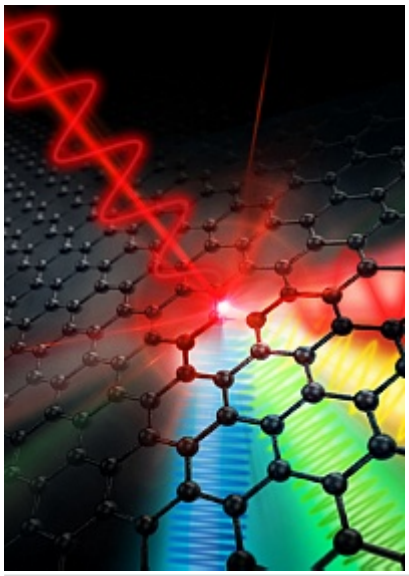
HZDR Online Annual Report 2018



Emission of harmonic THz oscillations in graphene
Source: HZDR/Juniks

Content

Impressum

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Words of Welcome

Dear Readers,

Scientific Director Professor Roland Sauerbrey (left) & Administrative Director Dr. Ulrich Breuer
Foto: HZDR/André Wirsig

One of the highlights in 2018 was the inauguration of our new Center for Radiopharmaceutical Tumor Research. The €36 million new development is Europe's leading-edge preclinical center for the development and production of radioactive and radioimmunological pharmaceuticals. The HZDR has considerable expertise in this field, and is a highly valued research partner throughout the world; now we have first-class infrastructure at our disposal.

Investing in the future

The Helmholtz International Beamline for Extreme Fields (HIBEF) has also made significant progress: under the coordination of the HZDR, the European XFEL X-ray laser in Schenefeld, near Hamburg, is set to provide novel experimental possibilities. Much of the instrumentation for the High-Energy Density (HED) scientific instrument is provided by the HIBEF. The first ultra-high power short-pulse laser was installed in 2018. In the future, scientists will be able to simulate conditions such as those found in the interior of planets.

Another building project had just got underway: 2018 saw the laying of the foundation stone for a new metallurgy pilot plant in Freiberg. The building, financed by the Free State with an investment exceeding €10 million, should help speed up the process of transforming innovative methods of extracting and recycling reusable materials developed in the laboratory into methods of practical use.

Focusing on young researchers

Even the best equipped labs and an excellent infrastructure cannot guarantee good science. What it needs is brilliant ideas, enthusiasm and interest. It is also essential to succeed in engaging talented young researchers. This is exactly what we have been doing for years with our DeltaX School Lab. An ultra-modern laboratory wing, completed in 2018, gives students even better wide-ranging and exciting opportunities to discover the diversity of research for themselves

The first few months of the year were also strongly influenced by the scientific evaluation of the HZDR in preparation for the fourth period of program-oriented funding by the Helmholtz Association. In January, the international committee of experts focused on the institutes and departments engaged in the research field Matter. In February and March, it was the research field Energy's turn. One thing is for sure: With the energy transition in mind, the Helmholtz Association will primarily strengthen research into energy systems. A number of joint research projects on this issue, in which the HZDR also plays a crucial role, have already been initiated.

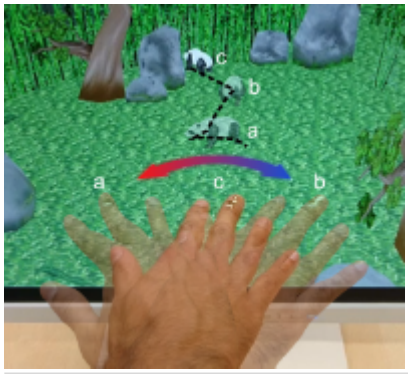
Collaborative research

"CROSSING", one of the first projects within the "Helmholtz European Partnering" program launched by the Helmholtz Association, is also based at the HZDR; our partner is the Jožef Stefan Institute in Slovenia. Two "Helmholtz-RSF Joint Research Groups" were also launched – with partners in Perm and Moscow, and in Chelyabinsk and Darmstadt.
We hope you enjoy reading our Online Annual Report 2018. The HZDR's more detailed Progress Report (Zentrumsfortschrittsbericht, in German only) can also be viewed on request.

Professor Roland Sauerbrey (Scientific Director) & Dr. Ulrich Breuer (Administrative Director)

Scientific Highlights

Electronic skin compass for artificial magnetoreception and interactive electronics



The magnetic skin sensor enables navigation of a panda in a virtual environment.
Source: HZDR / G.S. Cañón Bermúdez

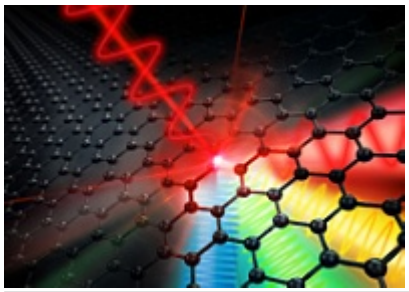
Researchers at HZDR's Institute of Ion Beam Physics and Materials Research have developed a new kind of magnetic field sensor that embeds the functionality of an electronic compass into a skin-like ultrathin patch. The micrometer-thick sensor is fabricated on a highly flexible substrate, and is capable of perceiving the direction of motion in the open by readily interacting with the earth's magnetic field. Such magnetic field sensors can be used as lightweight and imperceptible add-ons for real-time tracking a person's position and motion in outdoor environments.

In addition, the HZDR researchers have demonstrated, by interfacing their sensors with a game engine, that they can navigate virtual objects in virtual reality (VR) and augmented reality (AR) scenarios, relying only on the earth's magnetic field vector. In contrast to available human-machine interfaces, this new approach provides a seamless interactive experience for the user without the need for bulky equipment or motion restricting gadgets.

This innovative sensor technology has potential well beyond the computer and gaming industries. For instance, such an "e-skin compass", combined with targeted neurostimulation, may in future enable humans to imitate the magnetoreception sense that some animals naturally possess. Furthermore, this approach could be used as a therapeutic aid for patients suffering of sensory processing disorder or as a tool for cognitive research and sensory substitution experiments.

- **Publication:** Gilbert Santiago Cañón Bermúdez et al, Nature Electronics 1 (2018), 589-595
  DOI: 10.1038/s41928-018-0161-6
- **Contact:** Dr. Denys Makarov, Institute of Ion Beam Physics and Materials Research at HZDR

Graphene efficiently enables clock rates in the terahertz range



Graphene enables clock rates in the terahertz range.
Source: Juniks/HZDR

The logical next step in the development of innovative, ever-faster (opto-)electronic components is to access the terahertz frequency range. Until now, however, the materials and technologies required for the simple, efficient generation and conversion of spectral tunable terahertz radiation were lacking. Graphene – an ultrathin material consisting of a single layer of interlinked carbon atoms – has long been discussed as a potential material to achieve this. In a groundbreaking experiment, a team of HZDR researchers led by Dr. Sergey Kovalev and Prof. Michael Gensch (previously at HZDR, now at TU Berlin and Deutsches Zentrum für Luft- und Raumfahrt (DLR, German Aerospace Center) in collaboration with the Max Planck Institute for Polymer Research and the University of Duisburg-Essen (UDE), has managed for the first time to experimentally prove the theoretically predicted, strongly nonlinear properties of graphene in the terahertz range for the first time. With the aid of the unique experimental possibilities available at the TELBE – the terahertz user facility at the ELBE Center for High-Power Radiation Sources of the HZDR – the scientists involved have succeeded in providing the first direct proof of frequency multiplication from gigahertz to terahertz in a graphene monolayer.

The resulting nonlinear coefficients of graphene – a measure of process efficiency – were extremely high, exceeding values for other nonlinear materials by 7 to 18 orders of magnitude. Using a comparatively simple thermodynamic model, developed by the group led by Professor Dmitry Turchinovich (previously at UDE, now at Bielefeld University), the scientists were also able to interpret the experimental results quantitatively well. The model describes the effect of the excited field in the high gigahertz range as an ultrafast, collective heating and cooling process of the free charge carriers available in graphene. This results in the strong modulation of the opto-electronic properties of graphene, and especially electrical conductivity. If a sufficiently large number of free charge carriers are available, such as through doping, the excited field results in the emission of higher harmonic oscillations with three, five and seven times the initial frequency.

The study shows that graphene-based components may be a highly efficient way of creating a bridge from the gigahertz to the terahertz range. This finding paves the way for the realization of completely new ultrafast technologies.

- **Publication**: H.A. Hafez, S. Kovalev et al., Nature, 561 (2018), 507-511
  DOI: 10.1038/s41586-018-0508-1
- **Contact:** Dr. Sergey Kovalev, Institute of Radiation Physics at HZDR

Proton beams and magnetic resonance imaging: A promising combination in the fight against cancer

Dr. Aswin Hoffmann with the setup for the combination of proton beam and magnetic resonance imaging systems in the experimental room at the National Center for Radiation Research in Oncology – OncoRay.
Source: HZDR / R. Weisflog

One advantage that proton beam therapy has over conventional radiation therapy with X-rays in cancer treatment is its better ability to spare healthy tissues surrounding the tumor. However, a safety margin around the tumor is required, because, until now, it has been difficult to predict exactly where in the tumor the protons will have their full effect. Scientists at the HZDR are investigating methods to improve the targeting precision of proton therapy, such that the full

clinical benefit can be exploited. In a proof-of-concept study, the researchers for the first time investigated simultaneous proton beam irradiation and magnetic resonance imaging (MRI). Compared to X-ray-based computed tomography, MRI provides unparalleled soft-tissue contrast and avoids exposure to ionizing radiation. It therefore has the potential to provide continuous real-time imaging during proton irradiation.

The study focused on the electromagnetic interactions arising when systems for proton therapy and MRI were integrated. Since protons are positively charged particles, the beam is deflected by the magnetic fields of the MRI scanner, hence affecting the beam quality and dose distribution. Conversely, the magnetic fields produced by the proton therapy system influence the magnetic field of the MRI scanner, which latter must be homogenous to ensure a high geometric image quality. The HZDR researchers have managed to prove that it is possible to integrate the two systems without introducing degradations to the proton beam or MR image quality.

To conduct their investigations, the researchers placed a low-field open MRI scanner in the path of a proton beam in the experimental area of the National Center for Radiation Research in Oncology – OncoRay. A standardized MRI knee phantom and tissue-mimicking samples were used as test objects. Based on their results and accompanying calculations, the researchers were able to prove that, although the magnetic fields originating from the proton therapy system produced small geometrical shifts in the MR images, these shifts were easy to predict and eliminate. Furthermore, they demonstrated that it is also possible to accurately calculate the deflection of the beam while the protons slow down in the test objects in the presence of the MR magnetic field, and thus can be corrected for during treatment planning and dose delivery.
The importance of this work is underlined by the awarding of the 2019 Roberts' Prize by the Institute of Physics in Medicine (IPEM), Great Britain, for the best paper published in the scientific journal Physics in Medicine and Biology in 2018.

- **Publication:** Schellhammer et al. 2018: Phys. Med. Biol. 63 23LT01
  DOI: 10.1088/1361-6560/aaece8
- Contact: Dr. Aswin Hoffmann, Institute of Radiooncology – OncoRay

Biomineralization of uranium in rock salt deposits

Haloarchaea (pink) in rock salt are able to convert solved Uranium into a non-soluble mineral form (green needles).
Source: HZDR / Juniks

Salt domes are among the geological formations being investigated as potential sites for the final disposal of high-level radioactive waste in Germany. The ability to store the material safely over a period of one million years is relevant for assessment purposes. In this context, HZDR researchers investigated geobiological processes that could occur under the expected environmental conditions. Haloarchaea – primeval microorganisms – are the dominant life form in rock salt. Until now, little was known about how these organisms interact with radionuclides. A team of researchers from the HZDR has discovered that dissolved uranium is converted by means of biomineralization into U(VI) phosphate by the haloarchaea present in the rock salt.

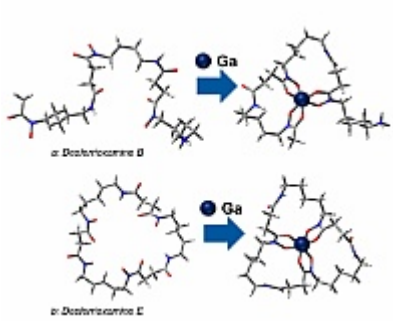
To conduct their investigations, the scientists used two microbial strains (Halobacterium noricense DSM 15987T and Halobacterium sp. putative noricense) that were originally found in a salt mine in Altaussee, Austria, and in a US-American Waste Isolation Pilot Plant (WIPP). During the experiment, haloarchaea that had been cultivated in a concentrated saline solution were exposed to different uranium concentrations for a longer period. The experimental conditions corresponded to a simulated worst-case scenario, such as that associated with water ingress in a salt dome repository.

Both Halobacterium strains exhibited unexpected multistage interaction with uranium: After an initial phase of sorption of the radionuclides, a period of release was observed, followed by renewed bioassociation. Using special spectroscopic methods, the scientists managed to unravel the structure of the uranium complexes that had formed over time. Finally,

mineral U(VI) phosphate was formed. The dominant microorganisms in rock salt are therefore capable of converting uranium into a non-soluble form in the event of its release, effectively preventing further distribution in the environment.

- **Publications:**
  Bader, M. et al, Journal of Hazardous Materials 327, 225-232
  DOI: 10.1016/j.jhazmat.2016.12.053
  Bader, M. et al, Environmental Science and Technology 52 (2018) 21, 12895-12904
  DOI: 10.1021/acs.est.8b02667
- **Contact:** Dr. Andrea Cherkouk, Institute of Resource Ecology at HZDR

Circular use of critical raw materials: Efficient recovery of gallium



Complexation of siderophores DFOB (a) and DFOE (b) with gallium(III)
Source: HZDR / Rohan Jain

Gallium is a critical raw material in developing renewable energy sources and energy-efficient systems. Since there are risks associated with gallium supplies on the world market, efficient recycling technologies are required, which may continue to ensure the availability of this rare metal for advanced technologies. HZDR researchers have developed a technology to recover gallium (III) ions from their low-concentrated industrial wastewaters generated during GaAs wafer fabrication. To this end, they used two different siderophores: desferrioxamine B (DFOB) and desferrioxamine E (DFOE) for the recovery of gallium.

Siderophores (the Greek term for “iron carriers“) are a group of around 500 low-molecular weight compounds (500 -1500 Dalton), characterized by the formation of stable complexes with iron ions. In nature, they are formed by a wide range of bacteria, fungi and plant roots following iron deficiency, enabling this essential mineral to be taken up from the surrounding area.

According to the investigations undertaken by the HZDR researchers, both DEOB and DEOE form highly stable gallium-siderophore complexes. This finding correlates with the observed high selectivity of both siderophores towards gallium. Indeed, the siderophores were able to successfully complex 100% gallium in two different process wastewaters stemming from wafer production. The researchers used different spectrometric methods (infrared and nuclear magnetic resonance) as well as density functional theory calculations to identify how gallium (III) ions are complexed. They found that the siderophores fix the metal to special functional groups containing not only carbon, oxygen and hydrogen, but also a nitrogen atom.

The scientists used chromatographic method – C18 reversed-phase column chromatography – to separate the gallium complex from the process wastewater. This enabled the researchers to complex almost 100% of the gallium and to recover more than 95% as a siderophore complex. The gallium was then released from the complex following the addition of a 6-fold excess of the complexing agent ethylenediaminetetraacetic acid (EDTA) to an acidic solution (pH value of 3.5), achieving a regeneration of > 90% of the siderophores without any loss of function. It was proven that the siderophores could be applied for at least ten cycles without any loss of function.

- **Publications:**
  Jain, R. et al. Water Research 158 (2019), 203-212
  DOI: 10.1016/j.watres.2019.04.005
  Jain, R. et al. German Patent registration No. 10 2018 107 923.0
- **Contact:** Dr. Katrin Pollmann, Helmholtz-Institut Freiberg für Ressourcentechnologie am HZDR

Calendar of Events

January: Dr. Breuer takes office

Prizewinner HZDR Innovation Contest
Source: HZDR/Robert Lohse

Dr. Ulrich Breuer, the new Administrative Director, was officially inaugurated during the award presentation ceremony on January 8. In this new role, Breuer, together with the Scientific Director, Professor Roland Sauerbrey, presented the HZDR Awards 2017. The top three winning teams in the HZDR Innovation Contest were also presented with an award. This competition was sponsored for the first time in 2017.

February: Teachers find out about innovative resources research

Drone launch with Dr. Gloaguen
Source: HZDR

On February 16, teachers from the whole of Saxony took up the invitation of the HZDR DeltaX School Lab to undergo a day of advanced training at the Helmholtz Institute Freiberg for Resource Technology. On the agenda: “The digital circular economy − current aspects of recycling, refurbishment and remote sensing”. Using the “Fairphone” as an example, the educators discovered which metals and other reusable materials are needed in modern communication devices, and how they can be recovered with the greatest sustainability. The participants also learned about modern and environmentally safe exploration and extraction methods.

March: Beller Lectureship for Alina Deac

Dr. Alina Deac
Source: HZDR/Robert Lohse

HZDR physicist Dr. Alina Deac (Institute of Ion Beam Physics and Materials Research) was among the guests invited to the Spring Meeting of the American Physical Society (APS) in Los Angeles, California: She received an APS Beller Lectureship for her achievements in the field of “magnetism and its applications“. Deac delivered her lecture on “Spin Polarization and Spin Order in Heterostructures and Oscillators” on March 18.

April: Topping-out ceremony at the NCT Dresden

Topping-out ceremony NCT Dresden
Source: UKD/Ulrich Lippke

The Dresden site of the National Center for Tumor Diseases (NCT) is starting to take shape. On April 13, a celebratory wreath was hoisted onto the top of the building's shell on the premises of the University Hospital Carl Gustav Carus. This is where a special research platform is being built over three floors: Interdisciplinary cancer research and patient care will be united under one roof, with the intention of feeding off each other. NCT Dresden is a joint institution of the German Cancer Research Center (DKFZ), the Faculty of Medicine at the Technische Universität Dresden, the University Hospital Carl Gustav Carus Dresden (UKD), and the Helmholtz-Zentrum Dresden-Rossendorf (HZDR). Saxony's Minister-President Michael Kretschmer joined forces with Professor Michael Baumann (DKFZ), Dr. Ulrich Breuer (HZDR), and Wilfried Winzer (UKD) to symbolically hammer in the final nails.

May: HZDR stages its third Health Days

Aktivrunden Rückengesundheit
Source: HZDR

From May 15 to 18, the HZDR Main Campus was dedicated entirely to the theme of "Fit for the job": The diverse program of the Health Days, held for the third time at the HZDR, included healthy back exercises, beginners' Nordic Walking courses, and calisthenics taster classes. Individual health advice was also available, involving vital screening, muscle tone and bone density measurement, balance checks, and skin screening. Support from health insurance companies, local healthcare providers, and fitness centers meant that 300 places altogether were available. To round off the program, talks were given on matters such as coping with mental illnesses in the workplace and healthy eating.

June: Big turn-out at "Kein Wunder: Wissenschaft" in Rossendorf

View into the clean rooms of the ZRT
Source: HZDR/Detlev Müller

Around 2,500 guests braved the hot summer weather to attend Open Lab Day on June 9. They took advantage of the opportunity to explore the whole spectrum of modern research in the HZDR laboratories – innovative electronic materials for storage and computer technologies and miniature sensors; strong magnets; new recycling concepts for reusable

materials; the development of radio-pharmaceuticals and medical devices; astroparticle research; and unique concepts for accelerators.

The biggest attractions were the Research Facilities at the HZDR – the ELBE Center for High-Power Radiation Sources, the Dresden High Magnetic Field Laboratory, and the Ion Beam Center. The newly built Center for Radiopharmaceutical Tumor Research (ZRT) opened its doors to the public for the first time, offering guided tours.

July: Summer students from three continents

The HZDR Summer Students 2018
Source: HZDR

The seventh HZDR Summer Student Program attracted 17 students from twelve different countries – China, Great Britain, India, Japan, Croatia, Poland, Portugal, Russia, Slovakia, the Czech Republic, Ukraine and Belarus – to Dresden. Under the expert guidance of a mentor, the students spent seven to twelve weeks of their semester break working independently on their own research topic. The program, involving work at the HZDR laboratories and a public presentation of the results, also included a series of lectures on HZDR research fields, as well as group trips and leisure activities. The program is open to students of science and technology. A scientific jury examines all applications and selects suitable candidates. The minimum requirement is a Bachelor's degree or an equal qualification.

August: Homing in on cancer

Prof. Ralf-Thorsten Hoffmann, Director Radiology, University Hospital Dresden, und Prof. Esther Troost, Director at OncoRay, HZDR Dual-Energy-CT
Source: UKD/Thomas Albrecht

The National Center for Tumor Diseases (NCT) Dresden established an imaging platform for patient-oriented research, worth €6 million. The ensemble includes an integrated whole-body device for combined magnetic resonance imaging (MRI) and positron emission tomography (PET), a dual-energy computer tomograph (DE-CT), and two state-of-the-art ultrasound systems. Such high-end imaging for medical research is available only at a handful of locations in Europe. The ensemble at NCT Dresden is earmarked for research around the clock. Cancer patients benefit from the excellent facilities in the context of clinical studies.

September: Inauguration of the Center for Radiopharmaceutical Tumor Research

Prof. Roland Sauerbrey, Dr. Georg Schütte, Dr. Eva-Maria Stange on the tour
Source: HZDR/André Wirsig

The Center for Radiopharmaceutical Tumor Research (ZRT) at the Helmholtz-Zentrum Dresden-Rossendorf, Europe's leading-edge preclinical center for the development and production of radioactive and radioimmunological pharmaceuticals, was launched on September 4. Among the guests of honor at the official inauguration were Dr. Georg Schütte (State Secretary at the Federal Ministry of Education and Research), Dr. Eva-Maria Stange (Saxony's State Minister for Higher Education, Research and the Arts), Professor Otmar Wiestler (President of the Helmholtz Association), and Dirk Hilbert (Lord Mayor of the State Capital Dresden).
The building, constructed and equipped at a total cost of €36 million, provides an ideal platform for the entire spectrum of radiopharmacy, from basics to the transfer of knowledge to clinical application in the diagnosis and treatment of cancer. The building complex now brings together under one roof all laboratories for research in chemistry, biology, and physics, certified clean rooms for the production of radioactive drugs (radiopharmaceuticals), a new circular accelerator (cyclotron), areas for contemporary laboratory animal welfare, and small animal imaging at the HZDR.

September: Dresden does well in the Excellence Initiative

TELBE Facility
Source: HZDR/Frank Bierstedt

Three Clusters of Excellence at the Technische Universität Dresden were confirmed by the German Research Foundation (DFG), which announced the results of the Federal Government's third Excellence Initiative on September 27. The HZDR is involved in two clusters: "PoL: Physics of Life" seeks to explore fundamental life processes, starting with molecules and their organization within the cell. HZDR biophysicist Professor Karim Fahmy and his team are active in this field. In addition, a dedicated experimental bench for biological experiments is to be set up at the Terahertz facility TELBE in the ELBE – Center for High-Power Radiation Sources at the HZDR. In the "ct.qmat: Complexity and Topology in Quantum Matter" cluster, scientists from Würzburg and Dresden cooperate to investigate fundamentally novel states of matter. Professor Jochen Wosnitza and his team at the Dresden High Magnetic Field Laboratory will contribute their vast experience and unique experimental equipment to the undertaking.

October: Construction gets underway on new metallurgy pilot plant in Freiberg

Ground-breaking ceremony with minister Dr. Eva-Maria Stange
Source: HZDR/Detlev Müller

The symbolic first cut of the spade performed by Saxony's State Minister for Research, Dr. Eva-Maria Stange, on October 17 marked the start of construction work on a new pilot plant at the Helmholtz Institute Freiberg for Resource Technology (HIF). The institute, which is part of the HZDR and works in close collaboration with the TU Bergakademie Freiberg, is thus further expanding its research into the sustainable extraction and recycling of strategic resources. The Free State of Saxony is financing the new development with a total investment of €10.2 million. The building will house a 12-meter-high technology hall and a 15-metre-high transverse building section with function rooms.

Most of the hall space, measuring more than 1,000 square meters, is earmarked for installations and equipment for processes involving heat and water. The facility will enable researchers to combine different processes and operations in pyrometallurgy and hydrometallurgy in a variety of practical applications up to pilot scale, and to analyze complex, digitally connected procedures down to the smallest detail. The aim is to help innovative ideas and concepts for extracting and recycling reusable materials in the laboratory achieve market maturity more quickly.

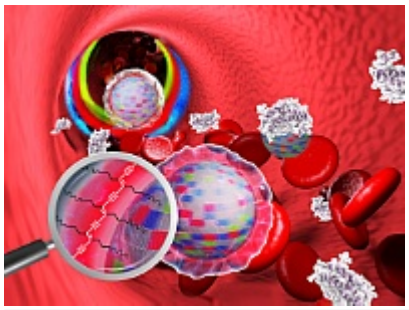
October: DeltaX School Lab gets new laboratory wing

Minister Christian Piwarz on the laboratory tour with pupils
Source: HZDR/Oliver Killig

The Helmholtz-Zentrum Dresden-Rossendorf officially launched the new laboratory wing of the DeltaX School Lab on October 30. The symbolic ribbon was cut by Saxony's State Minister of Culture, Christian Piwarz, together with Dr. Volkmar Dietz (Head of Large Facilities and Basic Research at the Federal Ministry of Education and Research), Dirk Hilbert (Lord Mayor of the State Capital Dresden), and Professor Roland Sauerbrey (Scientific Director of the HZDR). On a subsequent tour of the laboratory, students showed the 60-or-so-strong guests from education, politics, and science a number of experiments and the new options available at DeltaX.

The HZDR had invested a total of €1.5 million in building and equipping the laboratory wing, housed in a new building that was completed in 2018. Many schools in Saxony and south Brandenburg make regular use of the experimental days offered at DeltaX to expand on curriculum content in science at an extracurricular learning place. The HZDR School Lab seeks to give young people the opportunity to actively address and give critical thought to matters regarding nature, technology, the environment, and society. Another aim is to help talented young people get excited about STEM subjects in their early years.

November: Initiation of research cooperation with Australia



Cooperation between HZDR and Monash University: stealth-caps for nanoparticles
Source: HZDR/Katrin Klunker/ istockphoto.com/Thomas-Soellner/Molecuul

The HZDR and Monash University, based in Melbourne, Australia, have agreed to step up cooperation. On November 22, representatives from both institutions signed a Memorandum of Understanding to that effect in Melbourne. Cooperation focuses primarily on radiopharmacy and sensor development. A group of high-level HZDR scientists from different disciplines accompanied the delegation, led by HZDR Directors Professor Roland Sauerbrey and Dr. Ulrich Breuer, to Australia. Dr. Holger Stephan (Institute of Radiopharmaceutical Cancer Research) and Professor Bart Follink (Head of the School of Chemistry, Monash University) are the people to contact in matters of content. The two institutions have been working together for over a decade. Monash is one of the world's leading universities for Pharmacy and Pharmacology; QS, the international higher education and career network, currently ranks it third in the world.

Knowledge and Technology Transfer

Source: peshkova – fotolia.com

Development of Technology Transfer at the HZDR

Patents, licenses, and external revenues: On the whole, HZDR knowledge transfer indicators continued to develop well in 2018. The number of invention disclosures increased to 28 towards the end of the year. The number of licensed patents rose by 102 (35 percent) to a total of 291. Income from royalties doubled over the previous year. Once again in 2018, income from royalties exceeded the HZDR's patent costs.

In addition, transfer-related externally funded projects totaling €5 million were acquired in 2018. €2.1 million in revenues was generated from contracts with industry and from contract research.

Innovative Projects: The number of innovative projects at the HZDR remained consistently high – a total of 83 projects with a total volume of €15.6 million were realized in 2018. Examples include cooperative activities in research and development with industry, validation projects, and spin-offs. This demonstrates that, in addition to collaboration with industry in the form of contract research and infrastructure use, the majority of innovation activities involve funding projects. The number and scope of such projects exceed by far those of traditional bilateral projects with industry.

Innovation Contest: In 2018, the HZDR Innovation Contest was held for the second time, an again with great success. A total of 18 scientists and research teams submitted ideas for commercialization. Two all-day workshops were held in which the scientists were helped by their mentors to develop their ideas, ready for presentation to the jury. The three best teams received monetary rewards.

HZDR Innovation Fund: Greater use was made of the HZDR Innovation Fund in 2018. Five new projects received funding from the fund. As a result, 15 projects altogether have received funding since the fund was launched in 2016. The use of the Innovation Fund was also expanded in 2018 to pave the way for strategic partnerships with industry.

HZDR Innovation GmbH (HZDRI): Service and production orders for the industrial utilization of HZDR expertise and infrastructure, and the investment management of spin-offs are in the hands of HZDR Innovation GmbH (HZDRI). Business by the HZDR subsidiary continued to develop well. In 2018, annual turnover increased significantly over the previous year to €3.2 million, with a high level of profitability.

Spin-off projects: No new spin-offs were realized in 2018. In late 2018, the HZDR received confirmation that its current spin-off project "Tensormeter" was to gain funding from the Helmholtz Enterprise Program.

Policy consultation: In 2018, the HZDRI played a key role in drawing up an expert report on the concept of validation promotion for Saxony, commissioned by the Saxon State Ministry for Economic Affairs and Labor (SMWA). In 2018, approval was also given to the ECO II Funding Project of the Federal Ministry of Education and Research (BMBF). In this project, the HZDR has teamed up with the Technische Universität Dresden and the Leibniz Institute for Solid State and Materials Research Dresden (IFW) in a bid to transfer the HZDR Innovation Fund model to Leibniz institutes and to expand the validation of transfer projects involving external management and market expertise.

Education: The “BePerfekt – Empowering individuals and teams in transfer structures” joint research project was continued in 2018. The first training module on “Foundations: knowledge and technology transfer in practice” was implemented as a pilot project from May to June 2018. It included six webinars and a final two-day classroom event.

Events

In a bid to improve transfer culture and transfer support, a series of events were organized, especially in the context of the HZDR alumni project. Past HZDR scientists and doctoral students who now work successfully in industry were recruited to speak for the “Alumni Talk”. The project got off to a successful start in 2018, and is to be put on a permanent footing once the project comes to an end in mid-2020.

Personnel Matters and Organization

The previous Managing Director of HZDR Innovation GmbH, Professor Andreas Kolitsch, retired at the end of September due to age. Dr. Björn Wolf succeeded him. In this context, the Department of Technology Transfer and Legal Affairs was split into two new staff departments now operating under the names of “Technology Transfer and Innovation” and “Legal Affairs and Patents”.

Text: Melanie Giebel

- **Contact:** Dr. Björn Wolf, Head of the Department of Technology Transfer and Innovation at the HZDR

Personnel Matters & Awards

Nominations / Appointments / Functions / Habilitations

Dr. Ulrich Breuer
Source: HZDR/André Wirsig

- **Dr. Ulrich Breuer** took on the role of Administrative Director of the HZDR on January 1. The physicist succeeded Professor Peter Joehnk, who retired after serving on the Board of Directors for fifteen-and-a-half years. Breuer has been engaged in research management for many years, most recently in the capacity of Vice-President for Business Affairs and Finance at Karlsruhe Institute of Technology (KIT).

Prof. Hanno Glimm (NCT Dresden)
Source: HZDR/André Wirsig

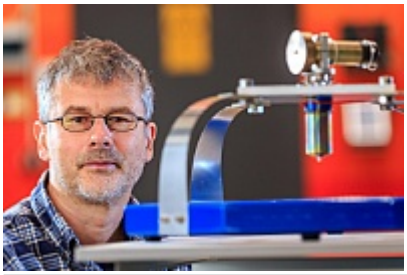
- Hematologist and oncologist **Hanno Glimm** was appointed Professor of "Translational Medical Oncology" at the National Center for Tumor Diseases (NCT) Dresden on March 1. He also became a member of the NCT Directorate in April. Glimm uses state-of-the-art molecular techniques to explore the genome of tumor cells. He is also developing novel therapeutic approaches for solid tumors. NCT Dresden is a joint institution of the German Cancer Research Center (DKFZ), the Faculty of Medicine Carl Gustav Carus at the Technische Universität Dresden, the University Hospital Carl Gustav Carus Dresden, and the Helmholtz-Zentrum Dresden-Rossendorf (HZDR).
  www.nct-dresden.de
  www.dkfz.de
  www.uniklinikum-dresden.de

Prof. Ralf Schützhold
Source: HZDR/André Wirsig

- On April 1, **Ralf Schützhold** took on the Chair of Theory of Nonequilibrium Phenomena in Solids or Plasmas (a joint appointment with the HZDR) at the Faculty of Physics, Institute of Theoretical Physics of the Technische Universität Dresden. At the HZDR, Schützhold leads the recently established "Theoretical Physics" research group, which reports directly to the Scientific Director, Professor Roland Sauerbrey, and is therefore on a par with the Center's eight institutes. Professor Schützhold explores the theory of strong-field physics, which is advanced experimentally at the Institute of Radiation Physics. Quantum electrodynamics in extremely strong fields is relevant to the high-performance lasers DRACO und PENELOPE, for instance.
  www.tu-dresden.de
- In July, **Professor Markus Reuter** (Director at the Helmholtz Institute Freiberg for Resource Technology of the HZDR) was awarded an honorary professorship by Curtin University in Perth, Australia. The expert in mining technologies, metallurgical processes, and recycling will visit the university in Western Australia once a year and co-supervise doctoral students.
  www.curtin.edu.au
  https://www.hzdr.de/hif
- At the end of 2018, **Michael Gensch** was offered a professorship for Terahertz and Laser Spectroscopy at the Technische Universität Berlin. At HZDR, Gensch established the "High-field THz-driven Phenomena" research group and the project group of the same name at the Institute of Radiation Physics. The terahertz user facility "TELBE" at the ELBE Center for High-Power Radiation Sources of the HZDR is currently the only dedicated large-scale research facility in this field of research.
  www.tu-berlin.de
- **Dr. Moritz Schmidt**, radiochemist at the Institute of Resource Ecology, qualified to become a professor at the Technische Universität Dresden, Faculty of Chemistry and Food Chemistry, after completing his post-doctoral thesis on the "Influence of structures and reactions at the water/mineral interface on radionuclide mobility".
  www.tu-dresden.de
- **Dr. Agnieszka Beata Kuc** (Institute of Resource Ecology, HZDR research site Leipzig) qualified to become a professor at the Jacobs University Bremen, Department Physics & Earth Sciences, having written her post-doctoral theses on the "Electronic properties of 2D and 1D inorganic materials for applications in nano(opto)electronics".
  www.jacobs-university.de/

Awards

- HZDR Awards 2018 (award presentation ceremony on March 14, 2019)



Dr. Frank Stefani
Source: HZDR/R.Weisflog

The European Research Council (ERC) awarded **Dr. Frank Stefani** (Institute of Fluid Dynamics) an ERC Advanced Grant. The physicist will receive around €2.5 million for his research over the next five years. Frank Stefani intends to use the funds to explore different magnetic phenomena in geophysics and astrophysics. To this end, the new DRESDYN experimental platform is being established at the HZDR Main Campus in Dresden.
www.erc.europa.eu

- The Behnken-Berger Prize 2018 went to **Dr. Patrick Wohlfahrt** from HZDR's Institute of Radiooncology – OncoRay for his doctorate on the topic of "Dual-Energy Computed Tomography for Accurate Stopping-Power Prediction in Proton Treatment Planning". The medical physicist conducted his research within the "High Precision Radiotherapy" research group, led by Dr. Christian Richter. The prize, worth €15,000, is awarded by the Behnken-Berger Foundation.
www.behnken-berger.de
- **Toni Hache** (Institute of Ion Beam Physics and Materials Research) was awarded the Georg Simon Ohm Prize 2018 by the German Physical Society (DPG) for his outstanding Master's thesis in the field of spintronics. In his thesis, Hache explored the generation of autooscillations in ferromagnetic nanostructures by pure spin currents. Such nanodevices have tremendous potential for application in information and sensor technology, for instance.
www.dpg-physik.de/auszeichnungen/dpg-preise/georg-simon-ohm-preis/georg-simon-ohm?set_language=en
- In February 2018, **Dr. Nana Nishida** began a two-year Humboldt Research Fellowship at the HZDR. Within the Emmy Noether Junior Research Group led by Dr. Helmut Schultheiß at the Institute of Ion Beam Physics and Materials Research, the physicist explores special phenomena of magnonics: She investigates the autooscillation of spin waves in the areas between adjacent magnetic domains.
www.humboldt-foundation.de

PhD Degrees

The following doctoral theses were completed at HZDR in the report period:

Institute of Fluid Dynamics

- **Dr. Mohammadreza Haghnegahdar:** „Experimental analysis of mass transfer of Taylor bubble flow in small channels“(Prof. Uwe Hampel)
- **Dr. Johannes Zalucky:** „Hydrodynamic and mass transfer performance of solid foam packed reactors at descending gas-liquid flows“ (Dr. Markus Schubert)
- **Dr. Pascal Beckstein:** „Modellentwicklung zur Simulation von strömungen mit freier Oberfläche unter dem Einfluss elektromagnetischer Wechselfelder“ (Dr. Sven Eckert)
- **Dr. Zhe Lei:** Rare Earth Technology: Magnetic Cooling and Magnetic Separation (Prof. Kerstin Eckert)

Helmholtz Institute Freiberg for Resource Technology

- **Dr. Jörg Ostendorf:** „Rb-Sr Geochronologie von Sphalerit in ausgewählten Pb-Zn Lagerstätten“ (Prof. Jens Gutzmer)
- **Dr. Solveig Pospiech:** „Geochemical Characterization of Tea Leaves (Camellia sinensis) and Soils for Provenance Studies based on Compositional Data Analysis“ (Dr. Raimon Tolosana Delgado)

Dresden High Magnetic Field Laboratory

- **Dr. Sandra Hamann:** „Investigation of quantum criticality in Ce-, Yb- and U-based compounds by means of thermodynamic and transport properties“ (Prof. Joachim Wosnitza)
- **Dr. Ajeesh Mukkatu Omanakuttan:** „Tuning ground states in the localised CePd2As2 and the itinerant AFe4X2 (A=Lu, Y, Zr; X=Si, Ge) magnets using external pressure“ (Prof. Joachim Wosnitza)
- **Dr. Stefan Lucas:** „Untersuchung stark korrelierter Elektronensysteme an neuartigen quantenkritischen Punkten“ (Prof. Joachim Wosnitza)
- **Dr. Sebastian Molatta:** „Magnetometrische Untersuchungen neuartiger Supraleiter“ (Prof. Joachim Wosnitza)
- **Dr. Lars Opherden:** „Untersuchung magnetischer Pyrochlor-Systeme, insbesondere der All-In-All-Out-Ordnung in Nd2T2O7 (T = Zr, Hf)" (Prof. Joachim Wosnitza)

Institute of Ion Beam Physics and Materials Research

- **Dr. Jacob König-Otto:** „Ladungsträgerdynamik in Graphen unterhalb der optischen Phonoenergie“ (Prof. Manfred Helm)
- **Dr. Fang Liu:** „Hyperdoping Si wih deep-level impurities by ion implantation and sub-second annealing“ (Prof. Manfred Helm)
- **Dr. Thu Trang Trinh:** „The microscopic effects of transition metal based hydrogen storing and sensing thin films“ (Prof. Jürgen Faßbender)
- **Dr. Kai Wagner:** „Spin-wave generation and transport in magnetic microstructures“ (Prof. Jürgen Faßbender)
- **Dr. Ewa Kowalska:** „Current-induced dynamics in hybrid geometry MgO-based spin torque nano-oscillators“ (Prof. Jürgen Faßbender)
- **Dr. Florian Günther:** „Theoretical studies of structural and electronic properties of donor-acceptor polymers“ (Prof. Sibylle Gemming)
- **Dr. Jeffrey Kelling:** „Efficient parallel Monte-Carlo simulations for large-scale studies of surface growth processes“ (Prof. Sibylle Gemming)

Institute of Radiation Physics

- **Dr. Andreas Otto:** „The Dynamically Assisted Schwinger Process: Primary and Secondary Effects“ (Prof. Burkhard Kämpfer)
- **Dr. Daniel Gehre:** „Investigations on CdZnTe-Semiconductor-Detectors for the Search of the Neutrinoless Double Beta Decay“ (Dr. Andreas Wagner)
- **Dr. Stefan Reinicke:** „Wasserstoffbrennen in der Sonne: Die 12C(p,γ)13N-Reaktion und die Radiofrequenz-Ionenquelle für den Felsenkeller-Beschleuniger“ (Dr. Daniel Bemmerer)
- **Dr. Louis Wagner:** „Precise nuclear data of the 14N (p,gamma)15O reaction for solar neutrino predictions“ (Dr. Daniel Bemmerer)
- **Dr. David Weinberger:** „Detektionsmethoden für Gammastrahlung in der therapeutischen Medizin mit CdZnTe-Detektoren“ (Dr. Fine Fiedler)
- **Dr. Jurjen Pieter Couperus:** „Optimal Beam Loading in a Nanocoulomb-class Laser Wakefield Accelerator“ (Prof. Ulrich Schramm)
- **Dr. Florian Kroll:** „The study and development of pulsed high-field magnets for application in laser-plasma physics“ (Prof. Ulrich Schramm)

Institute of Radiooncology – OncoRay

- **Dr. DEE. Eekers:** „Optimization of Brain ans Head & Neck radiotherapy“ (Prof. Esther Troost)
- **Dr. Eric Klapproth:** „Impact of beta 1 Integrin inhibition on C-abl activity dependend DNA-damage repair in human cancer cells“ (Prof. Nils Cordes)
- **Dr. Asrar Ahmad:** „Dosimetric consequences of prostate motion during therapetic irradiation“ (Prof. Dr. Wolfgang Enghardt)
- **Dr. Patrick Wohlfahrt:** „Dual-Energy Computed Tomography for Accurate Stopping-Power Prediction in Proton Treatment Planning“ (Dr. Christian Richter)

Institute of Resource Ecology

- **Dr. Miriam Bader:** „Untersuchung der Wechselwirkungen halophiler Miktroorganismen mit Radionukliden“ (Dr. Andrea Cherkouk)
- **Dr. Katharina Fritsch:** „Investigation of uranium(VI) retention by montmorillonite at high ionic strengths” (Dr. Katja Schmeide)
- **Dr. Claudia Wilke:** „Spektroskopische Untersuchungen zur Bindungsform trivalenter Actinide/Lanthanide in Biofluiden des menschlichen Verdauungstraktes“ (Dr. Astrid Barkleit)
- **Dr. Aniruddh Das:** „The influence of microstructure on the fracture behaviour of ferritic ODS steels“ (Dr. Hans-Werner Viehrig)
- **Dr. Evgeny Nikitin:** „Development of a model for the consideration of structural feedback effects for the reactor dynamics code DYN3D“ (Dr. Emil Fridman)
- **Dr. Maria Poetsch:** „Wechselwirkungs- und Transportuntersuchungen mehrwertiger Radiometalle in Ton unter Berücksichtigung des Einflusses von Fulvinsäuren und erhöhten Salinitäten“ (Dr. Holger Lippold)

Institute of Radiopharmaceutical Cancer Research

- **Dr. Marcel Lindemann**: „Entwicklung und Synthese neuartiger fluorhaltiger Liganden zur molekularen Bildgebung des Adenosin A2B-Rezeptors im Gehirn mittels Positronen-Emissions-Tomographie“ (Prof. Peter Brust)
- **Dr. Chao Wang:** „Theranostic Mercury: 197(m)Hg with high specific activity for imaging and therapy“ (Prof. Jörg Steinbach)

HZDR Facts and Figures

(Status as of Dezember 31, 2018)

Total annual budget including investment	approx. 132.15 million Euros
of that, external revenues	approx. 16.85 million Euros

Number of employees	1 243
including PhD students	176
including trainees	38

Professorships	32
including joint appointments at Saxon universities	13
including adjunct and honorary professorships	5

Junior Research Groups (as of 2018)	12
including groups externally funded in competition with other organizations	7
ERC Grants	currently: 2 in total: 4

Publications	
Articles (ISI-/Scopus cited)	640
Other cited publications	19
Books / book chapters	11
Doctoral theses	39

Large-scale scientific facilities (Helmholtz performance category II)	
Ion Beam Center IBC	14 658 hours

ELBE - Center for High-Power Radiation Sources	4 404 hours
Dresden High Magnetic Field Laboratory HLD	121 measurement campaigns / 172 measurement weeks / 7 827 applied magnetic pulses

Science and technology transfer	
Applications by priority	27

Students at DeltaX School Lab	approx. 2 900