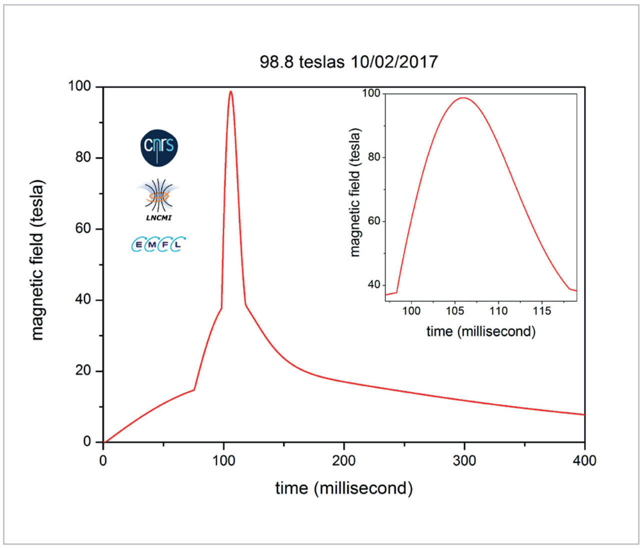
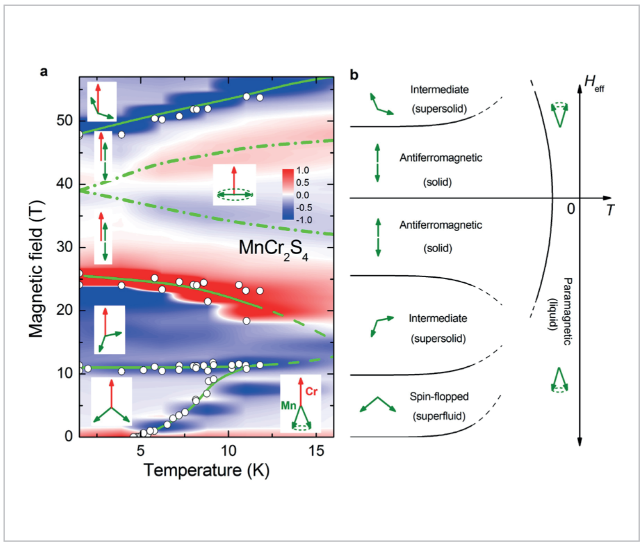
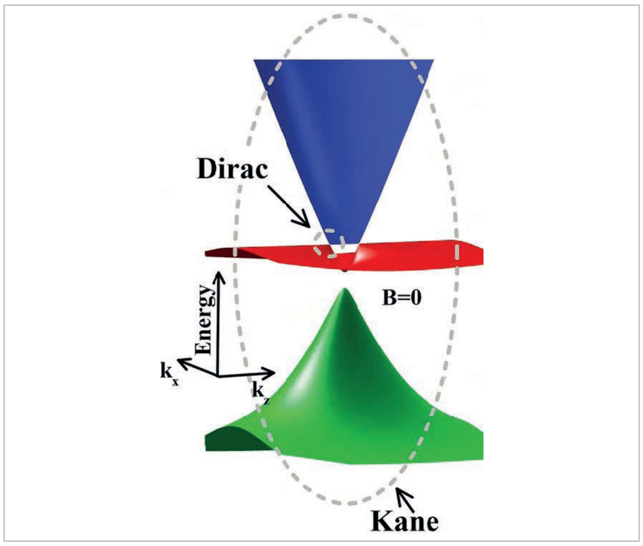
EMFLNEWS

N°1 2017







CONTENTS

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DEAR READER

The EMFL has started its third year of legal existence and, according to the statutes, a new chairman had to be elected. For this reason, it is now my pleasure to chair EMFL for the next two years. First of all, let me take this opportunity to thank Geert for his excellent chairmanship during the last two years of the starting phase of EMFL. Indeed, we can be proud about the achievements obtained so far. Research in highest magnetic fields within Europe and EMFL have become synonyms, and the exceptional cooperation of our research facilities has been recognized by achieving the Landmark status from the European Strategic Forum for Research Infrastructures (ESFRI).

Our magnets are continuously being improved and, in this issue, we can announce the new record field of 98.8 T made possible by the excellent work of the engineers at LNCMI-Toulouse. In recent years, a number of upgrades have been made in the EMFL labs to serve our user community in the best possibly way, one of which is the improved cooling capacity of the HFML. Besides, most importantly, the EMFL labs are producing top-class research results. Some of these scientific highlights as well as other news you may find, as usual, in this issue of our EMFL News.

I as well want to take this opportunity to invite you to the next EMFL User Meeting, taking place in Nottingham on 23th of June. This year, the meeting will be hosted by Prof. Amalia Patanè (The University of Nottingham, UK). She is the coordinator of the UK membership of the EMFL sponsored by the EPSRC. During the meeting the EMFL prize will be conferred, scientific highlights will be presented by our users, you will be informed on the latest developments and plans of the EMFL facilities, and you can chat with facility staff and other users on high-field science and instrumentation. You can find the preliminary program in this issue.

Have an exciting and stimulating reading,
Jochen Wosnitza
Director HLD
Chairman EMFL

MEET OUR PEOPLE

Questions to Harriëtte Koop and Caroline Obermeyer

Caroline Obermeyer and Harriëtte Koop recently joined the EMFL News team. Since December 2016 they work in the field of communications in Dresden-Rossendorf/Germany and Nijmegen/Netherlands, respectively. We interviewed both of them and talked about their jobs, their positions, their expectations, and their life in general.

What is your position in general and what are your tasks regarding EMFL?

Caroline: Regarding the EMFL News I took over the project management from Christine Bohnet. I coordinate the delivery of articles and work closely together with Jochen Wosnitza regarding the content. I communicate with the advertising agency as well as with the EMFL board of directors and the people who are in charge at the sites in Grenoble, Nijmegen, and Toulouse.
At the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), I work in the department of technology transfer and legal affairs. Mainly I am responsible for a project called „TTO-Alumni". Together with the Karlsruhe Institute of Technology (KIT) we are currently exploring opportunities to enhance technology transfer into society.

Harriëtte: In December 2016, I started working as a Science Communication Officer at the High Field Magnet Laboratory (HFML) in Nijmegen, The Netherlands. Hereby, I replaced the former Science Communication Officer, Iris Kruijen. In this job, I am concerned with the communication of new scientific research and other news of HFML towards the media and the general - non-scientific - public. Regarding EMFL, I write news articles, which are published on the EMFL website and in the EMFL News, such as items for this 'Meet-our-People' section. For EMFL News I work together with Caroline.

Where do you come from?

Caroline: I am originally from North Rhine-Westphalia/West Germany but I live in Dresden/East Germany for several years now. I really like the city and the landscape of Saxony. Especially the Saxon Switzerland is a natural paradise to go hiking and climbing. I can highly recommend everybody to visit this region.

Harriëtte: After living in Utrecht for several years, I recently moved back to Nijmegen. Unlike Utrecht, Nijmegen is a small and intimate city right near the German border. It is the city where I did the first part of my studies, so being back again evokes some nostalgic feelings.

What is your professional background?

Caroline: Before I started my job at HZDR, I worked at the BASF Schwarzheide GmbH. There, I was in charge of public relations and internal communication. I did my Master's Degree in „Culture & Management" at the University of Applied Sciences Zittau/Görlitz. I received my Bachelor's degree in „Sciences of literature, culture and language for Spanish and German" at the Technical University of Dresden. During my studies I worked at the department of communications at Siemens AG and gained a lot of experience in the field of public relations and marketing.

Harriëtte: After I've graduated with a Master's degree in Neurobiology, I started working as a science journalist at the Dutch national science radio and television program 'De Kennis van Nu'. Several years later, I currently have actually three positions as a Science Communication officer at the Radboud University: I work at the HFML, at the FELIX Laboratory, which is a free-electron laser laboratory and located right next to the HFML, and I also work at the Donders Institute, a neuroscience research institute. In these jobs, I inform the media on new science results, support researchers with their media appearances, and organize open days and other events for the general public.

What do you like about your job here?

Caroline: I really like the fact that I am surrounded by scientists who admire the things they are doing. It is very interesting to learn something new every day. Since I don't have a scientific background, it is even more exciting to get an inside view to this working field.

Harriëtte: The high complexity of the technology necessary for creating the high magnetic fields at HFML fascinates me immensely. Since I do not have a background in physics, I still need to learn a lot about the science behind all the research at HFML. But I am convinced that I will find my way, with some help of the researchers at HFML.

What is important for you regarding the fact that you work in an international team?

Caroline: I think it is a big privilege to work in such an international work area. The most important thing for me is that the tasks are clear and that you can rely on your team members. Of course all of us have a different cultural background. But in my opinion that makes it even more exciting. Since Harriëtte and I are working together on the EMFL News, I really hope I can meet her in person someday. This hasn't happened yet, but it anyway works just fine.

Harriëtte Koop

Caroline Obermeyer

Harriëtte: When walking through the corridors at HFML, you hear a wide variety of languages spoken. The fact that both the visitors as the in-house researchers are so international creates a very nice and open atmosphere. Furthermore, I like to collaborate with people from other magnetic field labs in Europe, such as Caroline regarding the EMFL News, and see how things are done over there.

If you are not in the office, where do we find you?

Caroline: If I am not in the office, you can either find me sitting at the sewing machine or doing outdoor activities. In my spare time I really like to do creative work like sewing and wood-work. Besides that I like to go hiking in the woods, traveling to different countries, or do biking trips. A good book gives me the chance to relax and to enjoy Sunday afternoons.

Harriëtte: When I am not in the office, you can find me either in the cinema or hanging on a climbing wall. Nijmegen is a nice city for these activities, since it has a very nice arthouse cinema and a brand-new indoor climbing wall. However, when I have the chance, I would like to do more outdoor climbing in more mountainous areas.

TWO KINDS OF MASSLESS CARRIERS IN CADMIUM ARSENIDE

Ana Akrap, University of Geneva, Switzerland and Milan Orlita, LNCMI-Grenoble

Instead of obeying Schrödinger equation, in some materials the low-energy excitations behave as massless Dirac particles. Three-dimensional (3D) Dirac semimetals represent one such class of materials, constituting the closest archetype of truly relativistic massless systems. Cadmium arsenide, Cd_3As_2, is a prime candidate for a 3D Dirac material that is stable at ambient conditions. Two stable Dirac cones are predicted to exist around the center of the Brillouin zone. However, a conundrum appeared regarding the scale at which the Dirac cones appear, unresolved despite a large number of experiments. Different spectroscopies claimed different outcomes; most prominently, ARPES indicated a large energy spread of Dirac cones (several hundred meV) while STM/STS measurements implied a scale at least one order of magnitude smaller.

Our magneto-optical experiments lift the controversy of the electronic bands of cadmium arsenide. We show that two kinds of massless carriers can exist in this material, Dirac- and Kane-like carriers. In other words, the band structure includes not only one, but two types of conical features, see Figure. We show that the large cone observed by ARPES is not a Dirac cone, but results in fact from the standard Kane model applied to a semiconductor with a nearly vanishing band gap. Our experiments explore the magneto-optical response of single-crystalline cadmium arsenide, with two different orientations and two different positions of the Fermi level. By applying a strong magnetic field, the system is driven into the quantum limit. In such a case, electrons occupy only the lowest electronic Landau level and only the fundamental cyclotron resonance mode is active. Its specific character allows us to eliminate with certainty the Dirac-carrier response. Moreover, no significant anisotropy is observed in the conical feature. These results can quantitatively be explained within the standard Kane model developed in the past for the description of ordinary zinc-blende semiconductors, leading us to conclude the presence of massless Kane electrons in this material. While the symmetry-protected Dirac electrons may still be present as well, our experiments limit their existence to a fairly small energy range (several tens of meV).

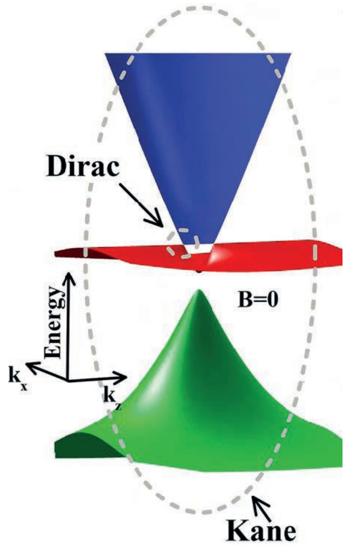

Figure: Schematic view of the electronic bands in Cd_3As_2 with two types of conical features.

Magneto-optical signature of massless Kane electrons in Cd_3As_2,
A. Akrap, M. Hakl, S. Tchoumakov, I. Crassee, J. Kuba, M. O. Goerbig, C. C. Homes, O. Caha, J. Novak, F. Teppe, W. Desrat, S. Koohpayeh, L. Wu, N. P. Armitage, A. Nateprov, E. Arushanov, Q. D. Gibson, R. J. Cava, D. van der Marel, B. A. Piot, C. Faugeras, G. Martinez, M. Potemski, and M. Orlita, Phys. Rev. Lett. **117**, 136401 (2016).

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ELECTRON–HOLE ASYMMETRY OF THE TOPOLOGICAL SURFACE STATES IN STRAINED HgTe

A. Jost and S. Wiedmann, HFML Nijmegen

Researchers from the University of Würzburg and the European Magnetic Field Laboratory (EMFL) in Nijmegen have investigated the electrical and thermal transport properties of the three-dimensional topological insulator – strained HgTe. They demonstrate the existence of exclusively surface-dominated transport and find in thermopower experiments that the metallic surface states, which are widely assumed to display a Dirac-type dispersion, exhibit a strong deviation from a linear dispersion across the Fermi level but remain topologically protected.

Topological insulators are a new class of materials with an insulating bulk and topologically protected metallic surface states, thus distinct from conventional states of matter such as metals, semiconductors, and insulators.

Here, the charge-carrier properties of the surface states in the topological insulator HgTe have been investigated by tuning the Fermi energy in the bulk band gap to have access to both surface electron and hole charge carriers (Figure 1). It has been found that the thermoelectric power of the electron like surface states is diffusion driven in contrast to hole-like surface carriers where both diffusion thermopower and phonon drag are essential. This is reflected in the magnitude of the signal and its temperature dependence (see Figure 2a and b). This distinct behavior in the thermoelectric response is explained by a strong deviation from the linear dispersion relation for the surface states, with a much flatter dispersion for holes compared to electrons making three-dimensional topological insulators distinct from other Dirac systems such as graphene with a symmetric dispersion for electrons and holes.

The exclusively surface-dominated transport manifests itself via the observation of an ambipolar surface quantum Hall effect (Figure 2c), a phenomenon that can only be observed if charge carriers are confined to two dimensions.

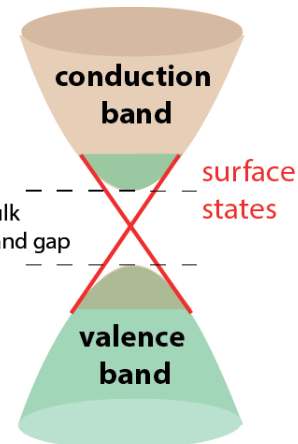

Figure1: Sketch of a topological insulator characterized by a bulk band gap with linearly dispersive surface states.

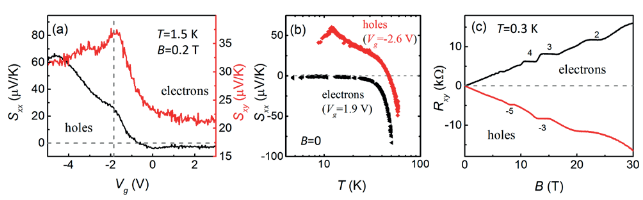

Figure 2: (a) Thermopower S_{xx} and Nernst effect S_{xy} at 0.2 T and 1.5 K. (b) S_{xx} as a function of temperature for electrons and holes (strong phonon peak for holes at 12 K). (c) Ambipolar surface quantum Hall effect (integer numbers are filling factors).

Electron–hole asymmetry of the topological surface states in strained HgTe,
A. Jost, M. Bendias, J. Böttcher, E. Hankiewicz, C. Brüne, H. Buhmann, L. W. Molenkamp, J. C. Maan, U. Zeitler, N. Hussey, and S. Wiedmann, PNAS **114**, 3381 (2017).

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NEW EUROPEAN RECORD FOR NON-DESTRUCTIVE PULSED MAGNETIC FIELDS

Jérôme Béard, LNCMI-Toulouse

On February 10, 2017, the LNCMI team in Toulouse has managed to generate, non-destructively, 98.8 T as shown in Figure 1.

To obtain this result it was necessary to combine three independent concentric coils, shown in Figure 2, energized by the three main capacitor banks of the laboratory. The total amount of energy required to generate this field is close to 20 MJ. The next objective is to go beyond the symbolic limit of 100 T and the current world record of 100.75 T held by the Los Alamos National Laboratory since June 2012. The LNCMI engineers are now working to improve on this record later this year.

This magnet is, most importantly, a tool for scientific research and the pulse duration of the new LNCMI magnet is the world's longest at such a high field. Most of the existing experimental techniques, as transport or optical measurements will be feasible down to 1.4 K in its 8 mm free bore diameter. It completes the list of available high-field magnets, like the 12 MJ dual-coil system, available in two configurations: 80 T in 13 mm and 90 T in 8 mm.

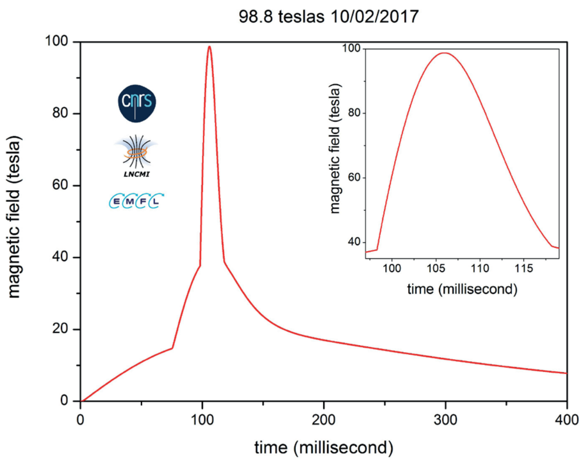

Figure 1: Temporal profile of the magnetic pulse. Only 400 milliseconds are represented, the field decay still continues during one second. The inset represents a zoom on the innercoil pulse.

Figure 2: Picture of the magnet before installation in its nitrogen cryostat. The magnet measures about 70 centimeters in diameter and weights near to 600 kilograms.

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SUPERSOLIDITY IN BOND-FRUSTRATED $MnCr_2S_4$

V. Tsurkan, Institute of Physics, University of Augsburg, S. Zherlitsyn, HLD Dresden

Frustrated magnets provide a promising avenue for realizing exotic quantum states of matter, such as spin-liquid, spin-ice, and even supersolid states. A supersolid is an ordered solid which, due to quantum phenomena, has also superfluid properties and, under some conditions, can thus behave as a liquid without viscosity. This can be considered as an example of a Bose-Einstein condensate (BEC). Active search for the supersolidity has been performed in solid helium and, very recently, in ultracold trapped atoms. Researchers from the Center for Electronic Correlations and Magnetism at the University of Augsburg and the Dresden High Magnetic Field Laboratory have chosen another way by investigating the spin states in the frustrated magnet $MnCr_2S_4$.

In this material, prominent anomalies in the magnetization and sound velocity have been observed in high magnetic fields, which reveal two fascinating features: (i) an extremely robust magnetization plateau with an unusual spin structure stabilized by field-induced lattice distortions (Figure 1) and (ii) two intermediate phases, indicating possible realizations of a supersolid state (Figure 2).

The measurements reveal that $MnCr_2S_4$ exhibits a manifold of competing spin states as a function of external magnetic field. Thereby, the chromium moments are always aligned parallel to the external field, but the manganese spins exhibit different types of transverse and longitudinal order, which, by analogy with bosonic systems, can be described as superliquid and supersolid phases.

Indeed, the comparison of the phase diagram with respect to the manganese spins with theoretical predictions from the quantum-lattice-gas model suggests the existence of extended supersolid phases, in addition to superfluid and crystalline phases (Figure 2).

The work shows that magnetic systems under extreme conditions are prime candidates for the emergence of coherent quantum phenomena.

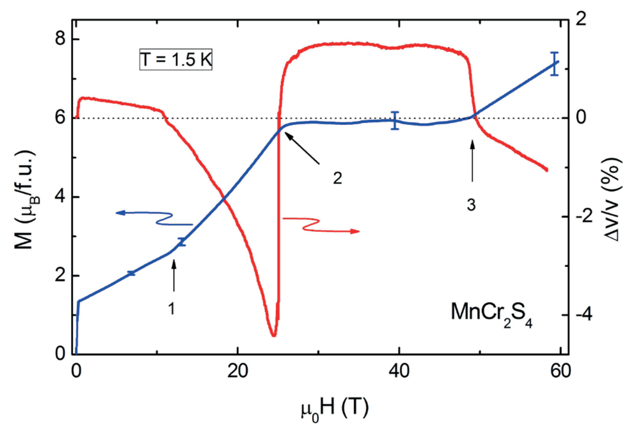

Figure 1: Field dependence of the magnetization and ultrasound velocity in $MnCr_2S_4$ at 1.5 K.

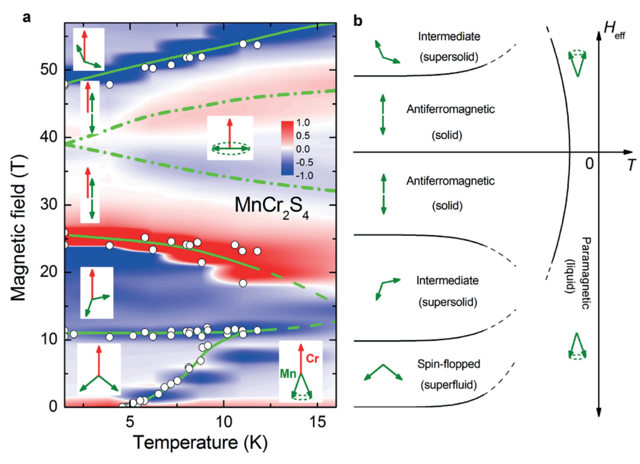

Figure 2: (a) Experimental and (b) theoretical phase diagram. (a) Color-coded plot of the derivative of the sound velocity. Open circles represent anomalies in the field-dependent magnetization. The solid lines denote maxima in the field derivatives of the sound velocity. The most probable spin configurations are shown for the different magnetic phases.

Ultra-robust high-field magnetization plateau and supersolidity in bond-frustrated $MnCr_2S_4$,
V. Tsurkan, S. Zherlitsyn, L. Prodan, V. Felea, P. T. Cong, Y. Skourski, Z. Wang, J. Deisenhofer, H.-A. Krug von Nidda, J. Wosnitza, and A. Loidl, Sci. Adv. **3**, e1601982 (2017).

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OPENING OF THE SEVENTEENTH CALL FOR ACCESS

The 17th call for proposals has been launched in April, 2017 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 90 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 May 15, 2017.

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)“

- 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

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.”

ADDITIONAL COOLING TANK FOR HFML MAGNETS NOW OPERATIONAL

On March 30, 2017 the site-acceptance test (SAT) of the new underground cooling-water tank took place at the high-field lab in Nijmegen. The HFML has now 2.500 m^3 additional water available to cool its magnets, increasing its total cooling capacity thereby significantly. The contractor parties (REEF infra, Croonwolterendros and Building Technology) have shown during the SAT that all installed items (pumps, valves, etc) work according to the specifications and are integrated and functioning via the control software.

This third buffer already proved its use during some tests and internal experiments. However, before the scientists can use the buffer on a regular basis, some parameters need to be fine-tuned and the safety system thoroughly tested. We are confident that by the time this EMFL News is published the third buffer is available for external users.

Currently, not much can be seen of the enormous pit dug out and the underground construction of the tank. The only remainder is an inspection hatch to access the tank. With the park and picnic seats on top of it, inspiring ideas might appear here, and we hope the new buffer together with the other great HFML infrastructure can help to realize them.

Digging operations to set up the tank underground.

A nice picnic area is built on the surface of the tank.

Constructions on the new underground cooling water tank in progress.

ULI ZEITLER APPOINTED PROFESSOR

Dr. Uli Zeitler has been appointed as a Professor of Semiconductors and Nanostructures in High Magnetic Fields at the Faculty of Science of Radboud University as of 15 March 2017. Uli Zeitler (1964, Schaffhausen, Switzerland) studied physics in Konstanz and Grenoble and obtained his PhD degree – summa cum laude – from the University of Konstanz in 1994 for work performed at the Grenoble High Magnetic Field Laboratory (now LNCMI-Grenoble).

After postdocs in Nijmegen and Nottingham he was appointed research and teaching associate at the Leibniz-Universität Hannover where he completed his habilitation thesis in 2001.

He joined the Nijmegen High Field Magnet Laboratory as an Associate Professor in 2002 and was actively involved in transforming it from a national research laboratory into a world-leading internationally recognized facility. He has published more than 150 papers in the fields of semiconductors, nanostructures, magnetism, and superconductivity.

Uli Zeitler brings a broad experience in the field of semiconductors and nanostructures in high magnetic fields with a specific focus on semiconductors at reduced dimensionality and he has established national and international collaboration with world-leading scientists in the field. Examples of his research activity cover materials such as graphene and other 2D materials, oxide heterostructures, insulators, and Weyl semimetals; all of them have been discovered only quite recently.

› Contact: u.zeitler@science.ru.nl

EMFL USER MEETING 2017 IN NOTTINGHAM

Program for the User Meeting on June 23 – School of Physics and Astronomy, Room B1

09.00 am	**Arrival and registration**
09.10 am	**Welcome and introduction** **Amalia Patanè, Jochen Wosnitza**
09.30 am	**Announcement of the 2017 EMFL prize winner and presentation by EMFL prize winner**
10.00 am	**Presentations by EMFL users**
11.00 am	Coffee break
11.20 am	**Technical session on facility developments at the EMFL**
12.40 pm	Lunch
13.20 pm	**Poster session,** Room B23
14.20 pm	**Presentations by EMFL users**
15:40 pm	Coffee break
16.00 pm	**User Committee Meeting** (open to all users), Room B1
16.00 pm	**Discussion Meeting of the Board of Directors of the EMFL with EPSRC representatives** (close meeting), Room C142
17.00 pm	**Report of User Committee to Board of Directors**, Room B1
17.30 pm	Wrap up meeting and closure by Amalia Patanè

www.nottingham.ac.uk/physics/

USER-MANAGEMENT TEAM MEETS IN NIJMEGEN

On the 9th and 10th of March the staff from Grenoble, Dresden, and Nijmegen responsible for the user-management processes at the facilities met at the EMFL lab in Nijmegen. The EMFL-days in Frankfurt, where a dedicated user-management session was organized, inspired to meet regularly to harmonize the various procedures (user support, experiment planning, online proposal call, and database for EMFL) at the EMFL facilities.

The first contact of a user with EMFL is often through the website and when interested to use the high-field facility, the EMFL proposal portal, where the scientific proposal can be submitted, is the next step. After submission the Selection Committee receives, evaluates, and ranks the proposals, of which the user is informed. All this happens silently at the background with a dedicated team, taking care of the administrative and information-technology components. When the user is going to visit one of the EMFL facilities, he/she will meet members of the user-management team to obtain access to the magnet site and often as well to the guesthouse. We (the user-management team) try to improve and harmonize these procedures, keep the administrative burden for you at a minimum, and making all steps as transparent as possible. In return, we would be thankful to receive from you, our users, all information required by our funding agencies and our directorates. This time, you will find a new progress-report form in the proposal portal and we will ask you to fill this out after performing your experiment. We do want to keep things as simple as possible, so if you have ideas for improvements and/or suggestions for the website, the submission procedure, or other administrative issues, please let us know via **info@emfl.eu**.

Screenshot of the progress report section. The green button indicates the progress report is filled out. By clicking on the red marked proposal, the progress report website is entered and the details can be filled out.

User-management team met at the EMFL lab in Nijmegen

European Magnetic Field Laboratory

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LNCMI Toulouse
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France

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