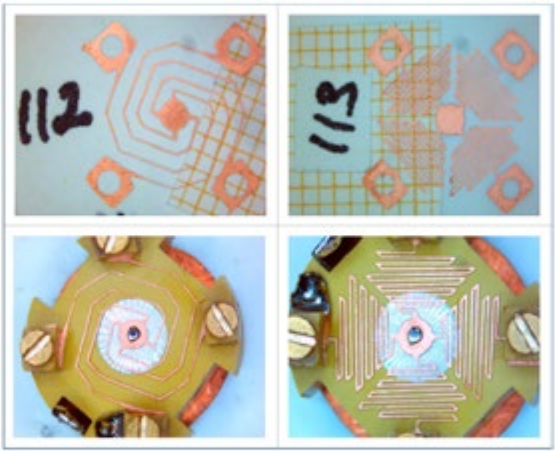
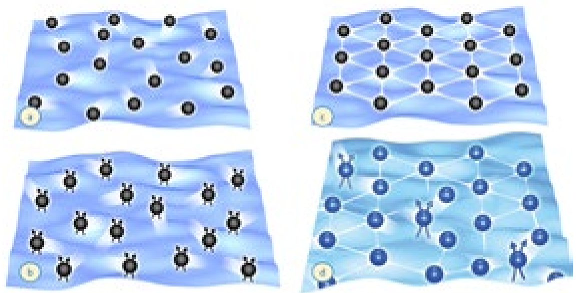
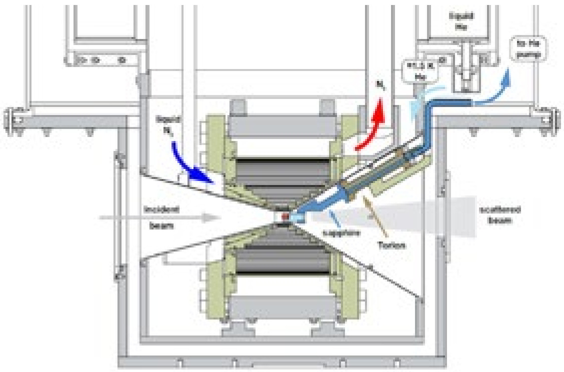
European Magnetic Field Laboratory

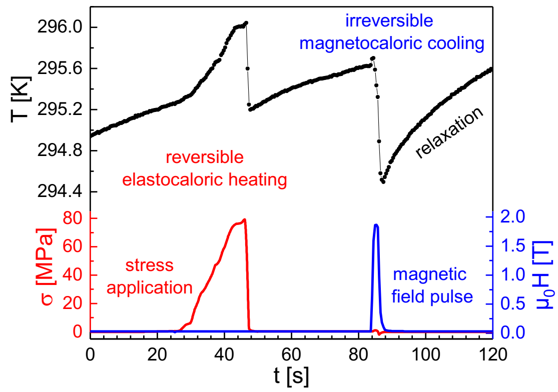
EMFLNEWS

N°3 2018









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DEAR READER

In this issue of the EMFL News, we are announcing the opening of the 20th call for access to our high-field installations. As every semester, you have the chance to submit your proposals and, if access is granted, to perform your experiments in our facilities with expert support from our staff members. This is part of our mission and we are happy to supply this service to the community. Indeed, during the last years there was a steady growth in the number of proposals (from 285 in 2013 to more than 330 in 2017) and the amount of requested magnet hours and pulses. This increasing demand shows the need for sophisticated high-field facilities and gives us confidence that our local contacts did a good job. On the other side, it means that there is increasing competition and that, due to capacity reasons, a growing number of projects cannot be performed or only with reduced access time. However, we will do our best to accommodate as many of your top-level research projects as possible.
I also would like to take this opportunity to thank Nigel Hussey for his excellent work during the last five years in helping to establish EMFL as a world-known distributed large-scale facility. Nigel has recently stepped down as director of the HFML, but will continue his scientific work at the HFML. Peter Christianen is now the new director of HFML and we are happy to have him in the EMFL Board of Directors team (see the news article in this issue).

Have a stimulating reading,

Jochen Wosnitza
Director HLD
Chairman EMFL

MEET OUR PEOPLE

Nicolas Bruyant, LNCMI Toulouse

What is your actual position?
I am in charge of the Scientific Infrastructure team at LNCMI Toulouse, which consist of 4 engineers and technicians.

Where do you come from?
I did most of my studies in Grenoble: I first obtained an engineering degree before doing my thesis in spintronics in the laboratory Spintec (SPINtronique et TEchnologie des Composants).

What is your professional background?
Before working at LNCMI, I was involved in the physical characterization of organic electronic devices and on the x-ray characterization of 3rd-generation solar cells.

What do you like about your job / lab / EMFL?
Meeting people from very different scientific backgrounds and cultures. Before a user arrives it is important to understand his/her scientific needs in order to prepare his/her experiment. During the experiment, often changes are necessary to deal with the pressure of an experiment in the very short time available. I find this both very interesting and challenging.

What are your current activities?
There are two main components of my work: First, the administrative user support: I am responsible for the scheduling and the organization of the users' stay. I also participate in the development of the EMFL website, the Selcom and user portal. I am in charge of the development of the Data Management Plan according to the "Guidelines on Data Management in Horizon 2020". On the scientific level, with my team we are responsible for the development and exploitation of optical experiments, magnetization, NMR, and contactless resistivity measurements. I am particularly involved in NMR and contactless resistivity for which I am local contact, but I can also assist users for more traditional measurements such as AC resistivity or some more exotic ones such as calorimetric measurements.

What are your perspectives?
In the future, I would like to further develop NMR measurements to enable all the power of this technique to be used in pulsed fields, and also to provide improved RF techniques to better serve our user community.

› Nicolas Bruyant

FARADAY BALANCE MAGNETOMETER AT LNCMI-G

Gabriel Seyfarth, LNCMI Grenoble

A new Faraday-balance magnetometer for low temperatures and high magnetic fields has been developed at LNCMI Grenoble. It has been designed to probe the longitudinal sample magnetization. The determination of absolute values is possible via separate calibration measurements. The working principle is based on the fact that magnetic moments are subject to a force in the presence of a magnetic field gradient (created here by placing a ferromagnet close to the sample). Experimentally, the displacement induced by this force is detected via a capacitance change: the sample is placed on a suspended CuBe platform which constitutes one of the electrodes of the capacitor (Figure). The set-up is well adapted for measuring field-dependent magnetization curves of small single crystals of typical size of 1 mm x 1 mm x 500 µm. So far, the magnetometer has been used down to a temperature of 1.3 K and up to magnetic fields of 36 T (an extension to dilution-refrigerator temperatures is planned). The sensitivity can be adapted to the magnetic moment of the samples and reaches at the moment a minimum value of about 10^{-7} emu. Well-resolved quantum oscillations (de Haas-van Alphen effect) could be observed in several systems.

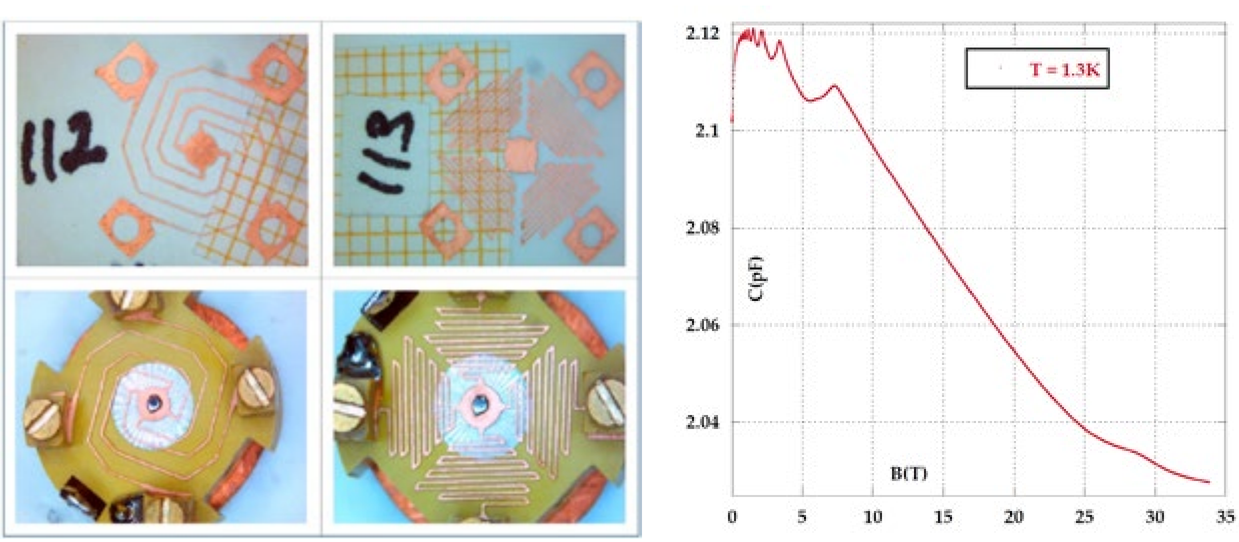

Figure: (Left panel) Top view of the magnetometer with crystals in the center of more or less rigid (sensitive) CuBe sample platforms (shown separately in the upper row). (Right Panel) Raw (as measured) data of the capacitance (proportional to the sample magnetization). The overall amplitude at high fields corresponds to roughly 10^{-4} emu. Superimposed small quantum oscillations can easily be resolved.

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ELECTRONIC PHASES IN HIGH MAGNETIC FIELDS – COMPETITION BETWEEN A LAUGHLIN LIQUID AND A WIGNER SOLID

U. Zeitler, HFML Nijmegen

Electrons are one of the fundamental constituents of solids, responsible for most of the important phenomena and applications in condensed-matter physics. Therefore, understanding, controlling, and manipulating electronic properties is still one of the great challenges of condensed-matter research. An ideal testbed for this endeavour are high-quality two-dimensional electron systems (2DESs) subject to high magnetic fields. The competition between kinetic energy and the electron-electron action drives the 2DES through different gaseous, liquid, and solid phases, which can be controlled by temperature and magnetic field.

Researchers from the RIKEN Center for Emergent Matter Science and the University of Tokyo have now observed and explained all these phases in the 2DES of a MgZnO/ZnO heterojunction with exceptional quality. In collaboration with HFML-EMFL scientists they have performed state-of-the-art electronic magneto-transport experiments at very low temperatures down to 60 mK and high magnetic fields up to 33 T, which allowed the direct observation of a sequence of several liquid-solid transitions in a 2DES.

More specifically, as illustrated in the Figure, they have observed the competition between two opposing correlated phases in a 2DES over an unprecedentedly large parameter range: a Laughlin liquid (Figure 1b, leading to a fractional quantum Hall effect of so-called composite fermions) and a Wigner solid (Figure 1c). This is without a doubt a significant step forward in our understanding of interaction-driven electronic phases in solids. More generally, the knowledge gained with this research is useful for future technological developments on innovative correlation-based quantum computation devices.

Composite fermion liquid to Wigner solid transition in the lowest Landau level of zinc oxide, D. Maryenko, A. McCollam, J. Falson, Y. Kozuka, J. Bruin, U. Zeitler, and M. Kawasaki, Nat. Commun. **9**, 4356 (2018).

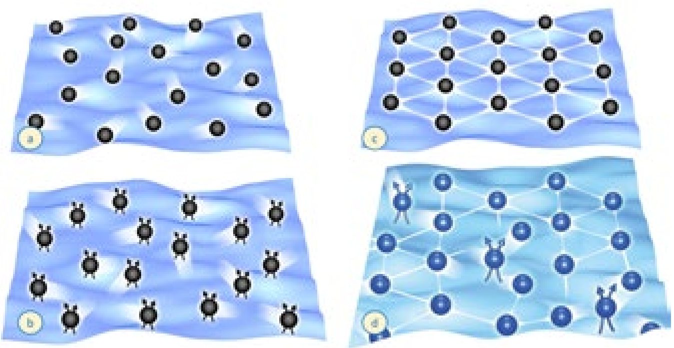

Figure 1: (Courtesy of Mari Ishida, RIKEN Center for Emergent Matter Science, Japan). The different phases of 2D electrons in MnZnO/ZnO. (a) Free, weekly interacting, electron gas at zero magnetic field. The quantization of these electrons into Landau levels leads to the observation of an integer quantum Hall effect. (b) Composite fermion (CF) gas consisting of electrons in high magnetic fields with two magnetic flux quanta attached to them. These particles are responsible for the observation of a fractional quantum Hall effect described by a Laughlin liquid. (c) Wigner solid of electrons in high magnetic fields. The competition of kinetic and potential energy makes it favourable for electrons to arrange in a solid phase, a so-called Wigner solid, rather than a free electron gas. (d) Coexistence of a CF liquid and a Wigner solid in the quantum limit of 2D electrons in MnZnO/ZnO.

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40-TESLA PULSED MAGNET FOR NEUTRON DIFFRACTION

A 40-T pulsed magnet for single crystal elastic neutron scattering, featuring an unprecedented high duty cycle, now offers new opportunities to investigate magnetic systems down to 2 K at the Institut Laue Langevin (ILL) in Grenoble (France).

This unique experimental setup results from a 4-year collaborative work between the LNCMI-Toulouse, the CEA-Grenoble, and the ILL. The magnet produces a horizontal field in a bi-conical geometry, ±15° upstream and ±30° downstream of the sample. Using a 1.15 MJ transportable generator installed on the triple-axis spectrometer IN22, magnetic-field pulses of 100 ms duration are generated, with a rise time of 23 ms and a rate of 7 pulses per hour at 40 T.

Since 2014, this magnet has already generated more than 5000 field pulses, with 70% of them at more than 30 T. They have allowed to investigate various magnetic systems such as heavy-fermion materials and quantum spin systems. This equipment is available to ILL users through a scientific collaboration with the LNCMI.

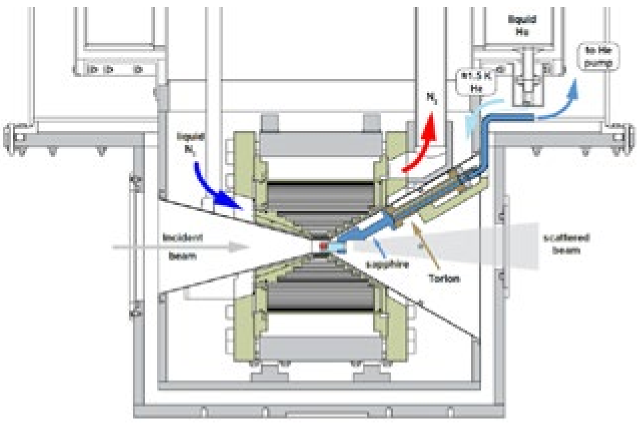

Figure 1: Overview of the bottom of the cryomagnet. The coil is immersed in liquid nitrogen. The sample is under vacuum and fixed at the end of a cold finger. This finger is cooled down using a flow of helium.

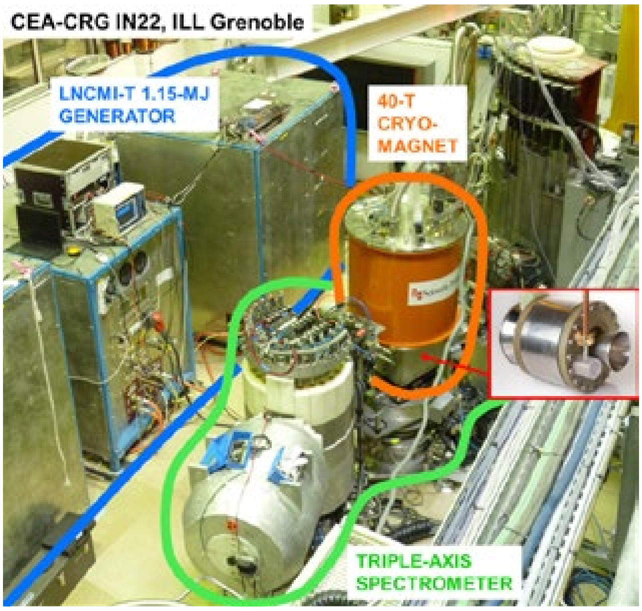

Figure 2: IN22 triple-axis spectrometer equipped with the mobile pulsed-magnet system consisting of the mobile 1.15 MJ pulsed-field generator and the 40-tesla cryomagnet.

40-Tesla pulsed-field cryomagnet for single crystal neutron diffraction, F. Duc, X. Tonon, J. Billette, B. Rollet, W. Knafo, F. Bourdarot, J. Béard, F. Mantegazza, B. Longuet, J.E. Lorenzo, E. Lelièvre-Berna, P. Frings, L.-P. Regnault, Rev. Sci. Instrum. **89**, 053905 (2018)

A MULTICALORIC COOLING CYCLE THAT EXPLOITS THERMAL HYSTERESIS

T. Gottschall, HLD Dresden

The giant magnetocaloric effect, in which large thermal changes are induced in a material on the application of a magnetic field, can be used for refrigeration applications. However, commercial uptake is limited. Researchers from Barcelona, Darmstadt, and the HLD proposed an approach to magnetic cooling that rejects the conventional idea that the hysteresis inherent in magnetostructural phase-change materials must be minimized to maximize the reversible magnetocaloric effect. Instead, they introduced a second stimulus, uniaxial stress, so that the hysteresis can be exploited rather than avoided. The working principle of such a device is schematically illustrated in Figure 1. This cycle allows to lock-in the ferromagnetic phase as the magnetizing field is removed, which allows one to drastically reduce the volume of the magnetic field source and, therefore, the amount of expensive Nd–Fe–B permanent magnets needed for a magnetic refrigerator.

In order to assess the suitability of multicaloric materials, direct measurements of the adiabatic temperature change in pulsed-field experiments are crucial. Varying the magnetic-field strength of the pulse between 1 and 50 T furthermore helps to deepen the understanding of time-dependent effects of the first-order transition in the materials needed for exploiting the hysteresis cycle. This could lead to an enhanced usage of the giant magnetocaloric effect in commercial applications. The technical feasibility of this hysteresis-positive approach is demonstrated using Ni–Mn–In Heusler alloys in pulsed magnetic fields and under uniaxial load (Figure 2).

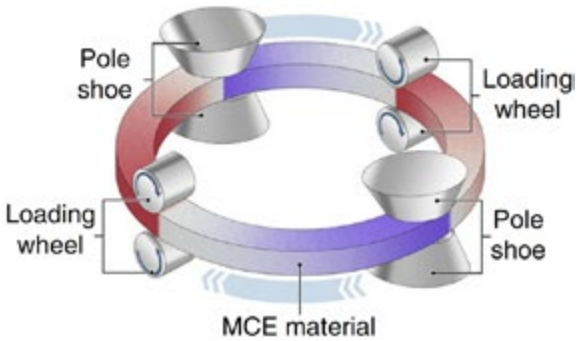

Figure 1: Schematic of a cooling device that could exploit the thermal hysteresis of multicaloric materials.

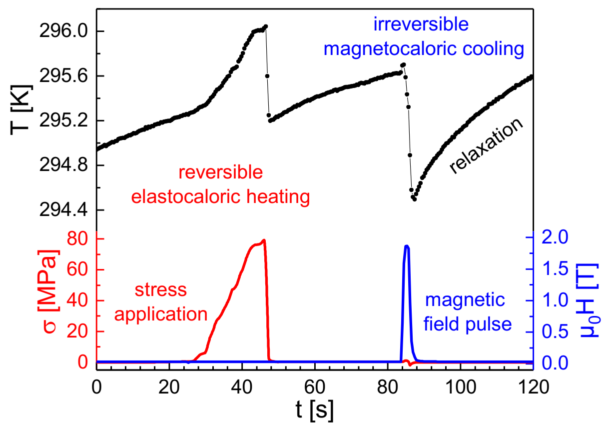

Figure 2: Experimental demonstration of a hysteresis cycle in Ni–Mn–In. As the stress is applied the temperature of the material increases, but this is reversed when the material is unloaded. A short magnetic field pulse then results in an irreversible cooling effect. After the pulse, the material slowly relaxes back to the temperature of the surroundings.

A multicaloric cooling cycle that exploits thermal hysteresis, T. Gottschall, A. Gràcia-Condal, M. Fries, A. Taubel, L. Pfeuffer, Ll. Mañosa, A. Planes, K. P. Skokov, and O. Gutfleisch, Nat. Mater. **17**, 929 (2018).

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OPENING OF THE CALL FOR ACCESS NO. 20

The 20th call for proposals has been launched in October, 2018 inviting researchers worldwide to apply for access to one of the large installations for high magnetic fields collaborating within EMFL.

The four facilities

- LNCMI - Grenoble - France: Static magnetic fields up to 36 T
- HFML - Nijmegen - the Netherlands: Static magnetic fields up to 37,5 T
- HLD - Dresden - Germany: Pulsed magnetic fields to beyond 90 T
- LNCMI - Toulouse - France: Pulsed magnetic fields of long duration to beyond 80 T and on the microsecond scale to beyond 180 T

run a joint proposal program, which allows full access to their installations and all accompanying scientific infrastructure to qualified external users, together with the necessary support from their scientific and technical staff.

Users may submit proposals for access to any of these installations by a unified procedure. The online form for these proposals can be found on the EMFL website.

www.emfl.eu/user

The next deadline for proposals for magnet time is November 16, 2018.

Proposals received after the deadline, that are considered of sufficient urgency, may be handled as they arrive and fit into any available time.

The proposals will be evaluated by a Selection Committee. Selection criteria are scientific quality (originality and soundness), justification of the need for high fields (are there good reasons to expect new results) and feasibility of the project (is it technically possible and are the necessary preparations done). It is strongly recommended to contact the local staff at the facilities to prepare a sound proposal and ideally indicate a local contact.

Please do acknowledge any support under this scheme in all resulting publications with „We acknowledge the support of the HFML-RU/FOM (or HLD-HZDR or LNCMI-CNRS), member of the European Magnetic Field Laboratory (EMFL)." UK users should, in addition, add "A portion of this work was supported by the Engineering and Physical Sciences Research Council (grant no. EP/K016709/1)."

- You may find more information on the available infrastructures for user experiments on the facility websites.

www.hzdr.de/hld
www.lncmi.cnrs.fr
www.ru.nl/hfml

EMFL
European Magnetic Field Laboratory

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

EMFL DAYS 2018 IN ARLES, FRANCE

This fourth edition of the EMFL Days was organized in Arles, in France in the first days of October. After La Colle-sur-Loup in 2011, Egmond aan Zee in 2013, and Königstein near Frankfurt in 2016, about 140 EMFL staff members gathered in the south of France. The aim of the meeting was to continue to learn more about each other's work at the different sites, exchange ideas, and define a common strategy for the future of EMFL. This included scientific work, but as well work on technological and administrative aspects. The program was divided into two parts: A formal program with plenary sessions and workgroups dealing with various topics, and an informal program including a visit of the city of Arles.

The EMFL Days started on Monday afternoon by a plenary session with an opening and welcome by Jochen Wosnitza, chair of the EMFL Board of Directors. The directors of the three laboratories - Peter Christianen (HFML), Geert Rikken (LNCMI), and Jochen Wosnitza (HLD) - presented the current state and future plans of their facilities. The session leaders presented their ideas on the program, goals, and objectives of their workgroups. This year, the workgroups covered the topics: i) Magnets and facilities development, ii) Instrumentation, iii) Administration / hosting users / communication, and iv) Science. Exchange of information and discussions started Tuesday morning during the two first sessions of the workgroups. Discussions continued during the poster session organized after lunch on Tuesday.

The rest of the afternoon was dedicated to an informal visit of Arles, allowing to visit the cultural attractions, enjoy leisurely strolls in the pleasant Provençal ambience, relax at the shaded terraces of its outdoor cafés, or follow the Van Gogh Trail to see the scenes of the artist's famous paintings and work of other artists.

Wednesday morning, the groups continued their work during the two last sessions and defined their vision of a common strategy for EMFL. The morning ended with the wrap up plenary meeting during which the outcome of the different sessions was shared.

Looking back, the EMFL Days are definitely ideal for exchanging information between the EMFL staff, whether to discuss the development of a project and its opportunities or to stimulate ideas by creating stronger bonds and intensified dialogue between the staff as well as by getting to know each other better. Indeed, the EMFL Days 2018 has been a very successful and fruitful meeting.

About 140 EMFL staff members attended the EMFL Days on October 1st - 3rd in Arles.

EMFL SUMMER SCHOOL: SCIENCE IN HIGH MAGNETIC FIELDS

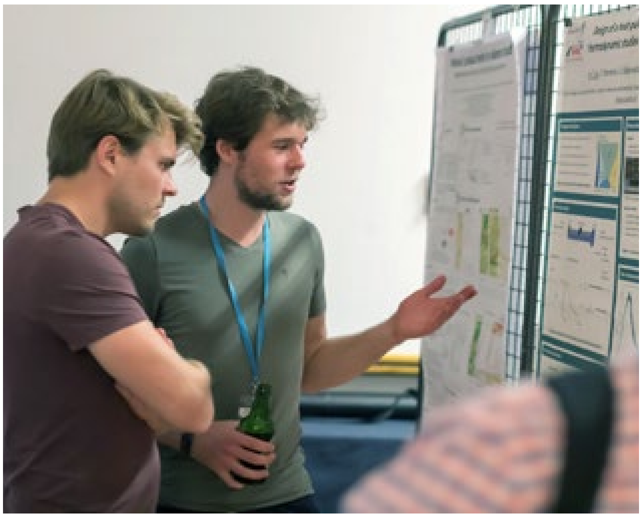
26-30 September 2018, Arles, France

Following the long tradition of the high-magnetic-field community in Europe, an EMFL summer school was held from 26 to 30 September 2018. The school took place in the pleasant environment of the Camargue region in South France, nearby the city of Arles, well known for its Roman history.

The school was dedicated to recent advances in science in high magnetic fields. The lectures given by 16 renowned speakers – experimentalists and theorists – covered important topics of current research in high magnetic fields: semiconductor physics, low-dimensional materials and nano-objects, soft-matter, strongly correlated electron systems, magnetism, superconductivity, molecular systems, high-magnetic-field technology and experimental techniques, but also other important aspects of scientific work such as public outreach.

The 60 participants of the school were selected primarily among young researchers, such as among Master/PhD students and postdocs. These included participants working in the EMFL laboratories, but also in universities and research institutions in Europe and worldwide. The participants had the opportunity to present their own research results during a specially dedicated poster session.

The EMFL school was in the scope of and co-organized with substantial contribution from the H2020 project TWINFUSYON (EC GA 692034).



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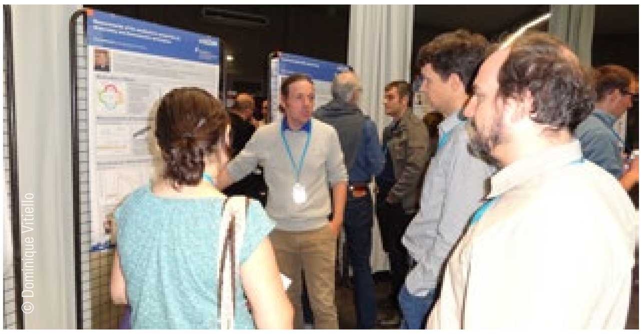

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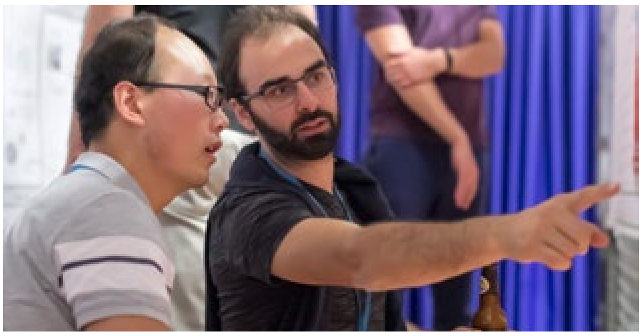

PROFESSOR DR. PETER CHRISTIANEN NEW DIRECTOR OF HFML

From the first of September HFML has a new director: Prof. Dr. Peter Christianen (1966). He is the successor of Prof. Dr. Nigel Hussey, who has led the lab successfully for the last five years during a period of rapid growth. With new roadmap funding, the production of magnet hours and number of projects has been doubled.

Peter Christianen is professor for Soft Condensed Matter & Nanomaterials in High Magnetic Fields. He has longstanding experience in the experimental investigation of hard and soft condensed matter in strong magnetic fields at HFML, mainly using optical techniques.

"I am very excited about my appointment as HFML director in this crucial period. We are constructing new magnets and together with the FELIX Laboratory we can now offer a genuinely unique experimental infrastructure that makes groundbreaking research in numerous research areas possible. I enjoyed the EMFL days in Arles, experiencing the enthusiasm of all participants and I aim to actively stimulate the collaboration between the EMFL facilities".

Nigel Hussey will continue his work at HFML as group leader of Correlated Electron Systems in High Magnetic Fields at the Radboud University.

UPCOMING EVENTS

1. 2019 Joint MMM-Intermag Conference, The IEEE International Magnetics Conference (INTERMAG) and the Conference on Magnetism and Magnetic Materials (MMM). Washington DC, USA, January 14-18, 2019. **http://www.magnetism.org**

2. APS March Meeting, Boston, USA, March 4-8, 2019. **https://www.aps.org/meetings/march/**

3. Gordon Research Conference: Superconducting Materials and Phenomena, Les Diablerets, Switzerland, May 12-17, 2019. **https://www.grc.org/superconductivity-conference/2019/**

4. Joint European Magnetic Symposia (JEMS) 2019, Uppsala, Sweden, August 26-30, 2019. **https://jems2019.se/**

5. MT26, International Conference on Magnet Technology, Vancouver, Canada, September 22-27, 2019. **http://mt26.triumf.ca/**

6. SCES 2019, International Conference of Strongly Correlated Electron Systems, Okayama, Japan, September 23-28, 2019. **http://sces2019.org**

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