these proposals.

INDUSTRIAL ACCESS MODE EMFL wants to stimulate the use of its infrastructure and know-how for any kind of experiment or test that industry may have. EMFL can provide cryogenic devices, pulsed and continuous magnets, data acquisition equipment and extensive know-how. This access mode is specifically adapted to the requirements of confidentiality that industrial users may have.

FAST TRACK ACCESS MODE The novel fast-track access mode is permanently open since 2022. A convincingly urgent scientific case may be addressed any time as request to the EMFL Board of Directors (BoD). The request will be evaluated and decided within typically two weeks by the BoD, who may optionally consult one or more EMFL Selection Committee members, and check the feasibility with the facility manager and the local contact. If the fast-track proposal is accepted, the user is asked to get in contact with the facility to schedule and plan the experiment in a timely fashion. Otherwise the user may submit a regular proposal at the next call.

TECHNICAL DEVELOPMENT ACCESS MODE This access is dedicated to the interests of scientists wishing to develop and improve technical installations and metrological procedures that could also be of great interest to other EMFL users. It aims at improving the quality of EMFL installations with clear benefit to the wider EMFL user community.

CONFERENCES IN GRENOBLE: EP2DS-25 AND MSS-21

The 25th International Conference on the Electronic Properties of Two-Dimensional Systems (EP2DS-25) and the 21st International Conference on Modulated Semiconductor Structures (MSS-21) were held from 9 to 14 July 2023 in the World Trade Center in downtown Grenoble. The city is considered the cradle of the quantum Hall effect, typical of two-dimensional systems and discovered in 1980 at the high magnetic field laboratory in Grenoble (GHMFL), at the time a German-French cooperation between MPI-FKF (Max-Planck-Institut für Festkörperforschung in Stuttgart) and CNRS. The two conferences were jointly organized by colleagues from the LNCMI in Grenoble, with shared plenary and poster sessions. During the conferences, more than 340 scientists from 24 countries spent five days discussing the latest advances concerning our knowledge of 2D electronic systems. The rich and representative program covered progress of the fundamental understanding, as well as in synthesis, processing, characterization, and applications, of a broad range of low-dimensional electronic systems. These include semiconductor quantum wells/wires/dots, two-dimensional materials such as graphene, transitionmetal dichalcogenides, magnetic and ferroelectric van der Waals materials, topological insulators, as well as hybrid systems.

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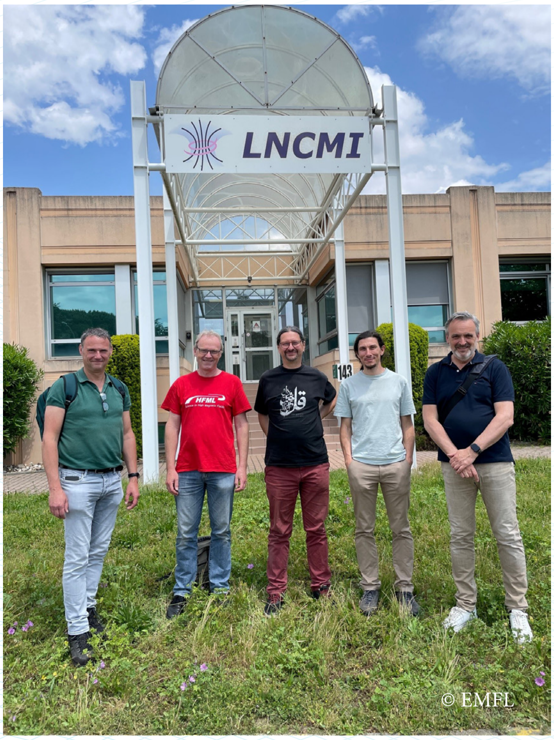
HFML EXCHANGE VISIT AT LNCMI-TOULOUSE

In May 2023, the HFML-FELIX technical user support group, Peter Albers, Lijnis Nelemans and Michel Peters, from Nijmegen visited the LNCMI pulsed-field facility in Toulouse. The aim was the exchange of knowledge on various magnet and measurement technologies between the two laboratories.

Scientists and engineers from the LNCMI warmly welcomed the Nijmegen team and enjoyed two days of intensive discussions with their colleagues. Topics included magnet and cryostat technology, materials science, manufacturing techniques, probes, optical measurement techniques, and data acquisition. It was a very successful and entertaining visit for both sides, allowing the exchange of innovative ideas.



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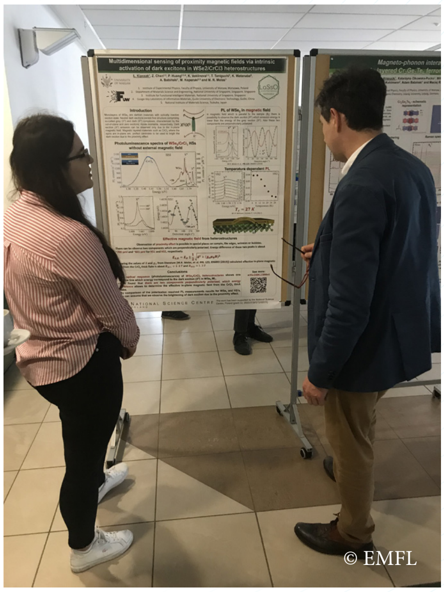
WORKSHOP IN WROCŁAW

From 22 to 24 May 2023, the University of Warsaw and Wrocław University of Science and Technology organized the workshop „Magnetic Fields in Materials Research“, with financial support from the ISABEL EU project. The meeting took place in Wrocław, Poland.



The goal was to provide a forum to exchange knowledge between the Polish community of high magnetic field users involved in EMFL and other groups in Europe, both in terms of experimental opportunities and in-house research. The thematic areas covered were quite diverse including general information on the EMFL facilities but as well scientific highlights of research done using high magnetic fields, such as on two-dimensional semiconductors, topological insulators, magnetic materials, and heavy-fermion materials. Almost 30 invited speakers presented their research in a very lively atmosphere. Numerous posters added to the relevance of the meeting and provided a unique opportunity for young researchers to discuss their results with their more experienced colleagues.

REGIONAL MEETING ON RESEARCH IN HIGH MAGNETIC FIELDS IN PRAGUE

A regional meeting, held by our ISABEL project partner, the Materials Growth and Measurement Laboratory (MGML), took place September 6 – 8, 2023, at the Faculty of Mathematics and Physics of the Charles University in Prague.

Besides a number of lectures dealing with science done using high magnetic fields, further presentations during the workshop covered general information on the EMFL facilities and their operation. The latter covered the EMFL operation as a whole as well as information on each EMFL facility individually. This included the EMFL user operation and modes of access.

As excursion highlights, the participants were able to visit all three sites of the MGML research infrastructure in Prague. The workshop attracted 38 participants from several universities and research institutions in the Czech Republic (Charles University, Masaryk University, University of West Bohemia, Institute of Physics of the Czech Academy of Sciences) and from other countries (Poland, Germany, and France).

EMFL WORKSHOPS:

In order to develop a scientific case for high-field experiments at advanced sources, ISABEL support of four joint workshops in collaboration with other large research facilities. The goal is to establish the scientific case for such experiments and to make an inventory of the user needs of magnet characteristics, instrumentation, and organization. Two workshops were held in 2023:

USER MEETING OF THE EMFL AND WORKSHOP "COMBINATION OF HIGH MAGNETIC FIELDS AND FREE ELECTRON LASERS"

Discussion session on the combination of high magnetic fields and THz radiation chaired by Ben Murdin.

The EMFL User Meeting 2023, combined with the HFML-FELIX user meeting and a workshop "Combination of high magnetic fields and free electron lasers" took place in Nijmegen from 13-15 June 2023.

The meeting started on Tuesday afternoon with an opening statement from HFML-FELIX director Britta Redlich and a plenary talk by Steen Brøndsted Nielsen (Aarhus University) addressed to the large group of both national and international attendees interested in research combining high magnetic fields and THz radiation.

Subsequently, Charles Simon (Chair of the Board of Directors of EMFL) opened the EMFL user meeting and presented an overview of recent developments at EMFL. The EMFL prize winner 2023, Jake Ayres (University of Bristol), gave the first scientific talk.

Further, eight researchers presented on Tuesday afternoon and Wednesday morning scientific talks covering a broad range of user work performed at the EMFL facilities. The users also discussed future scientific developments and possible new magnets that would be useful to have at the EMFL facilities.

During the user meeting on Tuesday afternoon, the User Committee chaired by Raivo Stern (NICPB, Tallinn, Estonia) critically discussed user-related issues of EMFL and reported back to the Board of Directors.

After the Wednesday morning session, both user groups from EMFL and HFML-FELIX joint again for the plenary talk by Ben Murdin (University of Surrey), who addressed the combination of high magnetic fields and THz radiation and presented some recent research examples. On Wednesday afternoon and Thursday morning, a dedicated workshop (supported by the ISABEL project) on the combination of high fields and THz radiation took place. Eight speakers stressed how such a unique combination provides our field with new research possibilities. In particular, the possibilities of the existing combination HFML-FELIX in Nijmegen and HLD-FELBE in Dresden were introduced. The workshop concluded with a general discussion on combined experiments, highlighting possibilities for future exciting collaborations.

EMFL PRIZE WINNER 2023: JAKE AYRES

Since 2009, the EMFL Board of Directors announces annually the EMFL prize for exceptional achievements in science done in high magnetic fields. An award committee selects the prize winner from the nominations received.

This year, the prize went to Dr. Jake Ayres, who currently holds a Leverhulme Early Career Fellowship at the University of Bristol, UK. During the user meeting in Nijmegen, Jochen Wosnitza, chair of the prize committee, had the honor of presenting the prize in a traditional small prize ceremony.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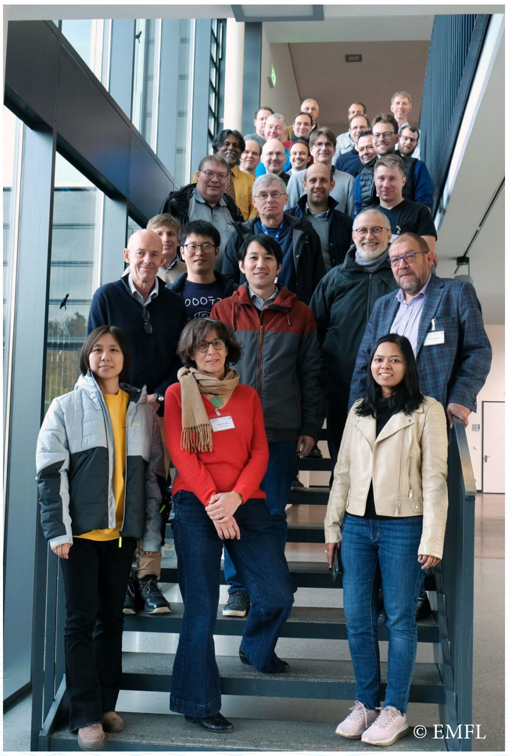
Jake Ayres, who performed his PhD work at HFML in Nijmegen, is a regular user of the EMFL facilities. His work is mainly focused on high-temperature superconductors. Significant results encompass his work on the in-plane magnetoresistance as well as the Hall effect under hydrostatic pressure of cuprate superconductors published in highly ranked journals. He further utilized the EMFL high magnetic fields to study the nematic iron-based superconductor FeSe and the nodal-line semimetal ZrSiS. In summary, Jake's substantial body of experimental work, performed at EMFL facilities, has made major advances in our understanding of unconventional superconductors.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FRONTIERS OF SYNCHROTRON AND XFEL RESEARCH AT HIGH MAGNETIC FIELDS

The workshop provided a forum for 46 registered participants to present and discuss the latest research results obtained using x-ray radiation sources and high magnetic fields. During the meeting, the scientists had the excellent opportunity to discuss the current state of the art of instrumentation and explore possible collaborations between participants and research institutions.

Indeed, the workshop covered topics such as:

- Current trends, challenges, and future perspectives in the field,
- X-ray scattering and spectroscopy at high magnetic fields,
- New sample materials perspectives,
- New high-field x-ray instruments and technologies.

This workshop received support through the European Horizon 2020 project ISABEL

REPORT OF THE ANNUAL EMFL USER COMMITTEE MEETING 2023

After the previous successful hybrid form user meeting in 2022 in Grenoble, the EMFL and its user community gathered in hybrid format, but mostly with onsite users for its annual user meeting for 2023 in Nijmegen. The user community reacts very positively to this meeting format and encourages the EMFL Board of Directors (BoD) to consider a hybrid format also for future meetings.

The EMFL User Committee (UC) joins the community in congratulating Dr. Jake Ayres (University of Bristol) for the 2023 EMFL prize. His works demonstrate the high-quality research carried out within the EMFL facilities and their dedication to driving new scientific development.

During the annual meeting of the UC, which is open to all users to attend and provide feedback, recommendations from the user community were discussed and presented to the BoD. The UC emphasizes that the first priority is the satisfaction of users' needs and the goal of performing world-class research. This priority implies a scientifically active staff with a significant amount of time dedicated to their in-house research and developing cutting-edge methods, driven by staff scientists own interests and collaborations with users. We are happy that this priority is well recognized and adopted by the BoD.

A key part of the UC's work is to review prior feedbacks and how the EMFL BoD has incorporated them. The UC together with the attendees concluded a very slow if any progress in this area. Those users who requested detailed descriptions available set-ups with resolution and documentation are asked to specify their needs with local contacts in the labs. Another continuous and steady progress is aimed at the users themselves. Without their clear communication of the needs for their experiments, the UC cannot help. UC stresses once again for all users should give sustentive feedback via the EMFL website.

Other issues discussed include general data protection rules (GDPR), open data strategy, and online safety trainings. Most of these activities are currently being run under the ISABEL project. Proposals were made for standardization of CAD software (which was set aside as all packages can generate STEP files that are seamlessly importable), part-week test experiments and/or for testing new perspective samples in advance of full proposals, and a dramatic increase in staff scientists that have a majorly of their time for individual research.

The user community is still concerned about the shortage of "workhorse" equipment. To get a good understanding of the most widely used magnets, we ask the user community to participate actively in the respective survey from ISABEL at https://emfl.eu/isabel/magnet-survey/. The UC will then discuss strategies with the BoD on how to meet the needs of the community.

Finally, the UC acknowledged the organizing team from HMFL-FELIX and the BoD for arranging an excellent user workshop (supported by the ISABEL project) on the combination of high fields and THz radiation. In particular, the possibilities of the existing combination HFML-FELIX in Nijmegen and HLD-ELBE in Dresden were introduced. This rich program was well received by the user community.

Last but not least, the UC on behalf of all users would like to thank the EMFL laboratories and their staff for the help during the past years in carrying out our experiments and the return to full on-site mode as fast and as safely as possible, further strengthened by the implementation of the ISABEL project.

EMFL SESSION DURING THE SWISS PHYSICAL SOCIETY ANNUAL MEETING

Swiss researchers benefit from access to EMFL allowing them to perform various experiments every year at the different locations of its large-scale facilities. It enables these Swiss scientists to execute research at the forefront of science. This was the motivation leading to the organization of the special session „Magnetic Fields for materials research" at the annual meeting of the Swiss Physical Society (SPS) and Austrian Physical Society, held in Basel on September 4 – 8, 2023. This annual gathering was selected for its large number of participants with more than 500 registrations – limiting at the same time the traveling efforts for potential future EMFL users – to highlight the remarkable impact of the EMFL on the Swiss and Austrian condensed-matter research.

During this event, Charles Simon, current chair of the Board of Directors of EMFL, presented the capabilities of the laboratories and their development plans. This, on the one hand, included the aim to reach even higher magnetic fields and, on the other hand, to become more sustainable, in particular with respect to its actual use of electric power. Advantages of accessing the high magnetic fields offered by EMFL were illustrated in the scientific talks given by Ana Akrap (University of Fribourg) and Matija Čulo (University of Zagreb). The two speakers discussed magneto-optic and magneto-transport experiments, respectively, performed at different EMFL facilities, in order to unveil the electronic band structure of two-dimensional semimetals and superconductors.

In a further invited talk, Alexander Steppke (PSI and University of Zürich) presented the progress of a collaboration with EMFL to provide pulsed magnetic fields at the Cristallina end-station of the Swiss Free Electron Laser (SwissFEL) for wide-angle x-ray scattering. The aim here is to reach magnetic fields up to 40 T within a repetition rate of minutes. The well-attended session, chaired by the Swiss representative of the ISABEL project, Stefano Gariglio (University of Geneva), sparked various discussions, both on the science done at highest magnetic fields as well as on future opportunities and developments at

NEW MEMBER OF EMFL

The partner Universita del Salento is coordinating a consortium of 20 institutions to secure Italian membership of the EMFL and its request for membership has been approved by the EMFL Council on the 9th of June 2023. The agreement has been signed on the 17th of November 2023. Meetings of other candidate user communities (Spain, Switzerland, Czech Republic) have been held.

CONNECTION WITH INDUSTRY

- A seminar cycle (https://emfl.eu/isabel/documents/) with around 200 attendees was given by experts of Intellectual Property Rights, technology transfer, patent registration and entrepreneurship with the aim to raise staff awareness on economic and societal issues related to their high field research and development activities.
- To strengthen the connection between the socio-economic needs and the academic research, EMFL starts an Industrial Partners Club. EMFL proposes to all of its partners and every interested industrial enterprise to join and discuss about different topics. The EMFL Industrial Club has been launched on the 12th of December 2022, with 17 organizations represented.

EMFL PARTICIPATIONS IN INDUSTRIAL EXHIBITIONS

With the goal of strengthening relations with industries that are in need for research activities pursued in the EMFL facilities, EMFL decided on active measures to advertise the industry-related knowhow, initiate promising collaborations, and establish new contacts with companies open for this endeavor. One of the measures is the active participation in important industrial fairs dedicated to the field. The ISABEL Horizon 2020 project made this goal a priority.

Since 2021, a project team has attended major events and congresses around Europe.

- **2021**

- Rendez-Vous Carnot – Lyon (November)

- **2022**

- Wire Düsseldorf – Düsseldorf (June)

- Ind Tech 2022 – Grenoble (June)

- Big Science Business Forum – Granada (October)

- Rendez-Vous Carnot – Paris (October)

- **2023**

- Metrology congress- Lyon (March)

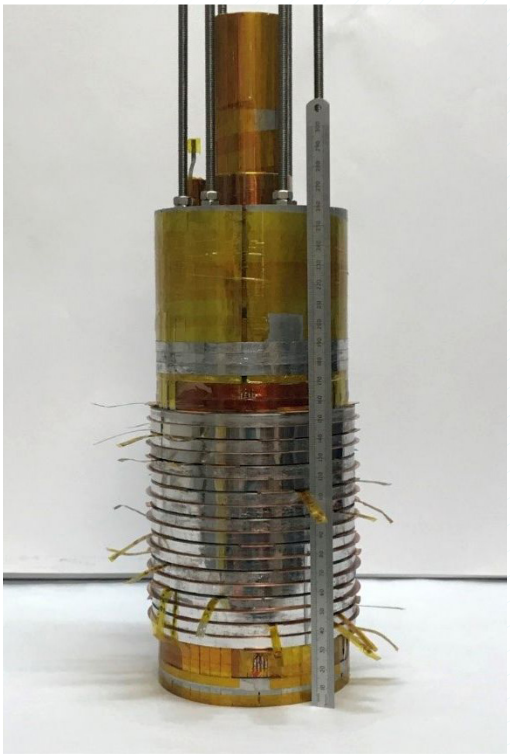
- Hannover Messe – Hannover (April)

- Rendez-Vous Carnot – Lyon (October)

As a result, more than 60 new contacts were initiated and numerous companies contacted EMFL to evaluate possible collaboration. Some of these contacts already led to cooperation contracts and research orders. Researchers and engineers from LNCMI, HZDR, and HFML contributed to these events and allowed for all these fruitful exchanges and new contacts.

This activity is supported by the project ISABEL that received funding from the European Union's Horizon 2020 research and innovation programme under GA n°871106.

SuperEMFL PROJECT



The EU-funded SuperEMFL project is a design study running from 2021 to the end of 2024. The aim is to add an entirely new dimension to EMFL through the development of novel superconducting magnets, using high-temperature superconductor (HTS) materials providing the European high-field user community with unprecedented high superconducting fields. The project partners want to achieve this by combining HTS insert magnets with low-temperature superconductor (LTS) outsert magnets.

The project has two design magnetic field targets, 32+ T and 40+ T, combining either a single stack of HTS pancakes with a 19 T/150 mm LTS magnet or two nested HTS coils with a 15 T/ 250 mm LTS magnet. The particular choice of the project is to use no insulation but a metallic tape co-wound with the bare HTS tape. This so-called metal-as-insulation (MI) technology enables a self-protection feature of the HTS coil by allowing the electrical bypass of defects as well as better mechanical performances in a very compact winding.

Recently, the partners focused on the tapes, coil manufacturing, and coil testing. Further, they studied the 40+ T designs, quench-simulation tools, including the interaction of LTS/HTS parts during a quench, and the protection scheme together with mechanical reinforcement. For that, they implemented and benchmarked a set of simulation tools. Finally, they prepared scientific cases for such LTS/HTS configuration to validate it as a user magnet.

The choice is to use a newly developed HTS tape with a particular enhancement of the critical current at low temperature and high magnetic field thanks to artificial pinning. The partners characterized a test coil, consisting of an assembly of two double HTS pancakes, under high magnetic fields. This allowed gaining important information on technical characteristics, such as the critical current, delamination, and joints performance. They performed a series of quench-test measurements up to 19 T, providing valuable information about the HTS/LTS coupling. A first scientific pilot experiment assessed the HTS/LTS magnet as a user magnet.

OUTREACH ACTIVITIES

- The quarterly newsletter EMFL News (https://emfl.eu/emfl newsletter/) which is widely distributed amongst the high field user community, has published in each issue articles on the different aspects of ISABEL. In particular a series of articles on the seven regional facilities has been achieved as well as the presentation of our industrial partners.
- A dedicated ISABEL website continuously updates its progress and the Twitter and LinkedIn pages continue to announce the major results and important events.
- A proper exhibition booth and presentation material for ISABEL is now used for all the industrial exhibitions that the project's team attends.
- In order to strengthen the dissemination towards a more general public, the EMFL facilities have developed virtual tours. Some are now accessible online (HFML - https://virtualtours.360totaal.nl/tour/hfml-felix), others are being finalized (HZDR, LNCMI-Toulouse) or planned (LNCMI-Grenoble).

Scientific Highlights

FIELD-TUNABLE BEREZINSKII-KOSTERLITZ-THOULESS CORRELATIONS IN A HEISENBERG MAGNET

Two-dimensional (2D) spin systems with an XY anisotropy are known to undergo a Berezinskii-Kosterlitz-Thouless (BKT) phase transition at a finite temperature T_{BKT}, which marks the binding of topological defects in vortex-antivortex pairs. So far, experimental efforts to probe a genuine BKT transition in bulk materials were compromised by the onset of 3D long-range order (LRO). Still, if the perturbative terms relative to a purely 2D XY model are small enough, magnetic properties associated with BKT correlations are still observable in the transition regime.

A group of researchers from Germany, the United Kingdom, and the USA investigated the concept of magnetic-field-driven tuning of a quasi-2D square-lattice spin-1/2 antiferromagnet from the Heisenberg to the XY limit. As a model system of this study, the molecularbased bulk material $[Cu(pz)_2(2\text{-}Hopy)_2](PF_6)_2$ (CuPOF hereafter) yields a moderate intralayer nearest-neighbor exchange coupling of J/k_B = 6.80 K, determined from pulsed-field magnetometry (Figure 1), and a small interlayer interaction of about 1 mK.

The researchers investigated the spin correlations in CuPOF by means of various techniques, including nuclear magnetic resonance (NMR) and quantum Monte Carlo (QMC) simulations. The results of the critical temperatures of the BKT transition as well as that of the onset of long-range order provide clear evidence that the magnetic phase diagram of CuPOF is determined by the field-tuned XY anisotropy and the concomitant BKT physics under the influence of small interlayer interactions (Figure 2). The findings of this study are of importance for the research of a number of materials that realize quasi-2D spin systems, with an emerging low-temperature phenomenology driven by BKT correlations

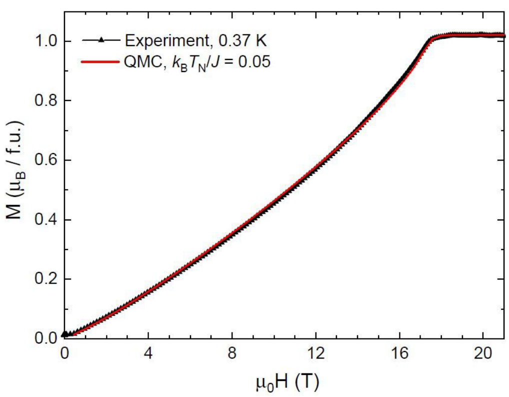


Figure 1: Pulsed-field magnetometry of CuPOF. The nearestneighbor exchange coupling between the spin-1/2 moments is determined by comparison of the data (triangles) with QMC

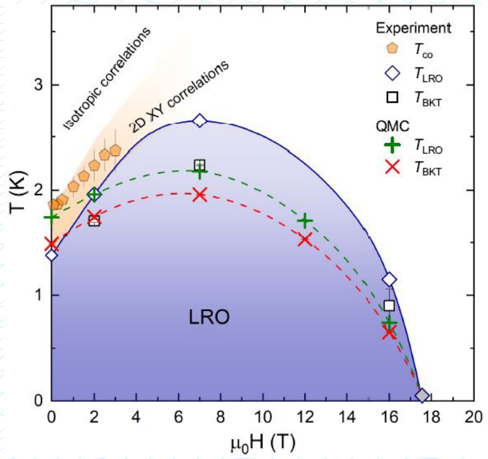


Figure 2: Magnetic phase diagram of CuPOF extracted from NMR, μSR, magnetometry, and QMC simulations.

Reference

"***Field-tunable Berezinskii-Kosterlit-Thouless correlations in a Heisenberg magnet***", D. Opherden, M. S. J. Tepaske, F. Bärtl, M. Weber, M. M. Turnbull, T. Lancaster, S. J. Blundell, M. Baenitz, J. Wosnitza, C. P. Landee, R. Moessner, D. J. Luitz, and H. Kühne,

Phys. Rev. Lett. **130**, 086704 (2023)

LAYERED BiOI SINGLE CRYSTALS CAPABLE OF DETECTING LOW DOSE RATES OF X-RAYS

Modern advances in x-ray imaging have greatly improved the quality of medical care. The ability to detect low doses of x-rays is critical to the development of safe radiological tools, but available absorber materials have their limitations. Reducing the x-ray dose would not only minimize harm to patients, but also enable innovative applications such as x-ray video techniques.

The ideal material for x-ray absorption should have a high effective atomic mass (Z) and mass density, a long charge-carrier drift length, and a low and stable dark-current density. Recently, metal-halide perovskites have shown promising properties for x-ray detection. However, lead-halide perovskites suffer from ion migration and contain toxic lead. Bismuth-based double perovskites, on the other hand, suffer from low charge-carrier drift lengths due to an exciton self-trapping effect.

In this work, we demonstrated the enormous potential of bismuth oxyiodide (BiOI) for x-ray detection. Bismuth oxyiodides are twodimensional layered crystals in which slabs of [I–Bi–O–Bi–I] are connected by van der Waals forces (Figure 1a). This material has a high effective Z number and density, resulting in strong x-ray attenuation. Extensive spectroscopic and magneto-optical measurements, as well as first-principles calculations, allow us to elucidate why this material also exhibits a significant drift length, which is essential for x-ray detectors. While photoexcited charge carriers structurally deform the lattice, they form delocalized large polarons instead of self-capturing excitons or small polarons common in other halide compounds.

To study the radial expansion of the exciton, we performed transmission experiments in the presence of strong magnetic fields of up to 65 T. By analyzing the shift of the absorption edge as a function of the magnetic field, we determined the coefficient for the diamagnetic shift and derived the radial expansion of the 1-s exciton (Figure 1b). This gave a diamagnetic shift coefficient of 0.43 μeVT^{-2}, resulting in an r.m.s. radius of the 1-s exciton of 15.3 Å. These values are comparable to those of other layered materials (e.g., WS2) and support the two-dimensional Wannier exciton nature, which span multiple unit cells within the plane. The photophysical principles discussed in this study provide novel design opportunities for materials containing heavy elements and low-dimensional electronic structures for x-ray detectors.

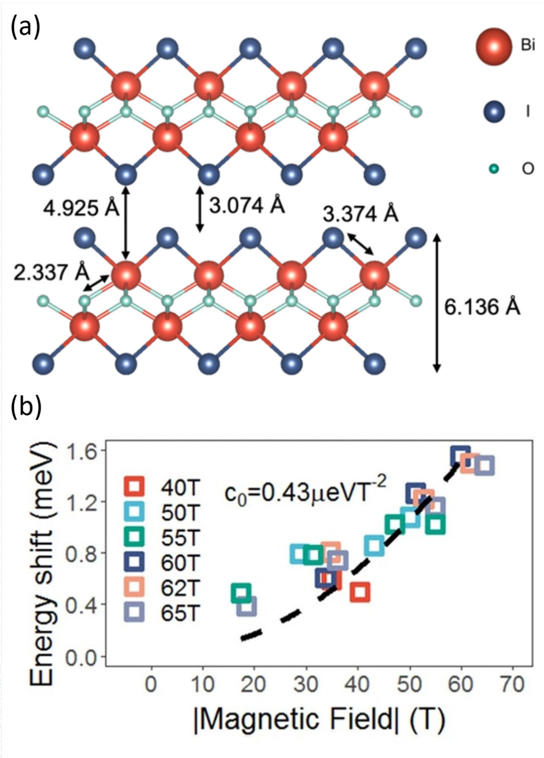


Figure: (a) BiOI lattice structure. (b) Change in absorption edge as a function of magnetic field strength.

Reference

"*Layered BiOI single crystals capable of detecting low dose rates of X-rays", R*.A. Jagt, I. Bravić, L. Eyre, K. Gałkowski, J. Borowiec, K. Reddy Dudipala, M. Baranowski, M. Dyksik, T. W. J. van de Goor, T. Kreouzis, M. Xiao, A.Bevan, P. Płochocka, S. D. Stranks, F. Deschler, B. Monserrat, J. L. MacManus-Driscoll, and R. L. Z. Hoye,

Nat. Commun. **14**, 2452 (2023).

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UNVEILING NEW QUANTUM PHASES IN THE SHASTRY-SUTHERLAND COMPOUND $SrCu_2(BO3)_2$

By investigating the Shastry-Sutherland compound $SrCu_2(BO_3)_2$ up to the saturation magnetic field of 140 T and beyond, researchers from Japan, the Netherlands, and Switzerland together with scientists from the HLD have succeeded in identifying several spin-supersolid phases (SSPs) between the 1/2 magnetization plateau and saturation (1/1 plateau). The SSPs simultaneously break translational symmetry and the U(1) symmetry associated with the total Sz conservation. They all exhibit a diagonal stripe pattern with a certain period.

The spin-lattice coupling plays an important role for the high-field properties of SrCu2(BO3)2. In this study, the researchers performed ultrasound and magnetostriction experiments, combined with the advanced high-magnetic-field generation equipment at the HLD-EMFL and at the ISSP of the University of Tokyo. They further supported their experimental data by extensive tensor-network calculations. They detected multiple anomalies in their experiments (Figure 1). Quite remarkably, the sound velocity of the 1/2 plateau exhibits a drastic decrease of-50 % (Figure 1a), related to a tetragonal-to-orthorhombic instability of the checkerboard-type magnon crystal. The magnetostriction results exhibit features similar to those of the magnetization; both start to increase when the spin gap closes (~ 25 T) and stay approximately constant in the plateau phases (Figures 1b and 1c).

The unveiled nature of this paradigmatic quantum system is a new milestone for exploring exotic quantum states of matter emerging under extreme conditions. The very good agreement between theory and experiment regarding the saturation field and other critical fields demonstrates how these cutting-edge studies contribute to our better understanding of complex quantum systems. This establishes the combination of ultrasound and magnetostriction measurements with pulsed fields up to 150 T as a rather unique source of information in a field range scarcely explored so far. This opens very interesting perspectives for the study of other quantum magnets and, more generally, of other strongly correlated materials with exotic magnetic properties at ultrahigh magnetic fields.

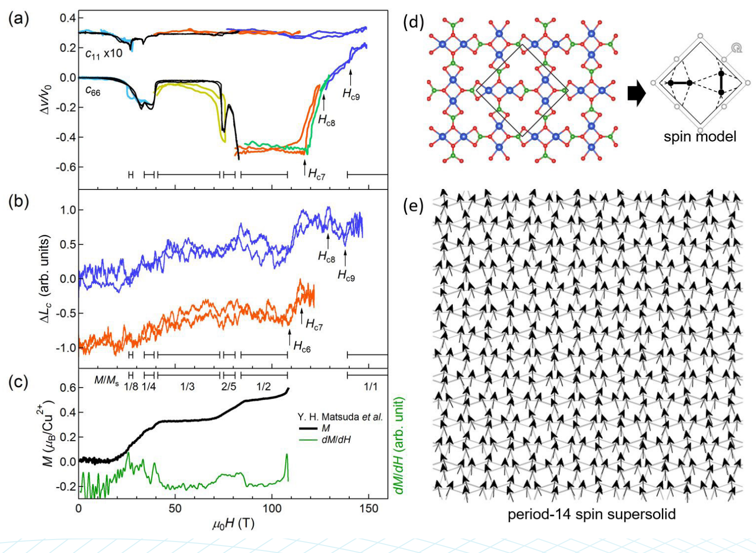

Figure: Ultrahigh-field data (H // c) obtained in $SrCu_2(BO_3)_2$: (a) sound velocity, (b) magnetostriction, and (c) magnetization. (d) Crystal structure in the ab plane with the dimer configuration built by Cu^{2+} ions with spin S = 1/2. (e) Spin pattern of the spinsupersolid state between H_{c8} and H_{c9}, just below saturation. The bars represent the regions of magnetization plateaus.

Reference

"*Unveiling new quantum phases in the Shastry-Sutherland compound SrCu2(BO3)2 up to the saturation magnetic field*", T. Nomura, P. Corboz, A. Miyata, S. Zherlitsyn, Y. Ishii, Y. Kohama, Y. H. Matsuda, A. Ikeda, C. Zhong, H. Kageyama, and F. Mila,

Nat. Commun. **14**, 3769 (2023).

MAGNETIC BREAKDOWN AND TOPOLOGY IN THE KAGOME SUPERCONDUCTOR CsV_3Sb_5

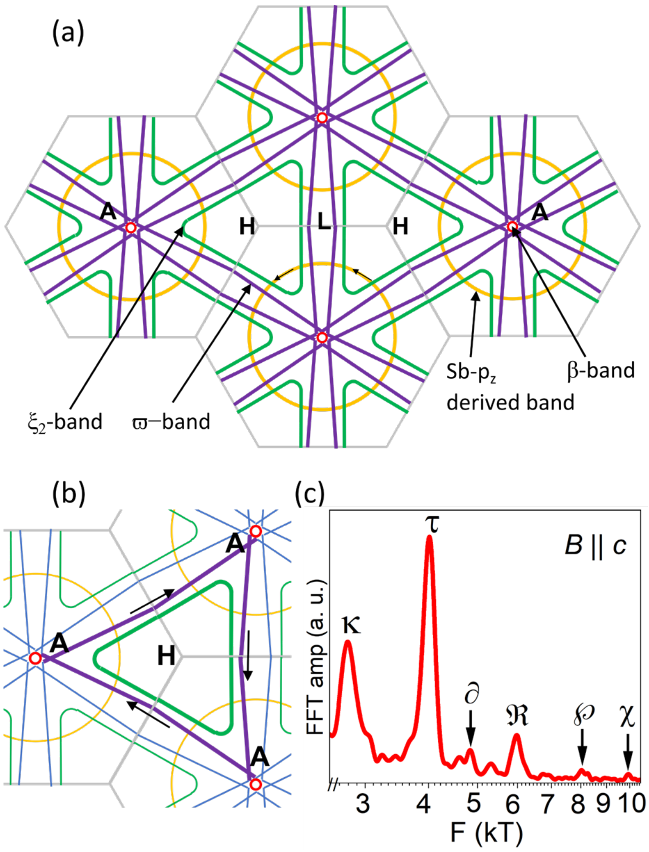

Figure1: (a) Schematic of the 2x2 reconstructed Fermi surface of CsV_3Sb_5 for $k_z = \pm\pi/c$ in repeated zones. Capital letters refer to Brillouin zone points. (b) Enlarged schematic of the ξ_2 and ϖ orbits. (c) High-frequency section of the oscillation spectrum at 1.5 K on a log field scale. The κ orbit corresponds to the sum of the ξ_2 and ϖ orbits, while the τ orbit represents two basic triangular ϖ units. Correspondingly R, L, and X contain 3, 4, and 5 triangular building blocks, respectively. ∂ is the sum of the ξ_2 and ϖ orbits.

The recently discovered-kagome lattice compounds AV_3Sb_5 (A = K, Rb, Cs) show a fascinating interplay of superconductivity, charge density wave (CDW) order, and nontrivial topology of the electronic band structure. The CDW order itself is unconventional due to the presence of chiral charge order and time-reversal symmetry breaking inducing a large anomalous Hall effect and non-reciprocal transport. The transition into the CDW state is accompanied by an extensive reconstruction of the Fermi surface. While angle-resolved photoemission spectroscopy (ARPES) has been invaluable in exploring the electronic structure, effects due to matrix elements have largely precluded the visualization of the reconstructed band structure. In contrast, quantum oscillations are a direct manifestation of the Fermi surface and can reveal information on the quasiparticle effective masses, their lifetimes, and their topological state.

Now, a research collaboration between Argonne National Laboratory, Hofstra University, and LNCMI-Toulouse has performed quantum-oscillation measurements on high-quality single crystals of CsV_3Sb_5 using the tunnel diode oscillator technique in fields up to 86 T. The high-field data reveal a sequence of magnetic-breakdown orbits that allow us to construct a model for the folded Fermi surface of CsV_3Sb_5, shown in Figure 1a.

The dominant features are large triangular Fermi-surface sheets that cover almost half of the folded Brillouin zone highlighted in Figure 1b in magenta (ϖ band with a frequency of 1943 T) and green (ξ_2 band at 804 T). These orbits form the 'building blocks' that combine one-by-one to form a series of approximately equally spaced frequencies that dominate the high-field oscillation spectrum as shown in Figure 1c. Notably, these Fermi-surface sheets have not yet been detected in ARPES. In addition to mapping this folded Fermi surface, we have extracted the Berry phases of the electron orbits from Landau-level fan diagrams near the quantum limit without the need for extrapolations, thereby unambiguously establishing the non-trivial topological character of several electron bands in this kagome-lattice superconductor.

Reference

"*Magnetic breakdown and topology in the Kagome superconductor CsV_3Sb_5 under high magnetic field*", R. Chapai, M. Leroux, V. Oliviero, D. Vignolles, N. Bruyant, M. P. Smylie, D. Y. Chung, M. G. Kanatzidis, W.-K. Kwok, J. F. Mitchell, and U. Welp,

Phys. Rev. Lett. **130,** 126401 (2023)

ENHANCED SUPERCONDUCTING PAIRING STRENGTH NEAR A PURE NEMATIC QUANTUM CRITICAL POINT

High-temperature superconductivity is one of the biggest unsolved problems in condensed-matter physics, due to its unconventional superconducting (SC) pairing mechanism, which goes beyond the standard electron-phonon interaction. Many materials with such an unconventional SC state commonly host an additional antiferromagnetic (AFM) phase that competes and/or coexists with the SC state. Interestingly, the SC transition temperature T_c is very often enhanced in the part of the phase diagram where this AFM phase transition is suppressed down to zero temperature, i.e., in vicinity of an AFM quantum critical point (QCP). Such a correlation has led to a strong belief that AFM quantum critical fluctuations play a decisive role in the SC pairing of unconventional superconductors.

Researchers from HFML for the first time showed that a similar enhancement of T_c occurs also in vicinity of a pure nematic QCP. This research is a result of an intensive collaboration between HFML, University of Tokyo, University of Bristol, and the Institute of Physics (Zagreb, Croatia), the latter being strengthened through a recently EMFL-funded secondment of Matija Čulo. The study was conducted on iron-based superconductors $FeSe_{1-x}S_x$ and $FeSe_{1-x}Te_x$, which are unique in the sense that superconductivity emerges from a pure electron nematic phase – a peculiar state that breaks the rotational symmetry while preserving the translational symmetry of a material. T_c values for $FeSe_{1-x}S_x$ and $FeSe_{1-x}Te_x$ were determined from electricresistivity measurements in high magnetic fields up to 35 T (HFML- EMFL) and 60 T (University of Tokyo), respectively.

From such determined T_c, the researchers successfully constructed a combined T_c vs. x phase diagram of $FeSe_{1-x}S_x$ and $FeSe_{1-x}Te_x$, for different field strengths (see Figure). For zero field, T_c stays finite in the whole measured x range, with no obvious enhancement at the respective nematic QCPs (x_c = 0.16 and 0.50 for $FeSe_{1-x}S_x$ and $FeSe_{1-x}Te_x$). Due to such behavior, it had long been believed that, in contrast to the AFM QCP, the nematic QCP has little or no influence on superconductivity in $FeSe_{1-x}S_x$ and $FeSe_{1-x}Te_x$. Our measurements, however, showed that the application of high magnetic field causes a suppression of T_c in such a way that two distinct SC domes emerge, the one for $FeSe_{1-x}Te_x$ being centered at $x_c \approx 0.50$, exactly where the nematic QCP occurs. Such behavior indicates that, in contrast to previous expectations, nematic quantum critical fluctuations may indeed play a dominant role in the SC pairing mechanism in $FeSe_{1-x}Te_x$, opening a nematic route to high-temperature superconductivity.

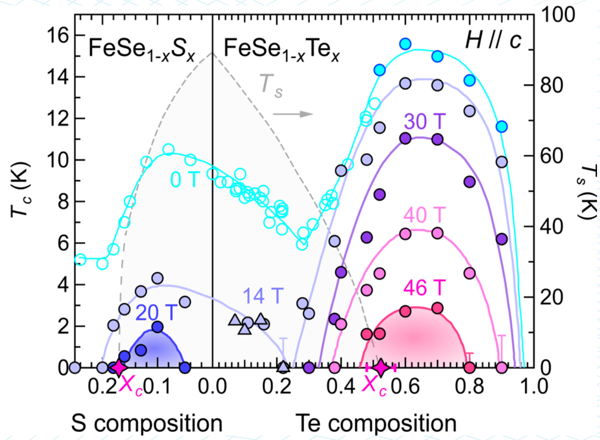

Figure: Combined T_c vs. x phase diagram for $FeSe_{1-x}S_x$ and $FeSe_{1-x}Te_x$ for different values of magnetic field H. T_c values are indicated by symbols (left axis), the nematic transition temperature T_s by the grey dashed line (right axis) and the nematic QCPs by the pink stars.

Reference

"*Enhanced Superconducting Pairing Strength near a Pure Nematic Quantum Critical Point*", K. Mukasa, K. Ishida, S. Imajo, M. Qiu, M. Saito, K. Matsuura, Y. Sugimura, S. Liu, Y. Uezono, T. Otsuka, M. Čulo, S. Kasahara, Y. Matsuda, N. E. Hussey, T. Watanabe,K. Kindo, and T. Shibuchi,

Phys. Rev. X **13,** 011032 (2023).

THE SEMIMETAL THAT WASN'T THERE

Weyl semimetals are an exciting new group of materials, showing unique signatures in their transport and optical behavior, inherited from their distinct topological features. The presence of nodes in the electronic band structure of Weyl semimetals makes their electrons behave as if they are massless, and this leads to a number of interesting properties. Material scientists have been searching for their experimental realizations ever since the first discoveries. One such proposed Weyl semimetal was $EuCd_2As_2$, which was described as a magnetic Weyl semimetal in various computational studies based on density functional theory (DFT) calculations, but also several experimental works.

In a magnetic Weyl semimetal, it would be possible to manipulate the topological properties using a small magnetic field. Without an external magnetic field, a small gap separates the conduction and valence bands. But in a magnetic field, the two bands overlap, creating a Weyl semimetal. In a broader context, the idea is to use the material's magnetic structure to control its topology. However, in a new study an international research team has studied this material in great detail. Most surprisingly, the widely investigated material $EuCd_2As_2$, turned out not to be a Weyl semimetal after all, but rather a magnetic semiconductor. These new results directly contradict about 30 published papers, both theoretical and experimental, that claimed that $EuCd_2As_2$ was a Weyl semimetal. Beyond the ground state of $EuCd_2As_2$, the main message is that the condensed-matter community has to be more careful when making conclusions mostly based on first-principle calculations.

The key development for the new experiments was synthesizing high-quality samples of $EuCd_2As_2$. Previously, all the investigated samples had metal-like resistivity. The new samples showed activated behavior of the resistivity, which is characteristic of semiconductors. The ability to prepare such pure samples allowed for more accurate magnetic and electric measurements than in previous studies. To achieve cleaner crystals, their careful crystal synthesis used very pure starting materials, in particular, extremely clean europium. Several different experimental techniques were used: electronic transport, optical spectroscopy, and excited-state photoemission spectroscopy. The goal was to determine the ground state of $EuCd_2As_2$. The material was studied at various temperatures and using infrared spectroscopy under an external magnetic field up to 16 T (see figure). All the experiments led to the same conclusion: the compound unmistakably behaves as a magnetic semiconductor – it combines antiferromagnetic behavior with activated electrical conductivity, and a band gap of 0.77 eV. An external magnetic field strongly impacts the band gap and the transport properties. Applying 2 T is enough to decrease the band gap by 125 meV. However, in contradiction to many previous studies, the material never ceases to behave as a semiconductor, even under a strong magnetic field. The coveted magnetic Weyl semimetal phase simply isn't there. How is it possible that so many studies could get the basic properties of $EuCd_2As_2$ so wrong? One of the main reasons is that europium has electrons in its f orbitals, leading to strong electron-correlation effects. Such localized electrons become notoriously difficult for DFT to simulate. The ab-initio community has taken note of this curious discrepancy. Most importantly, the positive takeaway is the almost forgotten power of magneto-optical spectroscopy, a technique that was widely used in the past to learn about semiconductors.

Reference: "*$EuCd_2As_2$: A Magnetic Semiconductor",* D. Santos-Cottin, I. Mohelský, J. Wyzula, F. Le Mardelé, I. Kapon, S. Nasrallah, N. Barišić, I. Živković, J.R. Soh, F. Guo, K. Rigaux, M. Puppin, J.H. Dil, B. Gudac, Z. Rukelj, M. Novak, A.B. Kuzmenko, C.C. Homes, Tomasz Dietl, M. Orlita, and Ana Akrap, Phys. Rev. Lett. **131**, 186704 (2023).

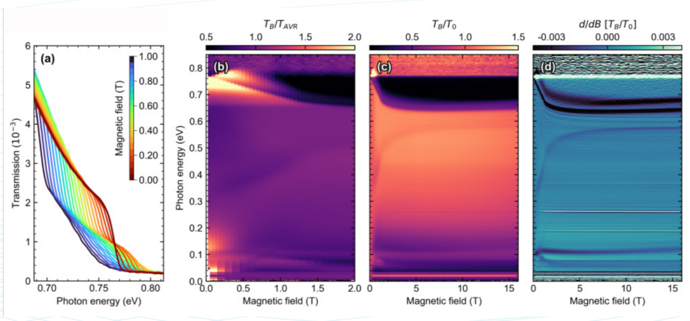

Figure: (a) Near-infrared transmission showing the interband absorption edge at low fields, B < 1 T. (b) Color plot of relative magnetotransmission, TB/TAVR, in a broad energy range and up to 2 T. (c) Magnetotransmission TB/T0 and (d) its first derivative, d/dE[TB/T0], in a broad energy and magnetic field range.

THE GRAPHITE PRINCESS AND THE MOIRÉ PEA

Graphite is made out of a stacking of layers of carbon atoms arranged in a honeycomb lattice. This recurring pattern gets disrupted at the surfaces of the crystal which leads to the occurrence of "surface states" – fading waves as one delves deeper into the bulk, which have been the subject of several investigations.

In this work, "twistronics", where one manipulates the properties of – usually two-dimensional (2D) - crystals through moiré patterns created by specific relative alignments between them, is taken one step further and applied to the surface of three-dimensional graphite. More precisely, electrical transport in bulk Bernal-stacked graphite aligned with hexagonal boron nitride was studied under high magnetic fields, high enough to bring the magnetic length (giving the spatial extent of the electronic wave function) close to the moiré superlattice unit cell, as previously done to evidence the Hofstadter butterfly in graphene. Our findings revealed that the moiré pattern does not just alter the graphite surface states, it also has a significant impact on the electronic spectrum of the entire bulk of the graphite crystal. Drawing a parallel with the well-known fairy-tale of The Princess and The Pea, where the princess felt the pea right through the twenty mattresses and the twenty eiderdown duvets, the moiré influence extends from the surface all the way through graphite of over 40 atomic layers.

As can be seen in the Figure, we observe a unique 2.5-dimensional (2.5D) intertwining of surface and bulk states that we describe as a 2.5D Hofstadter butterfly, a fractal version of the 2.5D quantum Hall effect discovered earlier on thin graphite, originating from the formation of confined vertical standing waves in the quantum limit. In the present case, the standing waves in graphite are orchestrated by twistronics, leading to the spiral dance of electrons trapped between the top and bottom surfaces to be directed both by the strong magnetic field and the moiré pattern. The extension of the surface moiré potential deep into the graphite bulk states opens a route to bring new non-trivial physics (spin-orbit coupling, ferromagnetism, and superconductivity) into graphite via proximity effects, and gives new prospects for controlling electronic properties in graphite or other semimetals.

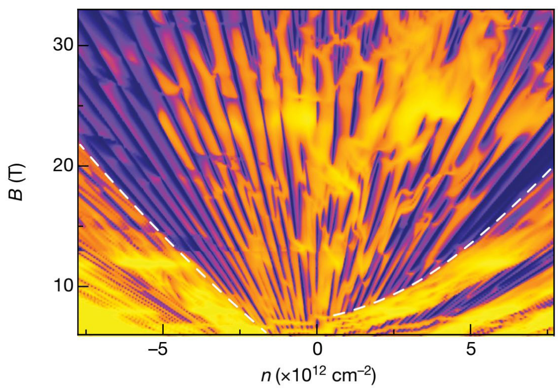

Figure: 2.5-dimensional Hofstadter butterfly. Color map of graphite's conductance (giving an image of the fractal electronic density of states) as a function of the magnetic field and the charge-carrier density. The white dashed curves indicate the transition from surface Landau levels to the bulk quantum regime.

Reference

"*Mixing of moiré-surface and bulk states in graphite*", C. Mullan, S. Slizovskiy, J. Yin, Z. Wang, Q. Yang, S. Xu, Y. Yang, B. A. Piot, S. Hu, T. Taniguchi, K. Watanabe, K. S. Novoselov, A. K. Geim, V. I. Fal'ko, and A. Mishchenko,

Nature **620**, 756 (2023).

ORBITAL HIGH-FIELD FFLO STATE IN ISING SUPERCONDUCTOR

Scientists from the University of Groningen, together with colleagues from HFML Nijmegen, the University of Twente, and the Harbin Institute of Technology (China), have discovered the existence of a superconducting state that was first predicted in 2017. In particular, they present evidence for a special variant of the so-called Fulde– Ferrell–Larkin–Ovchinnikov (FFLO) superconducting state, a discovery that could have significant applications in the field of superconducting electronics.

To create the FFLO state – with a real-space variation in the pairing gap – in a conventional superconductor, a strong magnetic field is needed. But, the role played by the magnetic field needs careful tweaking. Typically, the FFLO state relies on the Zeeman effect that separates electrons in Cooper pairs based on the direction of their spins (magnetic moment). The orbital effect- the other role that normally destroys superconductivity – has previously thought to play no substantive role for the observation of an FFLO state.

In an Ising superconductor with strong spin-orbit coupling, however, the Zeeman effect is suppressed and the in-plane upper critical field B_{c2} will be determined in principle by orbital effects. This work provides a first clear fingerprint of an orbitally driven FFLO state in an Ising superconductor. The FFLO state in conventional superconductors requires low temperatures and a very strong magnetic field, which makes it difficult to create. However, in an Ising superconductor, the state is reached with a weaker magnetic field and at higher temperatures. The high magnetic fields at HFML-EMFL were nevertheless important to enable researchers to establish the full phase diagram of this novel phenomenon.

This new superconducting state still needs further investigation, however. For example, how does the kinetic momentum influence the physical parameters? Studying this state will provide new insights into superconductivity and may ultimately allow to control this state in devices such as transistors.

Apart from its scientific importance, this work is also a nice example of an efficient international collaboration at an EMFL laboratory. State-of-the art devices processed in Groningen were brought to the high-field installation in Nijmegen, which allowed the researchers to explore the peculiar phase diagram of this superconductor at magnetic fields above 20 T, where the superconductivity is destroyed, providing convincing proof for the existence of FFLO state in the absence of strong Zeeman effects.

Finally, the findings of this work, namely that the presence of Ising spin-orbit coupling in combination with an in-plane magnetic field shifts the transition to the FFLO state closer to the critical temperature and lower fields, may allow easier access to this exotic state for other experimental groups.

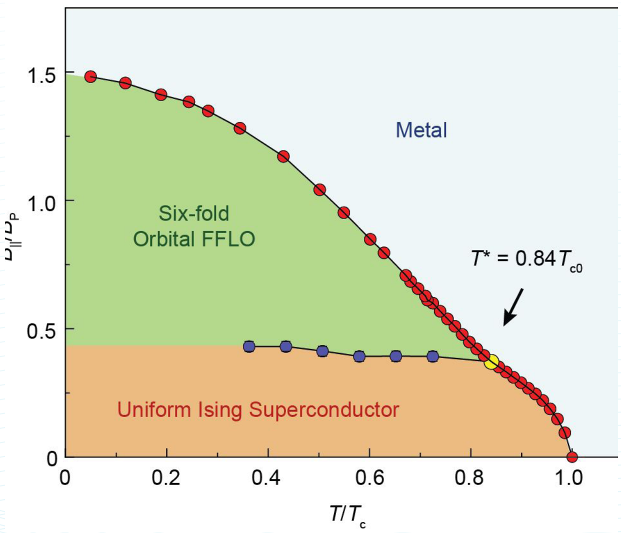

Figure: : Phase diagram of the orbital FFLO state as determined from the temperature and field dependence of B_{c2} in a parallel magnetic field.

Reference

"Orbital Fulde–Ferrell–Larkin–Ovchinnikov state in an Ising superconductor", P. Wan, O. Zheliuk, N. F. Q. Yuan, X. Peng, L. Zhang, M. Liang, U. Zeitler, S. Wiedmann, N. E. Hussey, T. T. M. Palstra, and J. Ye,

Nature **619**, 46 (2023).

DESIGN OF NOVEL SILVER-COPPER NANOCOMPOSITE WIRES TO BREAK THE STRENGTH-RESISTIVITY TRADE-OFF

The generation of record pulsed magnetic fields above 100 T requires the use of coils wound with low-resistivity wires in order to limit the heating, and with a very high mechanical strength in order to be able to resist the Lorentz forces. LNCMI and the Centre interuniversitaire de recherche et d'ingénierie des matériaux (CIRIMAT) explore the design of novel silver-copper nanocomposite wires with the aim to break the usual strength-resistivity trade-off.

Composite powders are prepared by mixing 1 vol. % Ag nanowires (diameter 0.2 µm, length 30 µm, prepared in-house) and bimodal fine (1 µm) and large (20 µm) grain-size Cu powder with 50/50 and 75/25 in weight. The obtained composite powders are consolidated into cylinders (8 mm in diameter and 30 mm long) by spark plasma sintering (SPS). The cylinders served as starting materials for room-temperature wire drawing for the preparation of fine wires (1-0.2 mm diameter). The bimodal character of Cu is preserved after the preparation steps, namely after the preparation of the powder, the SPS cylinders, and the wires.

We show that it is possible to improve the low resistivity vs. high ultimate tensile strength (UTS) compromise of the composite wires by simply adding large grains of Cu during the composite-powder preparation step. Because they form large areas with few grain boundaries and no Ag, the larger Cu grains act as channels for good electron conduction, thus allowing to maintain a low electrical resistivity (0.45 µΩcm at 77 K). Compared to wires with only fine-grained Cu, this represents a 12 % lower electrical resistivity for the same UTS (1082 MPa at 77 K), which is provided by the finer Cu grains and the Ag nanowires. The strength-resistivity trade-off can be finetuned simply by adjusting the large grain / fine grain proportion.

Reference: "*Influence of bimodal copper grain size distribution on electrical resistivity and tensile strength of silver-copper composite wires*", S. Tardieu, D. Mesguich, A. Lonjon, F. Lecouturier-Dupouy, N. Ferreira, G. Chevallier, A. Proietti, C. Estournès, and C. Laurent, Mater. Today Commun. **37**, 107403 (2023)

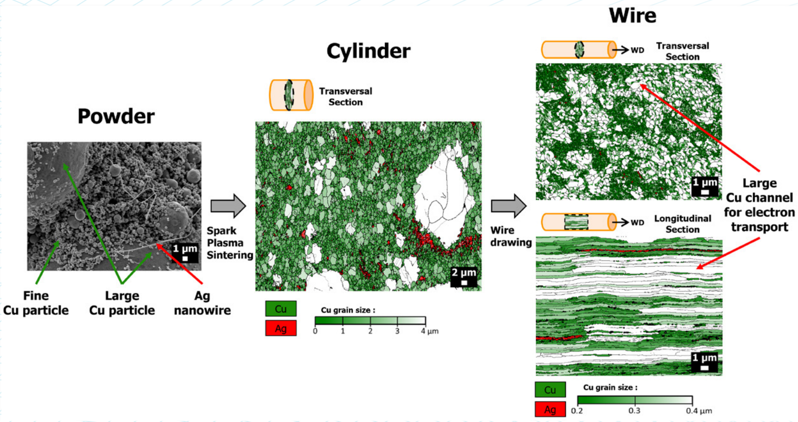

Figure 1: Representation of the method and microstructure of the powder, cylinder, and wire samples. The powder was analyzed by scanning electron microscopy and the cylinder and wires by electron backscatter diffraction.

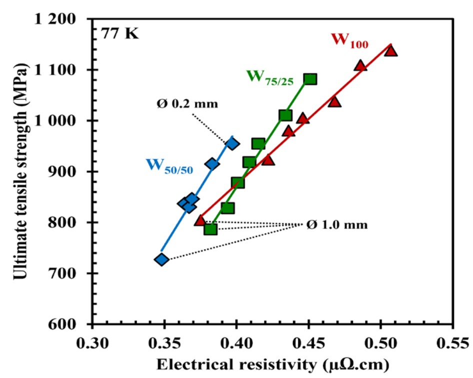

Figure 2: UTS vs. electrical resistivity at 77 K for wires with diameters from 1 to 0.2 mm for W50/50 (◊), W75/25 (□), and W100 (Δ). The dotted lines are used to indicate wires with a diameter of 1 mm and the 0.2 mm wire in the case of W50/50.

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 consists of:

Prof. Sebastian Schmidt (HZDR)
Prof. Amalia Patanè (University of Nottingham)
Prof. Adam Babiński (University of Warsaw)
Dr. Sylvain Ravy (CNRS, President of the EMFL Council)
Prof. José M. Sanders (RU/NWO-I)
Dr. Pierre Védrine (CEA-IRFU)


Sebastian Schmidt


Amalia Patanè


Adam Babiński


Sylvain Ravy


José M. Sanders


Pierre Védrine

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 consists of:

Dr. Charles Simon (LCNMI, Chair)
Prof. Jochen Wosnitza (HLD)
Dr. Britta Redlich (HFML, from 1.03.2023)


Jochen Wosnitza


Charles Simon


Britta Redlich

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 and 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

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	IISER	(Magneto)-optics of 2D semiconductors
Mathias Dörr	TU Dresden	Magnetism
Karel Prokes	Helmholtz-Zentrum Berlin	Magnetism
Carsten Putzke	MPI	for the Structure and Dynamics of Matter
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

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	Univ. College Cork	Metals and Superconductors
Ilya Sheikin	LNCMI-G	Metals and Superconductors
Duncan Maude	LNCMI-T	Semiconductors
Amalia Patanè	Univ. Nottingham	Semiconductors
Ana Akrap	Univ. Fribourg	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

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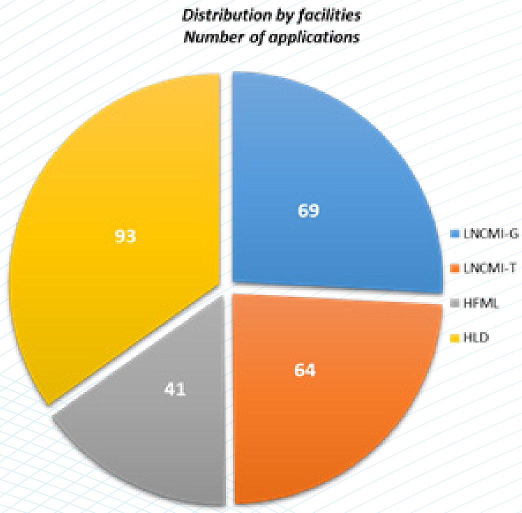
User Access

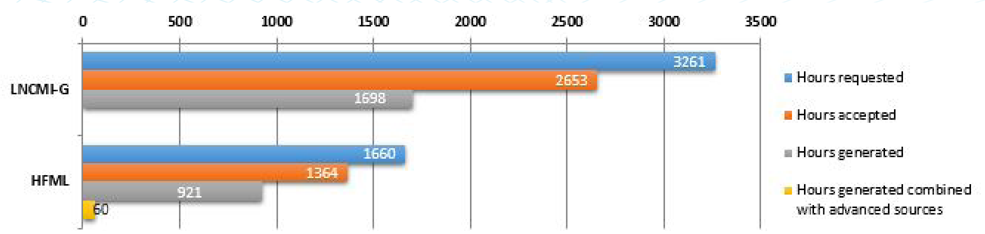
In 2023, 267 applications from 24 different countries were submitted to the EMFL facilities. This includes projects submitted at the 29th and 30th call for proposals closed in May and November 2023 and those going through the novel fast-track access procedure developped within the EMFL-ISABEL project as well as applications asking for the use of high magnetic fields in combination with advanced sources (ILL, ESRF, LULI, FELIX, CLF ...).

The EMFL Selection Committee (see page 27) has evaluated the proposals, covering five types of scientific topics:

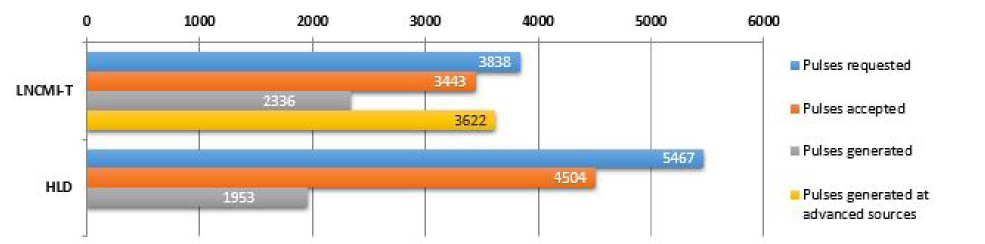
- Metals and Superconductors
- Magnetism
- Semiconductors
- Soft Matter and Magnetoscience
- Applied Superconductivity



Access to magnetic fields in combination with advanced sources can be gained also via the proposal submission procedure of these infrastructures after evaluation of the feasibility by EMFL scientists or engineers.



DC Facilities



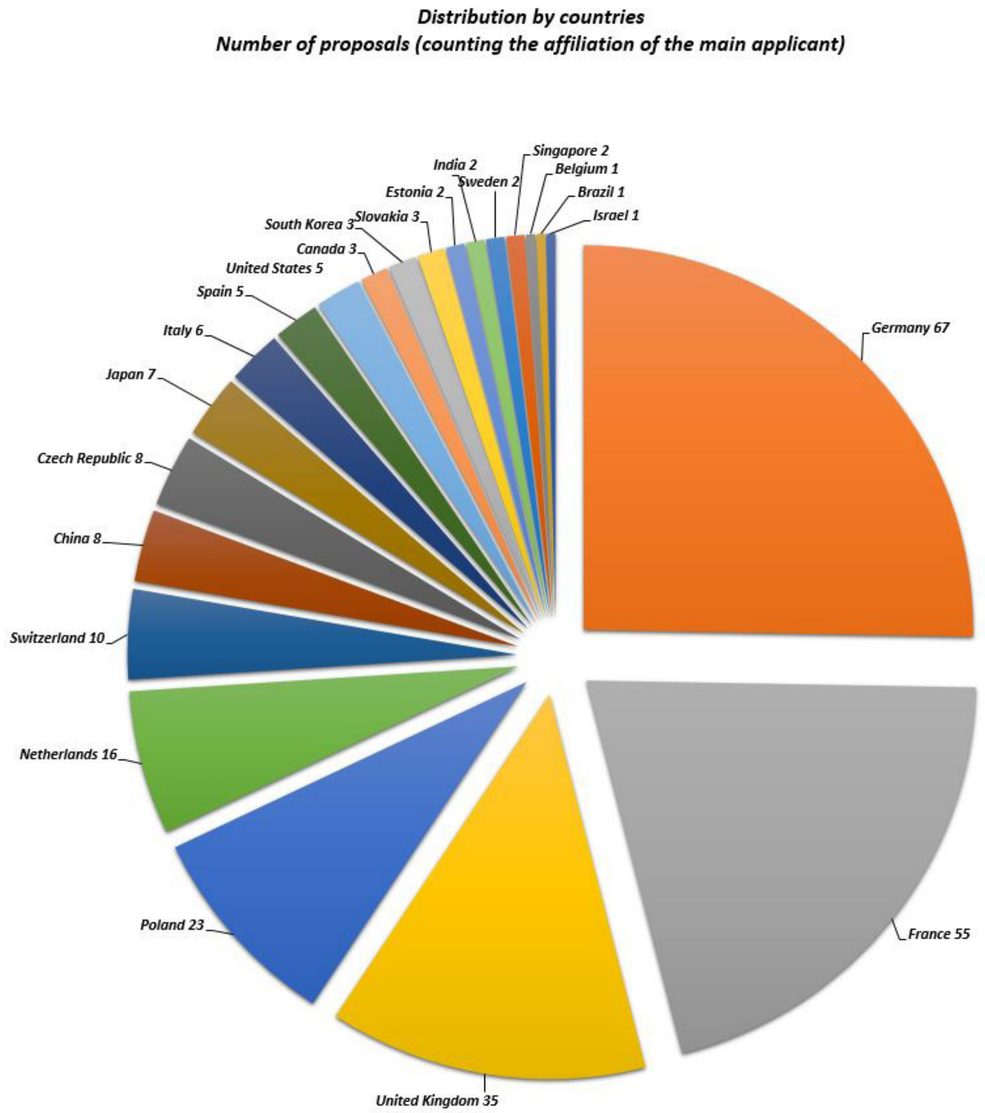
Pulsed facilities

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/



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Thesis defences 2023

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