HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

ANNUAL REPORT 2018

HIGHLIGHTS. FIGURES. PEOPLE.

CONTENTS

NOTE ON THE REPORTING PERIOD:

The Helmholtz Annual Report 2018 describes developments at the Helmholtz Association from August 31, 2017 to August 20th, 2018. The performance record is based solely on the 2017 calendar year. The Annual Report can also be downloaded as a PDF at www.helmholtz.de/annualreport18.

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We contribute to solving the major challenges facing society, science, and the economy by conducting top-level research in strategic programs within the Research Fields Energy, Earth and Environment, Health, Matter, Key Technologies and Aeronautics, Space and Transport.

We research highly complex systems using our large-scale facilities and scientific infrastructures, and cooperate with national and international partners in the process.

We shape our future by combining research and technological advancements with prospects for innovative applications and services for tomorrow's world.

We attract and promote the best talent by offering them a unique scientific environment and ongoing support throughout every stage of their career.

This is our mission.

Professor Otmar D. Wiestler,
President of the Helmholtz Association

Dear Readers,

People are our main focus here at Helmholtz. We want our top-level research to support society in mastering the key challenges of our time. In doing so, we count on our talented employees – and have enhanced our measures in this area to ensure we especially can provide them with even better support: The next phase of the Helmholtz Academy is getting off to a start, career development units are being set up at our Centers, new postdoc guidelines have been published, and many exciting positions are available through our funding programs. We are focusing on these aspects because we need the very best minds if we are to take a consistent, sustainable approach to challenges such as digitalization, climate change, and the energy transition in the future.

There is a recurring extensive process to review whether Helmholtz is able to take on these major tasks. Over the past few months, we underwent a scientific evaluation that was unique in terms of its format and scope. We succeeded in recruiting over 600 internationally renowned experts to carry out 32 evaluations at our 18 Centers. These experts subjected Helmholtz to an extremely thorough examination. The result: We are in a superb position and are among the best in the world in many areas. Together with partners from academia, business, and society, our Centers address the right questions. Our research infrastructures function as scientific hotspots. Based on the results of this detailed assessment, our job now is to set the course for our future. We will place an even stronger emphasis on major issues in our research and will transfer the achieved results to society and the economy even more effectively. In light of this, we are looking ahead to the next period of program-oriented funding with great confidence.

On the following pages, we would like to present exciting findings from all of our Research Fields in addition to highlights of recent months, including the commissioning of the European XFEL and the launch of ambitious projects such as MOSES. We want to give you an insight into how we are shaping the future with our top-level research – and introduce you to the incredible minds behind this work.

Thank you very much for your interest, and we hope you enjoy reading about Helmholtz.

Otmar D. Wiestler

OUR HIGHLIGHTS 2017/18

9/20/2017
Scientific operation of the world's largest X-ray laser facility, European XFEL, begun

10/4/2017
First scientific evaluation conducted within the scope of program-oriented funding

10/9/2017
Helmholtz Einstein International Research School on Data Science (HEIBRiDS) graduate school founded in Berlin

10/24/2017
Funding agreement signed for the high-performance climate computer at the German Climate Computing Center

11/1/2017
Antje Boetius appointed director of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)

11/13/2017
European light sources research facilities conclude cooperation agreement (LEAPS Consortium)

11/14/2017
Operation of the Ocean Science Centre Mindelo (OSCM) handed over to scientific community

1/18/2018
MOSES earth observation program launched

February 2018
Selection of first research projects as part of the Proof-of-Concept Initiative aimed at promoting translational research

3/7/2018
New assessment process for proposed trips by large and medium-sized research vessels initiated

3/14/2018
Anja Karliczek appointed Federal Minister of Education and Research

5/5/2018
NASA InSight probe launched

5/22/2018
GRACE-FO satellite mission launched

6/6/2018
Alexander Gerst embarked on his journey to the ISS as commander of the Horizons mission

6/13/2018
Helmholtz Institute for Metabolic, Obesity, and Vascular Research (HI-MAG) founded in Leipzig

Evaluation panel at the GEOMAR Helmholtz Centre for Ocean Research Kiel. Photo: Jan Steffen, GEOMAR

PROGRAM-ORIENTED FUNDING

Helmholtz pools its research activities in strategic programs which typically extend across Centers. From October 2017 to April 2018, these programs were evaluated by renowned experts from around the world.

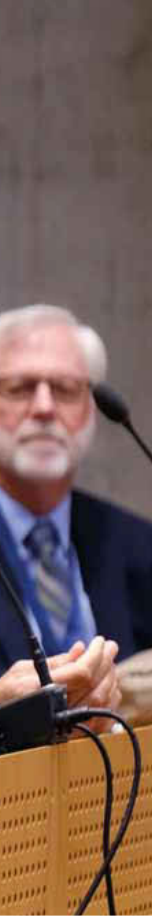
The Helmholtz Association's six Research Fields jointly pursue top-level interdisciplinary research that is relevant to society and develop system solutions for the major challenges facing society, science, and the economy. Our research is organized in 30 programs receiving government funding. The programs are developed within the scope of research policy guidelines and evaluated by committees of international experts according to the requirements of the highest scientific quality and strategic relevance. Helmholtz has developed a two-tier evaluation system for the upcoming program period:

- In-depth scientific assessment of the Centers and their ongoing programs at the individual Center level
- Strategic evaluation of future programs at the research field level

The Research Fields program period will conclude for the Earth and Environment, Health, and Aeronautics, Space, and Transport at the end of 2018 and for the Research Fields Energy, Key Technologies, and Matter in 2019. This was therefore an appropriate point in time to carry out a rigorous peer review of the Association's scientific performance and formulate a corresponding strategy for the future. An evaluation of Helmholtz's research activities – presumably unique with respect to its scope, intensity, and format – was therefore carried out: Helmholtz succeeded in recruiting over 600 experts from 27 countries for this purpose. Nearly half of these were from other countries in Europe and a third from countries outside Europe. Within half a year, the groups of experts carried out a total of 32 on-site evaluations, each lasting three to six days, at the 18 Helmholtz Centers. During this process, they evaluated the scientific performance of the individual research units as well as their contributions to the programs and their topics. Working on this basis, it was possible not only to assess the respective Center's international ranking, but to evaluate the programs as a whole thanks to expert cross-assessors who participated in a number of assessments.

Scientific Excellence Confirmed

The experts found impressive evidence that the Centers hold a unique position at the international level thanks to their size, interdisciplinary nature, infrastructure, and long-term funding base as well as their systematic approach. They are among the world's leading institutions in numerous fields.
The portfolio of the Research Field **Energy** comprises virtually all of the technologies required to implement the energy transition and plays a leading role in helping to shape key fields with academic excellence at the international level. The experts verified that the research field possesses unique sys-



The experts verified that the Centers hold a unique position thanks to their size, interdisciplinary nature, infrastructure, and long-term funding base as well as their systematic approach. They conduct top-level research at the international level in numerous fields.

tems expertise extending across various technologies and disciplines. This expertise has clearly improved due to the implementation of the recommendations from the previous evaluation, such as the *Energy Systems 2050* initiative.

The activities of the Research Field **Earth and Environment** likewise enjoy an outstanding reputation around the world and hold a leading international position in many cases. The integrated research it conducts into the Earth system, including its terrestrial sections, the atmosphere, the oceans, and the polar regions plays a key role in the success and impact of the research field's scientific work. A further aspect highlighted by the experts was the successful recruitment of outstanding international scientists who have succeeded in developing new reserach areas.

The evaluation process confirmed and reinforced the focus on widespread diseases in the Research Field **Health** as a successful concept. An impressive aspect for the expert groups was the research field's interdisciplinary, mission-driven research, extending from biomedical basics to translation into clinical application. The Helmholtz Health Centers were seen as initiators and catalysts for partnerships, and as important partners for German university hospitals.

The evaluation further confirmed that the Research Field **Aeronautics, Space, and Transport** is conducting top-level research at the global level based on a broad range of topics and a systematic approach. Among other aspects, interdisciplinary cooperation, extensive expertise in the area of modeling and simulation, and a unique ensemble of research infrastructures form the basis for this. The experts also emphasized the research field's successful transfer of knowledge and technologies via numerous partnerships with universities, industry, and politics.

The effectiveness of the restructuring into three programs within the Research Field **Matter** was clearly confirmed. These programs enable exceptional research results thanks to the strong links between particle, nuclear, and astrophysics, and the merging of exquisite accelerator and detector developments. In addition, the research field's excellent user facilities and research infrastructures are considered an outstanding example of the division of tasks in the German and international scientific system as well as cooperation between universities and Helmholtz.

The experts likewise highlighted the high standard of scientific quality in the Research Field **Key Technologies**. In particular, they placed special emphasis on the research field's world-leading activities in the fields of information technologies and processing (particularly the link between computing and brain research) as well as optics and photonics. They emphatically confirmed the effectiveness of the more concerted focus on the area of information.

It was clearly evident that the experts were impressed by the unique research infrastructures and platforms used for technological development and system integration on the whole. They also rated as outstanding the service that the Centers provide for international research communities who use various large-scale facilities. In addition to developing the latest technologies and measuring devices, this includes ensuring a high level of data quality as well as the *open data policy*. The valuable recommendations provided by the numerous expert groups will now form the basis for the Association's strategic assessment and the new programs.

DIGITALIZATION: THE HELMHOLTZ INFORMATION AND DATA SCIENCE INCUBATOR

Data-based research is advancing at a breathtaking pace. In response to this, the Helmholtz Incubator was developed with the aim of pooling the Association's expertise in this area and completely redefining the field of information-based research.

Science and research generate enormous volumes of data, thereby opening up entirely new prospects for gaining knowledge and information. Processing and analyzing these complex and increasingly large volumes of data is one of the biggest challenges for the scientific system as a whole. Helmholtz occupies an outstanding position in this field thanks to its broad spectrum of expertise, ranging from big data analytics, to supercomputing, to the entire data life cycle as well as software development, artificial intelligence, and robotics. The individual disciplines yield a wide range of opportunities – particularly at the points where they interact. Helmholtz founded the Helmholtz Information and Data Science Incubator in 2016 with the aim of bringing together and strengthening the Association's incredible expertise and enormous quantities of data.

Each Center appoints two researchers to the Incubator, and they are supported by experts from research-based companies. By founding the Incubator, Helmholtz is pursuing the goal of fostering regular interactions between creative minds from across the entire Association, creating a foundation for innovative, interdisciplinary networks and approaches, as well as identifying pioneering topics and disruptive pilot projects. Based on this goal, the Incubator has served as the catalyst for the development of project proposals spanning various subjects and disciplines. These transcend the traditional boundaries between disciplines and fields of research: In June 2017, five interdisciplinary pilot projects were selected from numerous applications and awarded funding in the amount of 18 million euros. The projects are already achieving initial successes. Further innovative pilot projects have been prepared at the Incubator's first conference in fall 2018.

The Incubator simultaneously initiated a comprehensive strategy process within the Association alongside the process of identifying pioneering pilot projects. Over the course of two years, more than 130 researchers and ten consultants from leading research-based companies have participated in the Incubator. Extensive analyses, assessments, and conceptual designs were developed at over 30 workshops and working group meetings. Helmholtz's entire top

Helmholtz links its enormous, continually growing quantities of big data with cutting-edge technologies and the data scientists of tomorrow.

management addressed the most important suggestions from the Incubator at a special meeting of the top management and is currently developing digitalization strategies for every level of the Association based on this valuable input. During this process, the Incubator and the top management identified five areas that are of special strategic importance for Helmholtz.

Artificial intelligence and machine learning: These methods make it possible to find answers for completely new scientific questions. The Incubator is developing a technology platform where the expertise, methodological knowledge, and technical solutions from all research fields can be pooled, further developed, and merged in cooperation with other partners.

Image data technologies: An ever-increasing share of information is captured and processed in the form of images. For this reason, it will be essential for all modern fields of research to have a good command of imaging techniques and intelligent methods for analyzing image data. To this end, Helmholtz is planning to systematically enhance and continually exploit the latest approaches for processing images using digital methods based on machine learning.

Metadata and knowledge systems: An innovative metadata management system is necessary to generate knowledge using data that increases in complexity and diversity, to reproduce results, and to effectively use the results. Promising approaches from various areas are to be made available on a single platform. In this context, we are also contributing significantly to the establishment of the National Research Data Infrastructure (NFDI).

Basic technologies and services: A powerful research network including supporting services, cloud technologies, and the development of innovative software is necessary in order to support modern research partnerships in the best possible way. Helmholtz already possesses comprehensive expertise in this area and will systematically advance the development of these technologies.

Next generation of researchers: The Incubator has already initiated numerous activities aimed at establishing a new kind of network for postgraduate training. This network will build upon six regional Helmholtz Information & Data Science Schools (HIDSS), which are currently being set up in close cooperation with partner universities. The Incubator is also linking these schools as a consortium – to enhance a Helmholtz Information & Data Science Academy (HIDA).

By consistently pursuing these goals, Helmholtz will continue to enhance its strengths and play a key role in maintaining the German scientific community 's leading role at the international level. Furthermore, the Association will foster links between national and international partners in a highly attractive area.

RECRUITMENT INITIATIVE

Leadership positions in science help define the profile of every research institution. The joint appointments with universities serve as an important link between Helmholtz as a non-university research organization and its university partners. Within the context of the Pact for Research and Innovation, Helmholtz is increasing its efforts to recruit outstanding female scientists from abroad for joint appointments. Together with its funding bodies, Helmholtz is moving forward with a new edition of the successful recruiting initiative from years past, the "Recruitment of top-level women scientists (W3)" tool.

A new call for applications for the funding was issued in March 2018, and the funding is now dedicated exclusively to recruiting top-level female scientists who are currently working at institutions abroad. Female researchers of German nationality are also welcome to apply, provided that they have been working abroad in recent years (typically for at least the last three years). The program has very high standards with respect to the qualifications of the female scientists who are to be recruited. Funding in the amount of 600,000 euros per scientist per year is provided for the position and equipment. A maximum of nine additional female scientists can still be recruited within the scope of the program up to the end of the current initiative period. Last but not least, the program also acts as a strong link between the Helmholtz Centers and their university partners. Thanks to the additional scope it provides, they have the opportunity to work together to develop new topic areas or continue to build upon key strategic focal points.

Since the initiative's first call for applications in 2012, 45 appointment processes have been successfully completed to date, including two in 2017. The researchers appointed thus far are at a ratio of 60% women to 40% men. Further appointment processes are currently in the implementation phase.

"The HZB is an exceptional place for a material scientist as it combines top world-class infrastructure with excellent working conditions and a multidisciplinary expertise environment."

PROFESSOR CATHERINE DUBOURDIEU

Director of the Functional Oxides for Energy-Efficient Information Technology Institute at the Helmholtz-Zentrum Berlin für Materialien und Energie (HZB) and Professor of Applied Physical Chemistry at Freie Universität Berlin.

“I found an ideal scientific environment for my lab at the DKFZ. Here, I work on epigenetic and epitranscriptomic mechanisms which are relevant to both cancer and healthy cell development.”

PROFESSOR NINA PAPAVASILIOU

Head of the Division of Immune Diversity at the German Cancer Research Center (DKFZ) and Professor at Heidelberg University

“The Helmholtz Recruitment Initiative allowed me to join world-leading phenotyping scientists at Jülich. We discover dynamic and sensory processes in plant roots for water and food security.”

PROFESSOR MICHELLE WATT

Director of the Institute for Bio- and Geosciences (Plant Sciences) at Forschungszentrum Jülich.

TALENT MANAGEMENT AND EQUAL OPPORTUNITIES

Offering opportunities that are suitable for the respective target group at every career stage, combining academic advancement with clear career prospects, and enhancing the professionalism of the Association's management level – these are the core elements of talent management at Helmholtz.

Helmholtz places a concerted emphasis on promoting and recruiting talent at every level of the Association. The "Helmholtz Talent-Management: In April 2017, the Assembly of Members approved the strategy paper "Rekrutierung und Karriereentwicklung als zentrale Zukunftsaufgaben" (Helmholtz Talent Management: Recruitment and Career Development as Key Tasks for the Future)", setting out objectives and measures for specific target groups in this area up to the year 2020. These efforts give special consideration to postdocs, talented female scientists, and function groups in management. The objectives of the Talent Management Strategy essentially consist of recruiting the best professionals for Helmholtz and providing them with the best support for their further development (career and development support).

The Talent Management Strategy comprises the following measures:

- Recruitment and promotion: active international recruitment and support for talent, particularly female scientists,
- Advice and development: providing support for attractive career paths in academia, infrastructure, administration, and other areas,
- Professional management: leadership training, coaching, and mentoring at the *Helmholtz Leadership Academy*.

As members of the largest scientific organization in Germany, the Helmholtz Centers are aware of the strategic significance of talent management. For this reason, the Association already has important talent management tools in place today, such as the *Helmholtz Leadership Academy* in the area of management training, the *Helmholtz Young Investigator Groups Program* aimed at recruiting and promoting academic talent, as well as mentoring opportunities and career advice at the *Helmholtz Graduate Schools* in the area of career support. A wealth of activities relating to personnel development, active recruitment, and career advice are also carried out at the Research Center level.

Over the course of the past year, Helmholtz updated and expanded its portfolio of tools for recruiting employees, developing their careers and supporting their progression. These include the following new aspects.

- Helmholtz strives to offer postdocs an outstanding academic environment and support them as they make deci-

"Equal opportunities efforts will only succeed if organizational cultures continue to change. Management on a part-time basis must become a matter of course, and female managers need to be more widely accepted."

Dagmar Schirmacher-Busch, participant at the Helmholtz Academy in 2015

sions regarding their ongoing professional development. The guidelines for the postdoc phase approved by the Assembly of Members in April 2018 describe the responsibilities of postdocs, principal investigators, and the Helmholtz Centers as well as crucial elements for a successful postdoc phase. Among other things, these guidelines recommend that research and qualification objectives are set out in an agreement at the beginning of this phase.

- The previous mentoring program, *Taking the lead*, has been restructured. Its name is now *Helmholtz Advance*, and it focuses primarily on aspects involved in career orientation and planning. The program has been expanded from 30 to 60 participants per year, and men and women alike are welcome to apply for these additional 30 places. Equal opportunities continue to play a central role. However, these efforts have now been adapted so that training to promote an awareness of diversity is now attended by the entire group.
- The Helmholtz Mentoring Program is supplemented by on-site advice provided at the Centers: The *Helmholtz Career Development Centers for Researchers* received funding from the Initiative and Networking Fund for the first time in 2017 as part of a call for applications. The aim is to turn these centers into central contact points that postdocs can turn to for needs-based career advice and development. A network linking the centers has also been established.
- As another first, the *Helmholtz International Research Schools* issued calls for applications in order to provide even more versatile support for postdocs, recruit international talent at an early stage, as well as establish and expand international contacts. The schools offer structured doctorate training in the form of a joint program by the Helmholtz Center, foreign partners, and a German university.
- The *W2/W3 program for outstanding female scientists* has been firmly established since 2006. This program has been further developed so that it now specifically aims to support female scientists who are seeking their first appointment. Another new aspect is that funding is now restricted to permanent professorships.

Equal opportunities for men and women is one of the core values of Helmholtz. They are firmly rooted in the Association's mission and are an integral part of its strategy to recruit the best and brightest minds at all stages of their careers. After all, cutting-edge research is only possible if the most talented people are appointed to the right positions, regardless of their gender. The topic of diversity – with a special focus on equal opportunities – is systematically incorporated into all of the Association's programs and measures. Helmholtz has been running an equal opportunities program since 2006, which continues to be implemented on an ongoing basis. The program includes support for outstanding young women in leadership positions, cross-mentoring opportunities, as well as a package of measures aimed at improving the compatibility of family and working life. The inclusion of these measures as a central component of the Talent Management Strategy represented a significant further development in this area in the 2017 business year.

TRANSFER & INNOVATIONS

The transfer of knowledge and new technologies is of tremendous importance to Helmholtz. We also play an important role in innovation activities through our active innovation management and internal funding programs.

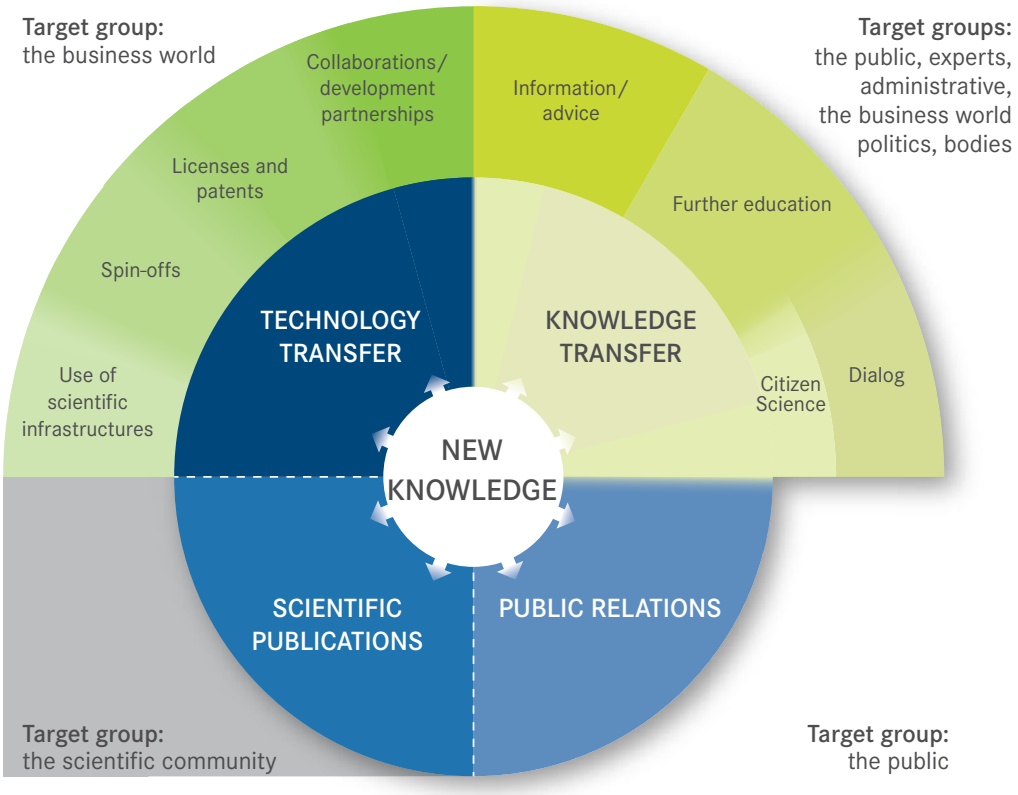
Helmholtz places a great deal of focus on the transfer of knowledge and technologies. During 2017, this was demonstrated by the priority placed on these topics in the President's Agenda and the Helmholtz Strategy as well as through the activities of the Research Centers and the success of their transfer processes.

Figures and Success Stories

In 2017, the Centers carried out over 2,000 partner projects with companies. These include long-term strategic alliances such as the partnerships established between KIT and SAP, Zeiss, BASF, and Bosch in 2017. The use of research infrastructures for industrial applications as well as publicly funded joint projects with industrial companies and SMEs contribute to the exchange of ideas with the business community. Revenue from the business sector amounted to 155 million euros, thanks in large part to contract research. In 2017, 433 patent applications were filed, and revenue from 1,500 ongoing licensing, option, and transfer contracts amounted to a total of approximately 15 million euros. The number of spin-offs in 2013 reached a level twice that of previous years. Twenty spin-offs were established in 2017. In this way, nearly 100 high-tech companies were founded in the past five years alone. The greatest successes achieved by Helmholtz spin-offs include the IPO of Mynaric AG, a spin-off called Vialight Communications GmbH from the DLR in 2009, and the awarding of the German Future Prize 2017 to FRANKA EMIKA GmbH, the subsidiary of a DLR spin-off. The team was recognized for the development of cost-effective, flexible robot technologies that can be operated intuitively. Also among the last three finalists for the award was Vincent Systems GmbH, a successful KIT spin-off dedicated to the development of the intelligent "BionikHand" hand prosthesis.

Activities and Funding Programs

Two of the success stories mentioned above received support from the Helmholtz Enterprise program, which provides funding for spin-offs. The Helmholtz Validation Fund perviously funded the importamt technologies for the intuitive programming of the robots. In addition to validation and spin-off funding, the Helmholtz Innovation Labs and Innovation Fund represent two additional internal funding tools that have been supporting the transfer of technology for some time. The Proof-of-Concept Initiative and funding for knowledge transfer entities were newly developed in 2017.



The following section provides a summary of selected activities:

- Six start-up projects were launched in 2017 with support from the redesigned Helmholtz Enterprise fund for spin-offs; Helmholtz Enterprise Plus, the external management support funding module, was also awarded four times.
- Six new projects were selected for funding under the Helmholtz Validation Fund in 2017. A total of 34 validation projects have therefore been launched since 2011 thanks to this fund.
- The seven Helmholtz Innovation Labs, which were selected from 27 applications for funding, significantly expanded their cooperation with SMEs and industry in 2017.
- The Centers' nine innovation funds became fully effective for the first time in 2017, enabling the financing of internal innovation projects in particular.
- Organized together with Fraunhofer and Deutsche Hochschulmedizin, the Proof-of-Concept Initiative represents a new and highly visible impetus for the further development of research results in the life sciences area. As part of a two-tier process, four projects were selected to receive funding from among 82 submitted project ideas in February 2018. There is enormous potential for development in this area.
- The Association's cooperation with the two transfer institutions initiated by the Max Planck Society – the Life Science Incubator and Lead Discovery Center GmbH – was continued.
- Start-up Days, a joint start-up event hosted by the four non-university research organizations, was held for the fifth time. Around 100 individuals interested in founding their own companies used this event as an opportunity to learn and exchange ideas in 2017. Various workshops with companies were also set up in order to provide impetus for strategic development partnerships between the Helmholtz Centers and business.
- The provision of funding to knowledge transfer entities began with an initial round in fall 2017, during which three projects in the fields of real-world labs, policy advice, school labs, and health information services were selected.

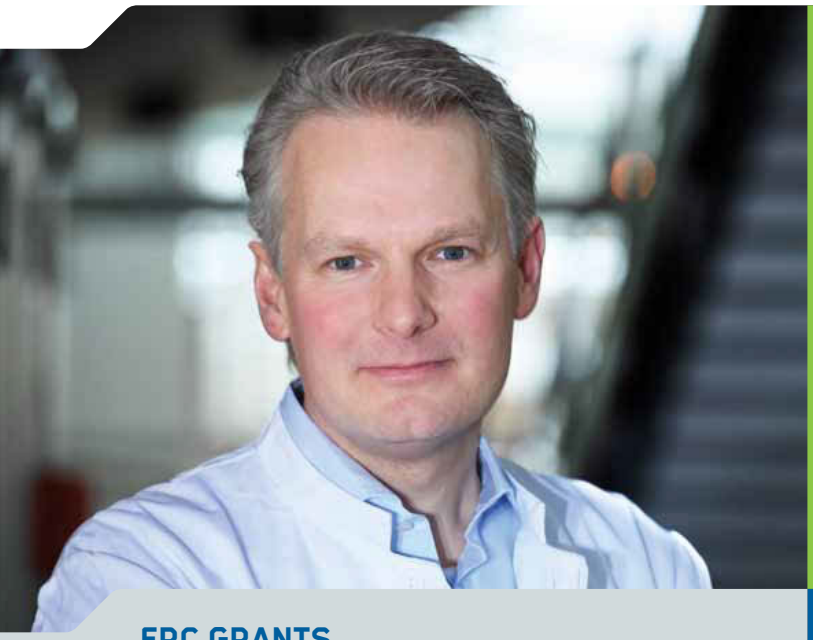
Knowledge Transfer

In the knowledge transfer area, the previous process aimed at establishing this area in the Association's strategy was continued. To this end, the system for recording knowledge transfer activities was developed further, and the successful work carried out by a cross-center team was transferred to the official knowledge transfer working group. In addition, a knowledge transfer meeting was held during the first half of 2018, offering participants from all of the Helmholtz Centers the opportunity to meet and discuss various aspects of knowledge transfer for the first time.

This area's broad range of activities, such as health or climate information services, policy advice offices, school labs, and citizen science projects are already having a great impact. At the same time, concerted networking efforts and funding will enable them to further enhance the Association's social impact in the future.

PRIZES AND AWARDS

Researchers from the Helmholtz Association were once again honored with prizes and awards in recognition of their outstanding research work this year.



2018 GOTTFRIED WILHELM LEIBNIZ PRIZE

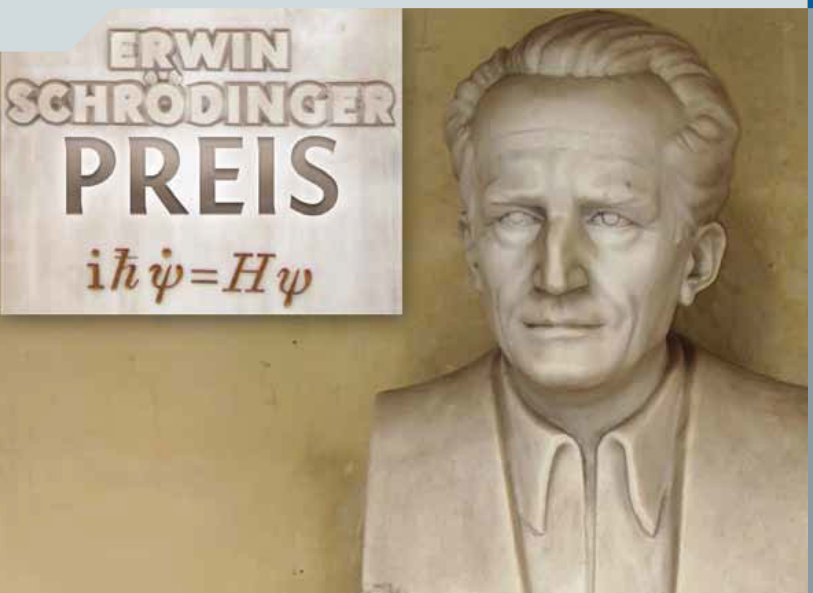
Eicke Latz, Director of the Institute for Innate Immunity at the University of Bonn and Department Head at the DZNE, was awarded the 2018 Leibniz Prize together with Munich-based researcher Veit Hornung. Latz is studying the "inflammatory workshop" of the cell and taking into consideration the activation mechanisms of what is known as the inflammasome in the process. A misdirected activation of inflammasomes plays a substantial role in widespread diseases such as diabetes and Alzheimer's. Through his work, Latz has had a profound impact on the field of innate immunity and developed new treatment concepts.

ERC GRANTS

__Advanced Grant: Norbert Hübner and Gary Lewin (both MDC), Frank Stefani (HZDR), Martin Schultz (FZ Jülich), Markus Zweckstetter (DZNE) __Starting Grant: Julia Frunzke, Dörte Rother, Christian Wagner (all FZ Jülich), Lars Pastewka, Cornelia Lee-Thedieck (both KIT), Cristina García Cáceres (HMGU), Kristina Kvashnina (HZDR), Fabricio Loayza-Puch (DKFZ), Olivia Roth (GEOMAR), Dirk Scherler (GFZ), and Anna Hirsch (HZI) __Consolidator Grant: Christian Greiner and Christian Koos (both KIT), Ulrike Herzschuh (AWI), Ana Martin-Villalba (DKFZ) __Proof of Concept Grant: Alexander Nesterov-Mueller, Pavel Levkin (both KIT), Michael Boutros (DKFZ), Rafal Dunin-Borkowski (FZ Jülich), Denys Makarov (HZDR) and Thomas Wolbers (DZNE)

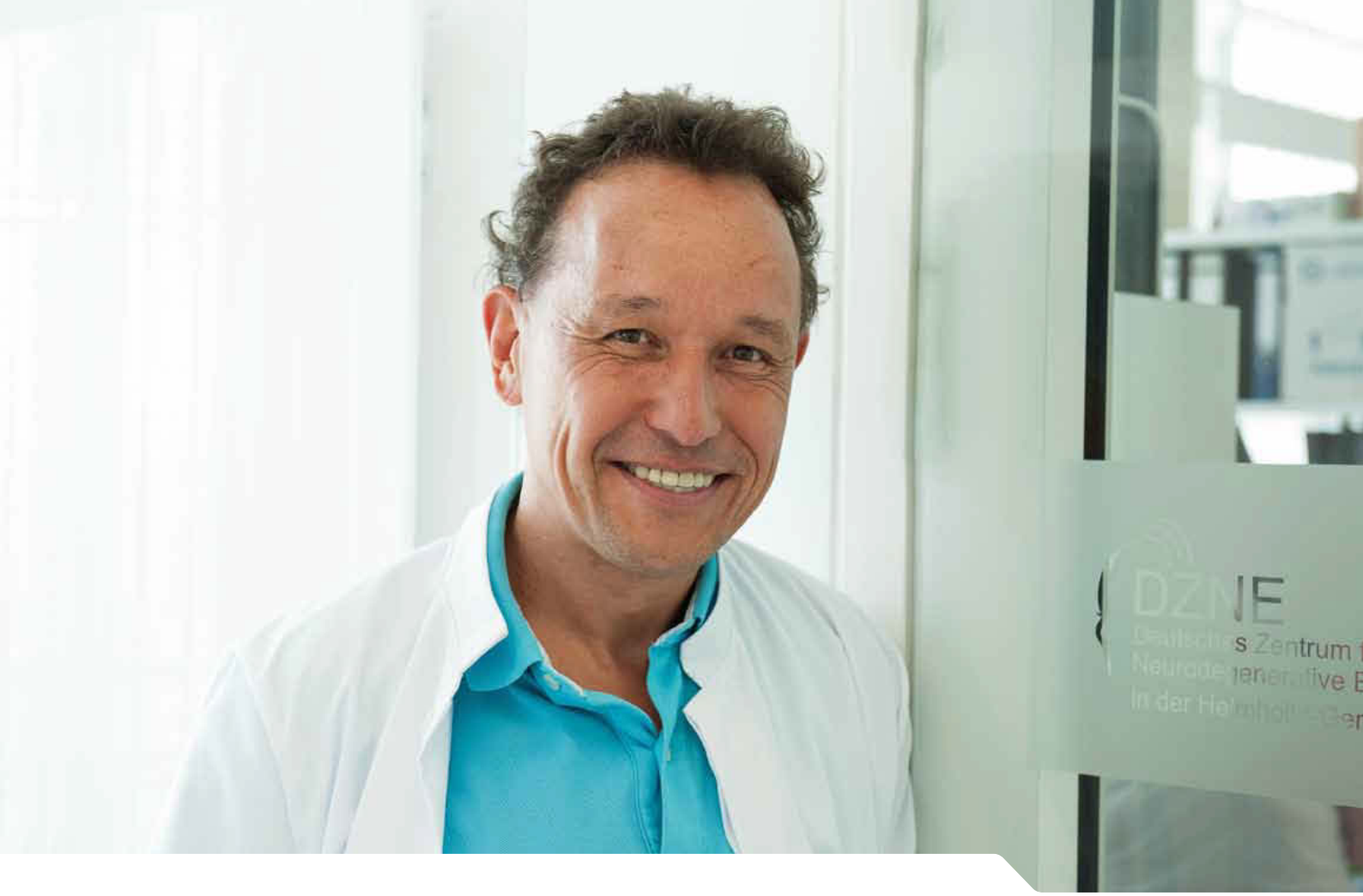
OTHER AWARDS

- German Cancer Award 2017 and Janeway Gold Medal 2018: Michael Baumann (DKFZ)
- Gay-Lussac Humboldt Prize 2018 and Gentner-Kastler Prize 2017: Johannes Orphal (KIT)
- German Environmental Award 2018, Communicator Award of the German Research Foundation (DFG), and the Vernadsky Medal 2018: Antje Boetius (AWI)
- German Environmental Award 2018: Roland A. Müller, Mi-Yong Lee, and Manfred van Afferden (UFZ)
- Chica and Heinz Schaller Research Award 2018: Marieke Essers (HI-STEM and DKFZ)
- Behnken-Berger Foundation Award for Young Scientists 2017: Mark Bangert (DKFZ)
- Walter Schulz Prize 2018: Simon Raffel (DKFZ)
- Otto Schmeil Prize 2018: Simon Haas (DKFZ)



ERWIN SCHRÖDINGER PRIZE 2018

In 2018, the Erwin Schrödinger Prize, worth 50,000 euros, was awarded to Matthias Eder (University of Freiburg, DKTK), Klaus Kopka (DKFZ), Uwe Haberkorn (University Hospital Heidelberg), and Michael Eisenhut (DKFZ, emer.) The researchers received the award for the development of a molecule which specifically detects prostate cancer cells and can improve both diagnosis and treatment. The Erwin Schrödinger Prize recognizes innovative achievements at the interface between various disciplines in medicine, the natural sciences, and engineering.



BRAIN PRIZE 2018

Christian Haass, speaker of the DZNE's munich site, is a pioneer in the field of Alzheimer's research. He was awarded the Brain Prize 2018, worth one million euros, in early May 2018.

The Brain Prize, which is awarded by the Lundbeck Foundation in Denmark, is one of the most valuable academic awards in the neurosciences with a value of one million euros. In addition to Christian Haass, speaker of the DZNE's munich site and professor at the LMU Munich, the prize was also awarded to neuroscientists Bart De Strooper (London and Leuven), Michel Goedert (Cambridge), and John Hardy (London) in May 2018. The scientists were jointly recognized for their fundamental discoveries relating to the genetic and molecular bases of Alzheimer's disease.

Back when Haass began to study this disease in 1990, very little was known about the cellular mechanisms involved. His work focused on the production and metabolization of amyloid, the main component of the disease, which causes protein deposits known as plaques. Among other aspects, the Munich-based researcher studied the chain of events, starting with the amyloid and followed by the development of plaques and neurofibrils, that ultimately kills brain cells and causes memory loss. Contrary to the general belief at the time, Haass hypothesized that the production of amyloid did not necessarily represent part of the pathological process. This crucial finding was extremely significant and has since led to the development of treatment approaches aimed at lowering the production of amyloids in patients. He demonstrated how amyloid is produced and how genetic mutations influence the production of amyloids in families with very aggressive and rare forms of Alzheimer's. Haass recently established that genetic mutations modify the function of special immune cells – the microglia – in the brain and that this can result in the onset of Alzheimer's.

"The Brain Prize is an ambassador for science and puts a spotlight on great discoveries," says Haass. "We are facing a time when more and more people don't believe in science anymore. Science may not always be right, but it is the only way we humans can find the truth and achieve progress."

RESEARCH FIELD ENERGY

PROFESSOR HOLGER HANSELKA
Vice-President of the Helmholtz Association,
Coordinator for the Research Field Energy,
Karlsruhe Institute of Technology

THE MISSION

Helmholtz scientists involved in the Research Field Energy are working to secure an economically, ecologically, and socially sustainable supply of energy. They examine conversion, distribution, storage, and utilization technologies while taking climatic and environmental impacts into account. One important goal is to replace fossil and nuclear fuels with climate-neutral energy sources and to develop end-to-end solutions for a sustainable energy system. For this purpose, they are seeking to determine the potential of renewables such as solar, biomass, and geothermal energy. Researchers are also working to increase the efficiency of conventional power plants. Finally, the Helmholtz Association pursues the long-term goal of developing nuclear fusion as a new source of energy and boasts outstanding expertise in the field of nuclear safety and final repository research.

PROGRAM STRUCTURE IN THE CURRENT FUNDING PERIOD

Eight Helmholtz Centers are currently collaborating in the Research Field Energy, which is divided into seven research programs:

- Energy Efficiency, Materials, and Resources
- Renewable Energies
- Storage and Cross-Linked Infrastructures
- Future Information Technology*
- Technology, Innovation, and Society*
- Nuclear Waste Management, Safety, and Radiation Research
- Nuclear Fusion

OUTLOOK

The “Energiewende”, or energy transition, is one of the greatest challenges facing present and future generations. In its sixth Energy Research Program, the German government is focusing on renewable energy, energy efficiency, energy storage, and grid technologies. The Helmholtz Association emphatically supports this strategy and makes a significant contribution to its implementation by focusing its expertise and experience in various programs. In addition, it is closing research gaps and promoting basic and application-oriented research. Socioeconomic studies are being used as a supplement to its technological research in order to ensure that all social, economic, and political aspects are included in its overall goal of transforming the energy system.

*Joint program with the Research Field Key Technologies

PROGRAMS IN THE 2015–2019 FUNDING PERIOD

Energy Efficiency, Materials and Resources

The target of the energy transition is to cut primary energy consumption in half by 2050 and achieve an 80 to 95 per cent reduction in greenhouse gas emissions over 1990 levels. For this purpose, process chains, resources, materials development, process engineering and energy conversion processes are being studied, interlinked and optimized. In addition, the flexibility required to restructure the energy supply needs to be improved with respect to fuel types, energy provision and infrastructure.

Renewable Energies

Renewable sources are intended to supply the lion’s share of energy. The goal is to exploit the various primary energy sources such as solar, wind, biomass and geothermal in an efficient, cost-effective way and to develop optimal tech-

Geothermal low-temperature demonstration power plant in Lahendong, Indonesia. Image: GFZ

Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

GEOTHERMAL ENERGY: FOR A SUSTAINABLE ENERGY SUPPLY

Heat from inside the Earth is a climate-friendly source of energy that is available around the clock regardless of the weather. Southern Germany is home to a large number of geothermal plants that supply electricity and heat. In the northern part of the country, which has a somewhat different geological makeup, this potential is only beginning to be exploited on a rudimentary basis. GFZ is examining optimal methods for developing this resource at a research site in the Schorfheide region north of Berlin as well as at other locations. This region has two existing boreholes extending to a depth of 4 km, and these are now set to be joined by a further borehole. A large-scale seismic measurement campaign was carried out in the spring of 2017 in order to find a favorable location for this drilling operation. Low-frequency acoustic waves can be used to identify hidden structures in the Earth's depths, similar to a CT scan of the human body.

Based on a wealth of measurement data, the team was able to create a virtual map of an 8-km by 8-km study area in the subsurface using sophisticated software tools. This revealed, for example, a salt pillow that made its way from deep within the Earth to the surface over millions of years, buckling and fragmenting adjacent layers of sediment as it moved. The new data significantly enhance researchers' ability to interpret structures in a three-dimensional space and thereby strengthen efforts to study and utilize geothermal energy.

Not only can the Earth's subsurface serve as a source of energy, it can store it as well. In November 2017, measurements providing insights into the hydraulic and geothermal properties of the layers of sediment were carried out at an exploratory drilling on the TU Berlin campus. These results can be used to assess whether certain layers would be suitable for the seasonal storage of heat. The experiences gleaned from the measurement project are also being used on an increasing basis for further projects with high-volume seasonal storage systems in urban areas.

GFZ also carried out research activities abroad, including the first geothermal low-temperature demonstration power plant in Indonesia, which was successfully put into operation in the fall of 2017. The plant in the village of Lahendong is run by researchers from Potsdam. There are plans to hand the project over to an Indonesian partner organization in January 2019. The versatile technology used here makes it possible to utilize wet steam reservoirs more efficiently and supply areas that are not connected to the network with decentralized energy.

Additional examples from this Research Field

nologies for centralized and decentralized applications. The strategic research focuses in this program revolve around scientific issues that require highly complex, long-term investigations using the large-scale facilities of the participating Helmholtz Centers.

Storage and Cross-Linked Infrastructures

In order to ensure a successful transition to an energy supply based primarily on renewable sources, highly volatile energy needs to be stored according to demand, and the infrastructure required for the different energy sources must be optimized and more effectively interlinked. This program encompasses the study of energy storage and conversion technologies as well as energy infrastructure. It combines R&D projects on thermal, electrical and chemical energy storage with process development and encompasses the study of distribution and storage infrastructure.

Holger Jorschick in the laboratory facility for chemical hydrogen storage at the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy. Image: FZ Jülich/C. Hesselmann

Forschungszentrum Jülich

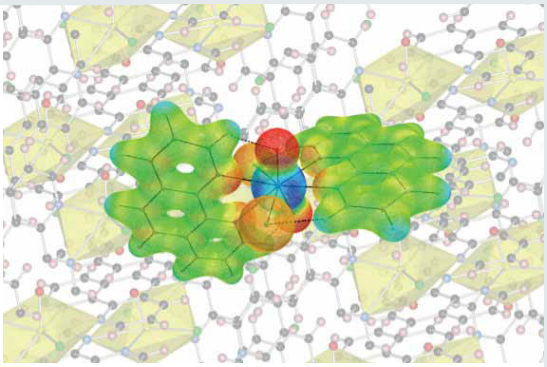
SIMPLIFIED METHOD FOR STORING HYDROGEN

Researchers at Forschungszentrum Jülich and the University of Erlangen-Nürnberg have developed a method that significantly simplifies the storage of hydrogen as a source of energy. This method reduces the technical effort required to chemically bond hydrogen to organic carrier fluids by using a new type of catalyst for the charge and discharge processes. Applying this method in the industrial setting in the future could significantly reduce the cost and energy consumption of hydrogen storage – and could be a vital step for the energy transition.

Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

BENT, NOT STRAIGHT

Chemists at HZDR have created a uranyl compound with a unique basic geometric structure. In normal uranyl complexes, two oxygen atoms and one uranium atom form a linear, stable unit at a 180-degree angle. In the new substance, however, the atoms bend to an angle of 161.8 degrees – one of the smallest documented angles for this molecule thus far. The increased reactivity of the uranium center that comes about as a result of the molecule's structure can be used effectively for future syntheses of new compounds.



The 180-degree angle of the oxygen (red) and uranium (blue) atoms shifts considerably in a new uranyl compound. Image: A. Ikeda-Ohno/HZDR

Graphite tile cladding in the plasma vessel of the Wendelstein 7-X fusion device. Image: IPP, Jan Michael Hosan

Max Planck Institute for Plasma Physics (IPP)

SECOND ROUND OF EXPERIMENTS ON WENDELSTEIN 7-X

Wendelstein 7-X, the world's largest fusion device of the stellerator type, at the Max Planck Institute for Plasma Physics has completed its first planned break for conversions. The plasma vessel has been clad with graphite tiles to make it ready for higher heating power and longer plasma pulses. New heating and measuring apparatuses were also installed. This has enabled researchers to conduct experiments that are confirming initial elements of the plant's optimized concept. Wendelstein 7-X is intended to investigate the suitability of this concept for application in a power plant.

Future Information Technology

Using innovative research approaches, this program aims to develop new components and architectural concepts to increase the computing power, data storage density and data transmission rates of information technology while significantly reducing the demand for electrical energy.

Technology, Innovation and Society

This program encompasses the systematic investigation of the diverse interfaces between technology, innovation and society with the goal of supporting decision-making processes in government, the economy and society. For this purpose it brings together expertise in energy system analysis, technology impact assessment and policy consulting.

Carnot batteries are cycle-proof power–heat–power systems for storing large amounts of electricity.
Image: DLR (CC-BY 3.0)

German Aerospace Center (DLR)

INEXPENSIVE, SITE-INDEPENDENT ENERGY STORAGE SYSTEMS IN THE GIGAWATT RANGE

DLR is developing the Carnot battery, a system for storing energy on the gigawatt-hour scale. Using a high-temperature heat pump, electricity is transformed into heat, which can be inexpensively stored in water (50 °C) or liquid salt (500 °C). The energy can be transformed back into electricity if required. As a result, a cycle-proof energy storage system can be made available at any desired location in the world. DLR is working on this tool for sector coupling together with industry partners.

Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)

HYDROGEN FROM SUNLIGHT: "ARTIFICIAL LEAF" WITH INEXPENSIVE METAL OXIDES

Metal oxides are inexpensive, stable photoelectrodes for splitting water using sunlight. Unfortunately, they exhibit only moderate levels of efficiency, but this can be increased using a heat treatment in a hydrogen atmosphere. An HZB team collaborating with international partners has now discovered that the heat treatment causes hydrogen to permeate the material. This reduces defects and doubles the "lifetime" of charge carriers, thereby boosting efficiency. The team's work has highlighted opportunities for enhancing photoelectrodes of this type.

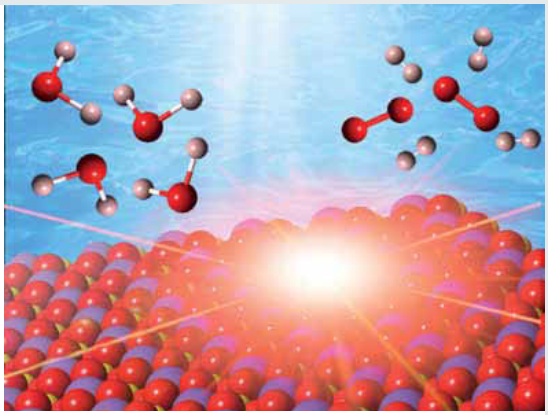


Image: HZB

Image: KIT/PCE

Karlsruhe Institute of Technology (KIT)

SMILES TESTS THE ENERGY INFRASTRUCTURE OF THE FUTURE

As the energy transition progresses, the storage of renewable energy and its integration in decentralized networks is becoming increasingly important. Coordinated by KIT, the SmILES (Smart Integration of Energy Storages in Local Multi Energy Systems) project is linking expertise and research projects from European partners involved in the simulation, optimization, and utilization of such an infrastructure. The goal is to set up a platform where data and best practices relating to the integration of diverse energy sources and storage technologies can be exchanged.

Nuclear Waste Management, Safety and Radiation Research

This program pursues technically coherent, effective research strategies that support the national goal of phasing out nuclear power. It concentrates on problems related to the final disposal of radioactive waste, nuclear reactor safety and the complete phase-out of nuclear power.

Nuclear Fusion

As a nearly inexhaustible, safe and CO_2-free energy source, fusion has the potential to contribute significantly to meeting the world's growing energy needs by mid-century. The goal of this program is to provide a foundation for developing and constructing a fusion power plant. ITER and Wendelstein 7-X are two of the central projects that will continue to dominate fusion research over the next 20 to 30 years.

RESEARCH FIELD EARTH AND ENVIRONMENT

PROFESSOR REINHARD F. J. HÜTTL
Vice-President of the Helmholtz Association,
Coordinator for the Research Field Earth and Environment,
Helmholtz Centre Potsdam – GFZ
German Research Centre for Geosciences

THE MISSION

The Helmholtz scientists involved in the Research Field Earth and Environment examine the basic functions of the Earth system and the interactions between nature and society. They focus on expanding and interconnecting long-term observation systems, improving predictions, and making findings quickly available to society. The researchers also formulate knowledge-based policy recommendations on how the Earth's resources can be used in a sustainable fashion without destroying the foundations of life. For example, REKLIM, a Helmholtz climate initiative, is pooling the expertise of nine Helmholtz Centers in order to improve regional and global climate models. Another important goal is to establish and operate infrastructure and facilities such as the HALO research aircraft and the TERENO network, for which terrestrial observatories have been set up in four selected regions of Germany thus far. As part of the COSYNA project, a long-term observation system will be set up for the German North Sea and later extended to Arctic coastal waters.

PROGRAM STRUCTURE IN THE CURRENT FUNDING PERIOD

Eight Helmholtz Centers are currently involved in the Research Field Earth and Environment. The research is currently subdivided into five programs:

- Geosystem: The Changing Earth
- Marine, Coastal, and Polar Systems
- Oceans
- Atmosphere and Climate
- Terrestrial Environment

OUTLOOK

To meet all these challenges, the Research Field Earth and Environment will continue to pool the capacities of the participating Centers in joint interdisciplinary activities. This strategy allows them to establish new alliances and facilitates the expansion of Earth observation and knowledge systems as well as integrated modeling approaches. The interdisciplinary "Earth System Knowledge Platform – Observation, Information, and Transfer" integrates the knowledge acquired by all of the Centers and their external partners in this Research Field. Its goal is to help society cope with the complex challenges brought about by changes in the Earth system.

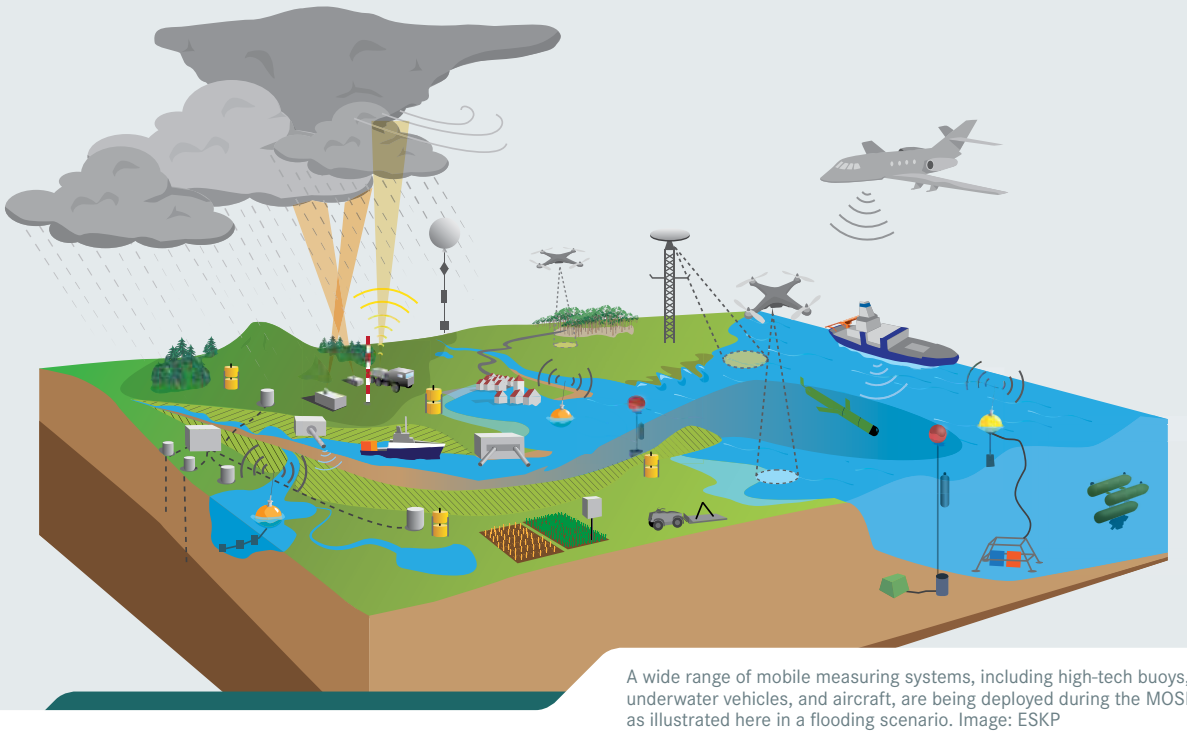
PROGRAMS IN THE 2014–2018 FUNDING PERIOD

Geosystem: The Changing Earth

This program analyses processes in the geosphere and their interaction with the hydrosphere, atmosphere and biosphere. Goals include monitoring, modeling, understanding and evaluating key processes, creating solutions and strategies to prevent disasters and developing geotechnologies for the utilization of subterranean space. To attain these goals the program relies on satellite missions, airborne systems, global geophysical and geodetic networks, regional observatories, deep drilling rigs and mobile instrument pools.

Marine, Coastal and Polar Systems

This program concentrates on a variety of topics, including changes in the Arctic and Antarctic, the interaction between these changes and the global climate and polar



A wide range of mobile measuring systems, including high-tech buoys, drones, underwater vehicles, and aircraft, are being deployed during the MOSES project, as illustrated here in a flooding scenario. Image: ESKP

Helmholtz Centre for Environmental Research – UFZ

MOSES: IN THE RIGHT PLACE AT THE RIGHT TIME

Over the next five years, nine Helmholtz Research Centers collaborate to create a flexible, mobile measuring system for Earth observation. This system is called MOSES – Modular Observation Solutions for Earth Systems. Researchers want to use it to investigate how highly dynamic short-term events influence long-term environmental developments: What impact do heat waves and droughts have on vegetation and air quality? How do flooding and low water conditions change water quality, ecosystems, and coastal areas? How do ocean eddies influence the marine energy transport and food chains? What are the causes and effects of abrupt thawing of permafrost soils? Up until now, researchers have been unable to find satis-factory answers to questions such as these. MOSES aims to bridge this gap and record changes in the Earth system on various spatial and temporal scales in the future. To this end, Helmholtz is investing nearly 28 million euros in setting up the research infrastructure for this project. MOSES is being coordinated at the Helmholtz Centre for Environmental Research – UFZ in Leipzig.

The system's observation concept is based on the interaction between event-oriented measuring systems that can be deployed on a short-term basis and monitoring programs designed for long-term use. Sensor systems based on combinations of various modules can be assembled to form multi-parameter networks and research platforms tailored to the specific event and site. In addition to developing new measuring instruments, existing technology is set to be adapted, miniaturized, or automated. For example, the size of some instruments needs to be significantly reduced so they can fit on carrier systems such as drones or miniature balloons: "Gliders," which are able to work autonomously while taking samples in varying water depths, are equipped with multi-parameter sensor systems, for example – as are underwater vehicles, which are intended to independently navigate along a prescribed course through the sea in the future. The observation data for the project's long-term development is taken from existing national and international monitoring programs. These include, for example, ICOS (Integrated Carbon Observation System), LTER (Long-Term Ecological Research), and Helmholtz observatories such as TERENO (Terrestrial Environmental Observatories), COSYNA (Coastal Observing System), CVOO (Cape Verde Ocean Observatory), the SAMOYLOV Permafrost Observation Station, and satellite missions like GRACE (Gravity Recovery and Climate Experiment).

Additional examples from this Research Field

ecosystems, vulnerable coasts and shelf seas, the polar perspective of Earth system analysis, and the interplay between science and society. It provides insights into climate variability and regional climate change, sea-level change as an element of risk analysis within the Earth system, and the transformation of coastal and polar ecosystems. The program is also providing a scientific foundation for assessing the social and economic consequences of climate change in our living environments. Research into the interaction between science and society focuses on how findings can be effectively integrated into information and decision-making processes in society as a whole.

Oceans

Oceans cover 70 per cent of the Earth's surface. Deep oceans, in particular, are difficult to reach and remain largely unstudied. This interdisciplinary program is examining the physical, chemical, biological and geological processes in

Ice drift and chemical fingerprints provide indications regarding the region in which pollution originated.
Image: Alfred Wegener Institute/Stefan Hendricks

Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)

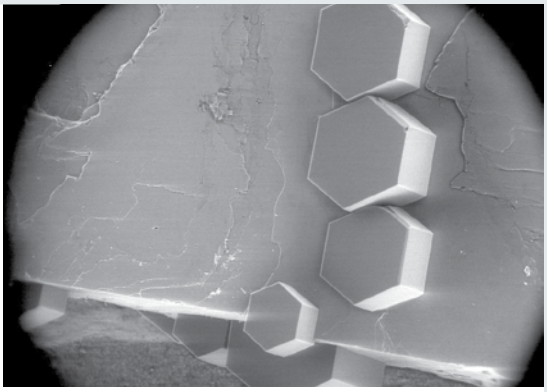
RECORD CONCENTRATION OF MICROPLASTICS IN ARCTIC SEA ICE

Researchers at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), have found higher amounts of microplastics in arctic sea ice than ever before. The ice samples contained more than 12,000 microplastic particles per liter of sea ice in some cases. These plastic particles can be traced back to a wide variety of sources, including the Great Pacific Garbage Patch. The high proportion of paint and nylon particles also points to intensified shipping and fishing activities in the Arctic Ocean.

Karlsruhe Institute of Technology (KIT)

CLOUD FORMATION: FELDSPAR AS AN ICE NUCLEUS

Around 90 percent of precipitation that occurs over land depends on the formation of ice crystals in clouds, which then fall to Earth due to their increasing weight. However, the water only freezes when certain rare particles of dust are present. These microscopic ice nuclei are often made of feldspar. Researchers at KIT and University College London have now succeeded in demonstrating that ice starts to grow not on the feldspar's externally accessible crystalline faces, but rather on microscopic defects like edges, cracks, and depressions.



Ice crystals on a feldspar crystal as seen under an electron microscope. Image: Alexei Kiselev, Dagmar Gerthsen/KIT

The ICOS research infrastructure makes it possible to study the exchange of greenhouse gases between the soil and atmosphere. Image: Forschungszentrum Jülich

Forschungszentrum Jülich

CHANGING SOILS

So far, it has proven difficult to calculate the extent to which green plants slow the increase of the CO_2 greenhouse gas in the atmosphere. Researchers led by Jülich-based agrosphere expert Alexander Graf and supported by the BMBF studied the exchange of greenhouse gases between the ground surface and the atmosphere and determined the CO_2 footprint of two fields that were farmed using different methods: The field in which catch crops were cultivated absorbed around 60 percent more CO_2. Measurements taken with the ICOS (Integrated Carbon Observation System) research infrastructure are intended to supply additional data.

oceans as well as the interactions between these processes and the ocean floor and the atmosphere. Its goal is to investigate the role of oceans in climate change, human impact on marine ecosystems, the possible use of the oceans' biological, mineral and energy resources, and the potential risks of geodynamic processes in the oceans and deep seas.

Atmosphere and Climate

The goal of this program is to better understand the function of the atmosphere within the climate system. To this end scientists are carrying out extensive measurements of atmospheric parameters, performing laboratory tests and creating numerical models of processes that play an important role in the atmosphere. Focuses include high-resolution satellite measurements of tropospheric trace gases, the role of the middle atmosphere in the climate system, the variability of biogenic emissions and the use of atmospheric water isotopes to gain a better understanding of the water cycle.

The Cape Verde Ocean Observatory (CVOO) helped to identify the oxygen-free eddies. Image: Toste Tanhua/GEOMAR

GEOMAR Helmholtz Centre for Ocean Research Kiel

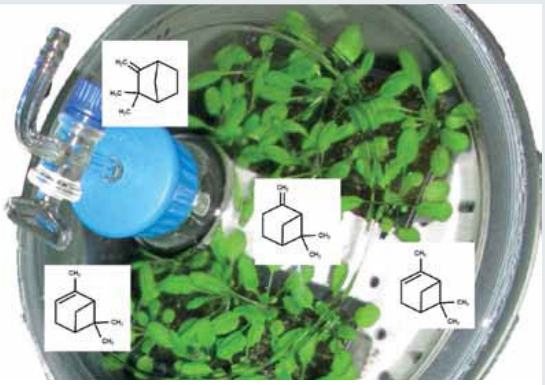
MOBILE DEAD ZONES IN THE ATLANTIC

Ocean eddies measuring 100 to 150 kilometers continually form off the coast of West Africa and slowly migrate westward across the Atlantic. Researchers at the GEOMAR Helmholtz Centre for Ocean Research Kiel have now succeeded in directly sampling these eddies for the first time. They established that the oxygen content inside the eddies is nearly zero. During the further evaluation of the data, the project's participants verified processes that had not been observed in the Atlantic prior to this. These also included the natural production of significant quantities of greenhouse gases.

Helmholtz Zentrum München – German Research Center for Environmental Health

HOW PLANTS USE SCENTS TO RESIST DISEASES

Volatile monoterpenes, which give spruce needles their scent, activate an immune response in plants that have been infected with bacteria. This immune response simultaneously issues a warning signal for neighboring plants. Working groups from the Institute of Biochemical Plant Pathology at the Helmholtz Zentrum München were able to prove this response for the first time based on *Arabidopsis thaliana* as a plant model. The effect that this scent has as a volatile immune signal could enable new approaches for protecting plants in the future, including those that combat bacterial pathogens and fungi.



Arabidopsis thaliana in a desiccator with monoterpenes (inserted as chemical formulas). Image: HMGU

The East African Rift is currently the largest rift system on Earth. Image: S. Brune, Nasa WorldWind

Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

WHEN CONTINENTS BREAK, THE EARTH HEATS UP

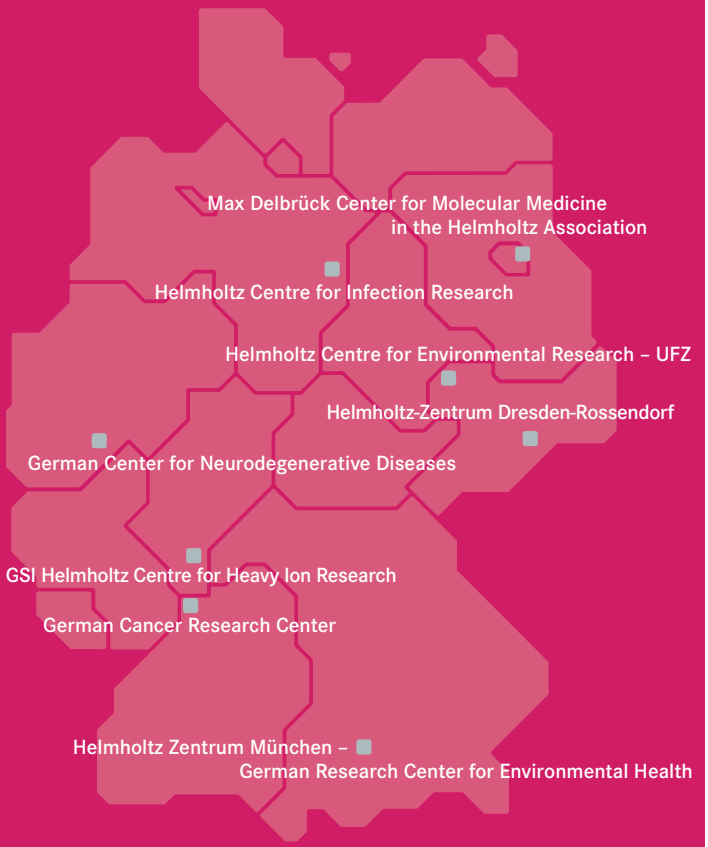
The concentration of CO_2 in the atmosphere plays a key role in climate change. Before humans began to have an impact on the amount of CO_2, quantities were determined solely by natural processes. One significant source of carbon was volcanic activity along mid-oceanic ridges, which resulted in the release of CO_2 from the depths of the ocean to the surface. Researchers at GFZ have now demonstrated that even more CO_2 is emitted at "rift zones," where continents break apart – for example in East Africa or the Eger Graben. However, this relates to geological periods of time. The current anthropogenic amount of CO_2 released is significantly greater by comparison.

Terrestrial Environment

The goal of this program is to preserve the natural foundations of human life and health. It is concerned with the effects of global and climate change on terrestrial environmental systems and formulates strategies for managing sustainable social and economic development. Research ranges from the micro to the global level, often emphasizing selected regions and landscapes because it is here that environmental problems become directly visible and management options can be identified. Program topics include land use, biodiversity, ecosystem services, plant growth, water resource management, the assessment and reduction of risks associated with chemicals in the environment, as well as observation platforms and integrated modeling.

RESEARCH FIELD HEALTH

PROFESSOR PIERLUIGI NICOTERA
Vice-President of the Helmholtz Association,
Coordinator for the Research Field Health
German Center for Neurodegenerative
Diseases (DZNE), Bonn



THE MISSION

The scientists involved in the Research Field Health at Helmholtz study the causes and development of major widespread diseases such as cancer, dementia, diabetes, cardiovascular, metabolic, lung, and infectious diseases as well as allergies. Building on a strong foundation of basic research, their shared objective is to elaborate new approaches for the evidence-based prevention, diagnosis, early detection, and individualized treatment of common diseases. Research into complex and often chronic illnesses requires interdisciplinary approaches, which are being pursued by the Helmholtz Centers in cooperation with partners from medical schools, other research organizations, and industry. As a partner to the German Centres for Health Research initiated by the Federal Ministry of Education and Research, Helmholtz aims at making research findings more rapidly available for clinical applications and individualized medicine.

PROGRAM STRUCTURE IN THE CURRENT FUNDING PERIOD

Eight Helmholtz Centers collaborate in the Research Field Health. During the current program period, they are active in the following five programs:

- Cancer Research
- Cardiovascular and Metabolic Diseases
- Infection Research
- Disorders of the Nervous System
- Genetic and Environmental Influences on Common Diseases

OUTLOOK

The long-term goal of Helmholtz health research is to improve medical care and quality of life for the population into old age by developing new preventive measures as well as earlier and more precise diagnostics and highly effective treatments. The “National Cohort” (NAKO) health study, which was initiated by Helmholtz and represents the largest nationwide, population-based health study in Germany, will continue to foster new approaches for assessing individual risk factors and developing personalized prevention strategies.

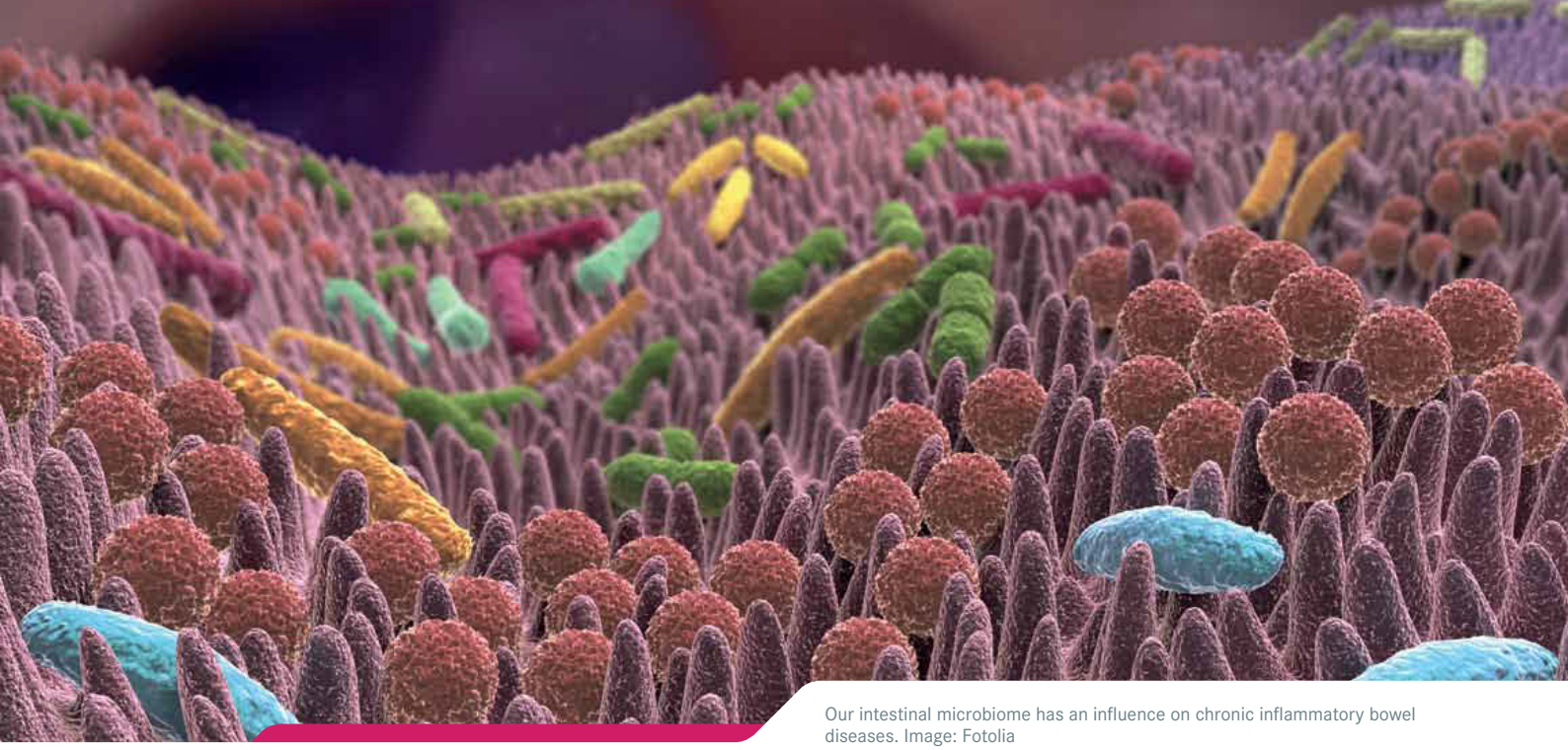
PROGRAMS IN THE 2014–2018 FUNDING PERIOD

Cancer Research

The goal of this program is to significantly improve the prevention, early detection, diagnosis and treatment of cancer. To this end it is developing new diagnostic and individualized therapeutic procedures on the basis of molecular, cell-biological, immunological and radio-physical findings and technologies. It is pushing ahead with the translation of basic research findings into clinical applications in collaboration with strategic partners. The National Center for Tumor Diseases in Heidelberg and Dresden and the German Consortium for Translational Cancer Research, which is active across Germany, play a key role in these efforts.

Cardiovascular and Metabolic Diseases

This program focuses on the causes and pathophysiological links of cardiovascular and metabolic disease, which



Our intestinal microbiome has an influence on chronic inflammatory bowel diseases. Image: Fotolia

Helmholtz Centre for Infection Research (HZI)

INTESTINAL FLORA AS A CAUSE OF CHRONIC INFLAMMATION

Under the right circumstances, more than 1,000 kinds of different bacteria live in the intestinal microbiome in peaceful coexistence with their human host, promote digestion, and even support the proper functioning of the immune system. However, this is not the case for patients with intestinal disorders such as Crohn's disease or ulcerative colitis: Studies have shown that these individuals' intestines exhibit reduced microbial diversity and alterations in the composition of the communities. This has been linked to an overreaction of the immune system to the bacteria in the intestine of genetically susceptible individuals and eventually to chronic inflammatory bowel disease. Some 300,000 people suffer from this condition in Germany. Unfortunately, no curative treatment is currently available, only symptom-based care. The medication provided typically consists of immune suppressants, which often make these individuals more susceptible to infections.
Based on experiments on mice, researchers at the Helmholtz Centre for Infection Research (HZI) have now shown that different types of alterations in the microbiome promote intestinal inflammation via different arms of the immune system. "The severe inflammatory reactions in the intestine are triggered by certain microbial communities. In order to recommend appropriate treatment, it is important to understand whether the existing microbial community is stimulating the innate or acquired immune system to produce a response and inflammation," says Professor Till Strowig, head of the department "Microbial Immune Regulation" at the HZI. The researchers succeeded in finding evidence of these correlations in immune-deficient mice, in which vital molecular switches for the immune system were disabled. These findings are relevant in terms of treating the disease in affected individuals, because modern treatment approaches rely on so-called biologicals, which block individual molecules and thereby exert a targeted influence on the immune system.
"In the future, we want to gain a more detailed understanding of which individual types of bacteria are responsible for the various types of chronic inflammatory bowel diseases," says Strowig. The researchers therefore search for additional ways of blocking and controlling misdirected immune responses and are exploring novel ways to properly stimulate the immune system to prevent infections in immunocompromised individuals via manipulations of the microbiome. Extensive cohort studies must still be carried out in order to arrive at a clinical application and treatment recommendation.

Additional examples from this Research Field

are studied at the cellular, genetic and epigenetic levels. In addition, it investigates the interaction between these factors and environmental causes. The findings are used to develop new diagnostic, preventive and therapeutic strategies. The program takes a translational approach to the topic with the goal of transforming new results into clinical applications as quickly as possible.

Infection Research

This program concentrates on the molecular mechanisms responsible for the development and course of infectious diseases. Knowledge about the interactions between hosts and pathogens is providing a foundation for the elaboration of new prevention and treatment strategies. Focuses include the study of newly emerging infectious diseases, the identification of new drugs to overcome pathogen resistance, the relationship between infection and age, as well as diagnostics for personalized therapies. An important role is played by post-infection diseases such as cancer, metabolic dysfunction, neurodegeneration and chronic infections.

Image: NCT Dresden/P. Benjamin, A. Bandurska-Luque

Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

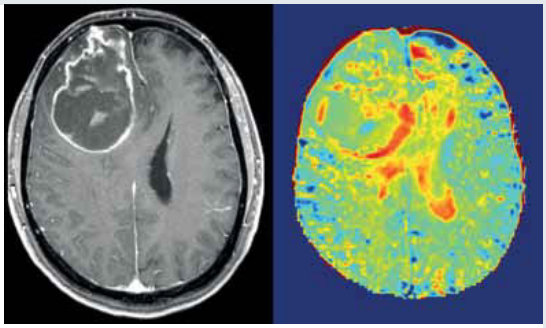
TOWARD INDIVIDUALIZED CANCER TREATMENT

Combining the positron emission tomography imaging method with FMISO, a molecule labeled with a radioactive tracer, makes it easier to predict the outcome of treatment in patients with head and neck tumors. The timing of the examination plays a crucial role here, as demonstrated by researchers at the HZDR during a cooperative project. Images recorded in the second week after the start of treatment are the most conclusive. Based on the prognosis, doctors are able to tailor cancer therapies on a more individual basis.

German Cancer Research Center (DKFZ)

MRI WITH A SUGAR SOLUTION

Researchers at DKFZ and Heidelberg University Hospital have succeeded in detecting brain tumors using a new MRI procedure that involves a simple sugar solution rather than the usual contrast agent. Around five sugar cubes are sufficient to observe a change in the glucose signal in cancer foci when using a seven-Tesla high field MRI scanner. Tumor areas that are growing particularly aggressively can even be identified. This procedure makes it possible to take measurements via a selective strengthening of the glucose signal – without exposing patients to radiation.



Brain tumor with conventional, contrast-enhanced MRI (left) and with glucose MRI (right). Image: D. Paech/DKFZ

Image: Roland Gockel/MDC

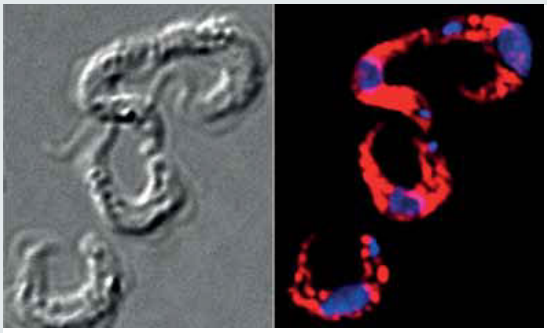
Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC)

HOW NAKED MOLE-RATS RESIST ANOXIA

When naked mole-rats lack air to breathe in their dens, they are able to temporarily supply organs like the heart and brain with energy without relying on oxygen. They do this by switching their metabolism from glucose to fructose, according to a paper in the scientific journal Science written by Gary Lewin's team at the Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC). As a result, the animals do not suffer any damage. This mechanism also has the potential to protect patients against the consequences of hypoxia caused by a heart attack or stroke.

Disorders of the Nervous System

The goal of this program is to study the causes of nervous system disorders and to create more efficient methods for their prevention, diagnosis, treatment and care. Research is focused primarily on major neurodegenerative diseases such as Alzheimer's and Parkinson's, but also addresses less common disorders such as Huntington's chorea, amyotrophic lateral sclerosis and prion diseases. In addition, scientists are studying diseases that may in part be based on similar pathological processes or that are often associated with well-known neurodegenerative diseases. In order to develop better strategies for diagnosis, treatment and care, it is necessary to learn more about the mechanisms of a disease and the brain's response.



Trypanosomes under a transmitted-light microscope (left) and under a fluorescence microscope (right). The glycosomes (red), which are targeted by the substance, and the DNA of the parasites (blue) are shown in color. Images: Prof. Dr. Ralf Erdmann and Dr. Vishal Kalel, Ruhr University Bochum

Helmholtz Zentrum München – German Research Center for Environmental Health

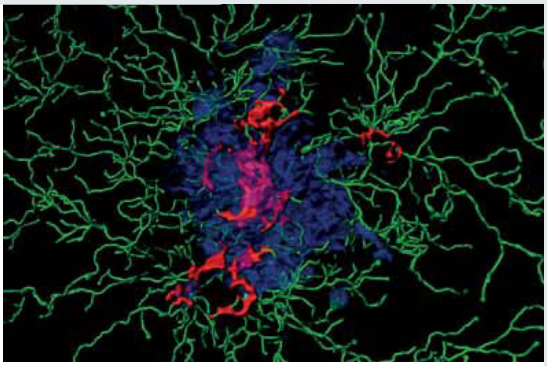
NEW SUBSTANCE TO COMBAT SLEEPING SICKNESS

Researchers at the Helmholtz Zentrum München have developed a new therapy approach which uses a targeted method to kill the pathogen that causes sleeping sickness. As reported in Science magazine, the team led by Michael Sattler and Grzegorz Popowicz first used cutting-edge methods from the field of structural biology to identify a molecular Achilles heel of the parasite, the so-called PEX protein. They then collaborated with international partners to develop a substance that inhibits the interaction necessary for the parasite's survival.

German Center for Neurodegenerative Diseases (DZNE)

IMMUNE MECHANISMS OF NERVOUS DISEASES

Researchers at DZNE have proven that immune mechanisms play a major role in the development of Alzheimer's disease. According to their research, the "NLRP3 inflammasome" – a sensor of the innate immune system – promotes the deposit of damaging proteins in the brain. A further study shows that a diet high in fat and calories activates the inflammasome and increases the immune system's susceptibility over the long term due to genetic reprogramming. This can contribute to the development of chronic inflammatory diseases – especially neurodegenerative disorders.



Computer visualization of protein deposits in the brain. Image: Dario Tejera, University of Bonn

Image: Rico Best/Fotolia

Helmholtz Centre for Environmental Research – UFZ

DIESEL BAN FOR BETTER AIR QUALITY?

A large share of anthropogenic nitrogen oxide emissions are produced by diesel road traffic in cities that do not have a significant inland shipping sector. Epidemiological studies show that these emissions represent an additional health risk. Small-scale driving restrictions can reduce emissions on streets where levels are particularly high and provide relief for groups of people who are most affected by them. However, reducing air pollution caused by particulate matter – in which other sources such as small heaters frequently play a prominent role – is more significant in terms of public health.

Genetic and Environmental Influences on Common Diseases

This program focuses on major common diseases such as diabetes, pulmonary illness and allergies. Like cardiovascular disease, cancer and disorders of the nervous system, these diseases have diverse causes and result from the interplay of genetics, environmental factors and personal lifestyles. Due to changing living conditions and longer life expectancies, they are becoming increasingly prevalent. The program deals with the influence of genes and environmental factors on human health. It is essential to clarify the interactions between the organism and environmental factors in order to develop strategies and procedures for the personalized prevention, early detection, diagnosis and treatment of chronic diseases.

RESEARCH FIELD AERONAUTICS, SPACE, AND TRANSPORT

PROFESSOR PASCALE EHRENFREUND
Vice-President of the Helmholtz Association,
Coordinator for the Research Field Aeronautics, Space,
and Transport, German Aerospace Center (DLR)

THE MISSION

The scientists involved in the Research Field Aeronautics, Space, and Transport address the major challenges facing our society today, primarily in the areas of digitalization, improved energy efficiency, smart mobility, climate monitoring, and approaches to big data and cyber security. The Research Field covers the entire innovation chain from basic research to preliminary marketable products. In doing so, it exploits the synergy potential and systems assessment capacity offered by the German Aerospace Center (DLR) thanks to its 40 institutes and facilities.

PROGRAM STRUCTURE IN THE CURRENT FUNDING PERIOD

The German Aerospace Center (DLR) is the only Center active in this Helmholtz Research Field. Its work is divided into the following programs:

- Aeronautics
- Space
- Transport

OUTLOOK

The German Aerospace Center's 2030 Strategy aims to strengthen its core competencies and use internal synergy potentials in a more targeted way. In doing so, it is striving to enhance its leading position to the benefit of society and the economy. Key milestones include establishing an area dedicated to digitalization, further expanding the seven new DLR institutes, and implementing ten interdisciplinary projects, for example on the topics of cyber security for autonomous and networked systems or Transport 5.0. One of the major challenges in the Research Field Aeronautics, Space, and Transport is developing green technologies that are to be used in electric aviation applications or in the area of climate-neutral fuels, for example. Thanks to satellite-based Earth observation and the evaluation of (geo) information, the Research Field will continue to make a significant contribution to the modeling of the Earth system and global climate change in the future.

PROGRAMS IN THE 2014–2018 FUNDING PERIOD

Aeronautics

The significant increase in air transport over recent decades is likely to continue. In Europe, policymakers, representatives of industry and scientists have already agreed on a common research agenda that establishes basic conditions for Helmholtz research. Its goals are an expansion of the capacity of the air transport system, greater cost-effectiveness at the developmental and operational levels, a reduction of aircraft noise and harmful emissions, enhanced attractiveness of air travel for passengers, and higher safety standards. Within this framework researchers are working on concrete developments for the next generation of aircraft and investigating ideas and concepts for future air transport systems. A key aspect of the research agenda is its comprehensive perspective. At the same time, the Helmholtz program places a strong emphasis on application-oriented research. Four research topics address the basic sectors of

Converted into a flying lab, NASA's DC-8 "sniffs" the exhaust stream of the DLR's ATRA. Image: DLR (CC-BY 3.0)

German Aerospace Center (DLR)

TEST FLIGHTS TO ASCERTAIN THE IMPACT OF BIOFUELS ON THE ATMOSPHERE AND CLIMATE

In January and February 2018, the skies over Mecklenburg-Vorpommern in northern Germany were the site of one-of-a-kind test flights. These consisted of an airborne chase to gather research data. The aim was to study the emissions produced by alternative fuels and their impact on the formation of clouds from contrails – and therefore their effect on climate. This project marked the first time that DLR and NASA conducted joint test flights in Germany.

DLR's A320 ATRA (Advanced Technology Research Aircraft) flew with various fuel mixtures, while NASA's DC-8 "flying lab" pursued it and was immersed in the ATRA's exhaust stream. A wide range of measuring devices from DLR were on board the NASA aircraft: These were used to precisely measure the size distribution of soot and ice particles as well as the gaseous emissions in the ATRA's wake. The researchers were particularly interested in seeing how the soot emissions from the various fuels affected the formation of contrails. The first DLR/NASA flights conducted in 2014 in Palmdale, California, showed that adding 50 percent alternative fuel for cruising flight reduces the soot particle emissions of an aircraft engine by 40 to 60 percent compared to the combustion of pure kerosene. Special fuel blends with a 30 to 50 percent share of added HEFA were produced for the three-week flight campaign, which involved eight flights from Ramstein Air Base in Rhineland-Palatinate in 2018. HEFA (hydroprocessed esters and fatty acids) is a biofuel derived primarily from the oil of camelina plants and was used as an example of alternative fuels, which could also be synthetic. Because HEFA contains no cyclic hydrocarbons, the formation of soot is reduced during combustion. This suggests that the number of ice crystals in contrails would decrease accordingly, thereby resulting in the formation of fewer cirrus clouds as well. The warming effect these cirrus clouds have on the Earth's atmosphere is likely to be greater than a local cooling effect depending on the position of the Sun and the characteristics of the ground. The evaluation of the results at the end of 2018 will shed light on the effect of biofuels on contrails, which is essential for assessing the climatic impact of aviation.

Additional examples from this Research Field

civil aviation: airplanes, helicopters, propulsion systems and air traffic/air safety. This work is being carried out above all in interdisciplinary projects. The digitalization of the field of aeronautics is playing a central role with the aim of establishing a design environment for virtual product development. With this in mind, four new institutes were recently established in which methods, tools, and processes are integrated and developed. These are used for applications ranging from creating a virtual model of the product ("digital thread" and "digital twin") to virtual certification.

Space

The overarching objective of space research at the DLR is to find socially beneficial applications for astronautics. Scientific insights gained from the investigation of the Earth and the universe, as well as from research under space conditions, inform both commercial ventures and government projects. In this context precedence is given to the needs of wider society, and our research accordingly addresses topics such as the rapid response to crises, the provision of precise navigation systems, rapid data acquisition, climate monitoring systems, land

Berlin Police's bike squadron also received a cargo bike. Chief Police Commissioner Kay Biewald during a test drive on April 3, 2018. Image: DLR (CC-BY 3.0)

German Aerospace Center (DLR)

TAKING THE LOAD OFF CITIES

Researchers at DLR investigate how cargo bikes can relieve motorized traffic in urban areas as part of the "Ich entlaste Städte" ("Taking the load off cities") mobility project being conducted across Germany until 2019. Based on questionnaires and analyses of cycle trips, the team wants to provide evidence that cargo bikes are suitable for everyday use. Several hundred companies and institutions that use the cargo bikes for commercial transportation purposes participate in the project. The project began in September 2017 and is capable of covering a broad range of transport requirements thanks to 17 different models thus far.

German Aerospace Center (DLR)

HAMMERING DOWN INTO THE DEPTHS OF MARS

On May 5, 2018, NASA launched the InSight probe, an exploratory mission designed to study the interior of the planet Mars. DLR contributes to one of the three main experiments by providing the HP^3, a small hammering probe. After InSight landed on 26 November 2018, the HP^3 will hammer into Mars' soil to a depth of five meters and measure the temperature and thermal conductivity at various depths. This resource-saving key technology developed by DLR is already being used in road construction in China, for agricultural applications in Poland, and avalanche surveillance in Switzerland.

The NASA InSight probe with DLR's HP^3 instrument in the lower right corner of the image. Artistic representation: NASA/ JPL-Caltech.

On the Jenny's navigation bridge: The system and its new assistance functions relieve skippers. Image: DLR (CC-BY 3.0).

German Aerospace Center (DLR)

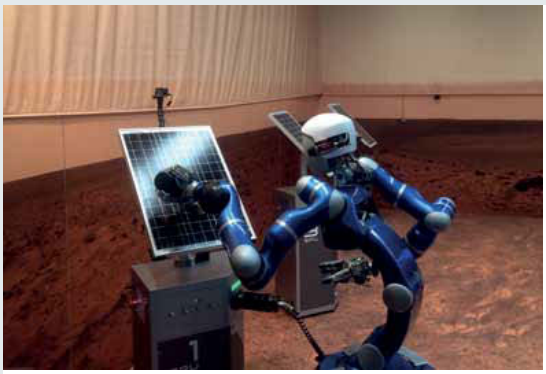
BASIC TECHNOLOGIES FOR AUTONOMOUS INLAND NAVIGATION

Researchers from DLR covered 20 kilometers and passed 12 bridges as they traveled along the River Main on the MS Jenny on March 22, 2018. The voyage on the inland vessel was testing a new assistance system developed in the course of a joint project called LAESSI. The system includes track control and mooring assistance features, a bridge warning function, as well as a conning display. These features are provided based on the highly accurate determination of the ship's position, height, and direction via satellite navigation.

use geared to the preservation of resources, and civil security. The work of the DLR is supported by a modern infrastructure that is constantly being adapted to the needs of researchers. It aims to develop innovative technologies, systems and operating procedures that will improve the competitiveness of German industry as regards astronautic applications and markets. The program is oriented towards the German government's space strategy and has been tasked with developing the required technological foundations for new space missions and the collection and analysis of data. Research topics include Earth observation, communications, navigation, space exploration, research under space conditions, space transport and space systems technology, including robotics.

Transport

Ensuring mobility in the future is a central challenge. For many years now, the traffic capacity for passengers and goods has been expanding. However, there is an ongoing



DLR's Justin robot cleans solar panels on Earth. Assignments for such tasks are issued by the ISS. Image: DLR (CC-BY 3.0)

German Aerospace Center (DLR)

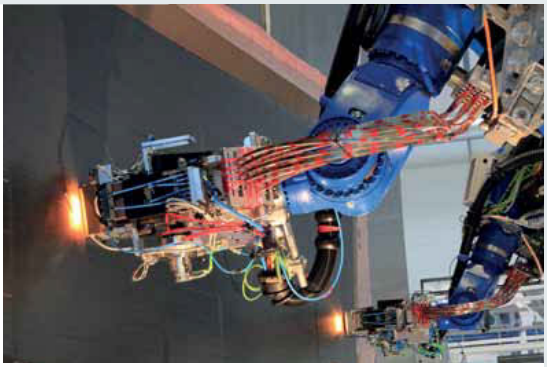
HORIZONS – KNOWLEDGE FOR HEALTH, ENVIRONMENT, AND INDUSTRY

On June 6, 2018, Alexander Gerst embarked on his journey to the ISS, where he carried out the "Horizons – Knowledge for Tomorrow" mission. His agenda included 151 experiments related to health, environment, and climate. Fifty of these experiments were set up by German institutions, including many from DLR. In addition to a smart astronaut assistant on board, a robot back on earth is waited for incoming commands from the team up in space and completed tasks autonomously. Research into aerogels and plasmas will support technological advances in industry.

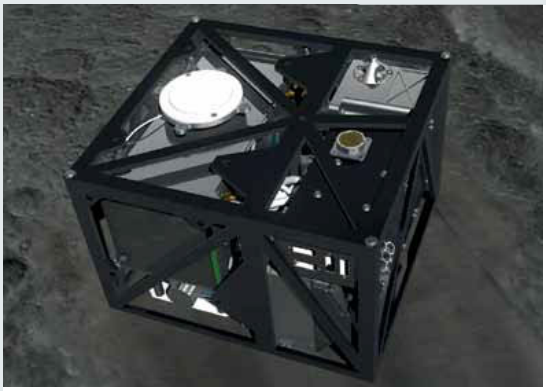
German Aerospace Center (DLR)

SYNCHRONOUS PRODUCTION OF LIGHTWEIGHT WINGS

Lightweight – and therefore fuel-saving – wings made from carbon fiber reinforced plastic (CFRP) are already being used in the quiet and fuel-efficient Airbus A350. But their production is still very time-consuming, because only one robot laying unit stacks carbon fibers layer by layer until a wing shell is formed. As part of the joint project EWiMa (Efficient Wing Cover Manufacturing), scientists at DLR demonstrated how two robots working in parallel without colliding could halve the production time.



Two robotic units with overlapping working areas simultaneously lay fibers on a wing shell tool. Image: DLR (CC-BY 3.0)



MASCOT (Mobile Asteroid Surface Scout) is a highly-integrated asteroid lander. Image: DLR (CC-BY 3.0).

German Aerospace Center (DLR)

MOMENT OF TRUTH FOR MASCOT ASTEROID LANDER

The MASCOT asteroid lander became active in 2018. After the Japanese space probe Hayabusa 2 landed on Ryugu on 3 October 2018, the small lander, whose development was coordinated by DLR, examined the asteroid using four observation devices and a hopping mechanism to move around. Hayabusa 2 is scheduled to return to Earth with probes at the end of 2020. The goal of the mission is to learn more about the development of our solar system. Asteroids offer a glimpse into the history of the cosmos.

conflict between the individual desire for unlimited mobility, on the one hand, and overburdened transport systems, the negative effects of traffic on people and the environment, and the large number of accident victims, on the other. The world requires modern transport systems for people and goods that are sustainable over the long term from an economic, ecological and social perspective. Transport experts at the DLR are utilizing the extensive potential for synergies between aeronautics, space and energy research to respond to these challenges. Research and development in this area are focusing on terrestrial vehicles, traffic management and the traffic system as well as on the cross-sectional topics electromobility and urban mobility. Scientists are developing concepts for next-generation cars, utility vehicles and trains with the aim of reducing both energy use and noise and improving safety and comfort.

RESEARCH FIELD MATTER

PROFESSOR HELMUT DOSCH
Vice-President of the Helmholtz Association,
Coordinator for the Research Field Matter,
Deutsches Elektronen-Synchrotron DESY

THE MISSION

Helmholtz researchers explore the constituent parts of matter and the forces operating between them on a wide range of levels, from elementary particles to complex functional materials to the systems and structures in the universe. Their work provides the basis not only for a better understanding of our universe but also for the design of materials and active substances to be used in medicine and industry. Important areas of research include the development, construction, and operation of research infrastructure and large-scale scientific devices. For all the areas of this Research Field, Helmholtz provides researchers from Germany and abroad with access to a variety of unique, large-scale scientific facilities, including detectors, complex data acquisition systems, and particle accelerators. Scientific work began at the European XFEL, the most sophisticated X-ray laser in the world, in mid-September 2017. This is one of the two largest, accelerator-based radiation sources in Germany, along with the Facility for Antiproton and Ion Research (FAIR).

PROGRAM STRUCTURE IN THE CURRENT FUNDING PERIOD

Seven Helmholtz Centers are currently working together in three programs dedicated to research into matter:

- Matter and the Universe
- From Matter to Materials and Life
- Matter and Technologies

OUTLOOK

The Research Field Matter has commenced the third period of program-oriented funding with a thematically oriented structure. The Association's large-scale research infrastructure and scientific facilities have been assigned to the relevant program themes, and these research facilities form the foundation of the scientific work within the research field. Strategic considerations regarding the research facilities are of great importance and inform the development of thematic strategies by the Helmholtz Centers. For example, the second program period saw the development of a roadmap for neutron research as well as preparatory work on the development of roadmaps for research into astroparticles and photons. The Research Field Matter has thereby initiated a process aimed at coordinating strategic development across the Association's Centers in the coming years. This will ensure that synergies between their individual research plans are identified and optimally utilized.

PROGRAMS IN THE 2015–2019 FUNDING PERIOD

Matter and the Universe

This program combines particle and astroparticle physics, the physics of hadrons and nuclei, and atomic and plasma physics in order to answer fundamental questions about the origin, structure and development of the universe. It also investigates the basic building blocks of matter, their interactions and the genesis of complex structures. These research questions are being explored by Helmholtz scientists in the context of large-scale international collaborations. In the three Helmholtz alliances "Physics at the Terascale", "Extreme Densities and Temperatures – Cosmic Matter in the Laboratory" and "Astroparticle Physics", the scientists are able to take advantage of networks with colleagues from other research facilities, universities and Max Planck institutes. The collaborations are also providing researchers with access to unique large-scale facilities and infrastructure, including not only the GSI accel-

Visualization of the merger of two neutron stars.
Image: Dana Berry, SkyWorks Digital, Inc

GSI Helmholtz Centre for Heavy Ion Research

EVIDENCE OF HEAVY ELEMENTS IN NEUTRON STAR MERGERS

In 2017, an international team of researchers announced that gravitational and electromagnetic waves originating from the merger of two neutron stars had been detected. Neutron star mergers could potentially be the astrophysical source for heavy elements such as gold, platinum, and uranium. An international collaboration headed by researchers from the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt and Columbia University in the US had already indicated that the synthesis of heavy elements in a neutron star merger process leads to the emission of a unique electromagnetic signal. The electromagnetic signal that has now been observed does in fact exhibit the predicted characteristic pattern. This confirms that the astrophysical source of the heavy elements has been found, solving one of the eleven most significant unsolved questions in the field of physics as identified by the US National Academies.
A number of observations suggest that the electromagnetic signal is generated by the radioactive decay of so-called r-process nuclei. It is estimated that the event produced approximately 0.06 solar masses of r-process material, including ten times the Earth's mass in gold and uranium. According to the predictions of those involved in the collaboration, the light emitted by the neutron star merger would be a thousand times brighter than that produced by a nova and would reach its maximum after approximately one day. The event was therefore dubbed "kilonova." This prediction has now also been confirmed by the observation of the counterpart of the gravitational wave of the neutron star merger in the optical and infrared range.
The r-process is the least understood element production process in the universe. Nuclei involved in the process are so rich in neutrons that it has not been possible to produce them in the laboratory thus far. The FAIR (Facility for Antiproton and Ion Research) accelerator complex, which is currently being constructed at GSI, will offer unique opportunities to produce and study the r-process nuclei. Up until its completion, the theorists at GSI will be gaging which information is key in terms of fully characterizing the electromagnetic signal of neutron star mergers and what conclusions can be drawn regarding r-process nucleosynthesis.

Additional examples from this Research Field

erator complex and the Large Hadron Collider (LHC) at CERN – the world's most powerful particle accelerator – but also numerous large-scale detectors, underground laboratories and observatories that allow them to look deep into the cosmos.

From Matter to Materials and Life

In this program, researchers use state-of-the-art radiation sources to investigate the structures, dynamic processes and functions of matter and materials. Their work involves close collaboration with universities and industry. Research focuses include transitional states in solids, molecules and biological systems, complex matter, tailored intelligent functional materials, and the design of new materials for the energy sector, transport systems and information technologies. A further goal is to improve the molecular structure and thus the properties of active substances. International research groups and collaborating partners are given access to photon, neutron and ion sources, high magnetic field

Two of the new X-ray laser's first users: DESY researchers Anton Barty (left) and Henry Chapman (right). Image: DESY/Lars Berg

Deutsches Elektronen-Synchrotron DESY

FIRST EXPERIMENTS AT THE EUROPEAN XFEL

A research team from DESY has successfully completed the first experiments at Europe's new X-ray laser, the European XFEL. Their goal is to record previously unknown atomic structures and processes in real time, including those of biomolecules that are interesting from a medical perspective. The European XFEL's very intensive, ultra-short X-ray laser flashes are a fundamental requirement for this measuring method. A high-speed detector developed at DESY enabled the researchers to capture the first structural images at an extremely high resolution.

Karlsruhe Institute of Technology (KIT)

AMBASSADORS FROM DISTANT GALAXIES

Extremely high-energy cosmic particles that enter the Earth's atmosphere have been known to exist since the early 1960s. Since then, scientists have been trying to uncover the origin of these particles and the process responsible for their high energy. Researchers at the Pierre Auger Observatory in Argentina, the world's largest cosmic ray detector, have now proven that these particles originate outside our own galaxy. The communications and project management office of the international Pierre Auger Observatory are located at KIT.

Image: KIT/PCE

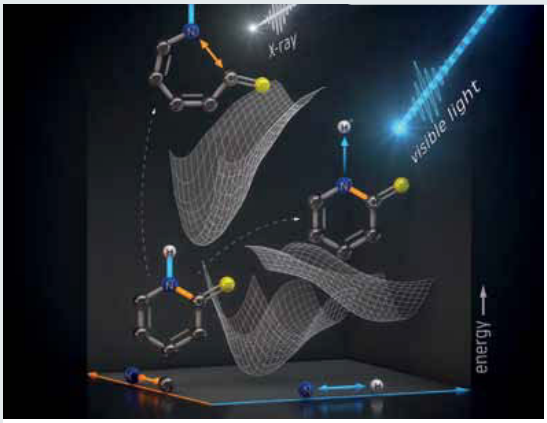


Image: Th. Splettstösser/HZB

Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)

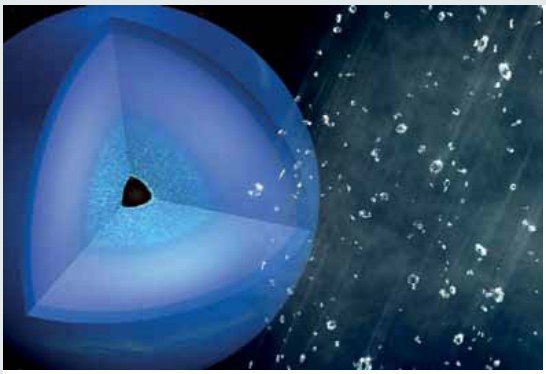
HOW BIOMOLECULES PROTECT THEMSELVES FROM LIGHT

Together with partners from Sweden and the US, a team at HZB studied how biomolecules such as DNA protect themselves against light damage. Based on experiments at the BESSY II synchrotron source at HZB and in California, they observed that biomolecules absorb the energy from photons and release it again by ejecting a proton (hydrogen nucleus). Important bonds are preserved in the process. The observation was carried out at BESSY II using a sensitive measurement procedure known as resonant inelastic X-ray scattering (RIXS).

laboratories and high-performance lasers. This research infrastructure includes ANKA, BER II, BESSY II, ELBE, FLASH, GEMS, HLD, IBC, JCNS and PETRA III, as well as the European XFEL, the Facility for Antiproton and Ion Research (FAIR) and the other international facilities in which Helmholtz is participating.

Matter and Technologies

This program is a new initiative designed to pool the technological know-how of the different Helmholtz centers and to further develop the research field in strategic terms. Challenges and goals in this context include the exploration and development of new accelerator technologies and the development of detector systems for a broad range of applications. Researchers are also focusing on the further development of high-



Hydrocarbon compounds split in the interior of ice planets and convert into diamonds. Image: G. Stewart/SLAC National Accelerator Laboratory

Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

IN NEPTUNE, IT'S RAINING DIAMONDS

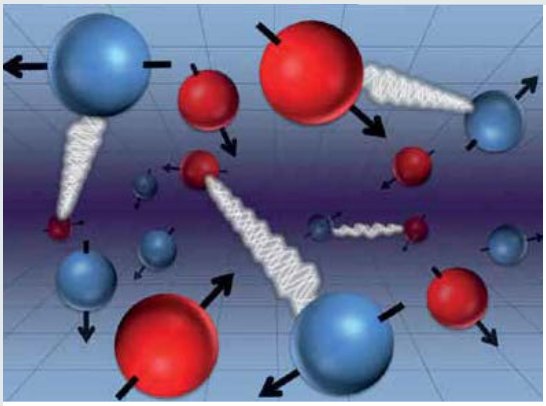
For the first time, an international team of researchers headed by HZDR physicist Dominik Kraus succeeded in observing in real time that the extreme pressure and high temperature in ice planets results in the splitting of hydrocarbons to form diamonds and hydrogen. They achieved this by using the LCLS X-ray laser at the Stanford Linear Accelerator Center to simulate the conditions in the interior of the cosmic giants. The researchers are planning to conduct similar experiments at the Helmholtz International Beamline for Extreme Fields (HIBEF), which HZDR is currently constructing at the European XFEL.

Helmholtz-Zentrum Geesthacht Centre for Material and Coastal Research (HZG)

FRICTION STIR WELDING IN AN X-RAY BEAM

FlexiStir, a new type of sample environment developed at HZG, enables in situ observation of what is referred to as the friction stir welding process at a measuring station in a synchrotron beam at DESY. This makes it possible to monitor changes in the microstructure of the material via diffraction and small-angle scattering. The advanced experimental technique resulted in both a deeper understanding of the material transformation process as well as significant improvements in the process simulation. Results from this simulation are used in the construction of aircraft, among other applications.

The plate to be studied is clamped under the welding head and can be permeated by an X-ray beam during welding. Image: C. Schmid/HZG



Interlinked protons and neutrons in an atomic nucleus. Image: University of Bonn/Serdar Elhatisari

Forschungszentrum Jülich

WHEN DO ATOMIC NUCLEI BECOME UNSTABLE?

When atomic nuclei contain too many neutrons, they break apart. An international team of physicists has now developed a method that makes it possible to precisely calculate the exact point at which the nuclei first become unstable. The Jülich Nuclear Physics Institute/Institute for Advanced Simulation played a decisive role in the study, and the calculations were carried out using JUQUEEN, a Jülich supercomputer. The results offer a detailed insight into the structure of the atomic nuclei – and should help to provide a better understanding of how the elements developed following the Big Bang.

performance computers and data storage. An additional aim is to expand knowledge transfer between the Helmholtz centers, other research organisations and industry while also strengthening the ties between the individual Research Fields within the Association.

The new program structure is creating numerous interfaces between the programs and program themes in the Research Field Matter. The Helmholtz Association's large-scale scientific facilities, in particular, offer numerous synergies. Using them requires thematic coordination and generates concrete cooperation within the framework of large-scale collaborations.

RESEARCH FIELD KEY TECHNOLOGIES

(IN THE FUTURE: INFORMATION)

PROFESSOR WOLFGANG MARQUARDT
Vice-President of the Helmholtz Association,
Coordinator for the Research Field Key Technologies,
Forschungszentrum Jülich

THE MISSION

The Research Field Key Technologies (in the future Research Field Information) investigates scientific issues in the area of information and communication technologies as well as in the material and life sciences. It also develops technologies that are expected to play a significant role in solving the major challenges facing society. We use an interdisciplinary approach to continually enhance our research infrastructure, which is made accessible to a broad community of users. This Research Field aims to provide impetus for innovation, thereby helping to maintain Germany's position as a leading center of science and technology. To this end, we dynamically develope the existing programs in this field in dialog with the scientific community, government, society, and industry.

PROGRAM STRUCTURE IN THE CURRENT FUNDING PERIOD

Three Helmholtz Centers are involved in the Research Field Key Technologies, which comprises nine programs:

- Supercomputing and Big Data
- Future Information Technology*
- Science and Technology of Nanosystems
- Advanced Engineering Materials
- BioSoft: Fundamentals for Future Technologies in the fields of Soft Matter and Life Sciences
- Biointerfaces in Technology and Medicine
- Decoding the Human Brain
- Key Technologies for the Bioeconomy
- Technology, Innovation, and Society*

OUTLOOK

This Research Field will be realigned to focus on the topic of information in the future. In order to achieve this, an integrative approach will be used to research and develop basic methods and concepts in natural, technical, cognitive, and social systems. The Research Field will aim to identify safe and reliable methods for collecting, storing, processing, transmitting, and using information. The information-oriented technologies and research infrastructure developed in the process will be made available for use by third parties. Their potential for creating value will also be demonstrated and their impact on society analyzed.

*Joint program with the Research Field Energy

PROGRAMS IN THE 2015–2019 FUNDING PERIOD

Supercomputing & Big Data

The aim of this program is to make available the tools and infrastructure required for high-performance computing and the management and analysis of large quantities of data. The constantly growing complexity of systems and processes investigated by scientists is reflected in the increasing demands being placed on analytical systems and methods.

Future Information Technology

Using innovative approaches, this program aims to develop new building components and architectural concepts in order to increase the processing power, data storage densities and transmission rates of information technologies while at the same time significantly reducing the amount of electrical energy they require.

Science and Technology of Nanosystems

This goal of this program is to create new technologies for the

A flow cell for tomographic imaging of the sample with X-ray light is installed on a measuring station at the Deutsches Elektronen-Synchrotron in Hamburg. Image: HZG

Helmholtz-Zentrum Geesthacht Centre for Material and Coastal Research (HZG)

4D X-RAY FILMS FOR THE MATERIAL SCIENCES

In recent years, magnesium and alloys based on this metal have attracted attention as a promising alternative to traditional titanium-based implants for use in the field of medicine. One of the prominent characteristics of implants made from this material is the fact that they degrade in the body over time. This means that a second operation is no longer required to remove an implant that is only needed temporarily, as it disappears on its own. The challenging aspect of developing the implants is adjusting the rate of degradation so the implant remains stable for as long as it is needed but then dissolves sufficiently quickly. Thus far, researchers working to develop novel magnesium alloys for implant materials examined their degradation behavior based on a number of test pieces, which were exposed to fluids similar to blood for varying periods of time. However, this approach is limited by the temporal resolution in particular.

At the Institute of Materials Research at the Helmholtz-Zentrum Geesthacht, a team made up of researchers in the materials physics and metallic biomaterials divisions developed a novel method for investigating the degradation of magnesium materials. This method permits studies to be carried out under environmental conditions similar to those found in the body with a high temporal resolution. To this end, the researchers use the large-scale devices operated by the German Engineering Materials Science Centre (GEMS) and an imaging technique called X-ray microtomography operated by HZG at the world's brightest X-ray light source. This technology is combined with a specially developed measuring environment consisting of a small flow cell that is linked to a bioreactor circuit as well as to additional sensors. Most importantly, this concept makes it possible to also continually track the early, very dynamic processes of degradation at a resolution of around 1 µm (one thousandth of a mm) non-destructively in a single sample over the course of several days. The resulting findings allow researchers to conduct targeted observations of the degradation processes, which in turn make it possible to develop novel, degradable substances for use in the material sciences and biomedicine.

Additional examples from this research field

synthesis and functionalisation of nanostructural materials and nanoparticles. Researchers are working on the development of new process technologies designed to manufacture and structure nanomaterials with specific characteristics.

Advanced Engineering Materials

The focus of this programme is to develop customized lightweight construction alloys and process technologies for a wide range of applications, such as extremely lightweight construction, heat-resistant, high-performance components and medical implants. The new, functionalized materials developed by researchers are predominantly used in membrane technologies for CO_2 separation and water purification, as well as in hydrogen production and storage.

BioSoft: Fundamentals for Future Technologies in the Fields of Soft Matter and Life Sciences

The properties and interactions of molecular structures determine the characteristics and functions of the systems they form, such as living cells or cell groups. Research in this field is provid-

Image: KIT

Karlsruhe Institute of Technology (KIT)

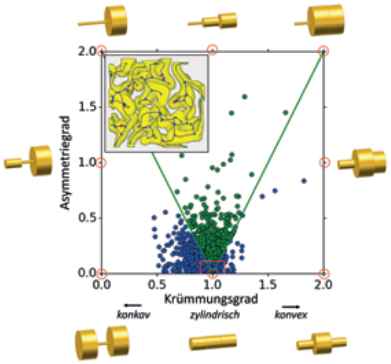
PRIPAY: PRIVACY-PROTECTING PAYMENT SYSTEMS

"Electronic wallets" are part of everyday life today – for example in loyalty programs. But very few people are aware that they relinquish their privacy to a large extent when using such services. Computer scientists at KIT have now succeeded in developing PriPay, a system that is simultaneously capable of working offline, is efficient, and proven to be secure. The system uses encryption and signatures as well as advanced cryptography such as zero-knowledge authentication systems to protect users against invasion of their privacy and to protect operators against fraud.

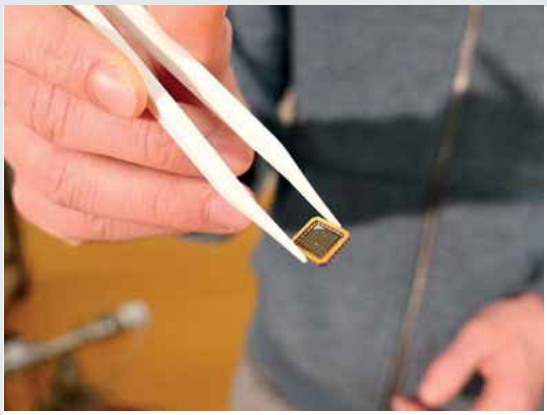
Helmholtz-Zentrum Geesthacht Centre for Material and Coastal Research (HZG)

DATA-DRIVEN ANALYSIS AND MODELING OF NANOPOROUS METALS

Nanoporous metals possess interesting functional and mechanical properties. Their complex structure resembles that of an open-pored sponge made of branched nano-ligaments. An analysis of big data from 800 ligaments captured using nanotomography showed that over half exhibited pronounced asymmetry. This discovery was taken into account in the developed modeling approach. The calculated rigidity of the structure showed that the usual method used to determine the thickness of this material overestimated the diameter of the ligaments by up to 30%.



Distribution of the ligament geometries from the data analysis. Image: metals, doi:10.3390/met8040282, CC BY 4.0/HZG



Photodiode containing tin. Image: Forschungszentrum Jülich

Forschungszentrum Jülich

NEXT STEP TOWARD OPTIC ON-CHIP DATA TRANSMISSION

Researchers have been looking for a suitable solution to integrate optical components on computer chips for quite some time. But silicon and germanium – the material basis for producing chips – are ill-suited as a source of light on their own. In cooperation with international partners, a team of physicists at Forschungszentrum Jülich has now introduced a diode that also contains tin in addition to silicon and germanium with the aim of improving the optical characteristics. The special feature of this diode is the fact that all of the elements belong to main group IV, which makes them fully compatible with existing silicon technology.

ing the knowledge required for the manufacture of functional nanoscale materials, the controlled manipulation of the flow properties of complex liquids, and the development of active molecular substances.

Biointerfaces in Technology and Medicine

Active biomaterials are becoming increasingly important in regenerative medicine, biological medical technology and biotechnical procedures. This program deals with the entire developmental chain from biomaterials to toxicological and immunological evaluation to the design of implants and controlled drug delivery systems.

Decoding the Human Brain

The aim of this program is to deploy innovative imaging techniques to develop a structurally and functionally realistic multimodal model of the human brain for basic and translationally oriented research. Due to the complexity of the brain and the many changes it undergoes over a lifetime, this goal can only be realized with the help of high-performance computers.

Gas separation membrane. Image: HZG

Helmholtz-Zentrum Geesthacht Centre for Material and Coastal Research (HZG)

SUPERIOR MEMBRANES FOR SEPARATING GASEOUS MIXTURES

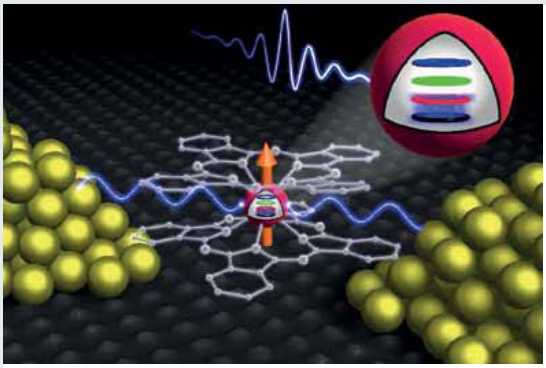
Membranes can be used to separate components from liquid or gaseous mixtures. The separation of the CO_2/CH_4 gas mixture plays a key role in the provision of renewable resources such as biogas, for example. In addition to energy-efficient membrane processes, teams of researchers at HZG are developing new types of suitable membrane materials such as Claisen thermally rearranged (CTR) polymers. These enable the production of mechanically and chemically stable, highly permeable, and selective multi-layer gas preparation membranes.

Forschungszentrum Jülich

GERMANY'S FASTEST COMPUTER

The JUWELS system at the Jülich Supercomputing Centre represents a milestone in efforts to build highly flexible, modular supercomputers. The system was developed over the course of several EU projects under the leadership of the Jülich research team. Its first module has a computing speed of 6.2 petaflops and therefore qualifies JUWELS as the fastest computer in Germany. A second module is set to double its computing power in 2019. Meanwhile, researchers at the JSC have achieved a world record with Chinese and Dutch colleagues: Using two supercomputers, they succeeded in simulating a quantum computer with 46 Qubits.

The first JUWELS module in the computer room at the JSC.
Image: Forschungszentrum Jülich/R.-U. Limbach



The $TbPc_2$ single-molecule transistor selects unsorted databases following the execution of Grover's quantum algorithm.
Image: KIT/Institut Néel

Karlsruhe Institute of Technology (KIT)

A STEP TOWARD QUANTUM COMPUTERS

A universal quantum computer remains a vision for the future. However, special quantum systems – promising to solve specific tasks faster than today – already play a significant role in the sciences. In order to reliably find a certain element in unsorted data, a conventional computer would have to run through all of the search elements in a worst-case scenario. KIT-researchers have now implemented a Grover's search algorithm in a molecular spin quantum system, which significantly reduces the search time. This is achieved due to the fact that it can be simultaneously applied to all conditions inside a molecule by generating a so-called super position.

Key Technologies for the Bioeconomy

This program focuses on the development of future technologies that can be used to develop a sustainable bioeconomy. The work being done on industrial biotechnology centers on the biobased production of chemicals, pharmaceuticals and proteins using microbial and enzymatic processes. The agronomists involved in the program are helping to improve the quality of plant biomass and produce plant-based chemicals and materials.

Technology, Innovation and Society

This program systematically investigates the diverse interfaces between technology, innovation and society with the goal of supporting decision-making processes in government, the economy and society. To this end it brings together expertise from the fields of energy systems analysis, technology impact assessment and policy consulting.

PERFORMANCE RECORD

The Helmholtz Association's mission is to conduct future-oriented research that contributes to solving the major and pressing problems facing science, society, and industry. It is Germany's largest scientific organization, with 39,255 staff members at 18 Research Centers and a total annual budget that has now increased to 4.56 billion euros. Approximately 70 percent of the Association's funds are provided by Germany's federal and state governments at a ratio of 9 to 1. The Centers raise around 30 percent of the total budget themselves in the form of third-party funding. The following pages present a range of key indicators showing the Helmholtz Association's performance and potential.

FRANZISKA BROER
Managing Director of Helmholtz

RESOURCES

DEVELOPMENT OF RESOURCES

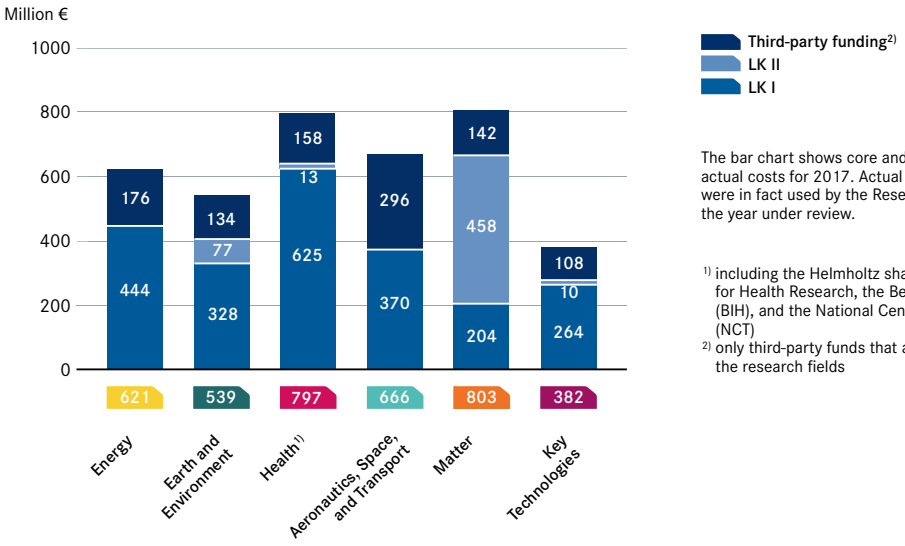
The Helmholtz Association's core funding for the fiscal year 2018 increased to around 3.27 billion euros from approximately 3.14 billion euros the previous year. This growth is essentially a result of the three-percent increase from the Joint Initiative for Research and Innovation III, which is financed entirely by the federal government, and the increase for certain special projects that received additional funding from the state and federal governments.

The core funding budget is divided into two performance categories (LK). LK I represents the resources for in-house research conducted by the Centers, which is broken down into a total of 32 research programs. LK II represents the budget for the Association's research infrastructure with its large-scale devices and user platforms.

Approximately 19 percent of the resources are currently allocated to LK II. This share has remained relatively consistent over a number of years, with the exception of the commissioning of the XFEL, the European X-Ray Free-Electron Laser Facility, in 2017.

At first glance, it may appear that, with the exception of the Research Field Key Technologies, overall financial resources are spread evenly across all of the research fields. However, closer examination shows that the resources allocated to the Research Field Matter are invested primarily in research infrastructure and user platforms (LK II facilities). Furthermore, the Research Field Earth & Environment is also allocated an increased share of PC II due to the research vessels and polar stations required here.

Budget for core and third-party funding for the Helmholtz Research Fields



The bar chart shows core and third-party funding as actual costs for 2017. Actual costs are funds that were in fact used by the Research Centers during the year under review.

[1] including the Helmholtz share of the German Centres for Health Research, the Berlin Institute of Health (BIH), and the National Center for Tumor Diseases (NCT)
[2] only third-party funds that are directly attributable to the research fields

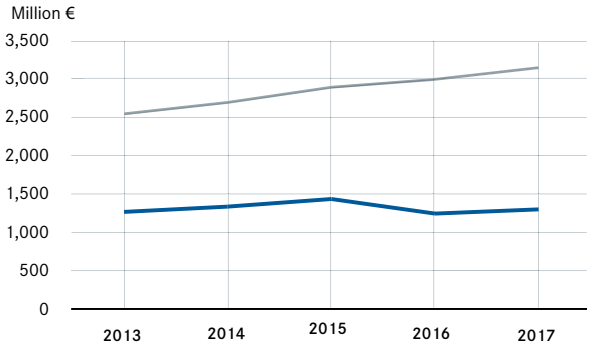
THIRD-PARTY FUNDING

In addition to core financing, a substantial amount of third-party funding – raised primarily in external competitive procedures – is available to the Helmholtz Centers. In 2017 the Helmholtz Association acquired third-party funding amounting to 1.29 billion euros (including 248 million euros in project sponsorships). This represents an increase of 55 million euros, or 4.4 percent, over the previous year, which can be largely attributed to a reimbursement from EU XFEL GmbH following the commissioning of the XFEL.

Approximately 80 percent of the acquired third-party funding consists of state funds and is obtained primarily from Germany's federal and state governments, municipalities, the DFG, ESA, EU, as well as the Association's activities as a project sponsor, stimulus packages, and ERDF. The remaining 20 percent consists of private third-party funding, which was acquired for example through contracts from commercial enterprises at home and abroad, donations, or inheritances.

The strength of the Helmholtz Association's research at the European level was once again demonstrated in 2017 by its success within the scope of Horizon 2020. The Helmholtz Centers participated in 253 projects that were newly funded by this European research program in 2017 and received total funding of 139 million euros.

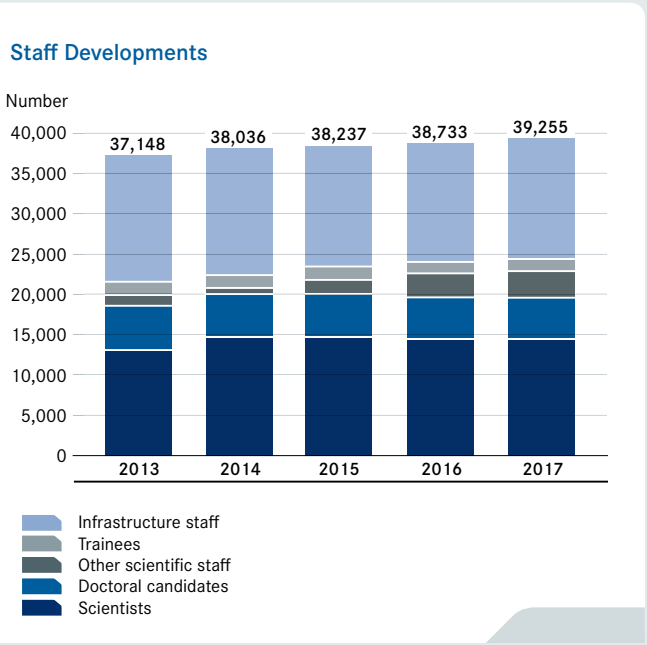
Third-party funds



[1] The figures for 2015 do not include the Berlin Institute of Health (BIH), which accounts for 44 million euros, because it has had its own budget since 2016 and is currently no longer part of the overall Helmholtz budget.

STAFF DEVELOPMENTS

The Helmholtz Association's extremely talented and committed employees are the most valuable resource for the research conducted here. Research excellence is always underpinned by outstanding technical and administrative support, which provides the researchers with the best conditions for their work. In 2017, the increase in the funding received by the Helmholtz Association from the Joint Initiative for Research and Innovation once again went hand in hand with moderate staff growth at the Helmholtz Centers. A significant increase was recorded in the area of project sponsors, while the overall number of employees increased by 1.3 percent to 39,255. Researchers make up just under 40 percent of this figure.
In addition, 3,380 doctoral candidates were supervised at the Centers. These individuals do not have an employment contract with the Centers but use the Helmholtz Association's research infrastructure.

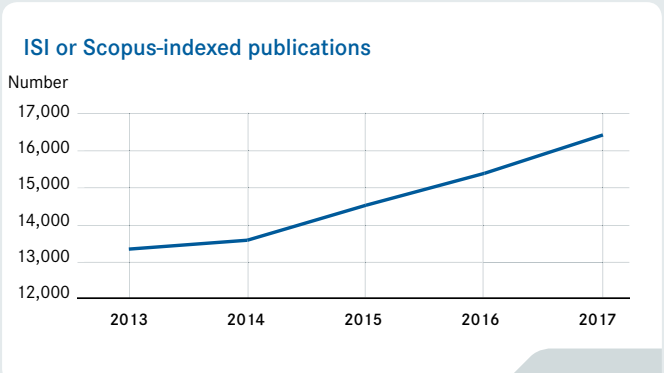


Detailed information about the Helmholtz Association's resources and a breakdown by Research Field and Research Center can be found on pages 50–51.

SCIENTIFIC PERFORMANCE

RESEARCH PERFORMANCE

Publications are a key measure of scientific productivity, and Helmholtz once again recorded clear growth in this area. In 2017, a total of 16,378 papers were published in ISI or Scopus-indexed scientific journals. The number of publications thus grew by 7 percent over the previous year and by a total of 23 percent in the last five years. As a result, Helmholtz was also able to substantially increase its share in the number of publications across Germany (publication rate) in 2017 in comparison with the previous year from 10 to 13 percent. Helmholtz occupies the top position among non-university research organizations.



A good measure of the quality of research findings is the number of times they are published in prestigious journals. The Nature Publishing Group releases a ranking of the top 200 research organizations worldwide. The “Nature Index” is based on publications in 82 journals that are independently selected as the most important by two panels of scientists from the fields of physics, chemistry, environmental science, and the life sciences. Helmholtz has ranked among the top ten international institutions for years. The table shows the Nature Index for the period January 1, 2017, to December 31, 2017.

Nature Index 2017

Rank	Institution	FC*
1	Chinese Academy of Sciences (CAS), China	1,510
2	Harvard University, USA	890
3	Max Planck Society, Germany	735
4	French National Centre for Scientific Research (CNRS), France	702
5	Stanford University (SU), USA	609
6	Massachusetts Institute of Technology (MIT), USA	529
7	Helmholtz Association, Germany	489
8	The University of Tokyo (UTokyo), Japan	462
9	University of California Berkeley, USA	409
10	University of Cambridge, UK	407

* Fractional count = figure taking into account the percentage of authors from the respective institution and the number of affiliated institutions per article. The calculation assumes that all authors contributed equally to the article, and their sum is 1.0 per article.

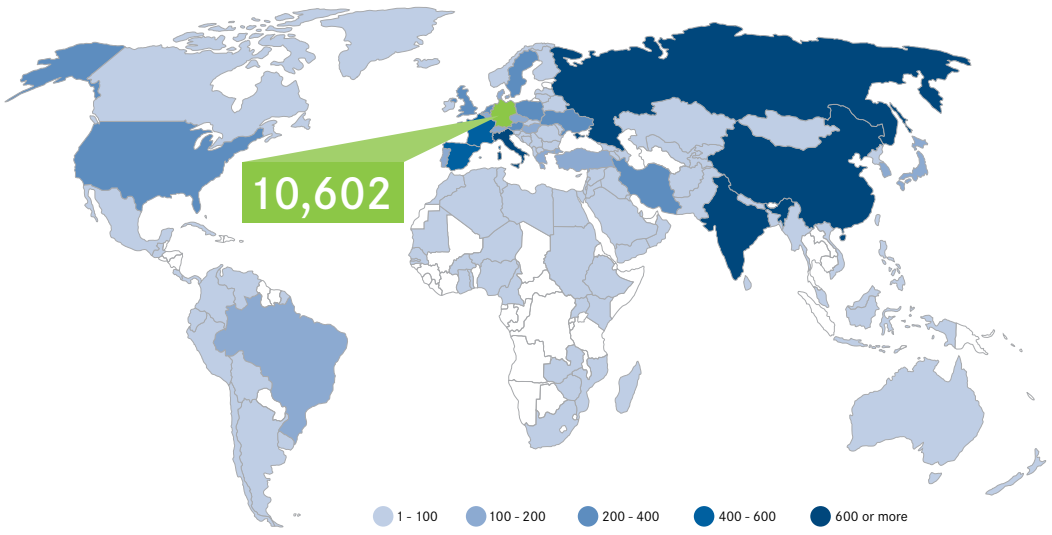
RESEARCH INFRASTRUCTURE

Designing, constructing, and operating large-scale and often unique scientific infrastructure is a key aspect of the Helmholtz Association’s mission. The extent to which it fulfills its aim of providing the scientific community with access to one-of-a-kind research facilities is therefore of great importance to Helmholtz. On average, the large-scale devices at the Helmholtz Centers were available on 94.4 percent of days in 2017. This meant that researchers from around the world could reliably utilize the unique working opportunities that these facilities offer.

The national and international scientific community (external researchers) accounted for a majority of the research infrastructure’s use, at 71 percent. By providing this service, Helmholtz plays an essential role in this area of the scientific system.

In 2017, 10,602 scientists from around the world used the research opportunities offered by the Helmholtz Centers. This corresponds to an increase of 4 percent over the previous year.

Number of scientists from abroad in 2017



NATIONAL COLLABORATION

Scientific excellence requires the best minds – and large-scale collaborative research depends on partnerships with the most effective research institutions in the scientific system. Helmholtz achieves both of these objectives through joint appointments, among other activities. Helmholtz has been successfully implementing the joint appointment model in cooperation with German universities for many years. The number of joint appointments has increased significantly in recent years and remains at a high level. Furthermore, scientific staff provided a total of 7,852 taught sessions per semester week over the past two semesters. In addition to joint appointments, the number of researchers participating in the programs coordinated by the German Research Foundation (DFG) and the Excellence Initiative, together with the respective universities in each case, demonstrates the extent of the Helmholtz Association's networking activities at the national level.

Since 2006, the universities have been eager to enlist the Helmholtz Centers as partners in all three funding lines of the Excellence Initiative. The Association's involvement has become increasingly important over the course of the two phases and demonstrates the close and growing interconnectedness between the Helmholtz Centers and its research-intensive partner universities. During the reporting period, Helmholtz participated in well over a third of all graduate schools (38%) and nearly half of all excellence clusters (44%) as well as three quarters of all institutional concepts (73%).

Joint Appointments

	2013	2014	2015	2016	2017
Joint appointments with universities, (W2 and W3)	499	554	609	644	633

DFG

Number in the year	2013	2014	2015	2016	2017
Research Centers	2	1	1	1	1
Collaborative Research Centers	67	62	65	69	74
Priority Programs	49	42	44	51	52
Research Units	61	55	49	46	41

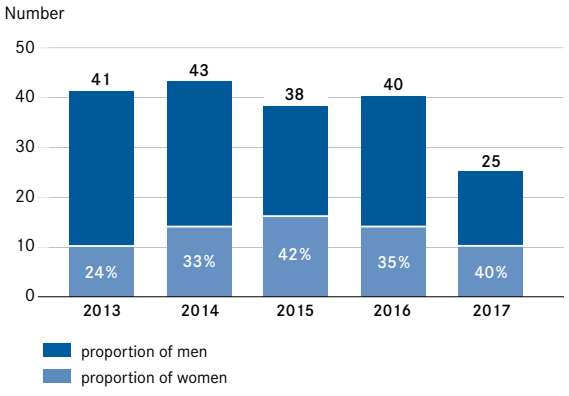
In certain programs, Helmholtz researchers can obtain funding from the DFG. In such cases the Helmholtz Centers serve as important strategic partners to universities when applications are submitted to the DFG – especially for structural initiatives.

Participation in the DFG's coordinated programs illustrates the success of the Helmholtz Centers in competitions held by the DFG. The count only includes projects in which the participating researchers noted their Helmholtz affiliation in their applications. In some cases, Helmholtz researchers who were appointed to positions jointly with universities applied for projects within the scope of their university activities. If these projects are also counted, the figures for 2017 increase as follows: 2 Research Centers, 122 Collaborative Research Centers, 59 Priority Programs, and 52 Research Units.

EQUAL OPPORTUNITIES

Equal opportunities for men and women is one of the core values of Helmholtz. It is firmly rooted in the Association's mission and represents an integral part of its strategy to recruit the best and brightest minds at all stages of their careers. This is why diversity – with a special focus on equal opportunities – is an important part of the Association's talent management program. It is a topic that is systematically integrated into all of its programs and activities. The striking effects of this approach can be seen in the staffing of W3 professorships, for example. While women made up 24 percent of new appointments in 2013, this figure increased to 40 percent in 2017; a pronounced positive trend can therefore be seen in the absolute figures over the last five years as well.

New W3 Appointments



TALENT MANAGEMENT

Fostering the development of young scientists is central to securing both the future of Helmholtz and the viability of Germany as a center of research and science. It is therefore part of the Association's mission. In the previous two periods of the Joint Initiative for Research and Innovation, Helmholtz developed numerous overarching funding instruments within the framework of the Initiative and Networking Fund. It also supported these instruments with substantial funding from the Joint Initiative, in addition to advancing the careers of young scientists at the Centers. The instruments have evolved into a comprehensive strategic talent management system that offers attractive conditions to talented young researchers at every stage of their careers:

- Doctoral training at graduate schools and colleges
- Postdoc program providing funding immediately upon completion of PhDs
- Helmholtz Young Investigator Groups for top international talent
- W2/W3 program for recruiting and supporting young female scientists
- Recruitment initiative to attract internationally renowned researchers to the Helmholtz Centers.

Doctoral degrees

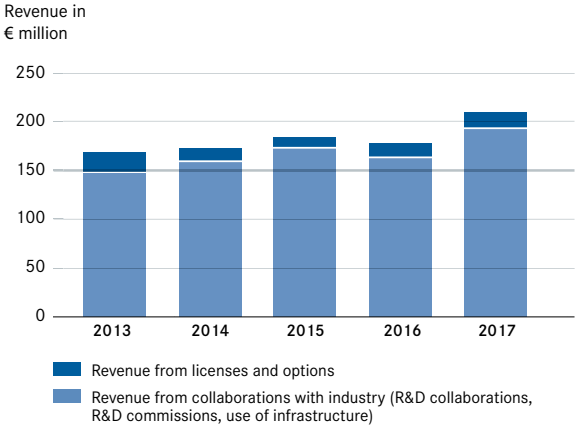
	2013	2014	2015	2016	2017
Number of supervised doctoral candidates*	6,789	7,446	8,044	8,054	8,456
Number of doctoral candidates employed	5,348	5,296	5,414	5,105	5,076
Number of completed doctoral degrees	964	1,059	1,219	1,041	1,118

* Including candidates who use the Helmholtz Association's research infrastructure.

TECHNOLOGY AND KNOWLEDGE TRANSFER

Helmholtz researchers significantly boost Germany's innovative capacity by disseminating knowledge and converting economically valuable results into entrepreneurial endeavors. Accordingly, Helmholtz places an increasing focus on the transfer of knowledge and technology. This is demonstrated both by the priority given to the topic of transfer in the President's Agenda and the Helmholtz Association's strategy as well as in the activities pursued by the Research Centers. Over the last few years, a variety of new instruments and platforms have been established to promote these aims, including the Helmholtz Validation Fund, the Helmholtz Innovation Labs, and the Innovation Funds of the Helmholtz Centers.
Revenue from industry partnerships increased by approximately 19 percent in 2017, which can be attributed in particular to reimbursements of funds following the completion of the European XFEL. Income from licenses and options has been volatile and typically ranged between 12 and 20 million euros. It amounted to 16 million euros in 2017.
The number of patent applications remained relatively constant, numbering 436 this year. This is attributable to the more stringent selection process focusing on commercial utilization.
Twenty spin-offs were founded, a figure that likewise remained stable in comparison with the high levels of recent years.

Technology transfer

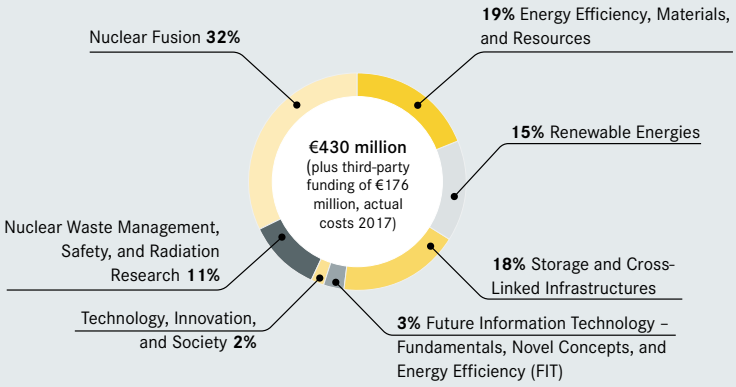


COSTS AND STAFF

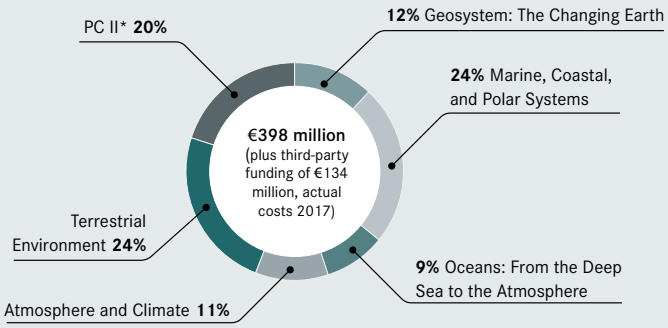
The Helmholtz Association's annual budget consists of core financing and third-party funding. A total of 90 percent of core financing is provided by the federal government, and 10 percent comes from the federal states in which the respective Helmholtz Centers are located. The Centers raise around 30 percent of the total budget themselves in the form of third-party funding. The core-financed target costs for the six Research Fields amounted to 2,683 million euros in 2017.

CORE-FINANCED TARGET COSTS FOR THE SIX RESEARCH FIELDS IN 2017

Research Field Energy

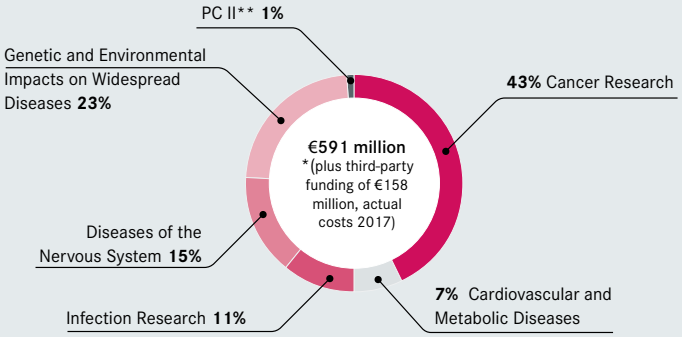


Research Field Earth and Environment



* MESI (GFZ); POLARSTERN, HEINCKE, Neumayer Station III (AWI); ALKOR, POSEIDON (GEOMAR)

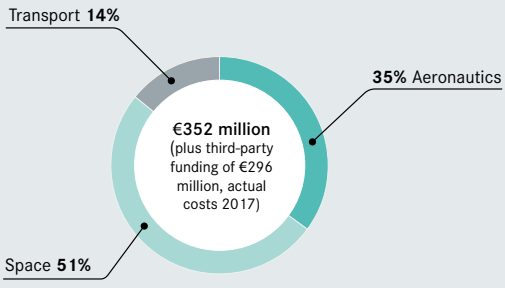
Research Field Health



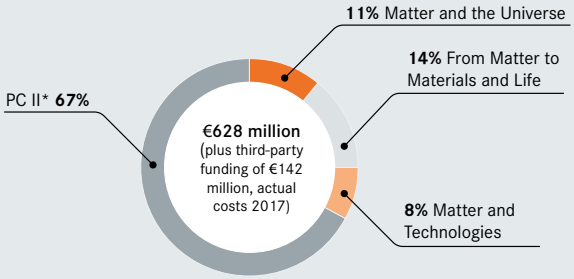
* Including funds of €80 million for the Helmholtz share of the German Centres for Health Research, the Berlin Institute of Health (BIH), and the expansion of the National Center for Tumor Diseases

** National Cohort (DKFZ, HMGU, HZI, MDC)

Research Field Aeronautics, Space, and Transport

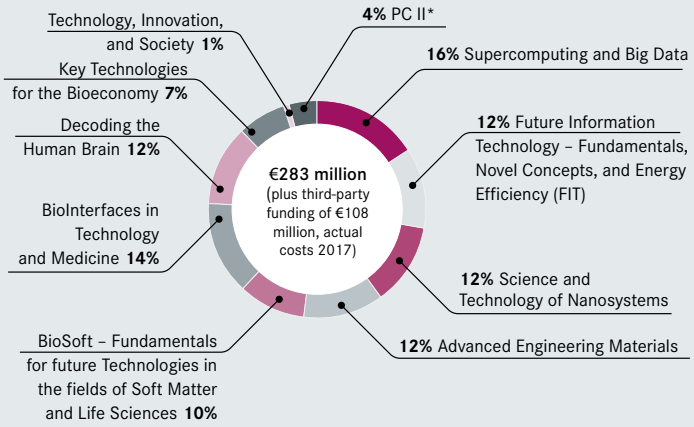


Research Field Matter



* FLASH, PETRA III, TIER II, XFEL (DESY); JCNS (FZJ); PC II under development – FAIR (GSI); BER II, BESSY II (HZB); ELBE, HLD, IBC (HZDR); GEMS (HZG); GridKa (KIT)

Research Field Key Technologies



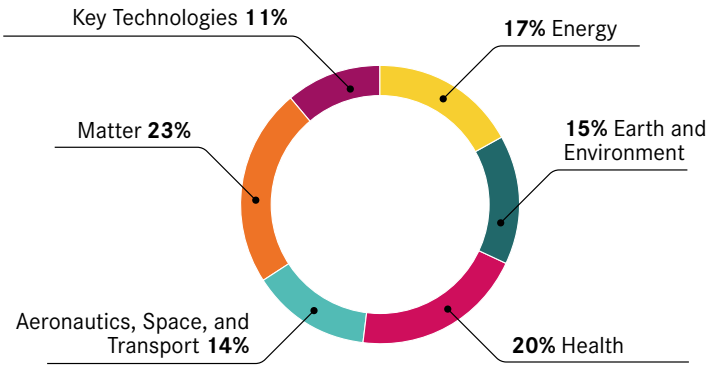
* KNMF (KIT)

TARGET COSTS FOR PROGRAM-ORIENTED FUNDING 2018

All of the research fields and their programs are currently in the third period of program-oriented funding. The financing recommendations for 2018, which the Helmholtz Senate made on the basis of its evaluations, are shown for all of the research fields in the following table.

	Target costs 2018 in million €
Energy	445
Earth and Environment	416
Health*	527
Aeronautics, Space, and Transport	362
Matter	623
Key Technologies	291
Total	**2,664**

* Not including the German Centres for Health Research, the Berlin Institute of Health (BIH), and the National Center of Tumor Diseases (NCT)



ACTUAL COSTS AND STAFF 2017

Due to the Helmholtz Association's strategic focus on six research fields, actual costs are listed by Centers and research fields for the 2017 reporting period. The overview is supplemented by information on the number of staff expressed in person-years.

	Actual core-financed costs, k€	Third-party funds, k€	Total, k€	Total staff, PY [1]
Research fields, total [2]	2,792,953	1,013,447	3,806,400	30,948
Non-program-linked research, total [3]	1,031	22,927	23,958	73
Special research tasks, total [4]	11,687	15,703	27,390	112
Project sponsorships, total		247,686	247,686	2,291
Redirected third-party funds, total		177,744	177,744	
Helmholtz Association, total	**2,805,671**	**1,477,507**	**4,283,178**	**33,424** [5]

[1] Person-years [2] In addition to the six research fields, this category includes the Helmholtz share of the German Centres for Health Research, the Berlin Institute of Health (BIH), and the expansion of the National Center for Tumor Diseases. [3] The funds for non-program-linked research amount to a maximum of 20 percent of all acquired program funding. If these funds are used by the Centers to expand existing research programs, they are assigned directly to the costs of the respective programs. [4] Mainly involving the decommissioning of nuclear facilities. [5] Expressed as natural persons, the Helmholtz Association has 39,255 employees.

ACTUAL COSTS AND STAFF BY CENTER

	Actual core-financed costs, k€	Third-party funds, k€	Total, k€	Total staff, PY [1]
Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)	143,874	20,063	163,937	980
Deutsches Elektronen-Synchrotron DESY	273,460	95,443	368,903	2,133
German Cancer Research Center (DKFZ)	200,116	69,372	269,488	2,473
German Aerospace Center (DLR)	404,274	342,235	746,509	5,842
German Center for Neurodegenerative Diseases (DZNE)	87,464	12,479	99,943	750
Forschungszentrum Jülich (FZJ)	309,003	122,387	431,390	3,792
GEOMAR Helmholtz Centre for Ocean Research Kiel	44,865	22,224	67,089	491
GSI Helmholtz Centre for Heavy Ion Research	136,480	11,455	147,935	1,508
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	136,653	14,030	150,683	961
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	108,176	19,345	127,521	976
Helmholtz Centre for Infection Research (HZI)	60,907	18,381	79,288	751
Helmholtz Centre for Environmental Research – UFZ	71,026	23,237	94,263	965
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	78,578	16,582	95,160	836
Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)	174,584	33,936	208,520	1,966
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	60,459	40,562	101,021	813
Karlsruhe Institute of Technology (KIT)	297,841	114,543	412,384	3,470
Max Delbrück Center for Molecular Medicine in the Helmholtz Association (MDC)	102,596	24,462	127,058	1,144
Max Planck Institute for Plasma Physics (IPP)	102,597	12,711	115,308	1,097
Non-Program-Linked Research	**1,031**	**22,927**	**23,958**	**73**
Special tasks[2]	**11,687**	**15,703**	**27,390**	**112**
Project sponsorships		**247,686**	**247,686**	**2,291**
Redirected third-party funds		**177,744**	**177,744**	
Helmholtz Association, total	**2,805,671**	**1,477,507**	**4,283,178**	**33,424**

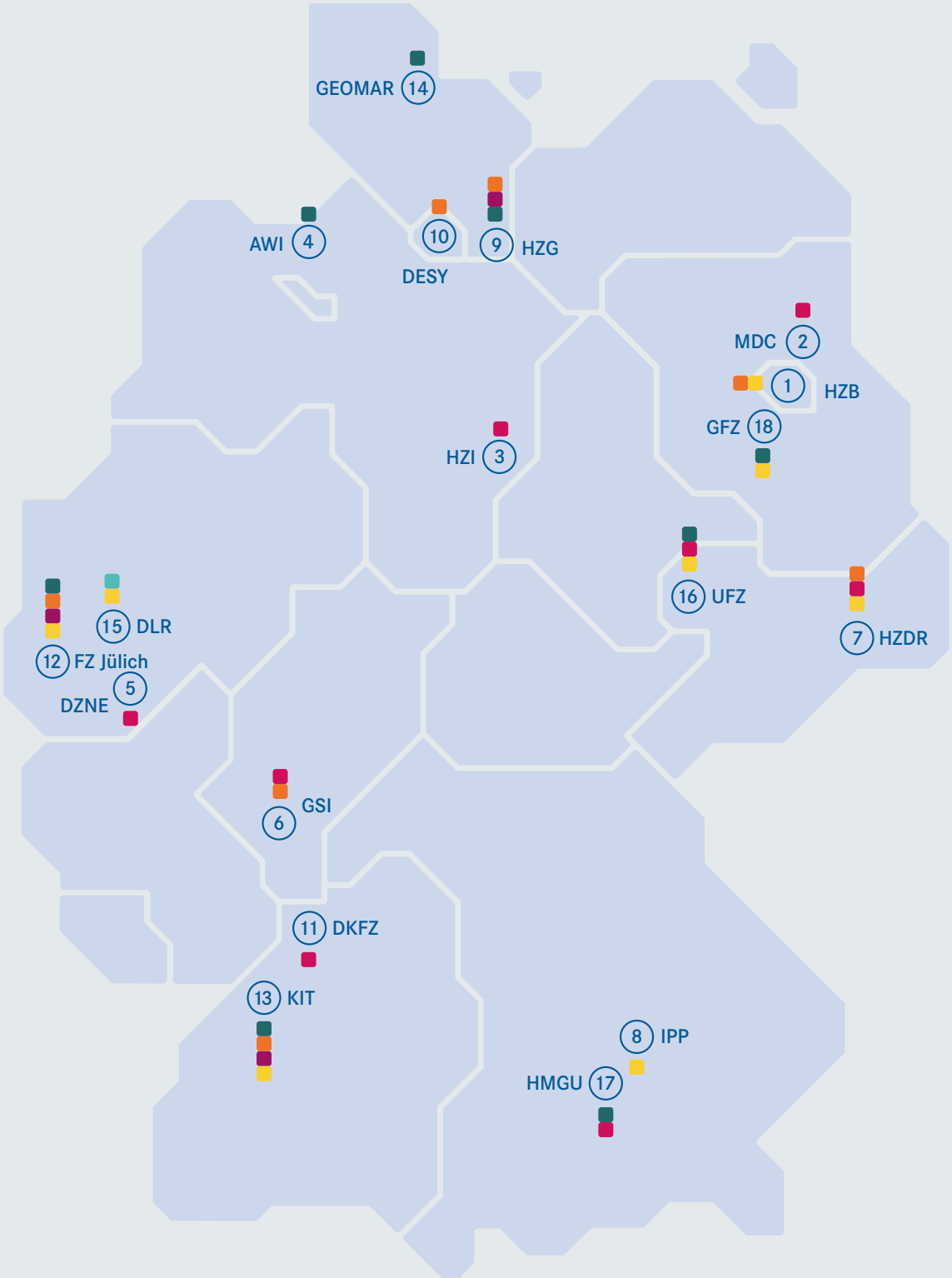
[1] Person-years [2] Mainly involving the decommissioning of nuclear facilities

ACTUAL COSTS AND STAFF BY RESEARCH FIELDS

Research Field Energy	Actual core-financed costs, k€	Third-party funds, k€	Total, k€	Total staff, PY [1]
German Aerospace Center e.V. (DLR)	34,702	46,259	80,961	609
Forschungszentrum Jülich GmbH (FZJ)	85,215	38,218	123,433	1,098
Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB)	35,220	8,512	43,732	362
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	35,084	9,376	44,460	364
Helmholtz Centre for Environmental Research GmbH – UFZ	5,704	2,539	8,243	89
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	3,207	5,985	9,192	73
Karlsruhe Institute of Technology (KIT)	142,722	52,672	195,394	1,623
Max Planck Institute for Plasma Physics (IPP)	102,597	12,711	115,308	1,097
Research Field Energy, total	**444,451**	**176,272**	**620,723**	**5,315**
Research Field Earth and Environment				
Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)	143,874	20,063	163,937	980
Forschungszentrum Jülich GmbH (FZJ)	28,798	12,249	41,047	376
GEOMAR – Helmholtz Centre for Ocean Research Kiel	44,865	22,224	67,089	491
Helmholtz Centre for Environmental Research GmbH – UFZ	60,806	20,489	81,295	827
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	26,423	5,676	32,099	293
Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)	19,796	5,147	24,943	227
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	57,252	34,577	91,829	740
Karlsruhe Institute of Technology (KIT)	23,261	13,283	36,544	322
Research Field Earth and Environment, total	**405,075**	**133,708**	**538,783**	**4,256**
Research Field Health				
German Cancer Research Center (DKFZ)	200,116	69,372	269,488	2,473
German Center for Neurodegenerative Diseases e.V. (DZNE)	87,464	12,479	99,943	750
GSI Helmholtz Centre for Heavy Ion Research GmbH (GSI)	4,795	1,457	6,252	66
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	23,308	2,907	26,215	206
Helmholtz Centre for Infection Research (HZI)	60,907	18,381	79,288	751
Helmholtz Centre for Environmental Research GmbH – UFZ	4,516	209	4,725	49
Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)	154,788	28,789	183,577	1,739
Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch	102,596	24,462	127,058	1,144
Research Field Health, total	**638,490**	**158,056**	**796,546**	**7,178**
Research Field Aeronautics, Space, and Transport				
German Aerospace Center e.V. (DLR)	369,572	295,976	665,548	5,233
Research Field Aeronautics, Space, and Transport, total	**369,572**	**295,976**	**665,548**	**5,233**
Research Field Matter				
Deutsches Elektronen-Synchrotron (DESY)	273,460	95,443	368,903	2,133
Forschungszentrum Jülich GmbH (FZJ)	46,628	14,349	60,977	472
GSI Helmholtz Centre for Heavy Ion Research GmbH (GSI)	131,685	9,998	141,683	1,442
Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB)	101,433	5,518	106,951	599
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	49,784	7,062	56,846	406
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	8,237	1,102	9,339	72
Karlsruhe Institute of Technology (KIT)	49,930	8,067	57,997	434
Research Field Matter, total	**661,157**	**141,539**	**802,696**	**5,558**
Research Field Key Technologies				
Forschungszentrum Jülich GmbH (FZJ)	148,362	57,571	205,933	1,846
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	43,918	9,804	53,722	471
Karlsruhe Institute of Technology (KIT)	81,928	40,521	122,449	1,091
Research Field Key Technologies, total	**274,208**	**107,896**	**382,104**	**3,408**

LOCATIONS OF THE HELMHOLTZ CENTERS

As of December 31, 2018



1 BERLIN
HELMHOLTZ-ZENTRUM BERLIN FÜR MATERIALIEN UND ENERGIE (HZB)

www.helmholtz-berlin.de

2 BERLIN-BUCH
MAX DELBRÜCK CENTER FOR MOLECULAR MEDICINE IN THE HELMHOLTZ ASSOCIATION (MDC)

www.mdc-berlin.de

3 BRUNSWICK
HELMHOLTZ CENTRE FOR INFECTION RESEARCH (HZI)

www.helmholtz-hzi.de

4 BREMERHAVEN
ALFRED WEGENER INSTITUTE, HELMHOLTZ CENTRE FOR POLAR AND MARINE RESEARCH (AWI)

www.awi.de

5 BONN
GERMAN CENTER FOR NEURODEGENERATIVE DISEASES (DZNE)

www.dzne.de

6 DARMSTADT
GSI HELMHOLTZ CENTRE FOR HEAVY ION RESEARCH

www.gsi.de

7 DRESDEN
HELMHOLTZ-ZENTRUM DRESDEN-ROSSENDORF (HZDR)

www.hzdr.de

8 GARCHING
MAX PLANCK INSTITUTE FOR PLASMA PHYSICS (IPP) (ASSOCIATE MEMBER)

www.ipp.mpg.de

9 GEESTHACHT
HELMHOLTZ-ZENTRUM GEESTHACHT CENTRE FOR MATERIALS AND COASTAL RESEARCH (HZG)

www.hzg.de

10 HAMBURG
DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

www.desy.de

11 HEIDELBERG
GERMAN CANCER RESEARCH CENTER (DKFZ)

www.dkfz.de

12 JÜLICH
FORSCHUNGSZENTRUM JÜLICH

www.fz-juelich.de

13 KARLSRUHE
KARLSRUHE INSTITUTE OF TECHNOLOGY (KIT)

www.kit.edu

14 KIEL
GEOMAR HELMHOLTZ CENTRE FOR OCEAN RESEARCH KIEL

www.geomar.de

15 COLOGNE
GERMAN AEROSPACE CENTER (DLR)

www.dlr.de

16 LEIPZIG
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

www.ufz.de

17 MUNICH
HELMHOLTZ ZENTRUM MÜNCHEN – GERMAN RESEARCH CENTER FOR ENVIRONMENTAL HEALTH

www.helmholtz-muenchen.de

18 POTSDAM
HELMHOLTZ CENTRE POTSDAM – GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES

www.gfz-potsdam.de

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As of December 31, 2018

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German Cancer Research Center

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German Center for Neurodegenerative Diseases (DZNE)

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Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

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(associate member)

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COMMITTEES AND CENTRAL BODIES

As of December 31, 2018

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Franziska Broer

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Dr. Siegfried Dais, Partner at Robert Bosch Industrietreuhand KG, Stuttgart

Dr. Heike Hanagarth, former Head of the Technology and Environment Division at Deutsche Bahn AG, Berlin

Professor Monika Henzinger, Professor of Computer Science, University of Vienna, Austria

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Professor Jürgen Klenner, former Senior Vice-President Structure & Flight Physics, ADS Toulouse, France

Professor Joël Mesot, Director of the Paul Scherrer Institute, Villigen, Switzerland

Professor Volker Josef Mosbrugger, Director of the Senckenberg Research Institute and Nature Museum, Frankfurt am Main (until August 2018)

Hildegard Müller, Chief Operating Officer Grid & Infrastructure, innogy SE, Essen

Professor Wolfgang Plischke, former Management Board Member of Bayer AG and Head of Bayer Healthcare

Professor Dierk Raabe, Executive Director, Max Planck Institute for Iron Research, Düsseldorf

Professor Monika Sester, Institute of Cartography and Geoinformatics, Leibniz University, Hanover (from September 2018)

Professor Dr. Sabine Werner, Professor of Cell Biology, Institute of Molecular Health Science, ETH Zurich, Switzerland

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Anja Karliczek, Federal Minister of Education and Research, Berlin

Dr. Stefan Kaufmann, Member of the German Bundestag, Berlin

Professor Matthias Kleiner, President of the Leibniz Association, Berlin

Bettina Lentz, State Councilor of the Department of Finances City of Hamburg

Mattias Machnig, State Secretary, Federal Ministry of Economic Affairs and Energy, Berlin (until March 15, 2018)

René Röspel, Member of the German Bundestag, Berlin

Isabel Pfeiffer-Poensgen, Minister of Culture and Science of the State of North Rhine-Westphalia

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Franziska Broer, Managing Director of the Helmholtz Association, Berlin

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Dr. Jörg Hoheisel, Chair of the Committee of Scientific-Technical Councils of the Helmholtz Centers, German Cancer Research Center, Heidelberg

Professor Reinhard F. J. Hüttl, Vice-President of the Helmholtz Association, Scientific Executive Director, Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

Elsbeth Lesner, Representative of the Staff and Works Councils of the Helmholtz Centers, Helmholtz-Zentrum Berlin für Materialien und Energie

Professor Wolfgang Marquardt, Vice-President of the Helmholtz Association, Chair of the Board of Directors, Forschungszentrum Jülich

Professor Reimund Neugebauer, President of the Fraunhofer Society, Munich

Professor Pierluigi Nicotera, Vice-President of the Helmholtz Association, Scientific Director of the German Center for Neurodegenerative Diseases, Bonn

Professor Martin Stratmann, President of the Max Planck Society for the Advancement of Science, Munich

Professor Peter Strohschneider, President of the German Research Foundation, Bonn

Dr. Katrin Wendt-Potthoff, Vice-Chair of the Committee of Scientific-Technical Councils of the Helmholtz Centers, Helmholtz Centre for Environmental Research – UFZ, Magdeburg

MEMBERS' ASSEMBLY

Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, SdöR*
Professor Antje Boetius, Director,
Dr. Karsten Wurr, Administrative Director

Deutsches Elektronen-Synchrotron DESY, SdpR*
Professor Helmut Dosch,
Chair of the Board of Directors,
Christian Harringa, Director of Administration

German Cancer Research Center, SdöR*
Professor Michael Baumann, Chair of the Executive Board and Scientific Director,
Professor Josef Puchta, Administrative Director

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Chair of the Executive Board,
Klaus Hamacher, Vice-Chair of the Executive Board

German Center for Neurodegenerative Diseases e.V. (DZNE)
Professor Pierluigi Nicotera,
Scientific Director and
Chair of the Executive Board,
Dr. Sabine Helling-Moegen,
Administrative Director

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Professor Wolfgang Marquardt,
Chair of the Board of Directors,
Karsten Beneke, Vice-Chair of the Board of Directors

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Professor Peter M. Herzig, Director,
Michael Wagner, Administrative Director

GSI Helmholtz Centre for Heavy Ion Research GmbH
Professor Paolo Giubellino,
Scientific Managing Director,
Ursula Weyrich, Administrative Managing Director

Helmholtz-Zentrum Berlin für Materialien und Energie GmbH
Professor Bernd Rech,
Acting Scientific Director,
Thomas Frederking,
Administrative Director

Helmholtz-Zentrum Dresden-Rossendorf e.V.
Professor Roland Sauerbrey,
Scientific Director,
Dr. Ulrich Breuer, Director of Administration

Helmholtz Centre for Infection Research GmbH
Professor Dirk Heinz,
Scientific Director,
Silke Tannapfel, Administrative Director

Helmholtz Centre for Environmental Research GmbH – UFZ
Professor Georg Teutsch,
Scientific Director,
Professor Heike Graßmann,
Administrative Director (until September 30, 2018; Acting Administrative Director as from October 2018)

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research GmbH
Professor Wolfgang Kaysser,
Scientific and Technical Director,
Michael Ganß,
Administrative Director (until July 31, 2018)

Kay Bern, Administrative Director
(from August 1, 2018, on an interim basis)

Helmholtz Zentrum München – German Research Center for Environmental Health GmbH
Professor Günther Wess, Scientific Director (until July 31, 2018),
Professor Matthias Tschöp (from August 1, 2018), Scientific Director
Heinrich Baßler, Administrative Director

Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, SdöR*
Professor Reinhard F. Hüttl,
Scientific Executive Director and Spokesman for the Executive Board,
Dr. Stefan Schwartze, Administrative Director

Karlsruhe Institute of Technology, KdöR*
Professor Holger Hanselka, President,
Michael Ganß (from August 1, 2018)/
Christine von Vangerow,
Administrative Vice-Presidents

Max Delbrück Center for Molecular Medicine in the Helmholtz Association, KdöR*
Professor Martin Lohse, Chair of the Executive Board and Scientific Director
Dr. Heike Wolke, Administrative Director (until September 2018)
Professor Heike Graßmann, Administrative Director (from October 1, 2018)

Max Planck Institute for Plasma Physics (associate member)
Professor Sibylle Günter, Chair and Scientific Director,
Dr. Josef Schweinzer, Administrative Director

*Abbreviations: SdöR: foundation under public law; SdpR: foundation under private law; KdöR: public body

GOVERNANCE STRUCTURE

As of December 31, 2018

COMMITTEE OF FUNDING BODIES

The Committee of Funding Bodies – made up of the federal government and the host states – adopts research policy guidelines for the individual research fields for a period of several years. It also appoints members to the Helmholtz Senate.

SENATE

Together with the Members' Assembly, the Senate, which is made up of external experts, is the Helmholtz Association's central decision-making body. It consists of both ex-officio members – representatives of the federal and state governments, the German Bundestag and scientific organizations – and figures from science and industry. The latter are elected for three years. The Senate deliberates on all matters of importance and is responsible for electing the president and the vice-presidents.

MEMBERS' ASSEMBLY

Together with the Senate, the association's central body is the Members' Assembly, to which the scientific and administrative directors of each member center belong.

The Members' Assembly is responsible for all the tasks performed by the association. It defines the framework for the cross-center development of both strategies and programs and makes proposals regarding the election of the president and Senate members.

PRESIDENT AND EXECUTIVE COMMITTEE

PRESIDENT

The president heads the Helmholtz Association and represents it externally. He or she moderates the dialogue between the world of science, industry and government and is responsible for preparing and implementing the Senate's recommendations on program funding. The president coordinates the development of programs across research fields and oversees cross-center controlling and the formulation of the association's overarching strategy. The president is supported, advised and represented by the other members of the executive committee, eight vice-presidents and the managing director.

MANAGING DIRECTOR

As a special officer for administrative affairs, the managing director represents the Helmholtz Association both internally and externally. He or she runs the association's head office.

VICE-PRESIDENTS

The eight vice-presidents are scientific or administrative directors of Helmholtz Centers. The six scientific vice-presidents serve as coordinators of the six Research Fields.

HEAD OFFICE

Together with the international offices in Brussels, Moscow, Beijing and Tel Aviv, the head office assists the president, the vice-presidents and the managing director in fulfilling their duties.

Energy | Earth and Environment | Health | Aeronautics, Space and Transport | Matter | Information

RESEARCH FIELDS

In the six Research Fields, which conduct their work on the basis of program-oriented funding, Helmholtz scientists carry out cross-center research with external partners in interdisciplinary international collaborations.

Within each Research Field, there are three bodies for its specific and cross-center issues:

MANAGEMENT BOARD

The Management Board serves as a communication and strategy platform for the management of the centers involved in the Research Field.

RESEARCH FIELD PLATFORM

In the Research Field Platform, the centers and the funding bodies discuss and unanimously decide on topics specific to the Research Field.

STRATEGY BOARD

The task of the Strategy Board is to provide independent, external scientific advice for the Research Field, the Senate and the President.

HELMHOLTZ ASSOCIATION

The Helmholtz Association is a registered association comprising 17 legally independent research centers and one associate institute.

- Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research
- Deutsches Elektronen-Synchrotron DESY
- German Cancer Research Center
- German Aerospace Center (DLR)
- German Center for Neurodegenerative Diseases (DZNE)
- Forschungszentrum Jülich
- GEOMAR Helmholtz Centre for Ocean Research Kiel
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz-Zentrum Berlin für Materialien und Energie
- Helmholtz-Zentrum Dresden-Rossendorf
- Helmholtz Centre for Infection Research
- Helmholtz Centre for Environmental Research – UFZ
- Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
- Helmholtz Zentrum München – German Research Center for Environmental Health
- Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences
- Karlsruhe Institute of Technology
- Max Delbrück Center for Molecular Medicine in the Helmholtz Association
- Max Planck Institute for Plasma Physics (associate member)

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