Hector Fellow Academy

Interdisziplinäres Netzwerk für Spitzenforschung

Hector Fellow Academy

Foreword

Dear readers,

How can the natural sciences and engineering meet the social, ecological and economic challenges of tomorrow? By bringing together top researchers from different disciplines, the Hector Fellow Academy supports the development of new ideas and approaches.

At the same time, the focus is on promoting young scientists and their innovative research projects. The Hector Fellows teach and conduct research at a wide variety of universities and research institutions in Germany. They represent disciplines within the natural and engineering sciences, AI, psychology and medicine. Their fields of activity range from research into cell mechanisms to the elucidation of galaxy evolution. In addition to the Hector Science Award, all Hector Fellows have received other prestigious national and international research awards. They hold important positions in central associations and societies in their field.

The Hector Fellow Academy aims to initiate visionary socio-political discourse, contribute to solving global challenges and at the same time strengthen Germany as a center of research and science.

Gain an insight into the activities of the Science Academy and the fascinating research of the Hector Fellows and their early career researchers. Get to know our network and join us in providing impetus for innovation.

Josephine and Dr. h.c. Hans-Werner Hector

10 Years Hector Fellow Academy

In 2013, the Hector Fellow Academy was established to strengthen the network among recipients of the Hector Science Award. In 2024, we will celebrate the 10th anniversary during the HFA Symposium in Hamburg.

10 Years Hector Fellow Academy

"From our original idea of honoring outstanding researchers for their special contribution with the Hector Science Award, something wonderful has emerged: A vibrant network of top scientists who not only pass on their knowledge to the next generation in the Hector Fellow Academy, but also face the challenges of our time together. With its diverse formats, the Academy not only focuses on the holistic promotion of young talent, but also contributes to the transfer of knowledge to society. We have been following the development of the Hector Fellow Academy for 10 years with great pleasure and are sure that the future holds many more success stories."

Josephine and Dr. h.c. Hans-Werner Hector

In December 2013, the Hector Fellow Academy was officially founded in a special ceremony. From left to right: Uwe Bleich and Horst-Bodo Schauer (both Hector Foundation II), Prof. Dr. Doris Wedlich (former Hector Fellow), Prof. Dr.-Ing. Hermann Hahn (former President of the Heidelberg Academy of Sciences and Humanities, Dr. Simone Schwanitz (former Ministerial Directorat the Ministry of Science, Research & Art in Baden-Württemberg), Prof. Dr. Axel Meyer, Prof. Dr. Holger Hanselka (former President of the Karlsruhe Institute of Technology (KIT), Dr. h.c. Hans-Werner Hector (Hector Foundation II), Dr.-Ing. Judith Elsner (Managing Director of the Hector Fellow Academy).

Congratulations from Hector Fellows

"The award and support from the Hector Foundation is not only a great honor and support for my research. The membership in the Hector Fellow Academy is also extraordinarily inspiring, as the Foundation's meetings and public symposia facilitate an exchange with excellent colleagues from other disciplines."

Prof. Dr. Katrin Amunts

"The Hector Fellow Academy offers a unique framework for interdisciplinary exchange and getting to know completely new scientific fields at the highest level. The promotion of young scientists is a particularly important aspect that helps to carry this knowledge into the future and develop it further."

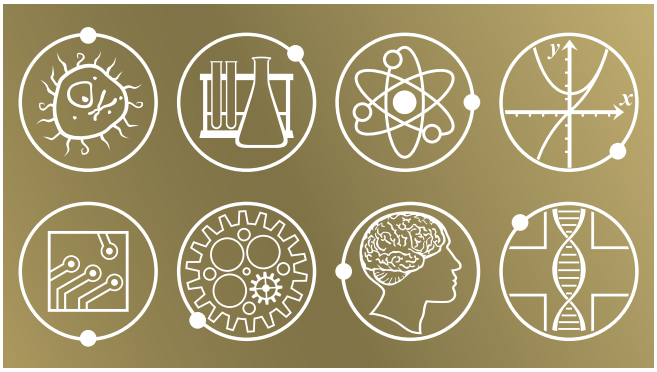
Prof. Dr. Immanuel Bloch

"10 years of the Hector Fellow Academy means a decade of promoting, challenging and celebrating deep, surprising and innovative scientific knowledge. The Hector Fellows come from such different disciplines that there is always something new to learn. For me, the promotion of young researchers with their very own ideas for projects with us Fellows is a particular highlight of the Academy."

Prof. Dr. Antje Boetius

"The HFA facilitates the realization of the potential of exceptional thinkers and researchers through mutual inspiration. It thus transcends the boundaries of contemporary knowledge and establishes a novel dimension of research and education that is inextricably linked with the pursuit of sustainable ethical reflection."

Prof. Dr. Thomas Elbert



10 YEARS OF INTERDISCIPLINARY CUTTING-EDGE RESEARCH

- Network of top researchers in the natural and engineering sciences, medicine and psychology
- Promotion of outstanding scientists
- Novel and innovative research projects
- Excellence in science beyond the boundaries of disciplines
- Promotion of young researchers
- Dialogue with the public

"It is a pleasure and an honor to be part of the Hector Fellow Academy. With its focus on excellence and interdisciplinarity, the HFA has been very successful in enabling new, innovative research projects that would otherwise not have been possible. A special highlight are the HFA's valuable and very successful career support measures for outstanding young researchers. The enormous interest in the HFA's outreach events underlines the high quality of the Academy's very effective science communication with the general public."

Prof. Dr. Eva Grebel

"The Hector Fellow Academy combines cutting-edge research with the promotion of early career scientists in an outstanding way. The unbureaucratic support of exciting scientific ideas and the interdisciplinary networking of researchers at different career levels are particularly noteworthy."

Prof. Dr. Dr. h.c. Nikolaus Pfanner

"Lively, interdisciplinary and inspiring - the Hector Fellow Academy is a great gift for our research landscape."

Prof. Dr. Bernhard Schölkopf

The Hector Fellow Academy (HFA)

The Hector Fellow Academy is a young science academy. It offers its members a platform for cross-field networking and interdisciplinary projects. The HFA also supports promising young scientists. In addition to the Hector Science Award winners, the HFA includes the Hector Research Career Development Awardees as well as doctoral and postdoctoral researchers from the STEM disciplines, medicine and psychology. The Academy has also established a network for former members to facilitate ongoing dialogue beyond the lifespan of individual projects.

Hector Science Award

Since 2008, the Hector Foundation II of Josephine and Dr. h.c. Hans-Werner Hector has awarded the Hector Science Award each year.

The award recognizes professors at German universities and research institutions working in the natural and engineering sciences, medicine or psychology for their outstanding research achievements and their special dedication to teaching and the fostering of young scientists. (page 7 ff.)

Hector Research Career Development Award

The Hector Fellow Academy has been awarding the Hector Research Career Development Award since 2020. With this award, the HFA supports excellent scientists with a W1 professorship or junior research group leadership on their academic career path.

The award winners' research projects can be made possible with the help of the prize money and funding for a doctoral position. (page 15 ff.)

Promotion of young talent: Doctoral projects

One focus of the HFA is the promotion of young academics. In the annual application process, excellent Master's graduates are selected to work as research assistants in the working group of the Hector Fellow or Hector RCD Awardee. They also receive additional research funding.

In line with a holistic approach, all early career researchers acquire management skills in addition to their research expertise.

In selected trainings, including courses at the HECTOR School of Engineering & Management – the Technology Business School of the Karlsruhe Institute of Technology – they acquire skills in project organization, scientific writing and presentation.

They can apply the know-how they acquire directly in their research project. At the same time, they gain long-term qualifications for leadership-level positions. (page 19 ff.)

Interdisciplinary research

The central concern of the HFA is the interdisciplinary exchange between its members. The HFA's support consists of creating a framework for interdisciplinary projects between Hector Fellows as well as Hector Research Career Development Awardees. They can employ junior researchers to work on the research projects.

In addition, annual symposia and interdisciplinary conferences on innovative issues create space to initiate new joint research topics.

As part of the activities of the Hector Fellow Academy office, networking among the members is a particularly central goal.

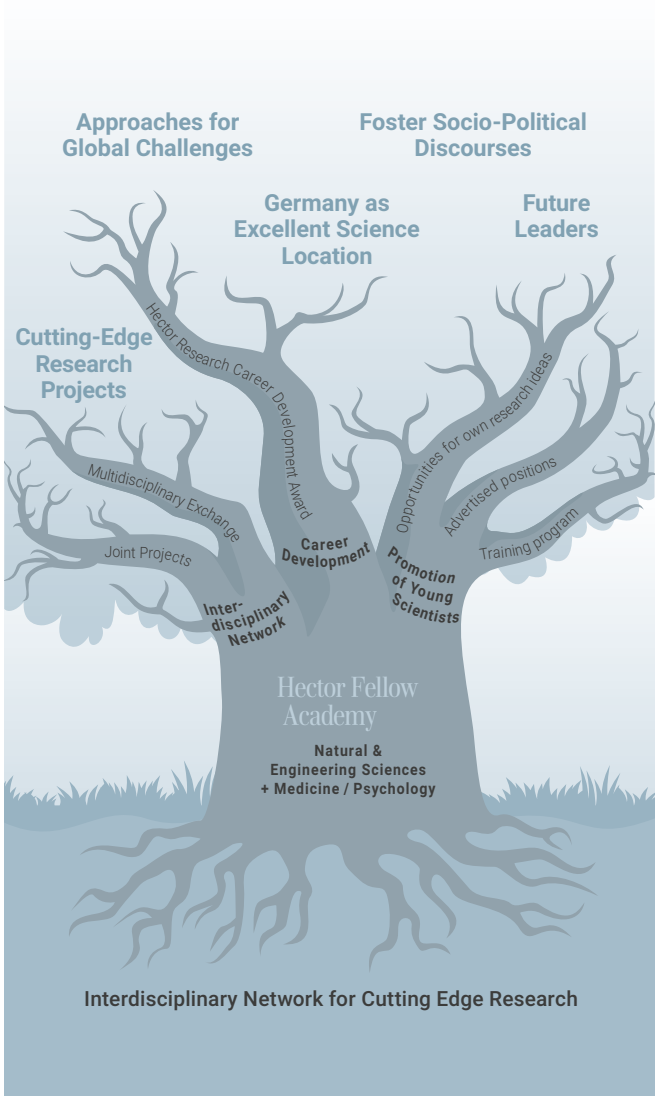


Illustration of the structure and objectives of the Hector Fellow Academy

A portrait of the HFA

On YouTube: https://youtu.be/Ga1G2TApukA

Events for scientific exchange

The Hector Fellow Academy sees itself as a place for dialog: The annual symposium offers members the opportunity to enter into an exchange with the public on socio-political topics as well as with representatives from science, politics and business. In addition, the HFA promotes joint conferences between Hector Fellows or Hector Research Career Development Awardees, supports the recruitment of keynote speakers and acts as a sponsor of Speaker's Awards at conferences.

Annual symposium & science evening

The HFA symposia take place annually throughout Germany on a rotating basis at the Hector Fellows' locations.

At the public science evening, bridges are built between the research topics of the Hector Fellows and the central challenges of our time. Experts present current research topics in a generally understandable way and discuss visions for the future. Discussion rounds promote dialog between science and the public and help to initiate visionary discourse.

During the internal program, HFA members can network, present the current status of funded projects and get to know the research facilities at the location. The Hector Research Career Development Award ceremony is also part of the symposium.

Conferences & Workshops

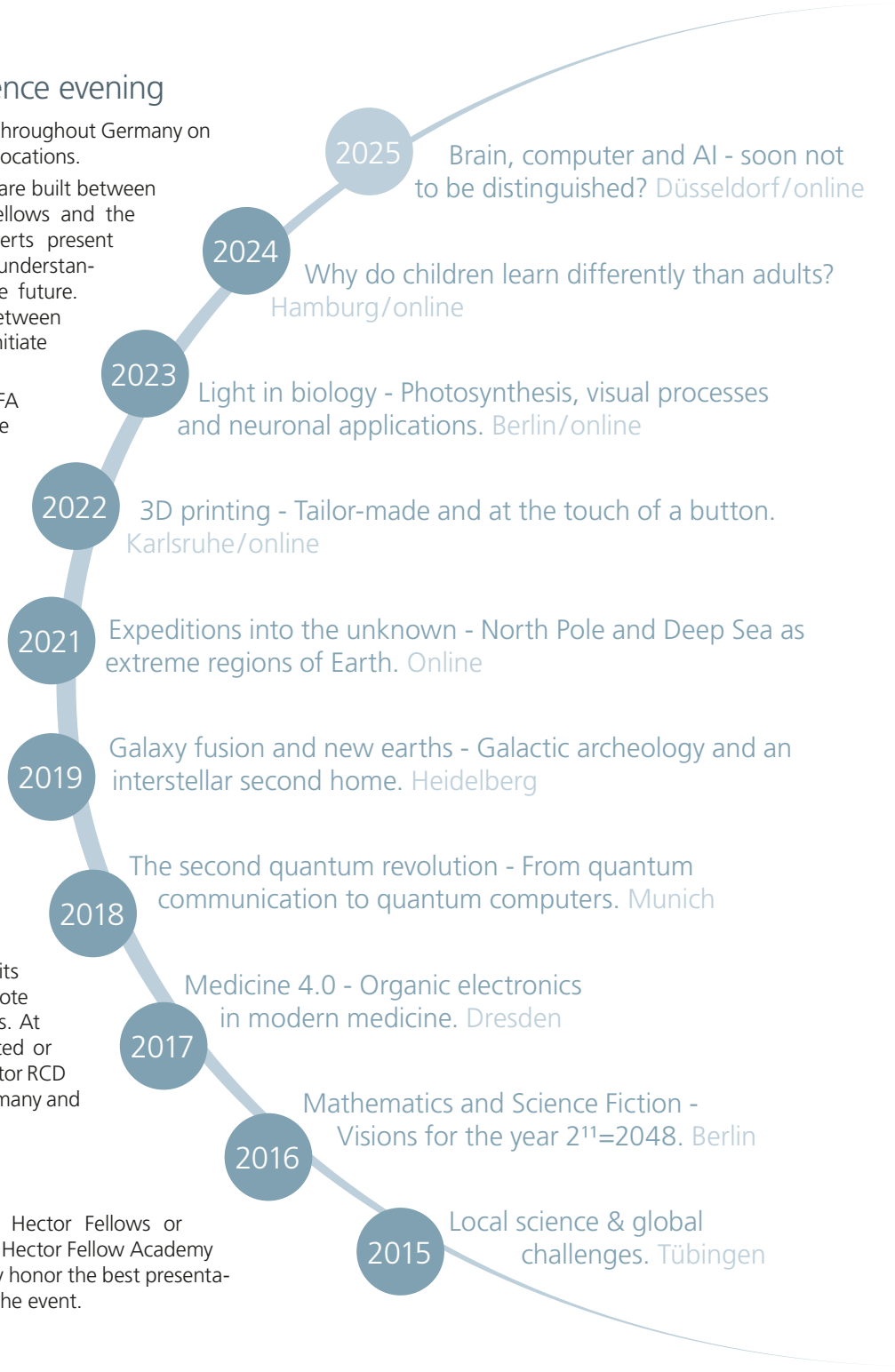
Joint workshops or conferences of several Hector Fellows and Hector Research Career Development Awardees can be funded by the HFA. This strengthens interdisciplinary cooperation between the Hector Fellows.

Keynote Speakers

The Hector Fellow Academy supports its members in attracting renowned keynote speakers for conferences and meetings. At such specialist events, which are hosted or co-organized by a Hector Fellow or Hector RCD Awardee, top-class scientists from Germany and abroad can be invited as speakers.

HFA Speaker´s Award

As Chair of a scientific conference, Hector Fellows or Hector RCD Awardees can present the Hector Fellow Academy Speaker's Award. With this award, they honor the best presentations given by young scientists during the event.



Impressions of past HFA Science Evenings (2015-2023)

Scientific organizer of the HFA Science Evening 2023 was Prof. Dr. Peter Hegemann. The event took place in Berlin.

First after-COVID Science Evening in 2022 by Prof. Dr. Martin Wegener (center) together with Prof. Dr. Tal Dvir (right) and Andrea Grießmann (left) in Karlsruhe.

Scientific organizer of the HFA Science Evening 2021 Prof. Dr. Antje Boetius (center) with speaker Prof. Dr. Markus Rex (left) and moderator Dirk Steffens (right), due to COVID it was an online-event streamed from Bremen.

From left to right: Prof. Dr. Stephen A. Hashmi, Hector Foundation II members Uwe Bleich, Horst-Bodo Schauer and Hans-Werner Hector, Prof. Dr. Eva Grebel (organizer), Prof. Dr. Joachim Wambsganß (speaker), Prof. Dr. Harald Lesch (moderator).

Prof. Dr. Anton Zeilinger in front of a big auditorium in Munich in 2018.

Scientific organizer of the HFA Science Evening 2017 in Dresden was Prof. Dr. Karl Leo. The event was moderated by Prof. Dr. Eberhart Zrenner.

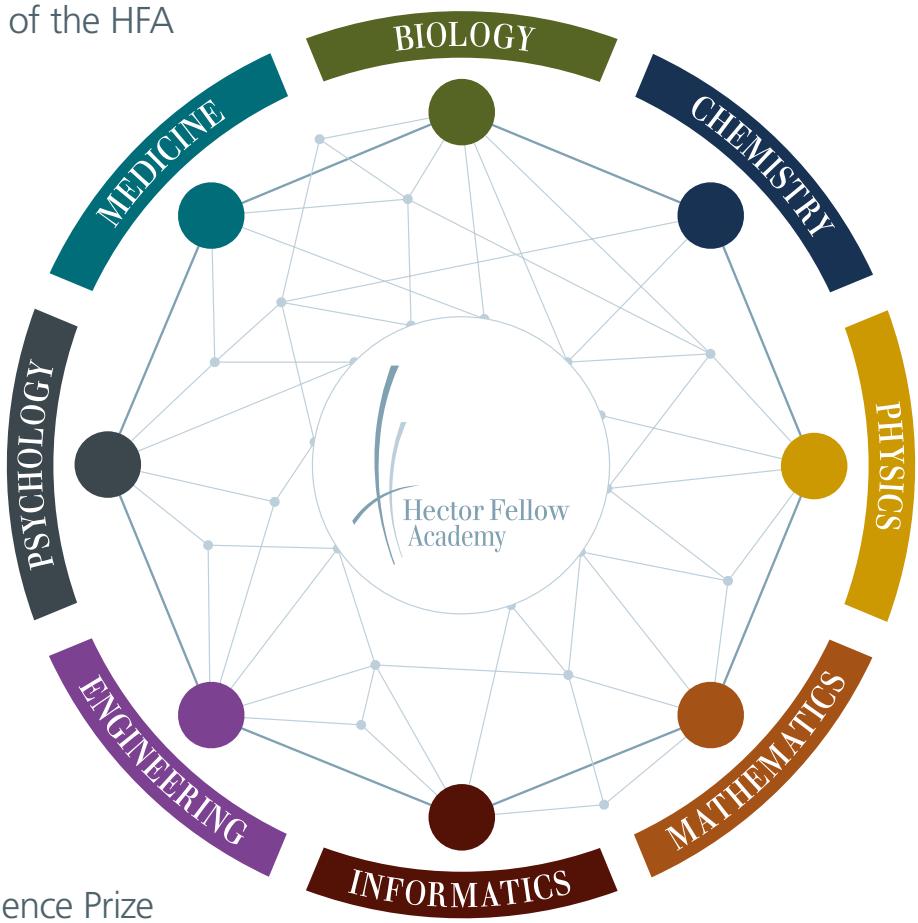
In 2016, the event took place in Berlin with Prof. Günter M. Ziegler, PhD.

The first public event was organized by Prof. Dr. Eberhart Zrenner in Tübingen, 2015.

Excellence across disciplines

Since 2008, the Hector Foundation of Josephine and Dr. h.c. Hans-Werner Hector have awarded the annual Hector Science Award, which is endowed with €150,000. The prize is awarded to professors from the STEM disciplines, psychology or medicine who have made an outstanding contribution to research and teaching. The Hector Fellows teach and conduct research at universities and research institutions in Germany and Switzerland.

The disciplines of the HFA



The Hector Science Prize and the Hector Fellows

Chosen as the best from the circle of extraordinary university lecturers, they are beacons in their fields," emphasized Dr. h.c. Hans-Werner Hector at the very first award ceremony in 2009.

With the announcement of the Hector Science Award, the honorees are named Hector Fellows. The award is intended to give the Hector Fellows an incentive to share their scientific expertise with students and young academics and to disseminate it to society. Rectors and presidents of German universities as well as the heads of renowned non-university research institutions can nominate one candidate from their institution each year.

The award winners are selected by the Hector Foundation's Board of Trustees, which is made up of the following people: Prof. Dr. Klaus van Ackern, long-time Dean of the Mannheim Faculty of Medicine at Heidelberg University, Dr. John Feldmann, former member of the Executive Board of BASF, Prof. Dr. Stefan Hell, 2014 Nobel Prize winner in Chemistry, Prof. Dr. Otmar Wiestler, President of the Helmholtz Association of German Research Centers, representatives of the Hector Fellows and the Hector Foundation's Board of Directors.

31 professors have already received the award for their outstanding research achievements and their exceptional commitment to teaching and the promotion of young scientists.

Many of the Hector Fellows are recipients of other national and international research awards and hold important positions in central committees and institutions in their discipline.

The award winners are automatically members of the Hector Fellow Academy. The members of the HFA are represented by an elected Executive Committee, which also directs the thematic and academic work of the HFA. The current members of the Executive Committee are Prof. Dr. Eva Grebel, Prof. Dr. Dr. h.c. Peter Hegemann and Prof. Dr. Brigitte Röder.

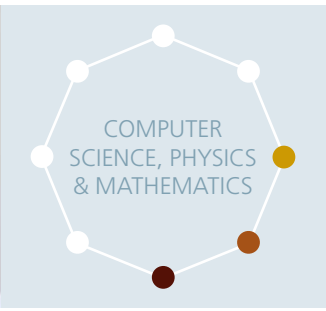
Members of the Hector Fellow Academy at the symposium in Karlsruhe 2023

Hector Fellow since 2023

Prof. Dr. Magdalena Götz

Magdalena Götz heads the Chair of Physiological Genomics at the Biomedical Center of the Ludwig-Maximilians University, the Institute for Stem Cell Research at the Helmholtz Zentrum Munich and is an external member of the Max Planck Institute for Biochemistry in Martinsried. She investigates the mechanisms by which nerve cells are formed during brain development and then uses them to replace nerve cells after brain injury. One of her most important discoveries is the transformation of glial cells into new neurons after brain injury. She continues to pursue these new approaches and new discoveries on the diversity of organelles in the direction of therapy. Among other awards, she received the Gottfried Wilhelm Leibniz Prize in 2007, the Ernst Schering Prize in 2014 and the Mendel Medal of the Leopoldina in 2019. She is also a member of EMBO, the Bavarian Academy of Sciences, Leopoldina and the Spanish Royal Academy of Pharmacy.

Hector Fellow since 2023



Prof. Dr. Klaus-Robert Müller

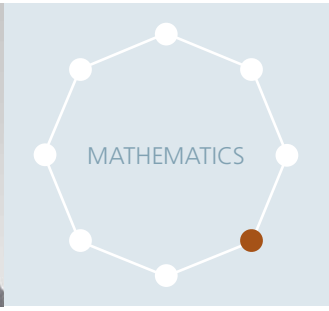
Klaus-Robert Müller is Professor of Machine Learning at the TU Berlin and Director of BIFOLD (Berlin Institute for the Foundations of Learning and Data). He conducts research in the field of machine learning and artificial intelligence, focusing on fundamental research at the intersection of machine learning and big data management, with an emphasis on explainable AI, deep learning and multimodal learning. He aims to apply the methods of machine learning and AI to other scientific disciplines, such as quantum chemistry, digital histopathology, neuroscience and humanities, to create genuinely new knowledge. He is a distinguished professor at Korea University in Seoul, a member of the Leopoldina, the Berlin Brandenburg Academy of Sciences and Humanities and the German Academy of Science and Engineering; in addition to various "best paper" awards, he received the Berlin Science Prize in 2014 and the Vodafone Innovation Prize in 2017. Since 2019, he has appeared on Clarivate Analytics' list of "Highly Cited" scientists.

Hector Fellow since 2022

Prof. Dr. Dr. h.c. Christian Haass

Christian Haass is Professor of Metabolic Biochemistry at the Ludwig-Maximilians-Universität München and spokesperson for the German Center for Neurodegenerative Diseases Munich. Christian Haass is a German biochemist known for his work on the cell biology of neurodegenerative diseases. Together with an interdisciplinary team, he has elucidated the molecular mechanisms of the development of Alzheimer's disease and identified target molecules for therapeutic approaches. Christian Haass is spokesperson for the Neurology Systems Cluster of Excellence. He is a member of the Leopoldina, the European Molecular Biology Organization (EMBO) and the Bavarian Academy of Sciences and Humanities. He is the recipient of numerous national and international prizes such as the Ernst Jung Prize for Medicine, the Gottfried Wilhelm Leibniz Prize of the German Research Foundation, the Brain Prize and the Potamkin Prize of the American Academy of Neurology. He has been one of the world's most cited researchers since 2018.

Hector Fellow since 2022



Prof. Dr. Anna Wienhard

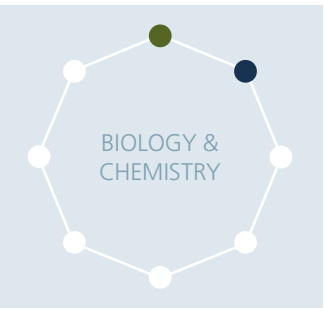
Anna Wienhard is Director at the Max Planck Institute for Mathematics in the Sciences and one of the world's leading mathematicians in the field of differential geometry. Symmetries and how they work in topological and geometric spaces play a central role in her research. One of her focal points is the field of higher Teichmüller theory, which she co-founded, and she is committed to closely linking basic mathematical research with other sciences. Her focus is on interactions with theoretical physics and the application of geometric and topological methods in data analysis and machine learning. Anna Wienhard is Scientific Director of the Heidelberg Laureate Forum Foundation. She was a founding member and co-spokesperson of the interdisciplinary Cluster of Excellence STRUCTURES, has been awarded an ERC Consolidator and an ERC Advanced Grant, is a Fellow of the American Mathematical Society and a member of several science academies..

Hector Fellow since 2021

Prof. Dr. Katrin Amunts

Katrin Amunts is Professor of Brain Research and Director of the C. and O. Vogt Institute for Brain Research at Heinrich Heine University Düsseldorf and Director of the Institute of Neuroscience and Medicine (INM-1) at Forschungszentrum Jülich. Since 2023, she has been Joint Chief Executive Officer of EBRAINS AISBL in Brussels. She is a German neuroscientist known for her work on mapping the human brain. In order to better understand the organizational principles of the human brain, she and her team have developed the Julich Brain Atlas, which brings together data from all levels of the brain and gives them a spatial framework. Katrin Amunts is spokesperson of the Helmholtz Joint Lab Supercomputing and Modelling for the Human Brain and coordinates the topic Decoding Brain Organization and Dysfunction of the Helmholtz Association. She is also a member of international advisory boards and several German Academies of Sciences and Humanities. In 2021, Katrin Amunts received the Federal Cross of Merit First Class and in 2023 the Justine and Yves Sergent Award.

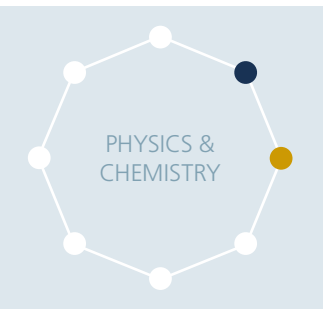
Hector Fellow since 2020



Prof. Dr. Patrick Cramer

Patrick Cramer is Director at the Max Planck Institute for Multidisciplinary Science and Honorary Professor at the Georg-August-Universität Göttingen. His field of research is the structural biology of macromolecular complexes of the cell nucleus and the functional genomics of gene regulation. He is one of the world's leading experts on the mechanisms of gene transcription in eukaryotic cells. He solved the three-dimensional structure of RNA polymerase II, discovered the mechanisms underlying gene regulation at the beginning of genes and developed methods to follow the metabolism of mRNA in the cell. He is now working on the development of new methods to visualize the transcription of the natural DNA template, called chromatin, and to analyze it functionally. Patrick Cramer has been awarded the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), the Ernst Schering Prize, the Ernst Jung Prize, the Otto Warburg Medal and the Order of Merit of the Federal Republic of Germany, among others.

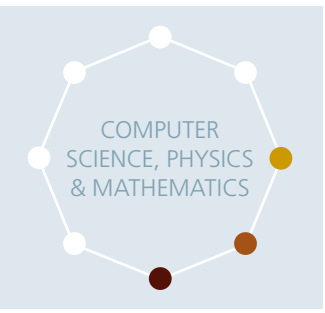
Hector Fellow since 2019



Prof. Dr. Wolfgang Wernsdorfer

Wolfgang Wernsdorfer is a Humboldt Professor at the Physics Institute and at the Institute for Quantum Materials and Technologies of the Karlsruhe Institute of Technology (KIT). He specializes in experimental solid-state physics at the interface of chemistry and materials science. He is one of the world's leading experts on nanomagnets and their use in molecular quantum spintronics. With the nano-SQUID, he has developed a groundbreaking measuring instrument with which he was able to investigate the magnetic properties of individual nanostructures and molecules. He is currently working on the integration of small, molecular quantum processors into other quantum technologies, such as superconducting circuits and CMOS microelectronics. Molecular nanomagnets could be used in future quantum computers. He is also working on miniaturized cryostats that can cool quantum technologies efficiently to very low temperatures. For this Wolfgang Wernsdorfer has been awarded numerous awards for his work.

Hector Fellow since 2018



Prof. Dr. Bernhard Schölkopf

Bernhard Schölkopf is Scientific Director of the new ELLIS Institute, Director at the Max Planck Institute for Intelligent Systems, Affiliated Professor at ETH Zurich, and Honorary Professor at the University of Tübingen and TU Berlin. He works on the recognition of regularities from observational data and has significantly shaped the research field of machine learning. With his work on kernel methods, he has shown how a large class of learning algorithms can be generalized to the non-linear case and to non-vectorial data. More recently, he has brought together machine learning and causal inference, in order to analyze not only statistical dependencies but also causal structures from observations and generative models that allow interventions. Bernhard Schölkopf is a member of the German National Academy of Sciences (Leopoldina) and has been awarded the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), the Milner Award of the Royal Society, the BBAW Foundation Frontiers of Knowledge Award, the Körber European Science Award and the ACM AAAI Allen Newell Award.

Hector Fellow since 2017

Prof. Dr. Brigitte Röder

Brigitte Röder is Professor of Biological Psychology and Neuropsychology at the University of Hamburg. She is co-opted into the Department of Medicine and is a visiting scholar at the LV Prasad Eye Institute in Hyderabad (India). The psychologist and neuroscientist investigates how the human brain manages to connect inputs from different sensory systems and how infants and children learn to do this. She researches age-dependent neuroplasticity, the dependence of human brain development and learning on experience. Sensitive phases in human development are studied, for example, in people who regain their sight after congenital blindness. Her team is also working on ways to promote neuronal plasticity and learning. Brigitte Röder is a member of the German National Academy of Sciences (Leopoldina) and the Academy of Sciences in Hamburg. She has received the Gottfried Wilhelm Leibniz Prize from the DFG, an ERC Advanced Investigator Grant and the Wilhelm Wundt Medal from the German Psychological Society. She has been a member of the DFG Senate since 2019.

Hector Fellow since 2016

Prof. Dr. Ralf Bartenschlager

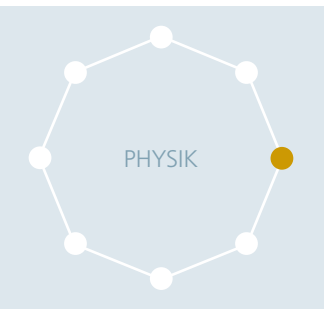
Ralf Bartenschlager is Director of the Department of Molecular Virology at the Center for Infectiology of the Medical Faculty of the Ruprecht-Karls-University Heidelberg and Head of the Department of Virus-associated Carcinogenesis at the German Cancer Research Center Heidelberg. The virologist researches replication strategies and immunobiology of medically important hepatitis viruses, flaviviruses (dengue virus, Zika virus) and the SARS coronavirus-2. He has succeeded in developing cell culture models for the hepatitis C virus (HCV), with which the viral replication cycle could be simulated in vitro for the first time. These models formed the basis for the development of antiviral drugs that eliminated the virus in more than 95% of those treated. His work provided fundamental insights into the replication strategy of the hepatitis C virus and flaviviruses. Ralf Bartenschlager has been honored with the Lasker-DeBakey Award, Robert Koch Prize, Prince Mahidol Award, Beijerick Virology Prize and Ernst Jung Prize, among others. He is a member of the German National Academy of Sciences (Leopoldina), the European Molecular Biology Organization (EMBO) and holds an honorary doctorate.

Hector Fellow since 2015

Prof. Dr. Dr. h.c. Peter Hegemann

Peter Hegemann is Head of the Experimental Biophysics Group and Hertie Senior Professor of Neuroscience at the Humboldt University in Berlin. The world's leading expert in photobiology is a co-founder of optogenetics, which combines methods of optics and genetics for the non-invasive stimulation of individual neurons. His research on algae photoreceptors led to the discovery of light-dependent ion channels. The proteins involved ("channelrhodopsins") enable the precise control of genetically modified cells by light pulses, opening up new possibilities for the treatment of neuronal diseases. Peter Hegemann has received the Albert Lasker Basic Medical Research Award, Shaw Prize, Rumford Prize, Gairdner Award, Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), Grete Lundbeck European Brain Research Prize, among others. He is a member of the German Academy of Science and Engineering (acatech), the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW), the European Molecular Biology Organization and the German National Academy of Sciences (Leopoldina).

Hector Fellow since 2014



Prof. Dr. Eva Grebel

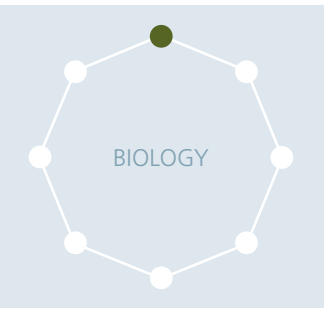
Eva Grebel is professor of astronomy and director of the Astronomisches Rechen-Institut at Heidelberg University. The astronomer is one of the world's leading researchers in the field of galaxy evolution. As a pioneer of "galactic archaeology", she uses ages, kinematics, and composition of stars as fossil tracers of the evolutionary history of nearby galaxies and our Milky Way. She investigates how star formation and enrichment with heavier elements occur and what role merger processes with smaller galaxies play. Eva Grebel has been awarded the Ludwig Biermann Prize, the Lautenschläger Research Prize, and the Caroline Herschel Medal, among others. She is a member of the Heidelberg Academy of Sciences and of the German National Academy of Sciences (Leopoldina). From 2013 to 2019 she was in the Senate of the DFG.

Hector Fellow since 2014

Prof. Dr. Dr. Thomas Lengauer

Thomas Lengauer was Director until 2018 and is an Emeritus Scientific Member at the Max Planck Institute for Informatics in Saarbrücken as well as an Honorary Professor at Saarland University, the University of Bonn and the University of Cologne. The pioneer in the field of bioinformatics has conducted research into the analysis of molecular sequences and structures, among other things, and is now primarily concerned with disease-oriented issues. His research has been honored with the Konrad Zuse Medal of the German Informatics Society, the Karl Heinz Beckurts Prize and the AIDS Research Prize of the Heinz Ansmann Foundation. He is a member of the Presidium of the German National Academy of Sciences (Leopoldina), the German Academy of Science and Engineering (acatech), the Academia Europaea and a Fellow of the Association for Computing Machinery (ACM) and the International Society for Computational Biology (ISCB). He was President of the International Society for Computational Biology from January 2018 to January 2021. He is co-founder of BioSolveIT GmbH, which develops software for computer-aided drug design.

Hector Fellow since 2013



Prof. Dr. Antje Boetius

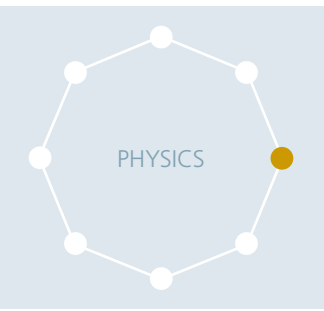
Antje Boetius is Director of the Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research, and Professor of Geomicrobiology at the University of Bremen. The internationally recognized deep-sea researcher investigates the biodiversity and biogeochemistry of the deep sea and polar oceans. She is particularly interested in interactions between the geosphere and biosphere and develops underwater technologies for observing the marine environment. Antje Boetius was awarded the Federal Cross of Merit in 2019. She has been awarded the German Environmental Prize, the Communicator Prize, the Carl Friedrich von Weizsäcker Prize from the Leopoldina and the Stifterverband, an ERC Advanced Grant and the Gottfried Wilhelm Leibniz Prize from the German Research Foundation (DFG), among others. She is a member of the German National Academy of Sciences (Leopoldina), the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW), the Academy of Sciences and Literature Mainz and the Max Planck Society. In 2022, she also received the "University Teacher of the Year" award.

Hector Fellow since 2013

Prof. Dr. Dr. Christoph Klein

Christoph Klein is Professor of Pediatrics and Adolescent Medicine and Medical Director of the Children's Clinic at the Dr. von Hauner Children's Hospital at Ludwig Maximilian University in Munich. He is one of the pioneers of cell and gene therapy for children with rare congenital immunological and hematological diseases. Together with his interdisciplinary team of researchers, he clarifies the genetic causes of diseases, studies the disease mechanisms and develops new therapeutic strategies with the aim of improving the chances of recovery for affected children in the long term. For his achievements, he has been awarded an Advanced Grant from the European Research Council (ERC), the William Dameshek Prize from the American Society of Hematology and the Gottfried Wilhelm Leibniz Prize from the German Research Foundation (DFG), among others. He is the founder of the Care-for-Rare Foundation to support children with rare diseases.

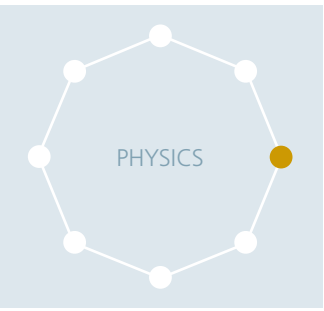
Hector Fellow since 2013



Prof. Dr. Karl Leo

Karl Leo is professor of optoelectronics and head of the Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP) at the Technical University of Dresden. He is one of the leading international scientists in the field of organic semiconductors. His research aims to explore the fundamental properties of novel flexible, biocompatible and degradable electronic components. His work has been awarded, among others, the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), the Federal President's Future Prize, and the Inventor Prize of the European Patent Office. He is a member of the European Academy of Sciences, the National Academy of Sciences (Leopoldina), the German Academy of Engineering Sciences (acatech), and a fellow of the Optical Society of America. With spin-offs (Novaled AG & Heliatek GmbH), he successfully transferred his research into industrial applications.

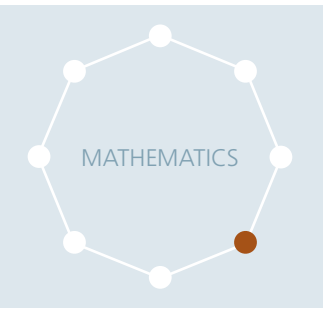
Hector Fellow since 2012



Prof. Dr. Immanuel Bloch

Immanuel Bloch is Professor of Experimental Physics at the Ludwig-Maximilians-Universität in Munich and Director at the Max Planck Institute for Quantum Optics in Garching. He is one of the world's leading scientists in the field of research into ultracold quantum matter near the absolute zero temperature. With the help of laser beams, he creates artificial crystals of light in which ultracold atoms can be trapped. This enables the investigation of fundamental quantum mechanical processes in materials. For his research, he has been awarded the Harvey Prize, the Körber Prize for European Science, an ERC Synergy Grant, the Senior Bose-Einstein Condensation Award, the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), the Bavarian Maximilian Order for Science and Art (2021), the ZEISS Research Award (2022) and the highest award in experimental physics of the German Physical Society, the Stern-Gerlach Medal 2024. He is a member of the German National Academy of Sciences (Leopoldina) and the Bavarian Academy of Sciences and Humanities.

Hector Fellow since 2012



Prof. Günter M. Ziegler, PhD

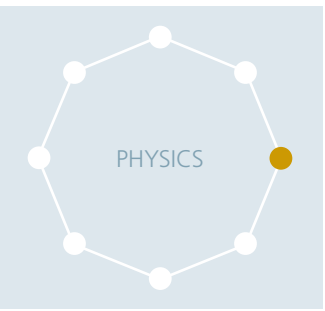
Günter M. Ziegler has been President of Freie Universität Berlin since July 2018. He is an internationally renowned mathematician who has become known for the construction and analysis of remarkably complex geometric structures, but also for the development and successful application of deep "topological" methods for problems from various fields, such as partitioning problems and optimization. Günter M. Ziegler has been awarded the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG) and an Advanced Grant of the European Research Council (ERC). He is a member of the Executive Committee of the German Mathematical Society and a member of the Executive Board of the International Mathematical Union (IMU). He is a member of the German National Academy of Sciences (Leopoldina) and the German Academy of Science and Engineering (acatech) and a Fellow of the American Mathematical Society.

Hector Fellow since 2012

Prof. Dr. med. Dr. h.c. mult. Eberhart Zrenner

Eberhart Zrenner is senior professor and founding director of the Research Institute for Ophthalmology at the Eberhard Karls University of Tübingen. He is a world-renowned expert in degenerative diseases of the retina, particularly in the field of causal research and therapy development. He has made a special contribution to the development of electronic subretinal retinal implants to restore vision in the blind. He played a key role in the development and implementation of the first gene therapy developments for hereditary retinal degenerations in Germany. Eberhart Zrenner has been awarded the Ludwig-von-Sallmann Prize and the Karl Heinz Beckurts Prize, among others. He is a member of the German National Academy of Sciences (Leopoldina) and the Heidelberg Academy of Sciences and Humanities, was spokesperson for the SFB 430, a member of the German Science Council and the Health Research Council until 2009, a Senator until 2005 and a member of the Board of Trustees of the Max Planck Society until 2020. He established the Foundation for Medical Innovation to support new therapeutic developments.

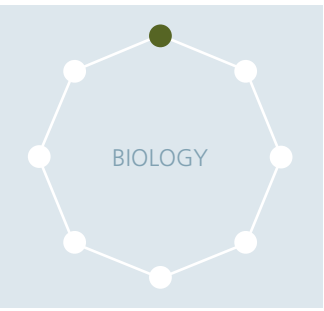
Hector Fellow since 2011



Prof. Dr. Hilbert von Löhneysen

Hilbert von Löhneysen is Professor Emeritus at the Institute of Physics and the Institute of Quantum Materials and Technology (IQMT) at the Karlsruhe Institute of Technology (KIT). He was also a founding member of the Institute of Nanotechnology (INT) at KIT and headed a working group there from 1999 to 2016. From 2000 to 2016, he was also head of the Institute for Solid State Physics (now IQMT) at KIT. His research focuses on experimental solid-state physics, on the one hand in the field of strongly correlated electron systems, in particular the investigation of magnetic quantum phase transitions, and on the other hand on the investigation of metallic nanostructures, for example nanocontacts between superconductors and ferromagnets. Hilbert von Löhneysen is a member of the Heidelberg Academy of Sciences and Humanities and the German Academy of Science and Engineering (acatech). He was a member of the Senate and Joint Committee of the German Research Foundation (DFG) until 2001, a member of the German Council of Science and Humanities until 2012 and Chairman of the Scientific Commission of the German Council of Science and Humanities until 2012.

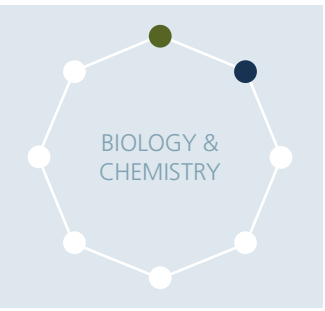
Hector Fellow since 2011



Prof. Dr. Axel Meyer

Axel Meyer is Professor of Zoology and Evolutionary Biology at the University of Konstanz. He is one of the world's leading experts in the field of evolutionary biology. He established the insight that species can evolve without geographical barriers and discovered that evolutionary change is possible in just a few decades. He also pioneered the use of genetic data to substantiate the relationship of individual species. Axel Meyer has received an Advanced Grant from the European Research Council (ERC) and the Carus Medal from the German National Academy of Sciences (Leopoldina) for his work. The magazine CICERO included him in its list of Germany's most important intellectuals. He is a member of the German National Academy of Sciences (Leopoldina), the American Academy of Arts and Science, the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW), the Academia Europaea and the European Molecular Biology Organization.

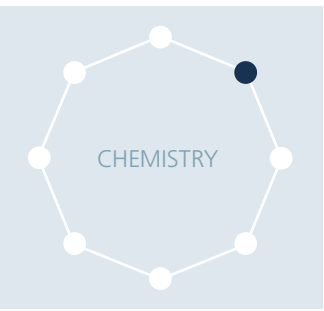
Hector Fellow since 2011



Prof. Dr. Dr. h.c. Nikolaus Pfanner

Nikolaus Pfanner is Director of the Institute of Biochemistry and Molecular Biology at the University of Freiburg. He is an expert in the field of mitochondria, the composition of which he and his team were the first to decipher. In addition to the organization of mitochondria, his research focuses on elucidating the transport mechanisms of proteins from the cytosol of the cell through the mitochondrial membranes to their destination inside the cellular power plants. Nikolaus Pfanner has been awarded the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), the Schleiden Medal of the German National Academy of Sciences (Leopoldina), the Otto Warburg Medal of the Society for Biochemistry and Molecular Biology, the Wilhelm Feldberg Prize, the Stein and Moore Award of the Protein Society, and the Order of Merit of the Federal Republic of Germany. He is a member of the Leopoldina, the Heidelberg Academy of Sciences and Humanities, and the Academia Europaea.

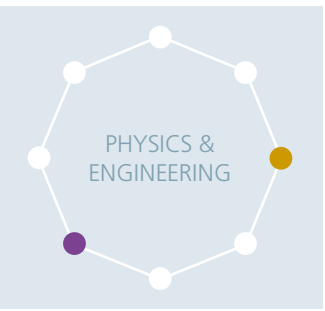
Hector Fellow since 2010



Prof. Dr. A. Stephen K. Hashmi

A. Stephen K. Hashmi is a professor at the Institute of Organic Chemistry at Heidelberg University. From 2013 to 2019 he was Vice Rector for Research and Transfer. He has gained worldwide recognition in the field of homogeneous gold catalysis. His research focuses on the production of new gold catalysts and the development of innovative synthesis methods as well as detailed mechanistic studies. Potential applications lie in the production of active ingredients for pharmaceuticals and compounds for materials science, e.g., in the field of organic electronics. A. Stephen K. Hashmi has been awarded a Lectureship at the Czech Academy of Sciences, the Tan Kah Kee Chemistry Lectureship at Xiamen University (China) and the Fred Pattison Senior Lectureship at the University of Western Ontario (Canada). He is a member of ChemPubSoc Europe, the Society of German Chemists, the American Chemical Society, honorary member of the Argentinean Society for Organic Chemistry, is a member of the Academia Europaea and is editor of the Springer/Nature Journal "Gold Bulletin".

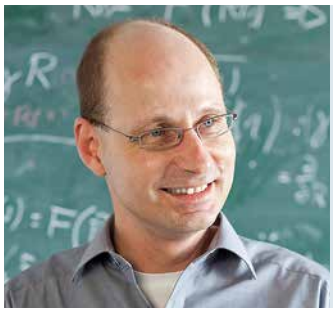
Hector Fellow since 2010

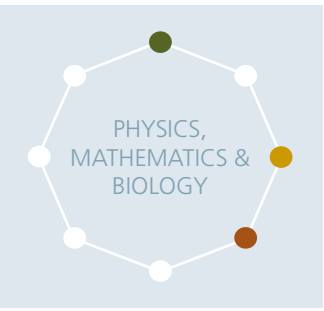


Prof. Dr. Jürg Leuthold

Jürg Leuthold is head of the Institute for Electromagnetic Fields at the Swiss Federal Institute of Technology (ETH) in Zurich. He holds a doctorate in physics and is working on new concepts and processes for optical signal processing at the highest data transmission rates. Among other things, his research aims to further increase the transmission rate of digital information, reduce energy consumption and miniaturize the components used. For example, his group is known for the smallest and fastest switches and detectors in the field of optical communication and mobile communication. Jürg Leuthold's work has been honored with an Advanced Grant from the European Research Council (ERC), the Baden-Württemberg State Research Prize and the Doron Prize. He is a Fellow of the Institute of Electrical and Electronics Engineers, a Fellow of the Optical Society, a member of the Swiss Academy of Engineering Sciences, a corresponding member of the Heidelberg Academy of Sciences and was a member of the Board of Directors of the Optical Society of America until 2018.

Hector Fellow since 2010





Prof. Dr. Jens Timmer

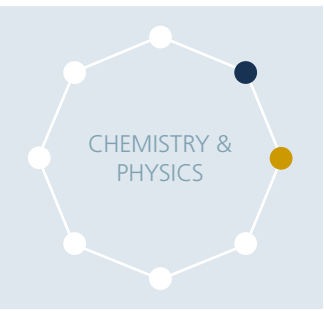
Jens Timmer is Professor of Theoretical Physics at the Institute of Physics at the University of Freiburg. He is one of the pioneers in the field of systems biology: with the help of data-based mathematical models from physics, he explains cell biological processes. His approach has made it possible, for example, to decipher signaling pathways that are of great importance in the of great importance in the development of cancer. He is co-founder of the medical technology companies seleon GmbH and TNI medical AG.

Hector Fellow since 2009

Prof. Dr. Thomas Elbert

Thomas Elbert is Professor Emeritus of Clinical Psychology and Behavioral Neuroscience at the University of Konstanz. He investigates the consequences of traumatic stress and the motivations for acts of violence and combat. In the laboratory and in war and crisis zones, he researches trauma-related changes in the psyche, body and gene expression and develops therapy options on this basis. Elbert is a member of the German National Academy of Sciences (Leopoldina), the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW), the Academia Europaea and holds honorary professorships at the Université Lumière (Burundi), among others. He has been awarded the German Psychology Prize and, together with Maggie Schauer, the Carl Friedrich von Weizsäcker Prize. As founding president of the non-profit organization vivo international, Thomas Elbert is committed to overcoming the psychological and physical consequences of traumatic stress and preventing violence. For this, the International Society for Research on Aggression presented him with its highest award, the Scott Award, in 2024.

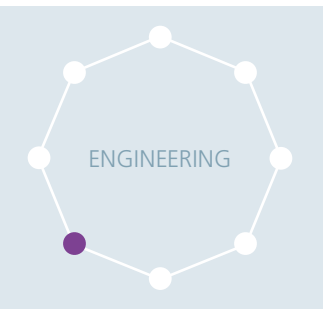
Hector Fellow since 2009



Prof. Dr. Manfred Kappes

Manfred Kappes is Professor at the Institute of Physical Chemistry and Director at the Institute of Nanotechnology and Group Leader at the Institute of Quantum Materials and Technologies at the Karlsruhe Institute of Technology (KIT). He deals with size-dependent properties of matter in the range of 0.5 to ten nanometers. Using ion beam and mass spectrometry methods that he developed himself, he investigates how optical, electronic, mechanical and chemical properties change with the atomic and charge number of particles. Among other things, his work aims to create new types of carbon materials with specific electronic and mechanical properties. Manfred Kappes has been awarded the Van't Hoff Prize of the German Bunsen Society for Physical Chemistry, the Xingda Lectureship of Peking University (China) and a Distinguished Professorship of IIT Madras (India). He is a member of the German National Academy of Sciences (Leopoldina), the Heidelberg Academy of Sciences and Humanities and the Berlin-Brandenburg Academy of Sciences and Humanities (BBAW).

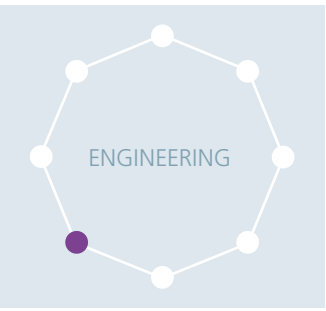
Hector Fellow since 2009



Prof. Dr.-Ing. Dr. h.c. mult. Franz Nestmann

Franz Nestmann was head of the Institute for Water and River Water Development at the Karlsruhe Institute of Technology (KIT) from 1994 until 202 and is President of the Baden-Württemberg Water Management Association. The expert in fluid mechanics and hydraulic engineering deals with solid matter transport processes, water and energy management, flood and bank protection as well as flowing waters in caves. He has already led numerous international joint projects from the planning and development phase through to the construction and operation of plants - currently a joint project on coastal and groundwater protection in the Mekong Delta. He is particularly interested in an interdisciplinary approach to the provision of water and energy in developing regions, which takes engineering and social science aspects into account. Franz Nestmann has received honorary doctorates from universities in Moscow and Nizhny Novgorod and is a member of the Russian Academy of Sciences. In 2019, he was made an honorary citizen of the Hang Giang region in northern Vietnam.

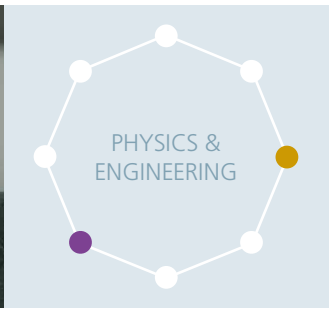
Hector Fellow since 2008



Prof. Dr. Peter Gumbsch

Peter Gumbsch heads the Chair of Mechanics of Materials at the Karlsruhe Institute of Technology (KIT) and the Fraunhofer Institute for Mechanics of Materials (IWM) in Freiburg. He conducts research into the behavior of materials under load and the limits of their load-bearing capacity. To this end, he investigates the structure and properties of materials from their atomic structure to their macroscopic behavior. His aim is to make materials and components safer, more reliable and more durable and to improve the material and energy efficiency of technical systems. Peter Gumbsch has received numerous awards and honors, including the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG) in 2007. He is a member of the German National Academy of Sciences (Leopoldina), the German Academy of Science and Engineering (acatech) and the US National Academy of Engineering (NAE). From 2017 to 2021, he was Chairman of the Scientific Commission of the German Council of Science and Humanities. He has been a member of the Executive Board of the Fraunhofer-Gesellschaft since 2019.

Hector Fellow since 2008



Prof. Dr. Martin Wegener

Martin Wegener is Professor at the Institute of Applied Physics at the Karlsruhe Institute of Technology (KIT), Scientific Director at the Institute of Nanotechnology at KIT and spokesperson for the Cluster of Excellence 3D Matter Made to Order at KIT and Heidelberg University. His research focuses on the high-precision 3D additive manufacturing of artificial materials, so-called metamaterials. The tailoring of "meta-atoms" on the nanometer or micrometer scale creates completely new properties. For example, his team succeeded in realizing cloaking caps in a wide variety of physical systems. He has received the Gottfried Wilhelm Leibniz Prize of the German Research Foundation (DFG), the Baden-Württemberg State Research Prize, the Carl Zeiss Research Prize and the René Descartes Prize of the EU, is a member of the German National Academy of Sciences (Leopoldina), the German Academy of Science and Engineering (acatech) and a Fellow of Optica. He is the initiator, co-founder and, until 2021, was a shareholder of Nanoscribe GmbH, a KIT start-up that brought innovative 3D laser lithography to marketability.

Hector Research Career Development Award

Since 2020, the Hector Fellow Academy has presented the Hector Research Career Development Award (Hector RCD Award) once a year. The Hector RCD Award supports outstanding young scientists in the natural and engineering sciences, medicine and psychology on their path to a professorship. They receive research funding and the opportunity to employ a doctoral researcher for the planned research project.

The Hector Research Career Development Award makes an active contribution to the promotion of young researchers in Germany. It recognizes outstanding scientific achievements and supports young scientists with a doctorate in their research career.

The award offers W1 professors (with or without tenure track) and junior research group leaders in comparable positions in the natural or engineering sciences, medicine or psychology the freedom to realize their own research project at the location of their choice and promotes their independence on the way to a professorship.

The award is endowed with €25,000. The researchers who receive the award, are accepted as temporary members of the Hector Fellow Academy and receive, among other things, additional funding for a doctoral position. Membership entitles the award winners to submit applications for further funding formats, e.g. for the organization of workshops or conferences and the presentation of a Speaker's Award, as well as for interdisciplinary projects.

The prize is awarded to three academics each year. When selecting the candidates, family care periods in the course of the academic career are also taken into account. The scientists supported by the Hector Research Career Development Award expand the network of the Academy of Science and create opportunities for new interdisciplinary collaborations between its members.

Awarding of the Hector Research Career Development Award in 2022.

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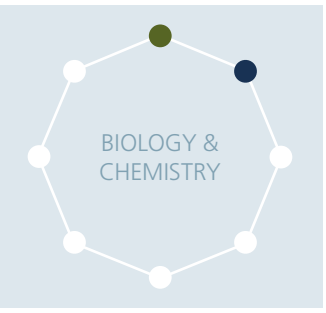
2023:
Three new Awardees

Hector Research Career Development Awardee 2023



Dr. Erik T. Frank

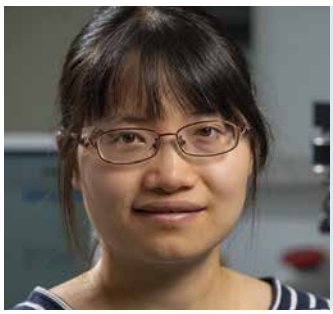
Erik T. Frank is an Emmy Noether Research Group Leader at the University of Würzburg and an expert in behavioral ecology and evolution. He researches how animals treat injuries - from ants that apply antimicrobial agents to their wounds to fight infections to chimpanzees that apply crushed flies to open wounds. To answer these questions, he uses behavioral experiments, microbiome analyses, chemical analyses, proteomic approaches and theoretical modeling to answer these questions. He is an advocate of science communication and has served as a scientific advisor for groundbreaking documentaries such as Life on Our Planet (Netflix), Sentient (National Geographic & Disney+) and Planet Insect (Curiosity Stream). He has also written a popular science book about his research that was nominated for the Science for All Award in France in 2022.

Hector Research Career Development Awardee 2023

Dr. Sebastian Frank

Dr. Sebastian Frank is an Emmy Noether research group leader at the Institute for Psychology within the Faculty of Human Sciences of the University of Regensburg. He was previously a postdoctoral researcher at Brown University (USA), after completing his PhD in Cognitive Neuroscience at Dartmouth College (USA). His group is interested in the biological mechanisms underlying learning and neuroplasticity in humans, with a focus on changes in these mechanisms across the lifespan. To this aim, they investigate learning and neuroplasticity in children, young and older adults, as well as older adults with dementia. They also develop training tools optimized for learning mechanisms in different age groups. Sebastian Frank's research is supported by the Deutsche Forschungsgemeinschaft and the Julitta und Richard Müller Stiftung. At "Brain Days" in elementary schools, he and his group share their enthusiasm for brain research with children.

Hector Research Career Development Awardee 2023



Dr. Jingyuan Xu

Jingyuan Xu is head of the CZS Nexus research group "Emission-free and environmentally friendly heating and cooling technologies" (ZEco Thermal Lab)" at the Institute of Microstructure Technology at the Karlsruhe Institute of Technology (KIT). Her research focuses on the development of heating and cooling technologies for the energy transition. She and her group are working on elastocaloric cooling - a field of research that is attracting increasing attention. This involves using stress-induced thermal changes in layers resulting from shape memory alloys to develop environmentally friendly, highly efficient cooling solutions. Her team is currently working on the development of CO^2-neutral elastocaloric cooling devices that do not require electricity. For her research, Jingyuan Xu was awarded the Leopoldina Prize for Young Scientists of the German Academy of Sciences, the Sadi Carnot Young Researcher Award of the International Institute of Refrigeration and the George T. Mulholland Memorial Award. She is a member of the Global Young Academy.

Hector Research Career Development Awardee 2022

Prof. Dr. Sofia-Iris Bibli

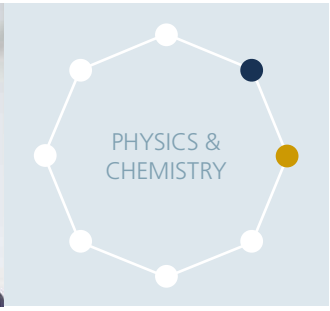
Sofia-Iris Bibli is Head of the Department of Vascular Dysfunction at the Mannheim Medical Faculty of Heidelberg University since 2024. Her research is focusing on vascular fate decisions and molecular mechanisms that drive endothelial cell transitions. Sofia-Iris Bibli studied Pharmacy from 2006 - 2011 and received her Master of Science in Molecular Pharmacology from 2011 - 2013. She received her PhD in Pharmacology in 2016 from the University of Athens. Sofia-Iris Bibli joined the Institute for Vascular Signalling, in the Medical Faculty of the Goethe University Frankfurt as a post-doctoral fellow in 2016 after being granted the European Society of Cardiology research grant. In 2021, she received the Emmy Noether Research grant and was appointed a W1 Professor for Cardiovascular Surveillance within the Excellence Cluster Cardiopulmonary Institute at the Medical Faculty of the Goethe University Frankfurt.

Hector Research Career Development Awardee 2022

Jun.-Prof. Dr. Anna Stöckl

Anna Stöckl is Junior Professor of Neuroethology and Emmy Noether Group Leader at the University of Konstanz. Anna Stöckl is an expert in sensory physiology. Her main research interest lies in how insects absorb and process information from their environment and use it to control their behavior. She uses a wide range of methods, from neuronal activity measurement, quantitative neuroanatomy, behavioral experiments to environmental imaging. She also works closely with robotics to use the insects' extraordinary abilities to develop autonomous robots. She has been honored with the Young Investigator Awards of the International Societies for Neuroethology and Experimental Biology as well as the KlarText! Prize for Science Communication from the Klaus Tschira Foundation. She is a fellow of the Zukunftskolleg Konstanz and a member of the Young Academy of the Bavarian Academy of Sciences and Humanities.

Hector Research Career Development Awardee 2022



TT-Prof. Dr. Philip Willke

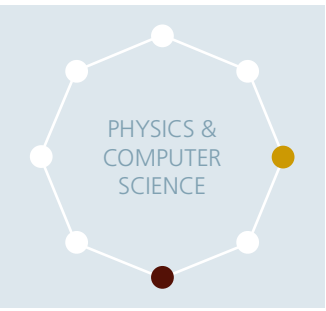
Philip Willke has been a W1 TenureTrack Professor at the Institute of Physics at the Karlsruhe Institute of Technology since 2022. Here, he has headed an Emmy Noether Research Group on "Quantum Coherent Control of Atomic and Molecular Spins on Surfaces" since 2020. His research focuses on the resolution and control of quantum systems on a microscopic scale and atom by atom. Using a scanning tunneling microscope, he and his group manipulate atoms and molecules. For example, his research has produced the world's smallest MRI scan, which images the magnetic field of a single atom, as well as the world's smallest magnetic data storage device. For his research, he was honored as "Young Scientist of the Year 2022" by the German Association of University Professors and Lecturers (DHV) and Academics.de. He received the Gaede Prize from the German Physical Society and the Gerhard Ertl Young Investigator Award 2022. He also took second place in the German Science Slam Championship in 2016.

Hector Research Career Development Awardee 2021

Prof. Dr. Kerstin Göpfrich

Kerstin Göpfrich is W3 Professor at the Center for Molecular Biology at Heidelberg University (ZMBH) and heads the Max Planck Research Group "Biophysical Engineering of Life" at the Max Planck Institute for Medical Research in Heidelberg. She is also Principal Investigator in the Cluster of Excellence 3D Matter Made to Order at KIT and Heidelberg University and a Fellow of the Max Planck School Matter to Life. Her research focuses on the construction of artificial cells from specially designed components. With the help of DNA/RNA nanotechnology, functional components are created that gradually endow lipid vesicles with the properties of living cells. For example, the team succeeded in producing artificial cytoskeletons or controlling the division of synthetic cells. Kerstin Göpfrich received the Women Interactive Materials Award for her work on materials with life-like properties. She was awarded an ERC Starting Grant and a Marie Skłodowska Curie Fellowship and received one of the prestigious Gates Cambridge Fellowships.

Hector Research Career Development Awardee 2021



Dr. Dylan Nelson

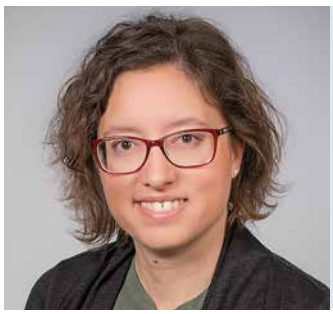
Dylan Nelson is Emmy Noether Research Group Leader at the Institute for Theoretical Astrophysics of the Center for Astronomy (ITA/ZAH) at Heidelberg University. His research group specializes in computational galaxy formation and evolution. It designs and performs numerical simulations to better understand how galaxies evolve over cosmic time. Dylan's research focuses on how gas flows: in, out and around galaxies. His interests include the cosmic baryon cycle, the circumgalactic medium and energetic feedback processes. Dylan is one of the leaders of the IllustrisTNG project, a new generation of cosmological magnetohydrodynamic simulations. He is a member of the DFG-funded research initiatives SFB881 The Milky Way System and the Cluster of Excellence STRUCTURES. After completing his PhD at Harvard University, he was a postdoctoral researcher at the Max Planck Institute for Astrophysics. In 2023, he was awarded the MERAC Prize of the European Astronomical Society.

Hector Research Career Development Awardee 2021

Jun.-Prof. Dr. Monika Schönauer

As a tenure-track professor, Monika Schönauer heads the Chair of Neuropsychology at the Institute of Psychology at the University of Freiburg, as well as the Emmy Noether Group The Development of the Engram. Monika Schönauer is an expert in the field of memory and sleep research. Her main research interest lies in how we form stable memories. To answer this question, she investigates functional activity and microstructural plasticity in the human brain using imaging techniques. She also uses machine learning approaches to track the development of memory representations - not only while awake, but also during sleep, where daytime experiences are processed covertly. Monika Schönauer was honored with the Leopoldina Early Career Award and the Heinz Maier-Leibnitz Prize of the DFG. She is a member of the Memory Disorders Research Society and the Wilhelm Wundt Society.

Hector Research Career Development Awardee 2020



Prof. Dr. Ana Rita Brochado

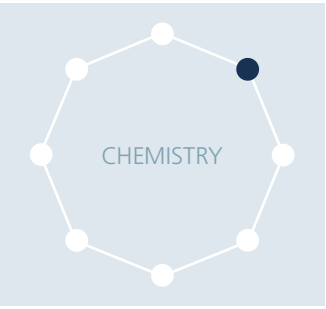
Ana Rita Brochado is an assistant professor working on systems microbiology at the University of Tübingen. She started an independent group leader at the University of Würzburg in 2019 with the aim of understanding how pathogenic bacteria respond to stress and how that shapes antimicrobial activity. The group combines microbiology, high-throughput screening and systems biology to gain insights into how bacteria operate. They especially focus on drug action beyond conventional targets to expose new druggable features in bacteria, thereby enabling better treatment design to overcome antibiotic resistance. Shortly after starting her research group, she was awarded an Emmy Noether Fellowship by the German Research Foundation (DFG). In 2021, she also received the Röntgen Prize of the University Association and the University of Würzburg. She is involved in several collaborative research initiates in Germany, including the SFB 1583 - Decision Points in Infections Diseases and the SPP 2330 New Concepts in Prokaryotic Virus-host Interactions – From Single Cells to Microbial Communities. In Tübingen, she is a member of the Cluster of Excellence Controlling Microbes to Fight Infections - CMFI.

Hector Research Career Development Awardee 2020

Dr. Dr. S. Leif Ludwig

Leif S. Ludwig is Emmy Noether Group Leader in the Research Focus on Single Cell Technologies for Personalized Medicine at the Berlin Institute of Health of Charité Universitätsmedizin and the Max Delbrück Center/Berlin Institute for Medical Systems Biology. His research focuses on the interface between hematology, human genetics and single cell genomics. His laboratory specializes in the development and application of single-cell multi-omics approaches to quantify, for example, stem cell activities and clonal dynamics in the context of human hematopoiesis. Another goal is to develop a deeper molecular understanding of how mitochondrial DNA mutations contribute to human disease. He has been awarded the Paul Ehrlich and Ludwig Darmstaedter Young Investigator Prize of the Paul Ehrlich Foundation and the Heinz Maier-Leibnitz Prize of the DFG, among others. He has been an EMBO Young Investigator since 2024.

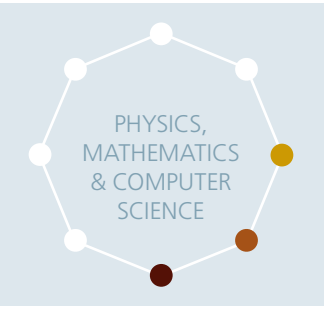
Hector Research Career Development Awardee 2020



Prof. Dr. Agnieszka Nowak-Król

Agnieszka Nowak-Król is a Professor and an Emmy Noether group leader at the Institute of Inorganic Chemistry and the Institute for Sustainable Chemistry & Catalysis with Boron of the University of Würzburg. Her research lies at the interface of organic, inorganic and materials chemistry. Agnieszka Nowak-Król's activities focus on the development of helically chiral π-conjugated organoboron compounds, boron-containing polycyclic aromatic hydrocarbons, photoswitches, helicenes containing other main group elements and their applications in organic electronics and bioimaging. Her group also develops potential inhibitors for cancer therapy. Agnieszka is the recipient of several awards and honors including the Arnold Sommerfeld Prize, the Thieme Chemistry Journals Award, the Wojciech Swietoslawski Award, the Zonta Award, and the Humboldt Research Fellowship. She is a member of the Societas Humboldtiana Polonorum, Soltech, the German Chemical Society, and the Polish Chemical Society.

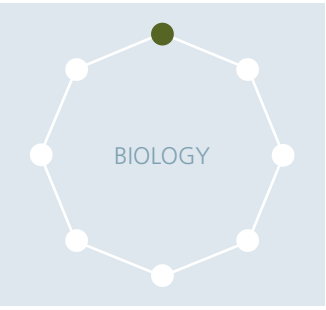
Hector Research Career Development Awardee 2020



Dr. Anna Pappa

Anna Pappa is Emmy Noether Junior Research Group Leader at the Department of Electrical Engineering and Computer Science at Technische Universität Berlin. Her field of research is quantum communication and cryptographic protocols. Her research aims to bridge the gap between theory and experiments to realize the full potential of quantum information processing. She has worked extensively on delegated quantum computation, quantum resource verification and quantum network routing as necessary processes for long-range quantum computation and is actively involved in the industrial application and utilization of quantum technologies. In addition to the six-year Emmy Noether fellowship from the German Research Foundation (DFG), Anna Pappa has received several other fellowships, including two Marie Skłodowska-Curie Individual Fellowships, an Alexander von Humboldt Research Fellowship and an Anita Borg Google Fellowship.

Hector Research Career Development Awardee 2020



Prof. Dr. Tessa Quax

Tessa Quax is Associate Professor at the Rijksuniversiteit Groningen. Her research focuses on the interaction between viruses and archaea. Archaea are present in many habitats, including those with extreme temperatures or salinities. She is interested in the molecular entry and exit mechanisms that viruses use to infect halophilic archaeal cells. Her goal is to gain insight into viral diversity, the viral impact on evolution and the arms race between viruses and cells. Tessa Quax has been awarded the EMBO Postdoctoral Fellowship, the Marie Curie Individual Fellowship and an ERC Starting Grant. She has also been awarded the Beijerinck Premium and the Early Career Award by the Royal Netherlands Academy of Sciences. She has recieved the Vidi grant from the Dutch research council (NWO), a HFSP young investigator grant and is coordinating a Marie Curie Doctoral network. Tessa is Chair of the Gordon Research Conference on archaea 2025 and member of the Scientific advisory board of the International Society for Viruses of Microbes.

Promoting young talent at the Hector Fellow Academy

The Hector Fellow Academy aims to promote and train outstanding young scientists. Every year, several doctoral positions in the working groups of the Hector Fellows and Hector RDC Awardees are filled with outstanding doctoral candidates from all over the world. As a science academy, the Hector Fellow Academy offers aspiring top researchers space for development and close collaboration with its members. On the other hand, they also receive financial support for the realization of interdisciplinary projects.

Doctoral projects

The Hector Fellow Academy offers graduates with excellent academic achievements and a very good Master's degree the opportunity to either complete a doctorate with their own research idea or to apply for an advertised doctoral topic of a Hector Fellow or Hector RCD Awardee. In the application process, the academic qualification, the maturity of the project outline and the correspondence of the topic with the research focus of the Hector Fellow or Hector RCD Awardee or the fit with the requirements of the advertised position are decisive. The application phase usually takes place once a year. The most promising applicants are invited to an interview in front of members of the Hector Fellow Academy. The successful candidates work on their research topic in the working group of the respective Hector Fellow or Hector RCD Awardee for up to four years. The doctoral candidates are employed as research assistants and receive research funds at their own disposal. In addition, a tailor-made training program is offered for doctoral candidates. Here, young researchers can develop interdisciplinary skills and soft skills at training days and networking meetings. Management skills are also taught and deepened.

Young scientists & alumni at the Alumni Meeting 2023 in Berlin.

Interdisciplinary projects

The central concern of the Academy of Science is to promote interdisciplinary exchange between its members. The HFA provides personnel and research funding for innovative scientific projects carried out jointly by several Hector Fellows. Each Hector Fellow as well as Hector Research Career Development Awardee can apply for funding for an interdisciplinary project with one or more other Hector Fellows. If approved, postdoctoral and/or doctoral positions can be advertised at the respective institutes or filled with researchers from their network. The funding is intended to enable unusual and unique interdisciplinary research collaborations that would otherwise not be possible. One example of such a joint interdisciplinary project is "RetinaSensor: Novel Electronic Retinal Implants for the Blind" by Hector Fellows Jürg Leuthold and Eberhart Zrenner.

Interdisciplinary work takes place in projects, but also at HFA networking events.

Associated Young Researchers Program

Hector Fellows and Hector RCD Awardees can nominate doctoral researchers or postdocs from their working group as Associated Fellows. They are given the opportunity to take part in training and networking events organized by the HFA.

BIOLOGY

Strategies to Escape Viral Infection in Archaea

Zaloa Aguirre - Hector RCD Awardee Tessa Quax

Viruses are the most abundant biological entities on earth, and it is estimated that they outnumber their hosts by at least an order of magnitude. Their hosts include members of the three domains of life: archaea, bacteria and eukaryotes and viruses are thus believed to be a major driver of evolution. Archaea are ubiquitous microorganisms that inhabit a wide array of environments ranging from extreme habitats such as hot springs, to moderate ones such as the oceans or the human digestive tract. Viruses infecting archaea display a high morphological and genetic diversity. However, little is known about their infection mechanisms and how archaeal cells can escape viral infection.

By combining light and electron microscopy with molecular biology and virological techniques, this research aims to gain insight into the interaction between archaea and their viruses. This will significantly advance our understanding of the evolutionary pressure that viruses exert on the archaeal cell surface. More specifically, this project focuses on viruses of halophilic archaea and aims to decipher the role of surface appendages in strategies to escape viral infection.

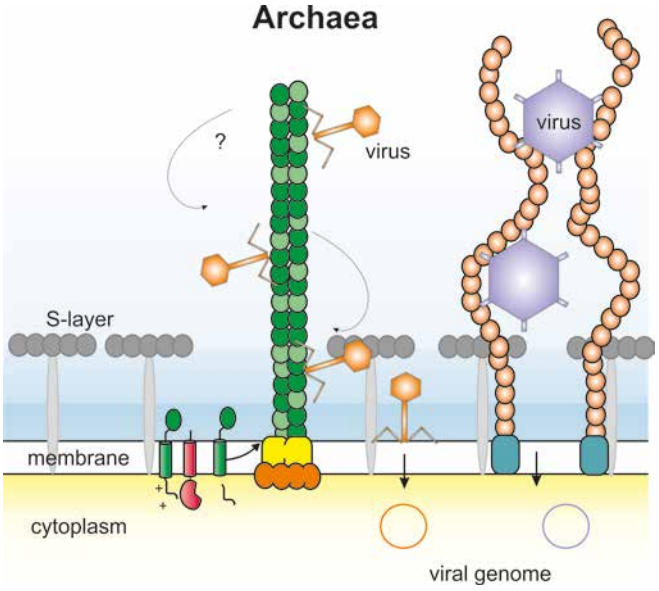


Diagram showing virus-host interactions at the archaeal cell surface. Viruses with different morphologies interact with different filamentous structures at the surface.

PHYSICS & CHEMISTRY

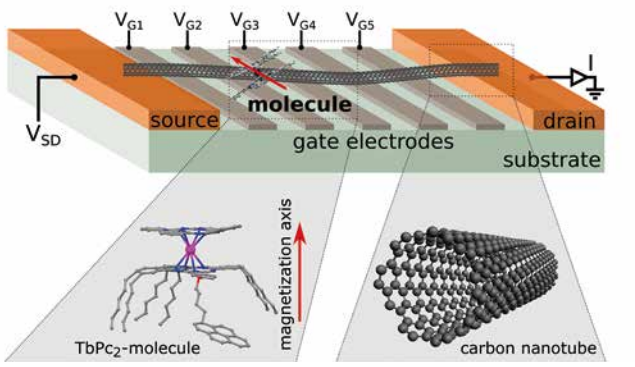
Manipulation of Molecular Spins Using Electronic Ciruits with Carbon Nanotubes

Tim Althuon - Hector Fellow Wolfgang Wernsdorfer

Building a functional quantum computer is one of the most ambitious technological goals of our century. A key challenge consists in finding quantum systems that are sufficiently protected from the environment while being easily accessible. As promising candidates for such quantum systems, single-molecule magnets and their nuclear spin states will be the core of this project.

We will exploit the excellent sensing properties of carbon nanotubes (CNTs) to investigate and coherently manipulate nuclear spin states in molecular magnets. Therefore we will integrate the CNTs into electrical ciruits, characterize their properties and graft single-molecule magnets on suspended CNTs. To interface the molecular spins, a carbon nanotube can be integrated into a nanomechanical resonator with the CNT as oscillating guitar string (cf. figure 1) and the coupling between the molecular spins and mechanical oscillations of the nanotube can be probed (spin-phonon coupling). Another option is based on integrating the carbon nanotube into a precise superconducting magnetometer, a so-called superconducting quantum interference device (SQUID) and probing the coupling between the magnetic moment of the molecule and the magnetic flux through the SQUID loop.

This project addresses fundamental physical questions regarding the physics of CNTs and molecular magnetism, whereas on the other hand, it can provide a first step towards quantum technologies based on single-molecule magnets.



Single-molecule magnet grafted on a suspended CNT. V_SD: applied bias between source and drain electrode, V_G1,...,V_G5: bias applied to capacitively coupled gate electrodes 1 to 5 to drive mechanical oscillations in the CNT, I: measured current through the CNT

PHYSICS

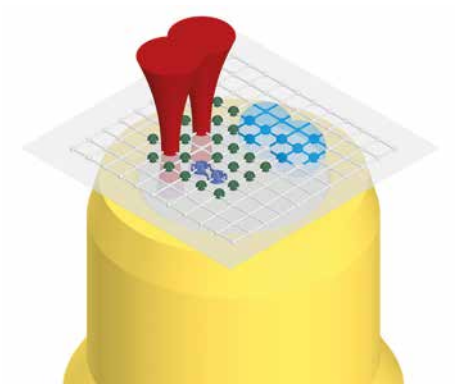
Realizing a Quantum Processor Based on Strontium Rydberg Atoms

Maximilian Ammenwerth – Hector Fellow Immanuel Bloch

Quantum gas microscopes have been successfully used for detailed studies of complex quantum many-body systems. In this project, an innovative quantum gas microscope is developed with a focus on fast measurement repetition rates and applications in the field of analog quantum simulation and additionally digital quantum computing.

Optical tweezers are used to rearrange neutral strontium atoms into configurable and defect-free arrangements within an optical lattice. The combination of active re-sorting followed by laser cooling into the motional ground state facilitates a fast initialization of the system. This serves as a starting point for the subsequent quantum simulation of many-body systems and as a qubit register with large system size.

The coupling of the trapped atoms to highly excited Rydberg states offers the opportunity to realize long-range interactions with variable strength and enables the analog quantum simulation of e.g. spin models. Furthermore, the direct addressability of individual atoms through a high-resolution microscope objective allows for the implementation of gate operations on individual qubits. The selective excitation of some qubits to Rydberg states enables the implementation of quantum logic gates. This opens the possibility to explore neutral atoms as a platform for quantum computing.



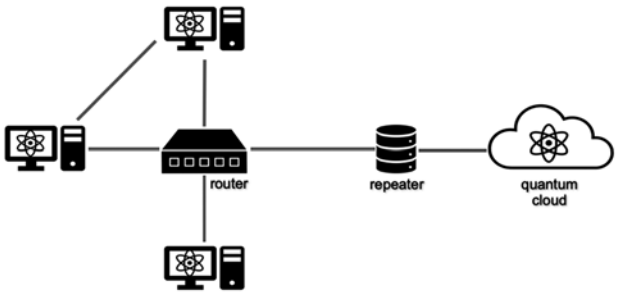
A model of a quantum network. The project focuses on designing secure and efficient near-future quantum networks.

PHYSICS, MATHEMATICS & COMPUTER SCIENCE

Security and Anonymity in Quantum Networks

Ziad Chaoui – Hector RCD Awardee Anna Pappa

The second quantum revolution is currently underway. Technological advances are allowing us to build devices that actively manipulate quantum mechanical objects and use them as information carriers. This research project deals with the possibilities to leverage quantum information carriers to develop communication protocols for the future. It will examine how to communicate securely over quantum networks, while preserving anonymity for the participating parties. It specifically aims to explore which communication tasks obtain an advantage in terms of security and anonymity when using quantum information carriers, and for which particular network architectures. A first approach is to further study the building blocks of known quantum communication protocols, in particular bit commitment. A better understanding of bit commitment and the constraints under which it remains secure, yet practical will allow us to develop protocols that can be implemented in the future. Other tasks like coin flipping, oblivious transfer, parallel generation of keys and secret-sharing, which are indispensable for establishing quantum networks as a medium for communication, will also be explored. Different network architectures will be studied starting with nearest-neighbour architectures, which are the most promising for near-future deployment. The goal is to enable the use of current experimental quantum quantum resources to carry out these tasks, by establishing protocols that are secure and anonymous, but at the same time remain practical.



A model of a quantum network. The project focuses on designing secure and efficient near-future quantum networks.

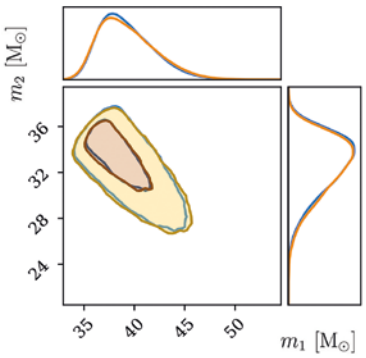
COMPUTER SCIENCE, PHYSICS & MATHEMATICS

Machine Learning Methods for Gravitational-Wave Data Analysis

Maximilian Dax – Hector Fellow Bernhard Schölkopf

The coalescences of binary systems of black holes or neutron stars emit gravitational waves (GWs) that encode information about the dynamics of the system. The detection of GWs therefore offers the exciting and unique opportunity to gain insight into these events. Current analysis methods are however slow and computationally expensive. This becomes increasingly problematic with the growing density of detected signals due to the continuous improvement of the detector sensitivity. More efficient analysis methods are therefore essential for the progress in gravitational physics. My research is concerned with the development of machine learning methods to accelerate the analysis of GWs.

My current focus is on inferring the parameters of astrophysical systems (e.g., the masses) from the GW data observed in detectors ('strain'). This task can be interpreted as an inverse problem. In the forward direction the waveform for a given set of parameters can be simulated within the theory of general relativity. We are interested in the backward direction; given the measured strain data that contains the GW waveform and detector noise we estimate the parameters using powerful methods for simulation-based inference. Specifically, we train deep neural networks to model the so-called posterior distribution. Due to the amortization of computation for different events and the capability to generate posterior densities using only forward passes through neural networks at inference time, our approach allows for rapid low-latency analysis of GWs.



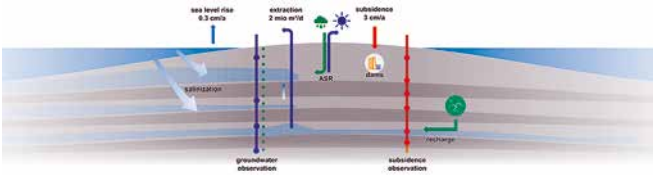
Posterior densities of the masses of the binary-black hole system associated with the first ever detected gravitational wave GW150914. The expensive standard method (shown in blue) requires days of computation, whereas our neural density estimator (orange) infers the posterior in just 20 seconds. The contours represent the 50% and 90% credible regions.

ENGINEERING

Land Subsidence & Groundwater Salinization in the Mekong Delta

Felix Dörr – Hector Fellow Franz Nestmann

The Mekong Delta (MD), home for approx. 17 million people, is being confronted with increasingly existence-threatening environmental changes since several years, in particular land subsidence and groundwater salinization. One of the main reasons for this is considered to be the high extraction of groundwater. In this PhD project, innovative measurement technologies are used to collect and evaluate new data on depth-differentiated land subsidence rates, the aquifer stratigraphy as well as the quality, age and dynamics of the groundwater, by which a comprehensive process understanding of land subsidence and groundwater salinization in the MD will be developed. On the basis of this data, a 3D land subsidence and groundwater model will be elaborated, with which the dynamics of land subsidence and groundwater salinization due to groundwater extraction and climate change will be investigated. The model will be used to calculate future scenarios in order to evaluate the further impact of climate change and the effect of potential countermeasures, e.g. artificial groundwater recharge (aquifer storage and recharge). The elaborated process understanding and the model calculations thus form the basis for sustainable water resource management concepts in the MD. The elaborated process understanding can also be adapted to other delta regions worldwide and can thus contribute to the clarification of comparable issues in other delta areas.



In the southern Mekong Delta, the effect of land subsidence significantly exceeds the effect of sea level rise. In which hydrogeological layers the relevant land subsidence processes take place and which role the extraction of groundwater plays is not yet clarified.
The cause of the groundwater salinization is also unclear - besides the saltwater intrusion from the sea, deep, saline paleo-groundwater can also be the cause.

PHYSICS & CHEMISTRY

Molecular Spin Systems on Surfaces

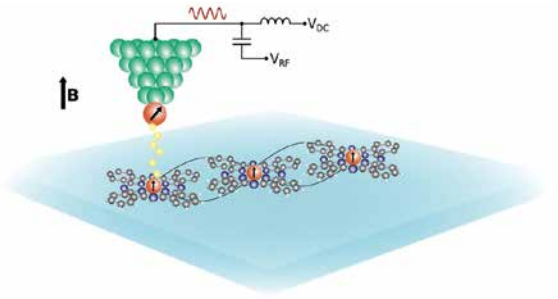
Paul Greule – Hector RCD Awardee Philip Willke

Single magnetic molecules can be used as building blocks to construct new artificial spin systems which are interesting for future quantum devices. We use scanning tunneling microscopy (STM) combined with electron spin resonance (ESR) to construct and investigate such spin systems on a surface. This enables the study of fundamental spin properties on the atomic scale and exploring novel magnetic phenomena in multi-spin systems.

For future quantum technologies, molecular spins have emerged as possible building blocks. They can self-assemble on a surface which facilitates the creation of quantum structures with interacting spins. Additionally, the molecule structure can be chemically engineered which enables the design of their magnetic properties.

The aim of our research is to construct and investigate a variety of multi-spin systems on a surface. The molecules are evaporated onto a conducting or insulating substrate and then investigated via scanning tunnelling microscopy (STM). Besides the self-assembly of the molecules, the microscope is used to further build artificial spin systems and to probe the physical properties of the molecules with a spatial resolution on the sub-atomic scale. In our research, we focus on investigating the energy levels and spin states of the constructed systems. Therefore, the STM is combined with electron spin resonance (ESR) to get high energy resolution and to coherently manipulate the spin states.

Thus, we are able to perform spin physics on the atomic scale while having the ability to engineer the magnetic properties of our system. This will allow us to access emerging magnetic phenomena of multi-spin systems for future quantum devices.



Graphical representation of the measurement.
The interacting molecules on the surface are examined via the tunnel tip (green) of the scanning tunneling microscope.

BIOLOGY & MEDICINE

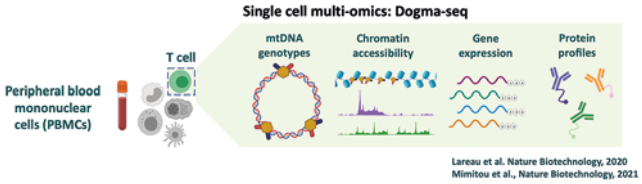
Mitochondrial DNA Mutational Landscape in Human T Cells

Yu-Hsin Hsieh – Hector RCD Awardee Leif Ludwig

Naïve T cells undergo clonal expansion after encountering antigens and further differentiate into effector cells. After the clearance of infected cells, a small proportion of T cells further differentiate into long-lived memory populations. Recent advances in single-cell genomics have unraveled plasticity and functional heterogeneity as well as novel subsets of human T cells. Moreover, studies have revealed the important role of mitochondrial function on T cell differentiation and function.

Mitochondria are known as the cell's powerhouse, carrying their own genomic DNA (mitochondrial DNA, mtDNA), which encodes 13 for proteins of the respiratory chain and their translational machinery. Thus, mtDNA mutations can compromise cellular metabolism and function. Nevertheless, how mtDNA mutational burden and heteroplasmy affect T cell differentiation and function remains unclear. Here, I hypothesize that T cells will manifest cell fate and functional biases in response to the overall mutational burden of mtDNA mutations.

Recently, Dr. Leif Ludwig, the Hector Research Career Development Awardee 2020, developed a novel multi-omics technique, known as DOGMA-seq, enabling the sequencing of the mitochondrial genome, the assessment of chromatin accessibility, gene expression, and protein profiling simultaneously in single cells. In this doctoral project, we will leverage this technique to decipher the impact of the mitochondrial genome mutational landscape on T cell differentiation and function.



Mapping and characterizing the mitochondrial mutational landscape and functional consequences in human T cells using single-cell multi-omics

PHYSICS, CHEMISTRY, BIOLOGY, ENGINEERING & MEDICINE

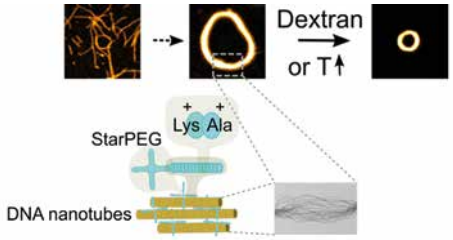
Triggered Contraction of Self-Assembled DNA Nanotube Rings

Maja Illig – Hector RCD Awardee Kerstin Göpfrich

DNA nanotubes are widely used as a mimic for cytoskeletal filaments in bottom-up synthetic biology. Using a synthetic starPEG construct that acts as a crosslinker, we succeed in bundling the few nanometer thick DNA nanotubes. In bulk they self assemble into micron-scale rings. We achieve their contraction upon temperature increase or molecular depletion with crowing molecules such as dextran (in collaboration with Kierfeld group, TU Dortmund).

Contractile rings formed from cytoskeletal filaments mediate the division of cells. Ring formation is induced by specific cross-linkers for filament bundling formation is induced by specific crosslinkers, while contraction is typically associated with motor protein activity. Here, we engineer DNA nanotubes as mimics of cytoskeletal filaments and a synthetic crosslinker based on a peptide-functionalized starPEG construct.

The crosslinker induces the bundling of tens of individual DNA nanotubes. Importantly, the DNA nanotube bundles curve into closed micron-scale rings in a one-pot self-assembly process yielding several thousand rings per microliter. Coarse-grained molecular dynamics simulations reproduce detailed architectural properties of DNA rings as observed by electron microscopy. Furthermore, the simulations predict DNA ring contraction – without motor proteins – upon increasing DNA nanotube attraction or decreasing DNA nanotube bending rigidity, yielding mechanistic insights within the parameter space relevant for efficient nanotube sliding. We experimentally realize these two conditions by addition of molecular crowders or temperature increase, respectively. We obtain ring contraction to less than half of the initial ring diameter. These DNA based contractile rings could be a future element of an artificial division machinery in synthetic cells. The combination of DNA nanotechnology and peptide engineering may yield new contractile and muscle-like material.



DNA nanotubes are bundled by a synthetic crosslinker and form rings on the micron scale that contract upon external triggers.

PHYSICS

Optical and Electronic Neuromorphic Systems

Richard Kantelberg – Hector Fellow Karl Leo

Why is our human brain capable of incredibly complex tasks such as image, speech and motion recognition while consuming only a few watts of power? Can we imitate the functional principles of the human brain in order to make its capabilities technically usable? Can these tasks also be implemented in resource efficient way using sustainable materials?

One promising approach is the direct use of physical systems for neuromorphic computing. The innovative idea is to classify the data directly on a small and energy-efficient sensor chip made of biocompatible materials instead of using large data centers.

In fact, there are hydrocarbon compounds that have the necessary semiconducting properties. So-called organic electronic-ionic mixed conductors, for example, are particularly exciting. Firstly, they are based on the same basic principles as synapses in the human brain, namely the exchange of electronic and ionic charge carriers in a liquid environment. Secondly, the switching and storage properties can be modified and controlled. Thirdly, they are sensitive to environmental influences such as light, temperature, chemical environment, etc. Thus, they offer the potential to simultaneously detect and classify signals. In the future, one could imagine even a direct interface with biological systems.

The research project aims to realize neuromorphic functions based on organic semiconductors. For example, fiber structures made of poly-3,4-ethylenedioxythiophene, can be used for this purpose. The structural formula represents the monomer (3,4-ethylenedioxythiophene).

MEDICINE & BIOLOGY

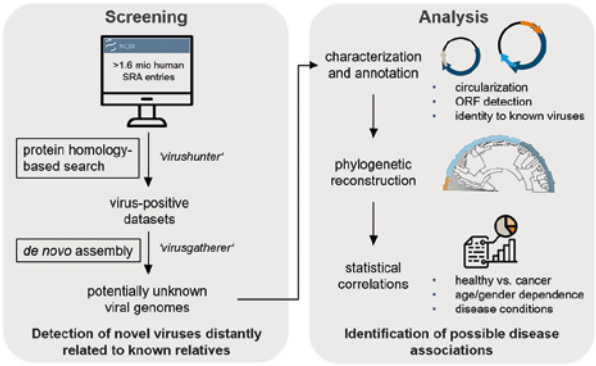
High-Throughput Virus Discovery in Next Generation Sequencing Data

Franziska Klingler – Hector Fellow Ralf Bartenschlager

Anelloviruses are a highly diverse group of non-enveloped viruses with circular single-stranded DNA genomes ranging between 2.8-3.8 kb. These viruses are ubiquitously present in humans and other vertebrates. Often several family members are detected simultaneously within the same tissue where they establish persistent infections. Currently, their role in development of human diseases, such as cancer and autoimmune disorders remains elusive. We hypothesize that, although in many cases not causing harm over years, disbalances in the composition of viral communities can induce disease onset and progression.

We created a powerful computational platform consisting of two modules. The first is termed 'virushunter', enabling high-throughput detection of viral sequences in unprocessed Next Generation Sequencing (NGS) data. The second one, 'virusgatherer' assembles the complete viral genomes. Thus, we are able to identify novel viral species only distantly related to any known viruses in distinct tissues and disease conditions.

This project aims at a comprehensive description of the spectrum of human anelloviruses by systematically screening NGS data of diseased and healthy tissues. We will then perform computational and laboratory analyses to determine i) possible disease association of identified viral species and subgroups, ii) the presence of oncogenes and iii) epidemiological data regarding the viral prevalence and the related risk of certain diseases. This will ultimately allow to thoroughly elucidate the pathogenic potential of human anelloviruses.



High-Throughput Virus Discovery in Next Generation Sequencing Data - Graphical scheme of workflow

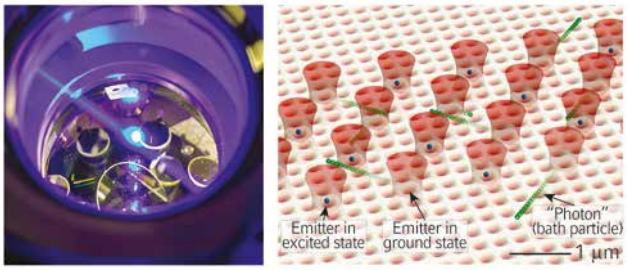
PHYSICS

Quantum Simulation of Strong Interactions of Light and Matter

Valentin Klüsener – Hector Fellow Immanuel Bloch

Analog quantum simulation allows studying complex quantum many-body systems by realizing the system of interest in a clean and precisely controllable setting of quantum particles. This avenue has been successfully pursued using ultracold atoms in optical lattices to study strongly correlated condensed matter systems. This project aims at extending the capabilities of this platform to simulations in the fields of quantum optics and nanophotonics. The central paradigm of quantum optics is the absorption of radiation by quantum emitters and subsequent emission into the surrounding environment. When the coupling between an emitter and its environment becomes strong, many-body quantum systems with interesting radiative properties can be engineered, such as directional emission patterns or exceptionally long-lived "subradiant" states.

These phenomena will be investigated by replacing the quantum emitter by an artificial two-level system of ultracold atoms in a state-dependent optical lattice. Trapped atoms in a metastable excited state will act as emitters, which can decay by "emitting" bath particles, corresponding to matter waves of ground state atoms. To study the dynamics of these bath particles the ground state atoms will be imaged with single-atom resolution. The proposed analog quantum simulator will enable the study of strongly coupled light-matter interfaces, which are inaccessible in state-of-theart nanophotonic devices.



A trapped cloud of ultracold strontium atoms at temperatures close to absolute zero (left). Artist's impression of emission of matter waves (bath particles) in a system of artificial emitters in an optical lattice (right)

MATHEMATIK

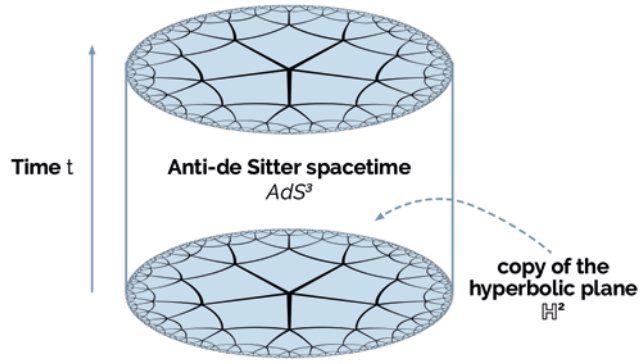
Higher Rank Teichmüller Theory with a Focus on SO(P,Q)

Laura Lankers – Hector Fellow Anna Wienhard

In a spacetime we have one time dimension and multiple space dimensions. In our reality we experience three space-like dimensions. Now in differential geometry, nothing keeps us from considering manifolds with multiple time-like dimensions. In this project we study algebraic structures, in particular the group SO(p,q), which describe the dynamics and the geometry of so-called pseudo-Riemannian hyperbolic spaces with at least one time dimension. In my project I will study higher rank Teichmüller theory, a topic that connects differential geometry and other mathematical areas such as algebra and analysis.

The base for this theory is studying two-dimensional surfaces and groups that induce certain "nice" dynamics on these surfaces. Of particular interest here are surfaces with a hyperbolic structure, meaning that the surface locally has a negative curvature, similar to the one of a saddle. So-called Teichmüller space then can be described as maps from the fundamental group of a surface into a special group related to the hyperbolic plane. In higher rank Teichmueller theory, we look at similar maps but instead consider groups connected to other spaces. During this project I will be particularly interested in pseudo-hyperbolic spaces that are connected to the group SO(p,q). These spaces can be thought of as spacetimes of negative curvature with multiple timelike directions as well as multiple spacelike directions. A low-dimensional example is the Anti-de Sitter space which plays a role in physics, for example in the AdS/CFT correspondence.

Concepts known in lower dimensional cases (for the numbers p and q small) can be generalized and studied further. The study of these higher rank Teichmueller spaces could be interesting as well for machine learning, using graph embeddings.



This three-dimensional Anti-de Sitter space is a spacetime with negative curvature. In particular, it has nicely embedded hyperbolic planes. The isometries of this space can be decribed by the group SO(2,2). The generalizations SO(p,q) are of big interest, because they yield a relatively new class of higher Teichmüller spaces.

PHYSIK, MATHEMATIK & BIOLOGIE

Using Mathematical Modeling to Facilitate the Translation of Research Findings

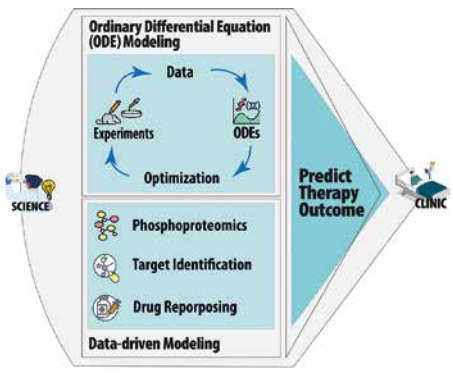
Katharina Lauk – Hector Fellow Jens Timmer

Despite extensive research in personalized medicine, promising personalized therapies still fail to translate into clinical practice. I aim to construct a pathway model that predicts the effects of potential therapies by combining mechanistic modeling and experimental approaches to meet ideal criteria for facilitating the translation of research to patients.

In personalized medicine, the underlying cause of a disease is precisely characterized based on specific changes to treat it with an appropriate targeted therapy. Unfortunately, successful personalized therapies do not make the transition to clinical practice and remain stuck in scientific literature, despite intensive research in this field.

The bench-to-bedside translation process requires consideration of a number of criteria, that should be ideally incorporated into the research process, including providing an answer to an important clinical question, showing a correct outcome classification, enabling standardization, and being cost-effective. The mathematical description of disease dynamics is ideal to fulfill these criteria during the research process, ensuring that basic science results do not remain lost in translation but find their way to the patient.

I plan an interdisciplinary approach with a combination of mathematical ordinary differential equation modeling, computational analysis, and experimental work to create a pathway model that can predict the effect of potential drugs. Networking with potential clinical collaborators will be a part of my work. With the increased relevance and reliability of the research results generated using the model and its successful validation, I would like to highlight that mathematical modeling is able to significantly enhance the translation process.



Facilitate the translation of scientific research into clinical practice using mathematical modeling.

PSYCHOLOGY & MEDICINE

The Role of Early Vision for Bidirectional Neural Communication

Tiago Lereno Mesquita – Hector Fellow Brigitte Röder

Collaborating with the LV Prasad Eye institute, we investigate sight recovery individuals with a history of transient congenital blindness due to cataracts to unveil the neural mechanisms of sensitive periods in brain development. More specifically, we investigate higher cortical representations and whether and how they emerge if visual input arrives delayed e.g., not before mid-childhood. The present PhD project will focus on object representations and how they emerge in the interaction with other visual areas. We expect a better understanding of how early experience shapes adult brain connectivity.

This doctoral project is a collaboration between Hector Fellow Prof. Dr. Brigitte Röder and the LV Prasad Eye Institute in Hyderabad, India, which aims at understanding the role of early experience for human brain development. Our focus lies on individuals born with dense congenital bilateral cataracts who undergo cataract removal surgery only relatively late in life. We employ behavioral and non-invasive neuroscience methods to evaluate brain parameters crucial for efficient visual functioning.

On the one hand, previous research has suggested deficits emerging particularly in higher order visual areas. On the other hand, recent evidence has suggested impairments of orchestrated bottom-up and top-down signaling. The present PhD project will investigate the role of early visual experience for the development of well-tuned object representations. In particular, we will explore the role of top-down and bottom-up brain connectivity for higher order visual functions. The present thesis will uncover major principles of human brain development. In the context of eye disease, our research will contribute to improved rehabilitation of humans with visual impairments.

The brain comprises a heavily connected network

CHEMISTRY

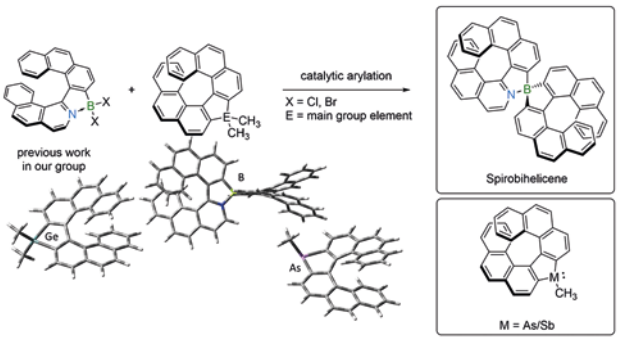
Main Group Heterohelicenes for Applications in Organic Electronics

Jan Niedens –Hector RCD Awardee Agnieszka Nowak-Król

This project is focused on the synthesis of novel helically chiral spiro-compounds containing boron as the spiro-atom and helicenes containing other main group elements.

Heterohelicenes, in particular those based on N-, S-, and O-heterocycles, are already widely researched materials with a broad range of applications. Nonetheless, other configurationally stable derivatives, including target molecules of this project, remain elusive due to the poor availability of starting materials and reagents, the instability of intermediates or lack of the effective synthetic methodology.

The linkage of aromatic moieties via a tetravalent spiro-atom (e.g. B) leads to interesting electronic behavior. It enforces a rigid and perpendicular orientation of the aromatic fragments. The chromophores are isolated from each other and retain their individual electronic properties in the ground state, while they couple in the excited state. Small spiro-compounds derived from azaboroles (boron as a spiro-atom) have shown excellent emissive properties. Thus, the combination of helicity and a B-spiro-center in a single molecule is expected to provide chiral materials with attractive properties for applications in electronic devices.



Main-group helicenes and synthetic strategy towards boron centered spiro-bihelicenes

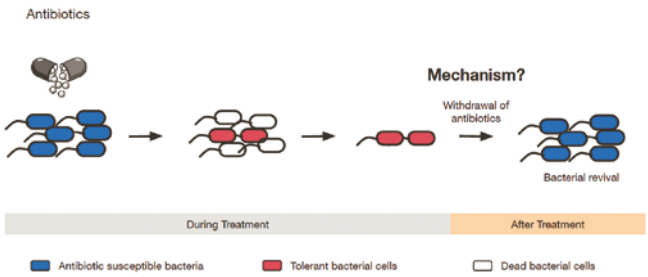
BIOLOGY & MEDICINE

Systems Biology Approach for Elucidating Bacterial Revival after Antibiotic Treatment

Adewale Ogunleye - Hwector RCD Awardee Ana Rita Brochado

Antibiotic resistance is a global healthcare crisis with severe socio-economic consequences. In susceptible bacterial species, antibiotics fail to eliminate a small subpopulation (known as tolerant bacteria) which are able to tolerate clinical doses of antibiotics. This is different from resistance which is typified by ability of the bacteria to grow in the presence of antibiotics. Tolerant bacteria revive after antibiotic treatment and are able to resume growth and cause chronic relapse of infections. Tolerance is known to be initiated by metabolic stress among others, however, little is known about the mechanisms that trigger revival of tolerant subpopulations.

This project aims to unravel the molecular mechanism that elicit bacterial revival after antibiotic treatment. To this end, I will develop high-throughput approaches to systematically investigate revival of the pathogen Salmonella Typhimurium, a model organism for infection biology. To further test the in vivo relevance of my project, I will re-assess whether bacterial revival is triggered differently inside murine macrophages, which are the preferred host niche during systemic salmonellosis



Revival process of tolerant bacterial population post-antibiotic treatment.

MEDICINE & BIOLOGY

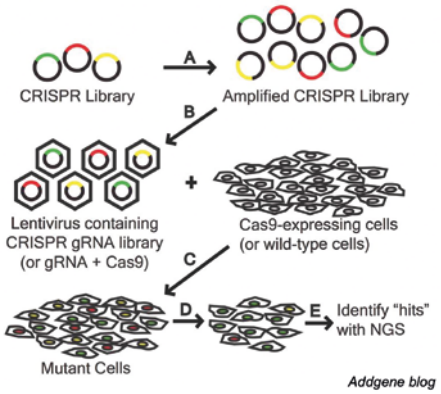
Defining Novel Resilience Pathways in Rare Monogenic Disorders

Daniel Petersheim – Hector Fellow Christoph Klein

Synthetic lethality, a concept originally introduced by Dobzhansky in the context of his studies on Drosophila, describes a genetic interaction where the co-occurrence of two independent genetic events results in cell death. Conversely, synthetic rescue (synthetic viability) occurs when a cellular phenotype, which is due to the presence of a genetic mutation, can be reversed when the original mutation is combined with a second mutation affecting a different gene.

In medicine, the concept of synthetic lethality has fertilized the search for anti-cancer drugs and led to the discovery of PARP inhibitors. Whereas the power of CRISPR-Cas-mediated genome interrogations has been recognized in cancer, their enormous potential for patients with rare diseases remains to be explored. Like in cancer cells, genome-wide searches for pathways modulating the phenotype of cells carrying specific mutations holds great potential.

In this project, we will make use of CRISPR-Cas-based forward genetic screens to search for genes and pathways that may counteract deleterious consequences of rare disease-causing mutations and to re-wire aberrant networks for therapeutic purposes. While this strategy can be applied to a myriad of defined monogenic mutations in numerous defined cellular contexts, initial studies will make use of the near-haploid cell line KBM-7 and focus on genetic defects associated with congenital neutropenia syndromes. Subsequent studies involving patient-derived iPS-cells will explore the clinical potential of the approach.



Typical workflow of a CRISPR-Cas9-based genetic screen

MEDICINE

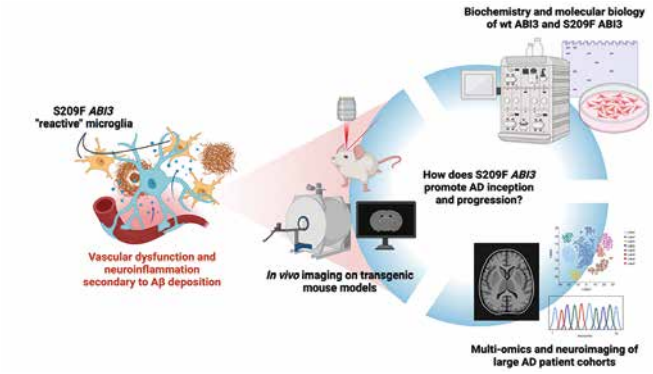
Neuroimmune-Vascular Interplay in Alzheimer's Disease

Matteo Rovere – Hector Fellow Christian Haass

Alzheimer's disease (AD) has a multifactorial etiology which includes vascular dysfunction and aberrant neuroimmunity. We investigate the gene ABI3 as a potential connection between these two facets of AD pathophysiology. Through transgenic murine models, and using a combination of biochemical, immunohistochemical, and *in vivo* imaging techniques, we explore how the late-onset AD risk variant S209F ABI3 affects neurodegeneration, immune fitness, and vascular dynamics.

AD is the foremost cause of dementia and constitutes a major societal and economic burden. There is still no established therapeutic regimen capable of stopping or reversing it. Given its complex nature, drug combinations hold the greatest potential and, among others, vascular pathology and neuroimmune dysfunction are both promising targets still out of therapeutic reach.

We are interested in the ABI3 gene, whose S209F variant carries an increased risk of developing late-onset AD. Transgenic mice carrying the murine analog of S209F ABI3 present with microglial and neurovascular abnormalities. This could be one way through which these seemingly independent mechanisms of disease synergize. We aim to characterize the biochemistry and molecular biology of ABI3 in health and disease and, through the use of transgenic AD murine models, detail its effects on the progression of neurodegeneration, neuroimmune responses, and vascular dynamics. We employ a combination of biochemistry, immunohistochemistry on murine and human tissues, *in vivo* imaging of microglial motility and vascular responses, and multi-omics of large patient cohorts. Our work could help identify novel translational targets, and inform the adoption of clinical interventions (e.g. vasoprotective measures) targeted at dementia patients.



S209F ABI3 knock-in and knockout transgenic mice exhibit neurovascular defects and microglial branching and motility changes. Our project aims to identify the molecular mechanism(s) behind these phenotypes.

PHYSICS & ENGINEERING

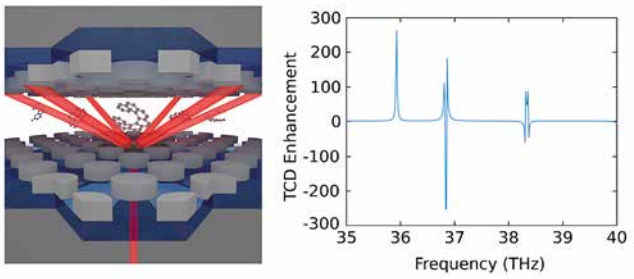
Helicity Preserving Cavity for Circular Dichroism Enhancement

Philip Scott – Hector Fellow Martin Wegener

It is sought after to enhance the CD signal because they are intrinsically very weak and it is crucial for drug testing. If the signal is small, then it can take a long time to check if the chiral molecule is of the correct handedness, and in modern medicine, it is important to be able to measure the drug quickly and accurately.

Through a collaboration between the Rockstuhl and Wegener groups at KIT, a metasurface-based optical cavity was designed that can enhance the CD signal, while keeping the sample size constant. To be advantageous for the CD, the cavity needs to adhere to three design requirements: it must be achiral, preserve helicity, and have large far field enhancement over large volumes. With these requirements, a design was proposed consisting of two silicon disk arrays that couple right- and left-handed circularly polarized light in and out of the cavity, while retaining helicity. Theoretical simulations of the metasurface cavity have resulted in enhancements of two orders of magnitude.

The two metasurface mirrors are placed into a custom-built microfluidic chamber. This chamber allows for both angular and axial alignment of the two mirrors so that the achiral requirement can be met. A microfluidic system is also designed so various solutions of chiral molecules can flow through the chamber to be measured.



Schematic representation of the metasurface-based optical cavity.

MEDICINE & BIOLOGY

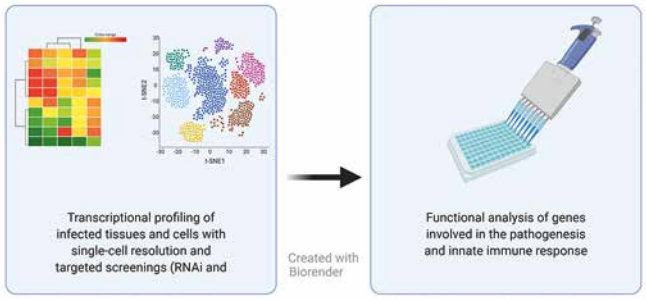
Mechanisms Underlying Pathogenesis of SARS-CoV-2 Infections

Yannick Stahl – Hector Fellow Ralf Bartenschlager

COVID-19 that is caused by infection with the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) remains a major threat to public health. Many interactions between the human host cell and the virus are still poorly understood. In-depth elucidation of virus-host cell interactions will reveal suitable targets for novel therapies.

I will use functional CRISPR/Cas9 based knock-out screenings to identify host proteins promoting or restricting the SARS-CoV-2 replication cycle. Bioinformatics will be employed to compare my results with data available in current literature. Potential hits will be validated and mechanistically investigated using biochemical, molecular biological, cell biological and virological methods.

In this way, I aim to elucidate the detailed mechanism and the importance of selected host factors contributing to the different stages of the viral replication cycle. Ultimately, my project is going to foster our understanding of the complex virus-host interactions and might deliver novel targets for the development of antiviral drugs to treat SARS-CoV-2 infections.



Schematic representation of the experimental design. Genes involved in the pathogenesis of COVID-19 or in the multiplication of SARS-CoV-2 will be identified by screenings and transcriptomic analyses and their function in the disease and reproduction of the virus will be studied.

PHYSICS

Steps Towards Solving the Enigma of Multiple Populations in Star Clusters

Abhinna Sundar Samantaray – Hector Fellow Eva Grebel

Star formation in galaxies occurs through the collapse of giant gas clouds and typically leads to star clusters. For decades, these clusters were believed to consist of stars that all formed simultaneously and with the same elemental abundances. The surprising discovery that these clusters contain multiple populations with characteristic abundance inhomogeneities remains an enigma. I will investigate whether rotational mixing is a plausible culprit, using massive emission-line stars as tracers of rapid rotation. Also, I will assess the validity of certain light elements as signatures of multiple populations.

One of the proposed culprits is rotationally induced mixing in stars. I will explore this possibility by conducting a survey of young star clusters using massive emission-line stars, so-called Be stars, as tracers of rapid stellar rotation and of nitrogen (N) enhancement. This first part of my thesis will be mainly based on a proprietary multi-wavelength survey of a companion galaxy of the Milky Way, the Small Magellanic Cloud.

In fact, N enrichment is one of the widely used indicators of multiple populations since it is easily measurable spectroscopically, but it might also have other origins. In the second part of my thesis, I will therefore assess the validity of this tracer in comparison with other light elements that exhibit variations using novel proprietary spectroscopic surveys.

Example of a star-forming region with a young star cluster: Westerlund 2, aged 1–2 million years, located in the constellation Carina.

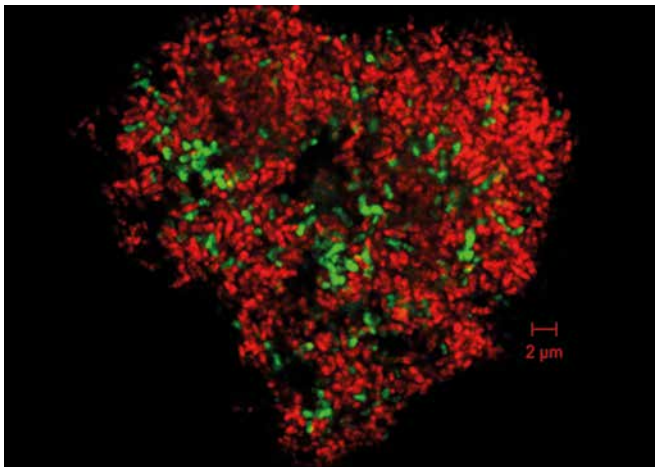
BIOLOGY

The Investigation of the Formation and Purpose of Black Matter in Anaerobic Methane Oxidisers and Methanogens

Stian Torset – Hector Fellow Antje Boetius

The project investigates the formation of amorphous carbon by archaea. So far this carbon has been identified in select methanogenic and methane-oxidizing archaea, yet the role of this carbon and molecular mechanisms underlying its formation are completely unknown. In the first phase of my PhD project, I will study the distribution of these carbon species in different archaea, and will employ biophysical methods such as high-resolution microscopy to determine its chemical and physical nature. Understanding these characteristics will be crucial to identify best target organisms to characterize this novel metabolic product.

I will use molecular approaches to study the mechanisms underlying the formation of this carbon. Metatranscriptomics will help to identify target genes potentially coding for enzymes involved in the formation of amorphous carbon. Based on such a target list I will use gene-editing tools such as CRISPR-Cas 9 to narrow down an involvement of encoded candidate enzymes in amorphous carbon formation. Structural analyses of such enzymes and biochemical experiments will help to resolve functioning of such enzymes. In addition, I will join ship-based expedition to gas-rich cold seeps such as found in the Black Sea to investigate the environmental role of microbially produced amorphous carbon.



Cand. Ethanoperedens (red), an ethane consuming archaea shown living in syntrophic consortia with a sulfate reducing partner bacteria (green) is one of the biological systems that produces the carbon compound that we are investigating.

MEDICINE & BIOLOGY

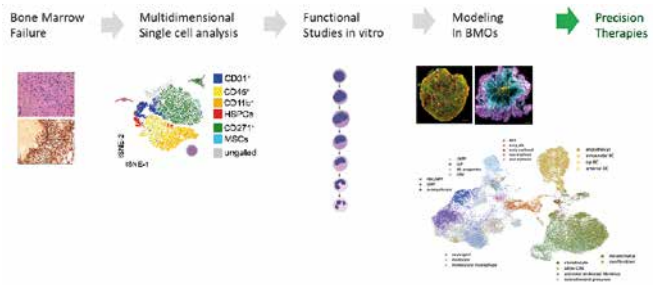
Multidimensional Modeling of Inborn Errors of Hematopoiesis in a New Three-Dimensional Human Bone Marrow Organoid Model System

Megha Varghese Mukherjee – Hector Fellow Christoph Klein

Rare genetic disorders lead to a failure to produce enough blood cells, proving frequently fatal in young children. They are primarily monogenic, caused by the loss of function in a single gene. My project mimics this loss outside of the human body in human bone marrow organoids (BMOs) to investigate the effects. The aim of studying BMOs is to identify critical factors contributing to bone marrow failure and ultimately using this information to develop new diagnostic methods.

All blood cells originate from hematopoietic stem cells (HSCs) in the bone marrow, a process known as hematopoiesis. HSCs can differentiate into both myeloid and lymphoid cells, giving rise to all blood cell types, and can undergo self-renewal and differentiation to increase their numbers. Hematopoiesis is a hierarchical and highly regulated process, and many genetic diseases are a result of dysfunction in this regulation, broadly termed bone marrow failure. Studying these diseases has been challenging due to the limited availability of human bone marrow samples and has proven difficult to study in animal models. Using human bone marrow organoids grown from iPSCs will allow the dysfunction to be modeled in a human setting.

I will determine if they can be used to investigate aberrations, aiming to elucidate the critical factors that lead to bone marrow dysfunction. Finally, I will establish how to translate this multi-omics single-cell-based analysis into cutting-edge diagnostics. My Ph.D. project aims to correlate morphological data on primary bone marrow smears and bone marrow organoids (BMOs) with genomic and transcriptomic datasets.



Human iPSC-derived bone marrow organoids – modeling errors in hematopoiesis

Doctoral projects

NEUROSCIENCE & BIOLOGY

The Algorithmic Basis of Pattern Recognition in an Insect Pollinator

Lochlan Walsh – Hector RCD Awardee Anna Stöckl

Active sensing, or using movement to actively acquire sensory input from the environment, is achieved through diverse mechanisms across species. In the case of vision, humans can use eye movements, and robots can manoeuvre cameras to actively collect and process information such as pattern features. Insects, however, tend to be much more restricted by morphology in how they can rotate or bend their visual sensors, if at all.

Insect pollinators are particularly interesting in this regard, as they need to recognize and respond to the visual patterns of flowers when deciding where to forage. To overcome their morphological restriction, the hummingbird hawkmoth (Macroglossum stellatarum) steers its' body while hovering over flowers, gathering information about their pattern features. Recognizing such features in varying conditions and contexts can require millions of neurons in humans. Limited computational power in hawkmoths suggest they may overcome this challenge through active pattern recognition – gathering visual information using a highly specialized sensorimotor system.

Human brains and vision-based robotics require intensive computation to recognize visual pattern features in various contexts and augmentations, known as invariant pattern recognition. The hummingbird hawkmoth similarly uses pattern features on flowers to select suitable foraging sites, with only a fraction of the 'computational power'. Aiming to understand how they do so with such efficiency, we will use behavioural, neural, and computational methods to uncover the algorithmic basis of (invariant) pattern recognition in insect pollinators, with potential application to computer vision and aerial robotics.

Movement tracking helps us to understand the mechanisms employed by insect pollinators in recognizing and responding to pattern features.

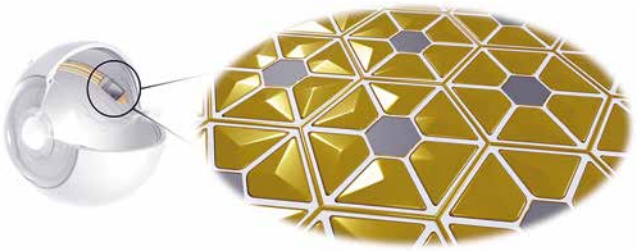
Interdisciplinary projects

BIOLOGY, MEDICINE, PHYSICS & ENGINEERING

RetinaSensor: Enhanced Vision Restoration in Blind People

Dr. Wadood Haq – Hector Fellow Eberhard Zrenner
Shadi Nashashibi / Marina Homs – Hector Fellow Jürg Leuthold

RetinaSensor is an interdisciplinary project with the aim of advancing the electrical retinal implant technology for enhanced vision restoration of blind people. Due to the genetic diversity of inherited retinal degenerative diseases (roughly 290 genes involved in retinal dystrophies) the electrical retinal implants are the only comprehensive gene-independent treatment for blindness caused by photoreceptor loss so far.
Hence, the RetinaSensor project synergize the latest technologies and know-how to overcome the limitations of subretinal implants and promote advanced artificial vision with unprecedent spatial and visual-temporal resolution. This is made possible due to the combined efforts of the Hector Fellows Jürg Leuthold specialized in photonics and Eberhart Zrenner, who has been developing and studying electric subretinal implants of the first generation in patients since the 90s.
The RetinaSensor will incorporate a highly sensitive photosensor array based on van-der-Waals heterostructure providing a high dynamic range for an ideal image capture of the surrounding environment under various light conditions. Coupled to an electrode array at a previously unachieved dense spatial resolution and combined with a novel biomimetic feature-based stimulation paradigm for a high visual-temporal resolution, the RetinaSensor will bring blind people a step closer to advanced artificial vision.



The RetinaSensor is illustrated as subretinal implant in a human eye. It contains highly sensitive photodetectors for capturing incoming light. The resulting electrical signals from the photodetectors are sent to the petal-shaped electrodes for retinal stimulation with a novel biomimetic stimulation paradigm.

Associated Young Researchers´ projects

NEUROSCIENCE & BIOLOGY

Dynamic Vision in Natural Low Light Environments – From Single Photons to Behaviour

Andrea Gonsek – Hector Fellow Awardee Anna Stöckl

Flying insects use visual information to control their flight. In nature, the visual scenery is highly complex, which poses a challenge for insect brains to extract relevant and reliable information. And yet, many animals master these challenges on a daily—and nightly—basis. Over the course of a single day, they face a wide range of light intensities from sunlight to starlight. Within a short moment, the light environment can rapidly change between celestial conditions or habitat types – and at night with artificial light. Insects are thus confronted with not only complex, but also dynamically changing information. How does the visual system adjust to these changes? What are the effects of light pollution? To answer these questions, I study both sensory processing and behaviour, which influence each other reciprocally. Using the nocturnal elephant hawkmoth, I am disentangling this closed loop using three key-stages: (i) adaptive behaviour, (ii) natural inputs, and (iii) sensory processing. The first stage will reveal natural flight dynamics of the moths in different light levels and forms the basis for imaging natural visual scenes. Here, I will quantify the dynamics of natural visual environments from a flying moth's perspective, and then measure how early visual neurons adjust to these spatiotemporal light variations. Finally, to close the loop from sensing to behaviour, I will use a computational model to predict responses of downstream neurons that guide flight behaviour.

CHEMISTRY

Access to pi-enhanced carbazoles and their application

Henrik Habeck – Hector Fellow A. Stephen K. Hashmi

In this project, the newly discovered Lewis acid-catalyzed reaction of naphthyl sulfilimines to dibenzocarbazoles will be further investigated. The goal is to elucidate the reaction mechanism in detail by using various analytical methods and theoretical studies. In addition, the newly discovered reaction will be extended to larger acenes such as anthracene or phenanthrene.

Using phenanthrene sulfilimines, aza-[7]-helicenes are formed, which exhibit interesting optical properties due to their structure. The use of anthracene and naphthyl sulfilimines gives π-expanded carbazoles. These compounds also show interesting electronic and optical properties. Similar carbazoles have already been successfully used as materials for OLEDs, OFETs, and solar cells in organic electronics. The synthesized carbazoles are being studied in detail for their suitability as organic semiconductor materials.

Another promising application of carbazoles is in the synthesis of porphyrins with a π-extended carbazole backbone. These particular porphyrins are characterized by their large conjugated π-system and exhibit intense absorption in the near-infrared region. This property opens up potential applications in solar cells as well as in medicine, especially in photodynamic therapy.

CHEMISTRY

Chiral Organoboron PAHs for Application in Organic Electronics

Felix Full – Hector RCD Awardee Agnieszka Nowak Król

Boron-containing polyaromatic hydrocarbons (PAHs) draw increasing interest due to their appealing optical and electronic features. They are promising candidates for applications in organic electronics, e.g. OLEDs, transistors and organic solar cells.

This project is focused on the synthesis of new chiral organoboron PAHs and the investigation of the impact of their chiral geometry on the operation of such devices.

BIOLOGY & MEDICINE

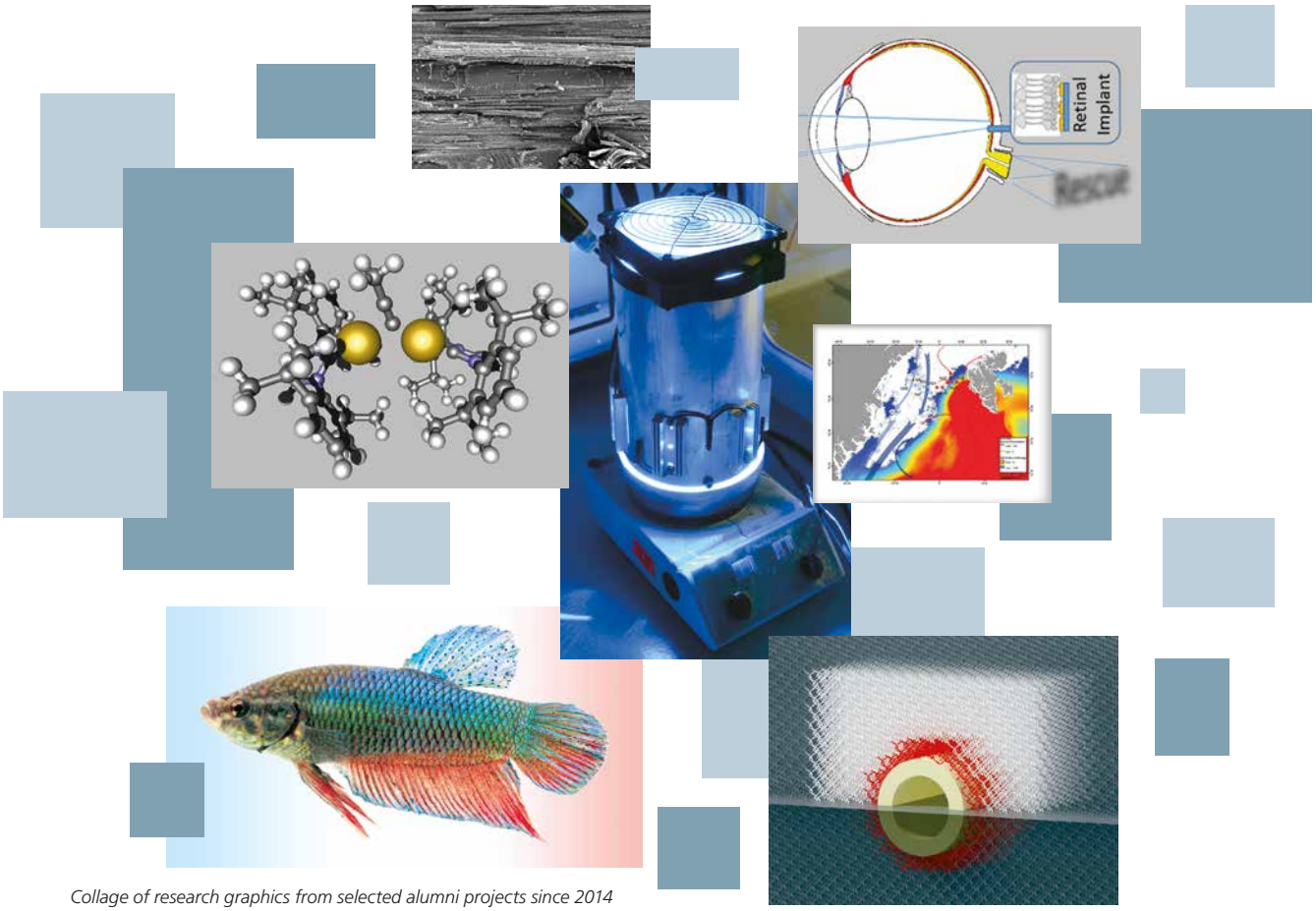
From Mitochondrial Genotypes to Phenotypes with Single-Cell Multi-Omics

Pauline Kautz – Hector RCD Awardee Leif Ludwig

Somatic mitochondrial DNA (mtDNA) mutations are associated with a wide range of human disorders, yet it has been difficult to reliably establish mitochondrial genotype-phenotype associations. Therefore, we aim to integrate metabolic profiling readouts with single-cell multi-omics sequencing techniques to characterise the consequences of pathogenic mtDNA mutations and increased mitochondrial mutational burden at the cellular and genomic level.

Completed projects

The Hector Fellow Academy has an active network for its alumni in order to maintain the dialog beyond the project periods and to preserve the expertise in the HFA. The regular exchange and transfer of research results as well as the possibility of long-term, interdisciplinary collaboration make the HFA a lively academy of science.



Collage of research graphics from selected alumni projects since 2014

Completed doctoral projects

BIOLOGY

Temporal and Spatial Microbial Dynamics in the Arctic Ocean

Magda Cardozo Mino – Hector Fellow Antje Boetius

The project investigates composition and function of microbial communities in Fram Strait, the major gateway between the Arctic and the Atlantic Oceans, and how these are linked with environmental conditions. A series of cutting-edge, molecular approaches are applied to assess microbial functional capacities, community composition and their temporal variation in a region under special threat by climate change.

PSYCHOLOGY

Genetics and Epigenetics of Posttraumatic Stress Disorder and its Treatment

Dr. Daniela Conrad – Hector Fellow Thomas Elbert

The risk to develop posttraumatic stress disorder (PTSD) depends on the number of traumatic events experienced and individual risk factors, e.g. genetic predispositions. However, to identify causal genetic variants of this polygenic disease, trauma exposure needs to be adequately assessed..

Completed doctoral projects

BIOLOGY & ENGINEERING

Applications of Non-Invasive Ocular Signal Measurements

Dr. Margaret Deibel – Hector Fellow Eberhart Zrenner

One of the aims of this work was to develop a new in vivo method for the non-invasive measurement of a person's ciliary muscle during the adaptation of the eye lens. The results of the project were used to develop a tool that mimics the recorded neuronal signals produced by the ciliary muscle and thus simulates the adaptation of the eye lens using a liquid crystal lens.

CHEMISTRY

Photocatalysis and Transition-Metal-Catalyzed Reactions of Furane-Derivatives

Dr. Daniel Eppel – Hector Fellow A. Stephen K. Hashmi

In the doctoral thesis, a sustainable, photochemical synthesis of [C^N^C]Au(III) complexes was developed, which were previously only produced using toxic mercury intermediates. This technology is an attractive route for the production of gold(III) anticancer agents and photoemitters without the generation of toxic waste.

PHYSICS

Fermionic Quantum Gas Microscope

Dr. Joannis Koepsell – Hector Fellow Immanuel Bloch

The microscopic description of a multitude of exotic phenomena such as magnetism or high-temperature superconductivity still raises questions. This project deals with the simulation of these phenomena using a quantum gas microscope. In this project, ultracold fermionic lithium atoms are made to behave identically to electrons in a solid state by controlled optical light fields. By using a high-resolution fluorescence image, the behaviour of each individual atom can be observed.

ENGINEERING

Continuum Damage Models for Reliability Assessment of Structural Composites

Zalikha Murni Abdul Hamid – Hector Fellow Peter Gumbsch

The demand for carbon fiber/epoxy composite structures is constantly growing due to their advantages for industry. The aim of this project was to observe the wear and failure process of these composite structures and, based on this, to develop a highly complex computer model that can calculate the deformation and failure of materials in advance.

PHYSICS

Magnetism in Perovskite Manganites and Cobaltites at the Nano Scale

Dr. Cornelia Hintze – Hector Fellow Hilbert von Löhneysen

In this project, the changes in the magnetic properties of materials at the nanometer level were investigated. Nanoparticles were produced by means of microemulsion synthesis. A direct correlation between the magnetic properties and the size of the material was demonstrated.

BIOLOGY

Stress & Epigenetics: Epigenetic effects of parental stress in offspring

Dr. Amber Makowicz – Hector Fellow Axel Meyer

The project focuses on the influence of environmental stress on epigenetic changes in gene expression. Using fish models, the influence of stress in parents on long-term maladaptive behavioral changes in subsequent generations will be investigated.

ENGINEERING

Bank Structuring in Urban Environments through Micro Groins

Andreas Müller – Hector Fellow Franz Nestmann

Instream river training is a form of river engineering in which the flow is modified by secondary currents in such a way that bank and bed erosion is prevented. The steering groynes used offer bank protection, cost savings and ecological advantages compared to classic longitudinal shoring. The resulting waterway structuring was examined here in order to demonstrate the suitability of steering groynes for creating varied habitats in urban watercourses.

PHYSICS

Unveiling the Galactic History with Pulsating Variable Stars

Gustavo Medina Toledo – Hector Fellow Eva Grebel

This project aims to explore the use of young and old pulsating variable stars to improve our current understanding of the Milky Way. This will be achieved by performing a novel study of the kinematics, ages and chemical compositions of Cepheids and RR Lyrae stars which, in spite of being archetypes of different stellar populations, represent key tracers of the recent star formation and assembly history of the Galaxy.

Completed doctoral projects

ENGINEERING

Influence of River Basin Morphology and Climate Change on Water Partitioning in Semi-Arid River Basins

Dr. Phoebe Pauline Onjira – Hector Fellow Franz Nestmann

In this project, hydrological models and statistics were used to investigate the role of morphology, climate and land use in hydrological partitioning with respect to the Olifants Basin-South Africa.

PSYCHOLOGY & MEDICINE

Sensitive period plasticity and functional recovery after sight restoration

Rashi Pant – Hector Fellow Brigitte Röder

Visual experience during a sensitive period is crucial for the normal development of the brain. Individuals who are treated for congenital cataracts more than a few weeks from birth suffer from low visual acuity as well as specific deficits (such as impaired face processing). This project investigates the possible mechanisms that mediate this sensitive period, by non-invasively assessing brain structure and function in congenitally and developmentally visually deprived individuals.

PHYSICS

RR Lyrae stars as tracers of substructure and Galactic archaeology

Dr. Zdenek Prudil – Hector Fellow Eva Grebel

Galactic archaeology uses stars as fossils to understand galaxy evolution. Cosmological simulations suggest that galaxies enlarge by swallowing dwarf galaxies. The project investigated the remains of mergers that can provide clues to the structure of the Milky Way.

PHYSIK

Towards Topological Many-Body Physics Using State-Dependent Optical Lattices

Dr. Hendrik von Raven – Hector Fellow Immanuel Bloch

Many fundamental phenomena in solids are caused by the topological properties of the system. Within the project, a new quantum gas experiment optimized for the study of topological systems was designed and developed. This cesium-based experiment combines state-dependent lattices as a novel method for generating complex topologies with modern tools such as high-resolution microscopes.

BIOLOGY

Mechanisms of Reproductive Isolation During Rapid Speciation

Sina Rometsch – Hector Fellow Axel Meyer

Reproductive isolation, the ceased exchange of genetic material, is crucial for the divergence of populations into distinct species. This is commonly facilitated by an extrinsic physical barrier, but rarely it can also occur devoid of such barriers. Whether speciation proceeds by the same or different reproductive isolation mechanisms under these two geographic scenarios remains a matter of debate. We aim to contribute to this fundamental question in biology by taking advantage of a model system of speciation: the Midas cichlid fishes.

PSYCHOLOGY

Epigenetic Underlying of Appetitive Aggression

Anja Rukundo-Zeller – Hector Fellow Thomas Elbert

Aggression can be divided into reactive forms (a protective response to an acute threat) and instrumental forms (purposeful exercise). Appetitive aggression is a sub-form of the latter, which is defined by feelings of pleasure in the exercise of violence. Until now, this form has only been researched on the basis of self-reports. The PhD project aimed to identify an objective, epigenetic marker for appetitive aggression.

BIOLOGY

Genetic & Developmental Basis of Color in Cichlid Fish

Dr. Margaret Sefton – Hector Fellow Axel Meyer

Cichlid fish are well-known for their beautiful colors and multitude of body shapes. They are found in the East African Rift lakes where they have formed so-called adaptive radiations, in which hundreds of new species originated extremely quickly–sometimes within less than 100,000 years. This thesis focuses on the genetic basis of adaptation and diversification in cichlids by examining genes involved in color pattern development.

Completed doctoral projects

CHEMISTRY

Gold-catalyzed functionalization of 1,3-diyne derivatives

Philipp Stein – Hector Fellow A. Stephen K. Hashmi

The efficient design of chemical processes is of great importance for the chemical industry. Current research makes an essential contribution to synthesizing complex substrates inexpensively in as few steps as possible and in high yield. This PhD project, under the direction of Hector Fellow A. Stephen K. Hashmi, therefore, deals with the mechanism and the functionalization of a wide range of 1,3-diynes with varying nucleophiles.

BIOLOGY, ENGINEERING & MEDICINE

Accommodation Behavior and Ciliary Muscle Activity in Myopia

Dr. Sandra Wagner – Hector Fellow Eberhart Zrenner

Prevalence of myopia (shortsightedness) increases considerably in industrialized countries. The mechanisms behind this development need to be fully understood in order to arrive at prevention. The aim of Sandra Wagner's research was to allow a better understanding of accommodation, address unanswered question regarding myopia onset and support the development of new devices.

CHEMISTRY

1,3-Diketon Based Ligands for Transition Metal Catalysis

Jonas Wunsch – Hector Fellow A. Stephen K. Hashmi

The development of catalysts to increase efficiency or to enable completely new chemical reactions is of enormous interest. This requires a broad selection of ligands. The aim of the project was to develop new ligands that arise from the formal double deprotonation of 1,3-diketones in order to expand the spectrum of known ligands. Investigations into synthesis routes revealed a way to isolate these as gold complexes. The complexes were characterized and proved to be active catalysts.

Completed interdisciplinary projects

CHEMISTRY & PHYSICS

Fundamentals of gold catalysis

Dr. Sarah Bay–Hector Fellow A. Stephen K. Hashmi
Dr. Jean-Francois Greisch–Hector Fellow Manfred Kappes

This project focused on the properties of innovative gold catalysts. The aim was to obtain new information about the mechanisms and species involved in gold catalysis reactions.

CHEMISTRY, PHYSICS, ENGINEERING & MEDICINE

CarboChip: High performance micro-electrodes for retinal implants

Dr. Wadood Haq – Hector Fellow Eberhart Zrenner
Dr. Franz Selzer – Hector Fellow Karl Leo
Hector Fellows Manfred Kappes & Martin Wegener

In the project, new micro-electrodes based on high-tech materials were developed for the spatially and temporally high-resolution electrical stimulation of neuronal tissue. These highly efficient electrodes are to be used for retinal implants and shall enhance the eye-sight of blind people.

PHYSICS & ENGINEERING

Mechanical Metamaterials

Dr. Claudio Findeisen – Hector Fellow Peter Gumbsch
Dr. Muamer Kadic – Hector Fellow Martin Wegener

In contrast to conventional materials, the properties of metamaterials depend on their special microstructure. New manufacturing processes allow the production of 3D metamaterials with microstructures at the micrometer level. The aim of this project was to research the design of new mechanical metamaterials.

BIOLOGY & PSYCHOLOGY

Towards Understanding the Genetic Basis of Appetitive Aggressive Behavior

Jan Gerwin – Hector Fellows Axel Meyer & Thomas Elbert

Many neurological processes associated with aggressive behavior are already known, but knowledge about other factors that influence aggressive behavior is limited. In this project, we used fighting fish (Betta sp.) to find out how environmental and genetic factors affect aggressive behavior.

Completed interdisciplinary projects

BIOLOGY, CHEMISTRY, PHYSICS & MEDICINE

High-Resolution Optogenetics with Organic Light-Emitting Diodes (OLEDs)

Giuseppe Ciccone – Hector Fellow Karl Leo
Rodrigo Fernandez Lahore – Hector Fellow Peter Hegemann

In this project, the application of organic light-emitting diodes (OLEDs) in optogenetics will be investigated. Several new technological approaches will be addressed to achieve optogenetic activation and inhibition of neurons with previously impossible lateral resolution. For this purpose, a new OLED technology is to be used, which can imitate electrically switchable different colours..

Completed Associated Young Researchers´ projects

PHYSICS & ENGINEERING

Three-dimensional Chiral Metamaterials

Julian Köpfler – Hector Fellow Martin Wegener

Metamaterials obtain their function through sophisticated microstructuring. This allows material properties to be achieved that go far beyond those of conventional materials. By introducing so-called topologically protected resonances, for example, mechanical vibrations in a material can be locally amplified and made robust against disturbances. This project dealt with the design, fabrication and characterization of chiral metamaterials with topologically protected resonances for the realization of a resonant mechanical laser scanner..

PHYSICS & ENGINEERING

Modular synthesis of nitrogen-stabilized carbene complexes

Vanessa Vethacke – Hector Fellow A. Stephen K. Hashmi

This project dealt with the development of a modular synthesis that allows access to a wide range of catalysts with properties tailored to the needs of the reactions to be catalyzed. The synthesis makes it possible to construct various N-heteroacyclic and N-heterocyclic carbene ligands with a wide range of electronic and steric properties directly at the metal center.

PHYSICS

Novel Applications with Organic Thermoelectric Modules

Dr. Shu-Jen Wang – Hector Fellow Karl Leo

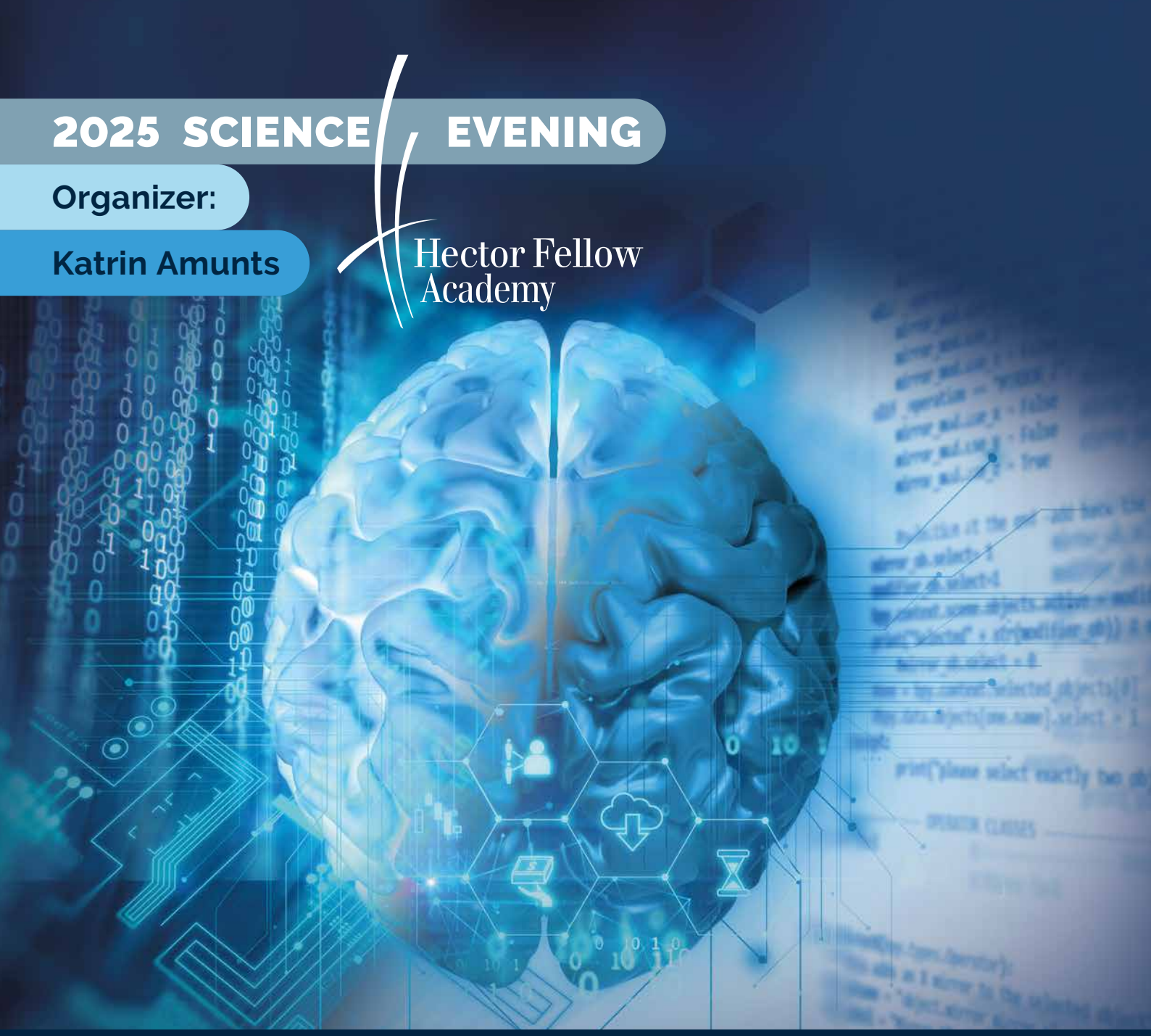
This project aims at using modulation doped organic thermoelectric modules for energy harvesting in niche areas where module flexibility is key. We will develop novel device architectures based on modulation doped organic thermoelectrics to enable innovative applications.

2025 SCIENCE EVENING

Organizer:

Katrin Amunts

Hector Fellow Academy



BRAIN, COMPUTER, AI:
SOON HARD TO DISTINGUISH?

July 10, 2025 | 6 pm
DÜSSELDORF

Publications

The research results of our young scientists are regularly published in internationally renowned journals. The following publications are an excerpt from 2023 and 2024.

2024

Althuon, T., Cubaynes, T., Auer, A., Sürgers, C., & **Wernsdorfer, W.** (2024). Nano-assembled open quantum dot nanotube devices. Communications Materials, 5(1). doi.org/10.1038/s43246-023-00439-3

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2023

Ayromlou, M., **Nelson, D.**, Pillepich, A., Rohr, E., Truong, N., Li, Y., Simionescu, A., **Lehle, K.**, & Lee, W. (2023). An Atlas of Gas Motions in the TNG-Cluster Simulation: from Cluster Cores to the Outskirts. Astronomy & Astrophysics. doi.org/10.48550/arXiv.2311.06339

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Imprint

Publisher & Editor

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Edition 2024