

Universität Stuttgart

forschung leben

January 2020

Intelligent Systems

for a sustainable society



Adaptive building

Digital approaches to
aesthetics and efficiency

Simulations

The value
of "what if?"

New ground

New funding
with risk tolerance

Prof. Wolfram Ressel

“We’re seeing the growing team spirit with which we shall continue to advance our strategic and operational objectives going forward.”

Dear Reader,

Having narrowly missed our objective last summer of achieving the title of “University of Excellence”, which is part of the federal and state governments strategy of excellence funding scheme, “excellent even without a title” is a fitting description of the University of Stuttgart’s position. To take Goethe’s advice, by “immediately looking around to see what we can retain and what we need to do in the event of the greatest loss”, we can see the University of Stuttgart’s excellent performance potential in terms of our profile, competence and areas of development. And we also see the team spirit that emerged during the recent competition, with which we will continue to advance our strategic and operational objectives in line with our vision: “intelligent systems for a sustainable society”. This issue of Forschung Leben, will give you an idea of the high level of research, teaching, knowledge transfer and self-reflection on the basis of which the University of Stuttgart will be entering the next selection round in the “Universities of Excellence” line of funding. And, to give you a more interesting and vivid insight into this vision, we have given our science magazine a make-over. As far as we’re concerned, the 2026 ideas competition is already underway.

Best regards,

Wolfram Ressel



Photo: Matthias Schmiedel

Prof. Wolfram Ressel
Rector of the University of Stuttgart

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WORLD VIEW

Nanorobots for medicine

Photos p. 5: Roland Halbe (top), Sven Cichowicz (bottom left), Günther Bayerl (bottom right).



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Programmed elegance



EXPERIENCE RESEARCH **p. 60**
Monilola Olayioye is researching tumor cells in context

NOTE^{PAD}

AWARDS

THREE NEW ERC GRANTS

Three researchers from the University of Stuttgart have each been awarded one of the European Research Council's (ERC) coveted grants in recent months. **Prof. Michael Pradel** of the Institute of Software Technology (ISTE) is using his ERC Starting Grant to search for ways to make software more reliable with the aid of artificial intelligence. To be able to predict and prevent future programming errors, Pradel and his team wish to develop new methods to enable a computer to "understand" a program as well as its underlying concept. The plan is to apply this so-called "deep learning" approach to programs and develop it further.



Professor Blazej Grabowski Head of the Department for Materials Design at the University of Stuttgart's Institute for Material Science (IMW), received one of the coveted ERC grants for the second time. Grabowski wants to use his current ERC "Materials 4.0" Consolidator Grant to achieve a quantum leap in the design of new materials using novel simulation methods. "Materials 4.0" is inspired by the "Industry 4.0" concept, which denotes a new era of industrial processes connected via data exchange networks. Similarly, "Materials 4.0" will mark a new era in material design, in which quantum mechanical simulations will enable qualitatively significantly improved predictions of material properties.

Prof. Jörn Birkmann Head of the University of Stuttgart's Institute of Spatial and Regional Planning (IREUS) and coordinating lead author of the Intergovernmental Panel on Climate Change's 6th Status Report, is using an ERC Synergy Grant to study emerging risks posed by climate change and urbanization. Partners in Great Britain, Greece and at the University of Freiburg are also involved in the project during which research will be carried out into the dynamics and interactions between cities and their development as well as climate and climate change. In particular, Birkmann is developing a new assessment and modelling approach to issues relating to geographic exposure and the vulnerability of urban populations and infrastructures to climate change and extreme events. The objective is to develop an assessment model that can identify and define sociodemographic dynamics, reactions to climate extremes and the drivers of urban transformation in cityscapes of various types.



Photos: P. 6 private (3), p. 7 top Bon Adriel A., p. 7 bottom Fabian Fischer



THE MOST IMPORTANT AWARD IN VISUALIZATION RESEARCH

Prof. Thomas Ertl Director of the Visualization Research Center (VISUS) and spokesman for the University of Stuttgart's Sim-Tech Cluster of Excellence has received the IEEE Technical Committee on Visualization and Graphics' "2019 Visualization Career Award". The award was made in recognition of Ertl's (left in the photo) basic research into volume and flow visualization, parallel and hardware-accelerated graphics, large data sets and their interactive manipulation and visual analysis. The jury also emphasized the leading role he has played in the development of this field of research and within the visualization community.



CULTURAL AND CREATIVE PILOT

The Stuttgart-based architect Aline Viola Otte has designed a mobile climbing wall under the Paulinen bridge in Stuttgart, which has won her an award from the German government. The so-called "Boulder Block" came from her research at the University of Stuttgart. For six years, Otte taught as an academic assistant at the Institute for Principles of Modern Architecture (Design and Theory) (IGmA) and in her dissertation she explored the spatial dimension of bouldering, a popular sport.

The Boulder Block has a surface area of around 50 m², a 35° degree overhang and a maximum climbing height of 3 m, which makes it suitable for a broad spectrum of the public. The doctoral researcher wants to use the project as a means of providing the public with free access to climbing, and to create a community as well as attractive local structures.



NEW RESEARCH TRAINING GROUP FOR ONCOLOGICAL SURGERY

A new Research Training Group (GRK) at the Universities of Stuttgart and Tübingen is planning to develop sensor systems that will enable surgeons to better differentiate between malignant and healthy tissues and to remove tumors more precisely. These sensor systems will provide high-resolution real-time data, which will allow surgeons to decide whether tissue should be removed or saved even as they operate. Currently, histopathological examinations of frozen sections outside of the operating theater are still required for this purpose. The sensor systems will also quickly provide information about the tumor's heterogeneity and complexity. Under the title "Intraoperative Multisensory Tissue Differentiation in Oncology", the GRK aims to improve patient safety and shorten lengthy operation times. The group's spokesman is Prof. Oliver Sawodny of the University of Stuttgart's Institute for System Dynamics (ISYS).

2050

SUSTAINABLE CHEMISTRY THROUGH ELECTRICITY

The chemical industry is expected to operate in an almost completely climate-neutral manner by 2050 and to do without fossil raw materials such as oil, gas and coal. Alternative carbon sources and renewable energies will therefore need be integrated into the production systems. A research initiative involving the University of Stuttgart, the German Aerospace Center (DLR), the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) is now planning to develop a concept for the chemical factory of tomorrow. The initiative, known as CHEMlampere, is aiming to research and develop the relevant technologies and processes in a basic and application-oriented manner. The spokesperson of the initiative is Prof. Elias Klemm, head of the University of Stuttgart's Institute of Technical Chemistry (ITC).

Photo: Santiago Nunez/Photocase

3 AN INTERVIEW WITH

PROF. DR. ALFRED KRABBE

What is SOFIA?

SOFIA is an airborne observatory: the only one in the world. It consists of a converted Boeing 747 SP with a 17-tonne telescope on board. It takes off into the stratosphere several times a week at night to enable scientists to observe such things as the formation of young stars and planetary systems as well as dust and gas clouds in the Milky Way.

What's so special about SOFIA?

One of its special features is the stabilization of the huge telescope, which mustn't move to ensure that SOFIA delivers good images. On the ground it would be placed on as solid a foundation as possible. However, the aircraft wobbles noticeably in flight, especially during turbulence. But the stabilization system is now so good that we can keep the telescope completely still in spite of all the shaking.

How does a SOFIA flight work?

SOFIA flights are expensive and must, therefore, be very well prepared – aircraft, telescope, instruments, everything has to work. Every team member knows exactly where they belong and what needs to be done. Once it reaches cruising altitude, the large hatch at the back of the aircraft fuselage is opened and the observation program is executed meticulously. The scientists look at the incoming observations as soon as they come in and decide how to proceed. It's so exciting that you can go all night without getting tired!



See the complete interview with Prof. Krabbe:
– Download the "AR Kiosk" app
– Scan this page using a smartphone or tablet
– The video will start automatically

Members of the Stratospheric Observatory for Infrared Astronomy (SOFIA) visited Stuttgart Airport in September 2019 from where they carried out their first observation flight over Europe. The scientific directorship for Germany is located at the German SOFIA Institute at the University of Stuttgart. Institute Director Prof. Alfred Krabbe, who has already been on over 30 flights, explains the project.



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Photo: private



SCHWARZWALD CAMPUS OPENED

Teaching and learning under real conditions: the Schwarzwald Campus in Freudenstadt, which was designed with the objective of merging industrial practice and university teaching, opened in November 2019. Research and teaching go hand in hand at the Center for Teaching, Research and Technology Transfer for the Mechanical Engineering and Manufacturing Industry. The building complex comprises a block of lecture halls for University of Stuttgart master's degree students, as well as an adjacent development laboratory, in which state-of-the-art machines and facilities are on hand for practical use. There are also premises, which start-ups can hire at favorable rates so that they can concentrate fully on their business concept.

EMISSION-FREE CAMPUS



The University of Stuttgart wishes to be a trailblazer in low-emission mobility, which is why we participated successfully in the “Mobility Concepts for the Emission-free Campus” ideas competition and won an award in the “University in urban areas” category. The award is endowed with 300,000 Euro prize money. The award ceremony was held in the presence of Theresia Bauer, Baden-Württemberg’s Minister of Science and Winfried Hermann, Minister for Transport. The “Mobilab” is designed to enable students and employees to study and work on an attractive campus and to enjoy a high quality of life during their stay, which is why the campus will be a car-free zone. In future, visitors to the Vaihingen campus could arrive at a central multi-storey car park, from which the campus would be accessed using new forms of low-emission vehicles such as autonomous e-scooters or an autonomous shuttle (research vehicle) that charges inductively as it drives. The parking spaces that this would free up would provide space for new developments.



Video of the Mobilab:
<https://www.youtube.com/watch?v=cZuBeljuHYo>

732,000 EURO

With around 732,000 euro in third-party funding per professorship, the University of Stuttgart ranks among the top universities in the Federal Statistical Office of Germany’s university ranking table for 2017, which was published in September 2019. Thus, its value increased by roughly 12 percent compared with the previous year.

Photos: Schwarzwald Campus,
Uli Regenscheit

12%

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The world of Supercomputers

TEXT: Jutta Witte
PHOTOS: Sven Cichowicz



Multitasker: Miriam Mehl looks forward to every new project.

Prof. Miriam Mehl has been researching, developing and optimizing the mathematical methods that are required in the increasingly complex world of simulations for over twenty years.

“Actually, we’re always faced with the same task in the field of simulation research”, explains Prof. Miriam Mehl: “We develop or optimize procedures that enable us to solve new problems by using as few and as simultaneously executable arithmetical operations as possible. The motivation always comes from the application.” Simulations currently complement or replace complex and expensive experiments in many areas, and optimize and accelerate processes. Or else they simply make things possible that would otherwise be inconceivable without supercomputers such as those at the High Performance Computing Center, Stuttgart (HLRS) (see p. 40). During the interview, Mehl, an expert in numerics and supercomputing cited examples from very different areas. One of the reasons for this is because she likes to leave her own professional comfort zone every now and again. “The really exciting thing is that we learn more from every new field of application”, says the 45-year-old, who, until October 2019, was Vice Dean at the Faculty of Computer Science, Electrical Engineering and Information Technology.

Even when she was still at school, the daughter of a physicist knew that she would go into mathematics or science. Yet, having taken her Diplom in mathematics at the Technical University of Munich (TUM), Mehl decided to do a doctorate in computer science, the deciding factor having been some fascinating application examples, which she saw in a summer school on simulations in South Tyrol. As a deputy professor, she made another detour into mathematics at the TUM before finally becoming professor for the simulation of large systems at the University of Stuttgart in 2013.

DETERMINING THE STARTING POINTS OF TUMORS

Since then, she has been involved in a large number of projects simultaneously, working at an international level and in interdisciplinary settings, among other things as head of a project network at the Data Integrated Simulation Science (SimTech) Cluster of Excellence. Together with scientists from the University of Texas in Austin, her group has, for example, developed a method that enables us to determine the starting point of a brain tumor on the basis of a single MRI image, as well as the parameters that determine its growth, and all within a matter of seconds. Until now, such a review of the developmental history of a tumor has not been possible, but could provide valuable diagnostic and therapeutic information. →

Sports and family: her work-life balance also includes bike rides.

Either maths or science: Mehl knew that at an early age.



PROF. MIRIAM MEHL

“The really exciting thing is that we learn more from every new field of application.”



International and interdisciplinary: a demand for simulation expertise.



Tens of thousands of computing cores: the new Hawk super computer.

Photo: University of Stuttgart/HLRS

Miriam Mehl is head of research at the “SimTech” Cluster of Excellence in Stuttgart.

→ “All” that is required in this context are two systems based on complicated differential equations which have to be made to communicate with one another. “One for the real MRI image, the other for mapping a statistically healthy brain onto that of the specific patient”, Mehl explains. In contrast, more systems come into play in other applications. For example, optimizing the design of wind turbines, requires the calculation and coupling together as simultaneously as possible of three phenomena: the flow, structural deformations due to forces from the flow, and the resulting acoustics. Not only do these systems differ per se and have interactions in all directions, they also require different computational periods – which presents a challenge in terms of the efficient use of parallel computers. The field of geophysics provides further examples of such interactions when, for example, evaporation processes in porous rocks are calculated – as in the Collaborative Research Center (CRC) 1313 (see pp. 46 and 80). In this context, it is necessary to harmonize the processes that take place within the cavities of such structures with the air flows on their surfaces.

COMPLEX PROGRAMMING OF THE SUPER COMPUTERS

Not only do these examples demonstrate the range of possible applications, but also the increasingly complex requirements in the so-called field of “multi-physics”, in which simulations only work if one proceeds iteratively rather than linearly, i.e., if one approaches as accurate a result as possible in an step by step manner. This involves combining programs, causing completely different and unpredictable computing costs. However, the simulation as a whole should still use tens of thousands of computing cores within a supercomputer in as balanced a manner as possible. Obtaining additional information, for example about uncertainties within the results, requires thousands of simulations. In addition, programming supercomputers is becoming increasingly complicated because of the parallel calculations and the use of heterogeneous, i.e., different, computing components.

However, in addition to such technical challenges, Mehl is also facing new overriding tasks, including the coordination and communications within heterogeneous research networks. She also wants to develop simulation programs that are not only suitable for a single doctoral thesis, but can be extended and used more widely for future, as yet unknown applications. In view of the enormous resources consumed by super computers, sometimes several megawatts which is as much energy as consumed by a small town, Mehl would also like to contribute towards increased sustainability in simulation science using new mathematical methods rather just by simulations.

So, the mother of two is unlikely to get bored in the future. She keeps herself fit for this multitasking between her family, teaching, research, supervision of doctoral candidates and committee work with lots of sport and is already looking forward to the next project: “I’m always happy when someone walks in the door with some new subject up their sleeve.” →

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The courage to take risks

TEXT: Judith Reker

“Terra incognita” is the name of a new funding program at the University of Stuttgart with the aid of which researchers are quite literally breaking new ground. Two examples from the first tender round.

Prof. André Bächtiger does not enjoy conflict. “I’m someone who loves to discuss issues in a cooperative way”, says the head of the Department of Political Theory and Empirical Democracy Research (SOWI II) at the University of Stuttgart’s Institute of Social Sciences (SOWI). “However”, he goes, “I’ve found that robust debates in an academic context do move me forward considerably, although I’m psychologically averse to them”. This personal insight may explain one of his main areas of research: the question as to how people ought best communicate to learn and develop mutual understanding.

Bächtiger hopes that his new project, which involves an interdisciplinary team from the fields of computational linguistics, social sciences and philosophy, will provide an answer. The scientists are conducting an online experiment under the title “Optimal Communication: Experimental Research in Combination with Simulation and Computational Linguistics”. Participants are divided into groups, which discuss a controversial topic using different discussion formats. In the “Contestatory Inquiry” format, for example, a facilitator confronts participants with counterarguments and asks them to respond. The “Appreciative Inquiry” format, on the other hand, emphasizes the commonalities between the different positions. Experts, including philosophers, who are not involved in the experiment, then examine who presented the most well-founded and most arguments, both at the individual and group levels.

NEW APPROACHES TO BETTER COMMUNICATION

Bächtiger’s hypothesis is that the confrontational format may well result in a greater knowledge gain, but not the greatest sense of community. In conjunction with the novel computational linguistic evaluation of the research experiment as a whole, Bächtiger views the project as pioneering research. The question is also highly relevant, says Bächtiger, Vice Dean of the SOWI. “Currently, debates, whether in politics or on talk shows, have a very bad image. Many people think: ”what’s the point? They all lay into one another, and in the end, nobody has learned anything.”“ If the planned analyses are successful, the project could point out ways in which communications could be optimally designed and analyzed, for example on the Internet or in citizens’ forums. →

Tibetan monks practice a confrontational culture of debate.

Photo: Shutterstock



Prof. André Bächtiger

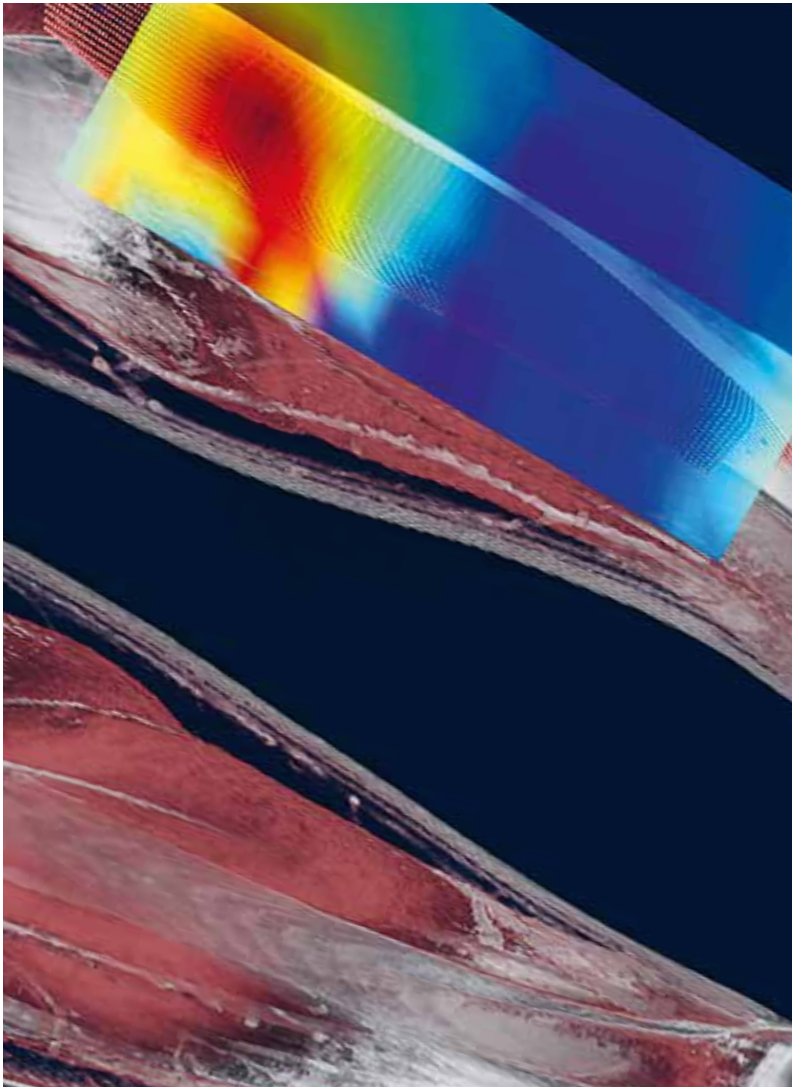
“Currently, debates, whether in politics or on talk shows, have a very bad image. Many people think: “what’s the point? They all lay into one another, and in the end, nobody has learned anything.”“

→ Bächtiger’s project is among the initial six projects to be funded by the University of Stuttgart’s new “Terra incognita” research funding program. It is called Terra incognita because the university literally wants to break new ground, or more accurately, it wants to enable scientists to do so. All researchers at the university are eligible to apply for funding, whether individually or in teams. Selected projects receive funding for six to twelve months with sums of up to 50,000 euro.

Something that particularly impresses Ruth Corkill about the new funding scheme is the programmatic freedom to fail. Her project application entitled “Magnetomyography of skeletal muscles” was also successful. “People submitting project proposals are often urged to play down the risks involved”, says the physicist and research assistant at the Institute for Modelling and Simulation of Biomechanical Systems (IMSB). “If possible, the path research will take must appear clear right from the start, which is not at all realistic. This then leads researchers to adopt a rather conservative approach to project design. But, innovation just doesn’t happen in that kind of environment.” On the other hand, she continues, Terra incognita promotes creativity, because it is based on the insight: “high risk, but high reward”. →

The intention is to make the activity of skeletal muscles visible in more detail.

Photo: University of Stuttgart



Ruth Corkill

“Terra Incognita promotes creativity, because it is based on the insight: “high risk, but high reward.”

→ A BETTER UNDERSTANDING OF MUSCLE ACTIVITY

Corkill’s project involves a radically new approach to taking more accurate measurements of the electrical activity of skeletal muscles. This topic touches upon fundamental medical questions: “if muscle activity is impaired”, she says, “it can hinder movement or even breathing and other fundamental bodily functions. However, we need to understand the mechanisms of muscle activity in much greater detail to develop new therapies. To do so will require better spatial and temporal resolutions, and we’ll need to be able to look much deeper into the muscles in a non-invasive way.”

However, there is one insurmountable problem with the current method of electro-myography, which is the measurement of electrical signals, which is that electrical signals attenuate as they propagate through biological tissues. In Corkill’s opinion →

→ the requisite paradigm shift could be brought about by measuring the magnetic fields generated by the electrical activity of skeletal muscles, because it is highly likely that estimating the location and size of a bioelectric source by means of magnetic measurement will be more accurate. She is currently collaborating with experts in the fields of quantum physics, simulation technology and ethics to develop novel quantum sensors to take these measurements and to confirm the concept.

Corkill, a New Zealander, who has been conducting research at the University of Stuttgart since April 2018, first learned about Terra Incognita through her supervisor Prof. Oliver Röhrle, Vice Dean of the Faculty of Civil and Environmental Engineering. With a master’s degree in physics and another in poetry, she originally came to Stuttgart because she saw an opportunity to work with Röhrle to combine sophisticated physics with applications “that do something positive for people”. →

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ANALYZING DIGITAL LITERATURE

TEXT: Daniel Völpe

The Science Data Center for Literature is a new platform that combines digital research and archiving methods for digitalized literature.

Contemporary literary scholars no longer simply pour over massive volumes of world literature: increasingly, they spend their time in front of computer screens. Digitization enables researchers in the humanities to pursue novel approaches to research summed up under the term Digital Humanities. Simultaneously, digitization is changing literature itself: Works of literature are being created on the computer and distributed across the Internet. The Science Data Center for Literature (SDC4Lit), new digital platform, is to be created by 2023 to explore this. To this end, some 15 researchers from various disciplines at the University of Stuttgart and the German Literature Archive Marbach (DLA) have joined forces. As Prof. Gabriel Viehhauser, head of Digital Humanities at the Institute of Literary Studies (ILW), explains, the aim of the data center is to map the entire cycle of scientific work. SDC4Lit is intended to record and archive works of literature, which researchers will then be able to evaluate using intelligent, digital tools in SDC4Lit. They will present their results via the platform and make them available to researchers and the general public. The state of Baden-Württemberg is funding the project with 1.8 million euro.

The DLA has been archiving texts published on the Internet since 2008 in the "Literature on the Net" project. It will also be selecting the works for SDC4Lit. "We will begin with case studies", Viehhauser explains. The texts selected by the DLA will help to clarify some initial questions: What is interesting and special about digital literature? Which texts on the Internet are considered to be literature at all? This question also remains unanswered. "Of course", says Viehhauser, "you wouldn't include every tweet ever written". But one of the characteristics of the digital world is that works of literature are so limitless and rampant. You can never tell whether something counts as a literary text. Is linked content included?" The researchers want to develop concepts for addressing these issues. According to project collaborator Claus-Michael Schlesinger, social media, in particular, is an interesting field of research. Communication there is →

→ often very playful and includes rhymes and works of art that incorporate emojis. As Schlesinger points out, there has been little research into digital literature within the German-speaking world. The aim of the SDC4Lit team, he says, is to become the central point of contact in connection with this.

To ensure its success, the High Performance Computing Center, Stuttgart will be contributing its expertise on data modelling and on the question of how to create meaningful metadata for the works in question to make them readily accessible over the long term. The Institute for Natural Language Processing (IMS) will be contributing its computer-linguistic methods for text evaluation, and will be developing additional intelligent, digital tools. Finally, the literary scholars will bring the project together at a conceptual level. The first step will be to create a simple prototype of the platform, which will incorporate standard methods of digital literary studies such as linguistic analysis. At the same time, another objective is to identify the needs of archivists and researchers: "which methods do we want to include and link?" asks Viehhauser: "What already exists that we could integrate?"

THE INTERNET IS CHANGING LITERATURE.

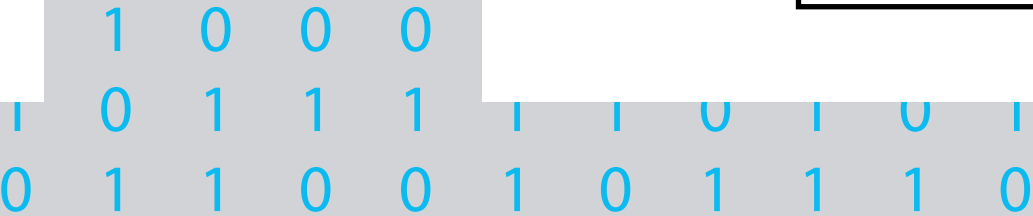
CUTTING THROUGH POWER STRUCTURES

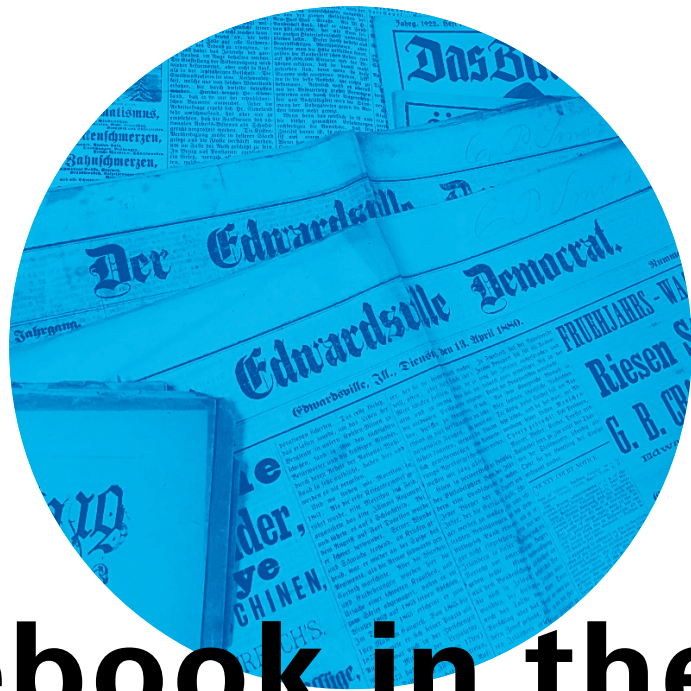
Once the system is up and running, the team wants to test its data and tools on it. At least one potential problem area has already been identified: digital texts often incorporate images and links, which must be transferred to the text data in a meaningful way so that it can be analyzed automatically. To this end, the group will build on experiences with "distant reading", i.e. the digital evaluation of large volumes of traditional literature. "We can't read every text individually with the computer", Viehhauser explains, "but we can evaluate them. Distant reading is designed to be comprehensive. In the past, people always discussed the same thousand books". Cutting through the power structures in the selection of literary texts is one of the advantages of computer-based methods.

Literary scholars will still be deciding the criteria according to which various works will be included in the analysis. "However", says Schlesinger, "we will no longer be dealing with people alone". Instead, there will be a reciprocal relationship between humans and computers. "This is highly dependent on technical developments. Both distant reading and computer-aided methods could reinvigorate literary studies" However, it is also evident that, when dealing with complex digital works of literature, it is the traditional methods of literary studies that can help us to better understand digital developments. Schlesinger cites narratology as an example, which seeks to explain the narrative aspects of a given text. Viehhauser is convinced that literary scholars will continue to carry out their research in the traditional way and not exclusively with the aid of computers. But SDC4Lit will give them the opportunity to expand their range of methods and texts. →

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The newspapers read by German immigrants in the USA, such as this one from 1880, are also being digitized.

Photo: Jana Keck/ILW/University of Stuttgart

Facebook in the 19th Century

TEXT: Daniel Völpe

An international team is analyzing how newspaper stories used to spread, in the “Ocean Exchanges” project. University of Stuttgart researchers from the fields of literature, computational linguistics and computer science are participating in the project.

When Krakatoa, a volcano between the islands of Sumatra and Java, erupted on the 27th of August 1883, people in Europe and other continents found out about it the very next day: they read about it in the newspapers. “That eruption is considered the first global media event”, says Prof. Marc Priewe, head of the Department of American Literature and Culture at the University of Stuttgart’s Institute of Literary Studies (ILW). How could news of the disaster spread so quickly around the world at that time? Researchers are now able to understand how, by analyzing digitized historical newspapers. Understanding how the globalization of information first took place in the 19th century is the objective of the “Oceanic Exchanges” (OcEx) project, which unites researchers from the USA, Mexico, Finland, the United Kingdom, the Netherlands and Germany. At the University of Stuttgart, the ILW and the Institutes of Natural Language Processing (IMS) and for Visualization and Interactive Systems (VIS) are involved.

The mass media was made possible in the 19th century the printing press and telegraphy. And more and more people were able to read, which increased the demand for political, but also sensational news. “Newspapers were the Facebook of the 19th century”, says Priewe, quoting Ryan Cordell, the initiator of OcEx. The professor of American literature at Northeastern University in Boston has been investigating how the various newspapers copied one another for years. “For example”, Priewe explains, “a news story would start in New York and show up a few days later in Louisville, Kentucky. →

→ “Some new stories ‘went viral’, as we would say today – especially news about notable persons.” Even in those days: “more was reported about a politician’s family circumstances and their choice of clothes than anything else”, as Priewe’s employee, the newspaper researcher Jana Keck, has discovered. In her dissertation, she investigates, how the newspapers produced for German immigrants reported on slavery among other things. “The German-language newspapers in Europe mainly reported the fact that slavery existed in the USA”, Keck explains: “The immigrants in the USA were shocked because they had not been aware of the existence of slavery. “What we see is that the German-language newspapers in the USA created a platform for discussions about the contradiction between the American emphasis on liberty on the one hand and slavery on the other.”

The data used in the OcEx project is based on over 100 million computer-readable newspaper pages from more than seven countries. According to Priewe, not even ten per cent of historical newspapers in Germany have been digitized. The process got underway in the 1990s and, to this day, libraries are still scanning their collections. For many years, their efforts were uncoordinated, which resulted in the production of inconsistent data sets. “We want to make the data digitally available to both the public and the science community and to save the newspaper pages from decay”, says Keck. This is why the Stuttgart-based OcEx team is collaborating closely with the Berlin State Library, which publishes guidelines and trains other libraries in best practices for digitization,

as the quality, particularly of early digital products, is often poor. “Text recognition software sometimes produces some weird character strings”, says Keck. That is why the group in Stuttgart is developing sophisticated digital search and word processing tools. “In this way we get robust results because we no longer search for single words, but for whole phrases.” The team uses neural networks in probability models to predict which words will occur in which context, for example, when “lock” refers to a door lock and when it means a canal lock. The researchers are also developing ways of presenting the research results in a visual and comprehensible way.

OcEx’s tools not only render the ways in which news was spread visible, but also show who changed the respective texts. As Priewe emphasizes: “One cannot overestimate the importance of these possibilities. Prior to digitization, one had to visit the archives and go through every single newspaper issue. We’re at the start of a revolution, now that we can search the data by entering keywords on the computer.” In another example, Native Americans in the southeastern USA were forcibly relocated to Oklahoma in the 1830s. “Historians refer to this episode as the Trail of Tears. Searching for this term in contemporary newspapers won’t produce any results” – because it was only coined at a later date. “We’re working on a tool that will first look up the Wikipedia article on the Trail of Tears and then the contemporary newspapers with search terms gleaned from that article.”

Although the OcEx project will end in the summer of 2020, “the humanities questions will never stop”, says Keck. Thanks to digital tools, it may be the case that nothing will be as new in the future as the newspapers of yesteryear. →

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Percentage of digitized newspapers in Germany:

10%

LET'S ALL JUST PAUSE FOR THOUGHT



GUEST ARTICLE: Jan-Martin Wiarda
ILLUSTRATION: André Gottschalk

There are two clusters of excellence University of Stuttgart, but we narrowly missed out on the title of "University of Excellence". Science journalist Jan-Martin Wiarda takes stock in his subjective guest article. Should the University be taking the view: post-application is pre-application? Or should it be exploring its potential in a different way?

Wallowing in self-pity won't get you anywhere. But I will admit: I did like the way the University of Stuttgart awaited the most important decision of the year this summer, in the student-run Beach Bar on the Vaihingen Campus, with public viewings and cocktails, almost as if to say: we're not taking the whole thing that seriously after all.

Which was not true of course. The excellence strategy was taken as seriously in Stuttgart as it was at all universities still in with a chance to be awarded the title of "University of Excellence" on the 19th of July. Seriously! Everyone knew that millions of euro were at stake. But, going forward, it was also a question of setting the course for an indefinite period, as those excluded from the winners club now will find it even more difficult to join in a few years' time. That was the underlying logic of the reformed competition: those institutions named as Universities of Excellence now should remain so for as long as possible.

Stuttgart missed out, and those responsible may take comfort in the fact that they were not among the favorites anyway and that having made two successful applications for clusters of excellence is an impressive achievement. And, that among those universities that also had to forget their hopes for the crown of excellence, some of them even earlier than Stuttgart, there were some big-name institutions.

One effective coping strategy would be to question the rules of competition, as the head of another university has just done. The question, he said, must be allowed as to "whether being part of a large research network really improves the quality of research at a university". In his opinion, this has not yet been proven and all one can say is "yes, the man is right!". But it's no use: those are the rules.

And, if I may say so, although the aforementioned proof is still lacking, the wind that the Excellence Strategy and its predecessor, the Excellence Initiative, blew through the establishment was certainly refreshing. →

Jan-Martin Wiarda

“The wind that the Excellence Strategy and its predecessor, the Excellence Initiative, blew through the establishment was certainly refreshing.”

Journalist, Dr. Jan-Martin Wiarda, focuses on topics relating to education, research and development. He has been working as a freelance journalist since 2015, prior to which he was, among other things, editor in the “Opportunities” department of the weekly newspaper “Die Zeit” and Head of Communications at the Helmholtz Association.

→ In Stuttgart, for example, it led to the emergence of new interdisciplinary connections – see the two successful clusters, for example – alliances that are commanding attention throughout Germany and beyond. I’ll come to the question of cost in a moment.

But before I do – the all important question: where do we go from here? Should a medium-sized technical university resign itself to being a second division leader among German universities with respect to its research reputation? To being one of those institutions that had sufficient “clusters” to be excellent but whose concept of excellence did not elicit cries of delight from the expert auditors? Should a university such as the University of Stuttgart allow itself to be defined by this circumstance at all? Or should it just shrug its shoulders and forget the “Excellence Strategy” (ExStra), content in the fact that it amounts to nothing more than a competition for external funding?

I believe there are two answers to this question, the first of which is rather trivial: there’ll be another one in 2026. “Four new funding cases”, as they’re called in the official German version of the ExStra Administrative Agreement, will then be included among the ranks of the universities of excellence “if successful in the competition process”. Provided the University of Stuttgart has listened carefully to the feedback from the concept auditors and, if it is still able and willing to make further efforts, then great!

If not - and this is my second answer - that’s okay too. In recent years, the public fixation on success and failure in the context of the Excellence Strategy, and particularly in the second line of funding, has led many universities to indulge in a never-ending pre-occupation with themselves, and to a nervous tweaking of strategies, in which, beyond a certain point, the effort involved certainly no longer stood in any reasonable proportion to the monies at stake.

This is even more true with respect to the reputation to be gained, although in this respect too one should avoid dwelling on exaggerated fears. Whilst it is often criticized for being all too egalitarian, the German system of higher education will ensure that the Excellence Universities will not divide the others to any undue extent. In the final analysis, sound basic funding structures – or a lack of them in many places - is far more crucial.

Yet, whether you, at the University of Stuttgart, lean towards answer number one or two: it would certainly be wrong to continue on the ExStra merry-go-round, launching into the next offensive of strategy rounds, concept papers and expert workshops, without pausing for thought. Provided they have not already been condemned by their success in the second line of funding to implement their respective concepts, those responsible within this republic’s university administrations and faculties would do well to take a sabbatical of one or two years from the ExStra to focus on other issues, particularly on teaching and how it might finally play a central role within the universities. Many find this question less exciting, less crucial for the fate of a university or a career in research, but my prediction is that this will change. The billions generated by the Pact for the Future, and particularly by the new Organization for Innovation in University Teaching, will place the onus on those universities that regard their students primarily as “teaching obligations” to explain their *raison d’être*. To put a more positive spin on it, what this means is that the potential for enormous reputational gains is also given in this context, especially for research universities. →

Warped behavior:
timber construc-
tion is being
reconceived in the
Urbach Tower.



Steeply twisted:
the Urbach Tower
stands 14 meters
high.

Programmed elegance

TEXT: Andrea Mayer-Grenu
PHOTOS: Roland Halbe

The “Integrative Computational Design and Construction for Architecture” Cluster of Excellence (IntCDC) at the University of Stuttgart is aiming to utilize digital methods to make the building industry more effective and save resources. Intelligent construction systems such the “Urbach Tower” are also paving the way for a breathtaking new aesthetics.

Form follows function: a timber board bends exactly as calculated.



As they approach it, the Urbach Tower appears to cyclists on the Rems valley route near Stuttgart as an elegantly curved landmark in the foothills of the Schurwald. But, looking up from the plinth of the observation tower, will take your breath away: 14 meters high, the timber elements spiral skyward completely unsupported, each of them curved in an almost absurd manner and perfectly interlocked with the adjacent panels. Can timber panels be shaped like this?

Yes, they can. However, until now, it has required heavy pressing plant and a lot of energy. In contrast, the panels used in the Urbach Tower deform themselves into a precisely calculated, complex curvature virtually of their own accord – unprecedented anywhere in the world!

The process on which the tower is based was developed collaboratively by the University of Stuttgart’s Institute for Computational Design and Construction (ICD), the ETH Zurich and the Swiss Federal Laboratories for Materials Science and Technology (Empa), and applied together with the University of Stuttgart’s Institute of Building Structures and Structural Design (ITKE). It takes advantage of a characteristic of timber that is actually undesirable, namely warping.

When it dries, damp timber contracts more strongly perpendicular to the direction of grain than along the grain. The researchers exploit this property by laminating two layers of wood such that their grains are oriented differently. These laminated plates, which are known as “bilayers” form the basic building blocks of the new process. One layer shrinks more than the other when the moisture content in the bilayer decreases. The timber is deformed, because the two layers are firmly glued together. The precise degree of deformation depends on the thickness of the layers, the orientation of the fibers and the moisture content, all of which can be calculated in a computer model. The researchers refer to this process as “timber programming”.

As Dylan Wood, head of the Materials Programming Research Group at the ICD explains, the ingenious use of self-forming makes it possible to give an ancient building material such as timber completely new functions, because curved components have a higher structural capacity than flat ones: “this lends a new perspective to the digital design and manufacture of large timber components with complex geometries”.

CLUSTER OF EXCELLENCE FOR NOVEL CONCEPTS IN ARCHITECTURE

Thus, this project clearly demonstrates how the use of digital planning, simulation and manufacturing processes can pave the way for a new way of thinking. This is one of the key concerns of the “Integrative Computational Design and Construction for Architecture” Cluster of Excellence (IntCDC) at the University of Stuttgart, which will receive a total of 45.5 million euro in an initial funding phase until 2025 as part of the strategy of excellence for strengthening cutting-edge research in Germany.

The cluster aims to find answers to an alarming development: over the next 35 years, additional urban housing will be required for 2.6 billion people due to population growth and urbanization. However the construction industry is already consuming 40 percent of the world’s resources, which is partly due to the fact that productivity in the construction industry has been stagnating for years. And the spatial requirements continue to increase rapidly.

The 22 professors within the cluster are relying on co-design to make construction more innovative and efficient. As Prof. Achim Menges, the cluster spokesman and head of the ICD, explains, the digital networking of planning, construction processes and building systems is key to this: “what we want is to exploit the full potential of digital technologies through an integrative and interdisciplinary research approach, to create the basis for groundbreaking innovations and sustainable planning and construction.”

Two pavilions erected on the grounds of the Federal Horticultural Show (BUGA) in Heilbronn in the summer of 2019, which drew in millions of visitors, also demonstrate

this new way of thinking, which has attracted worldwide attention: one is a seven-meter high, extremely material-efficient unsupported timber construction that spans a floor area of 500 m²; the other is an equally high, transparent glass and carbon fiber dome, and was the first ever construction system to be digitally developed throughout. →

40% of the world’s resources, is what the construction industry has been consuming until now.



Robotic prefabrication of a timber element (top).

The timber cassettes being joined together.

Support-free elegance: the completed timber pavilion at the Federal Garden Show in Heilbronn.



Developed digitally:
a glass and carbon fiber
dome in Heilbronn.

Computer support-
ed: the analysis of
the structures.



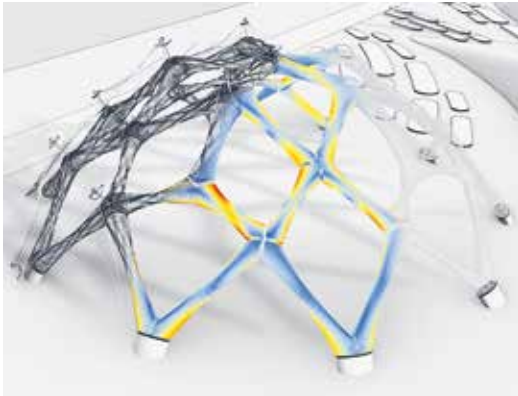
Prof. Achim Menges

“For us, biology
serves as a
motivation for
scientific lateral
thinking.”



From model to implementation (left).

Measuring the load distribution and deformation.



The Timber Prototype House, exhibited at the IBA 2019 in Thuringia.

440 timber frames slot together with no metal or glue (bottom).



→ LEARNING FROM BIOLOGY – UNDERSTANDING NATURAL STRUCTURES

Such constructions are often inspired by nature: the sand dollar, a subspecies of the sea urchin served as the biological model for the panel structures used in the timber pavilion. The shell structure of the fiber pavilion is based on the wings of a flying beetle. Self-shaping mechanisms are also found, for example, in plants that alter their shapes to release their seeds. “For us”, says Menges, “biology serves as a motivation for scientific lateral thinking”. The challenge for architects is to gain a structural understanding of the principles and functions of nature and to implement them using newly developed materials and tools. “We’ve developed a new design process in which planning and construction are conceptualized together from the very outset.” It starts with the preparatory software development for novel construction systems and encompasses the robotic production process and simulations aimed at increasing material efficiency to the preparation of new legal standards, for such things as structural stability certification. Such a comprehensive approach can only succeed on an interdisciplinary basis. The IntCDC Cluster of Excellence therefore includes researchers from the fields of architecture, civil engineering, building physics, engineering geodesy, production and systems engineering, computer science and robotics, as well as from the humanities and social sciences.

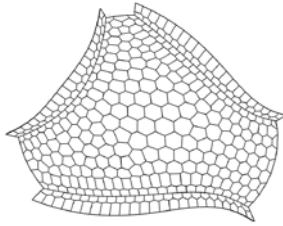
Robotic prefabrication is an important step en route to a new architecture. The timber pavilion at the BUGA in Heilbronn comprises almost 400 hollow cassette elements, the manufacture of which would have been extremely costly using conventional methods. Instead, the design was implemented at the Müllerblaustein timber construction site near Ulm, Germany in a fully automated production process developed by the ICD, which involved the use of intercommunicating robotic systems, which cut the materials, joined the layers together and milled out the notches where the segments interlock. The deviation in the timber elements is less than two tenths of a millimeter.

The robot used for manufacturing the fiber pavilion, which winds the glass and carbon fiber around anchor points, is located at one University of Stuttgart’s satellite sites in the Wangen district . The fibers are deformed during the winding process, which gives them a curvature after which they harden. This process makes it possible to specifically adapt the geometry and structure of the fibers for each of the 60 components to meet the relevant requirements without the need for molds and without creating any waste.

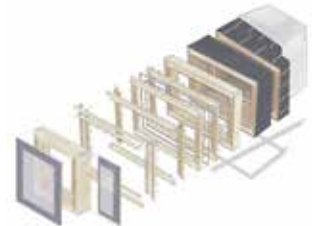
A HOUSE WITH A TWIST – SMALL PROTOTYPE, MAJOR IMPACT

Just what digital design and manufacturing methods can achieve in house construction was demonstrated in the Timber Prototype House, a small, digitally manufactured log cabin at the International Building Exhibition (IBA) 2019 in Thuringia, Germany. Whereas traditional log cabins consist of horizontally stacked logs, the IBA prototype house comprises 440 vertically offset support frames made of squared CNC-milled timber. Intelligent slits in the spruce beams prevent the notorious cracking and increase the insulating properties. A parameterized corner joint is milled into the ends of the timber, which enables the on-site tradesman to simply join the timber frames together with no metal parts or glue. And, finally, the fully integrated computer-aided design and manufacturing process enables the gentle bending of walls and ceilings. This twist, not only minimizes the materials used to construct the micro-house, but also makes an architectural delight. →

Robots cut the timber, joined the layers and milled out the notches. Deviations: minimal.



Audacious: the roof of the Buga Pavilion has an unsupported span of 30 meters.



Deconstructed: the components of the Timber Prototype House.

Photos: pp. 28, 29, 32, 34 Roland Halbe, pp. 30, 31, 33, 34, 35 University of Stuttgart/ICD/ITKE, p. 34 Thomas Müller

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A ROOF IN THE RIVER

TEXT: Daniel Völpe

Three University of Stuttgart master's students are developing architecture that (almost) constructs itself.

Miguel Aflalo, Jingcheng Chen and Behrooz Tahanzadeh were not thinking about bricks or other rigid building materials when they came up with their idea for a “drone-aided construction system”. The three master students based their project on “cyber physical macro material”, which is to say that the roof elements are made of carbon fibers and weigh just 700 grams each. Each of the individual elements communicates its position and other sensory data to its neighbors as well as to the builder, which happens to be a robot drone, which assembles the elements to form a roof. “The building” as Dylan Wood, supervisor of the master's thesis and research assistant at the University of Stuttgart's Institute for Computational Design and Construction (ICD) explains “knows where it is and can move”.

The sensor-controlled roof moves with the sun and is therefore able to provide continuous shade. Users could also use an app to control the system and tell it where to go. The system can even learn something about its environment and adapt its behavior accordingly. Pins are located in each of the magnetic connections between the components for this purpose, which transmit data from the sensors and microprocessors from one component to the next. As the project's second supervisor, Maria Yablonina explains, the system must itself determine precisely when it moves which element to prevent itself from collapsing: “It's not the robot that decides how to build, but rather it's the material that tells it how it wants to be built.” The designers only provide the structure and a construction strategy. “The building then finds its form through interacting with its environment and users.” →

Top: the roof beams fit together like a jigsaw puzzle.

Bottom: the drone carries a roofbeam to a new location.



Photos: University of Stuttgart/ ICD/ITKE

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You can see even more in the video:
- Download the “AR Kiosk” app
- Scan this page with your smartphone or tablet
- The video will start automatically



A provider of shade: the artificial wings consist of 30 kilometers of carbon and glass fiber tapes.

Like ladybird wings

TEXT: Daniel Völpe

Biology as a model for architecture: a concept being realized by young researchers in perfect designs.

A bench with a roof of futuristically flexible, shady wings: this is the ITECH research showcase 2018-19, a project by young researchers. They are All master students in the “Integrative Technologies and Architectural Design Research” (ITECH) program. Several University of Stuttgart institutes are involved including the Institute for Computational Design and Construction (ICD), the Institute of Building Structures and Structural Design (ITKE) and the Institute for Textile and Fiber Technologies (ITFT).

“We're motivated by the idea of developing flexible mechanisms for architectural applications, such as façade shading”, explains Axel Körner, a research assistant at ITKE and one of the project managers. The wing folding mechanism of the ladybird, whose rear wings store energy when folded and open as soon as there is no active pressure, served as a model for the approximately three meter high wings . The ITECH sash is only closed with pressure in the same way. The ITECH team constructed and simulated this mechanism on the computer with the support of biologists from the University of Tübingen. From there, the data was fed into a robot, which gave the artificial wings their shape using around 30 kilometers of carbon and glass fiber tapes.

Because they have no joints, the wing structures require less maintenance than a parasol. The fiber-reinforced plastic in the joint zones is just thicker on the back and therefore stiffer than on the front. The are air cushions between the two sides. Sensors continuously report the positions of the component parts. The corresponding app simulates a digital 3D twin from this data. If one uses a smartphone or the buttons directly on the wing to make change, the system pumps air into the cushions. The front part of the joint zone bulges thus folding the wings →

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Photos: University of Stuttgart/ICD/ITKE/ITFT

BUILDING CLADDING THAT BREATHES

TEXT: Jutta Witte

The adaptive lightweight buildings of the future will require new technologies, including for the building cladding, which regulates the moisture and energy balance. Researchers at the University of Stuttgart have developed a system of actuators with which the breathability of this outer cladding can be turned on and off.

The structure and shells of ultralight structures can adapt flexibly to changing and even extreme loads. They are intended to help prevent the enormous consumption of energy and resources as well as the high level of emissions and waste generated by the construction industry worldwide. “What we’re dealing with here is a trend that points the way to the future, but which presents us with completely new challenges”, says Prof. Thomas Bauernhansl, Head of the University of Stuttgart’s Institute of Industrial Manufacturing and Management (IFF).

Under the leadership of Raphael Neuhaus, the project team is continuing to develop membranes that are already being used as building cladding in large buildings such as the Olympic swimming hall in Beijing, known as the “Water Cube”, and the Burj al Arab, a sail-shaped high-rise building in Dubai. The team’s research project, “Electroactive polymer actuators and actuator arrays for switchable breathability in envelopes and spaces”, is a sub-project of the Collaborative Research Center 1244 “Adaptive skins and structures for the built environment of tomorrow”, which is funded by the German Research Foundation (DFG). 14 University of Stuttgart Institutes and two Fraunhofer Institutes are participating in the SFB, which was launched in 2017 under the leadership of Prof. Werner Sobek, head of the University of Stuttgart’s Institute of Lightweight Structures and Conceptual Design (ILEK).

REDUCED ENERGY CONSUMPTION

The membranes that Neuhaus and his team are working on are light and flexible. However, unlike concrete walls, they are unable to store thermal energy and are impermeable to air and moisture. Just like human skin, which both protects and breathes simultaneously, modern building claddings must also be properly ventilated and aerated – in short, it must be able to breathe.

Currently, this only works with a considerable input of energy: for example, to prevent corrosion damage caused by condensation or moisture penetration into the insulation layer, diaphragm constructions are actively ventilated by means of electric pumps that blow warm air into the building shell. “Our goal”, explains Neuhaus, “is to make such membranes breathable in the future, to which end we have to activate them in some way”. The researchers at the IFF are using actuators made of electroactive polymers (EAPs), which are integrated directly into the membrane and ensure that its “breathability” can be →



Façade demonstrator:
The integrated flaps can be opened individually.

Photo: Michael Frick



Membrane construction: it is double-curved, multi-layered and breathable.

Photo: Michael Frick



Raphael Neuhaus is developing novel membranes: they are lightweight and above all breathable.

Photo: IFF University of Stuttgart

→ switched on without complex adjustment systems such as electric motors or compressed air. This is known as “material intrinsic” activation among experts. The IFF team is working with ionic EAPs made of carbon nanotubes (CNT), a lightweight, stable and electrically conductive material. The actuators comprise two CNT electrodes with a separation layer between them. An ionic liquid is added to all three layers. When an electrical voltage is applied to the electrodes of the three-layer system, the particles within the system move in such a way that the positively charged electrode contracts whilst the negatively charged one expands. The electrical energy is converted into mechanical energy in an electrochemical process, the actuator bends and is therefore capable of moving slits or other openings in the membrane.

Ionic EAPs get by with a voltage of just three volts. Usually, their deflection is also well controllable and the actuator can be controlled with pinpoint accuracy. So, there is little doubt as to their technical feasibility. However, the economical production and robust integration of the EAPs into the membrane material are also crucial for a successful application at a later date. 20 to 30 of the super-thin actuators are needed to ventilate an area of one square meter.

Therefore, the research team is not only using relatively inexpensive multi-walled CNTs as a starting material, but have also optimized the previously expensive production process, which had only been possible in the laboratory, such that it is now suitable for industrial use. A coating system, which was specially converted for the project enables the automated production of large quantities of electrode and separator material. A mixture of polymer, CNTs, solvents, additives and ionic liquid is pumped into a slotted nozzle, applied to a smooth substrate, such as a glass plate, and dried with an integrated heating element to produce each layer. The whole process, from mixing to the finished dry layer, takes less than five hours. In the past, the wet layer alone took up to 72 hours to dry in a vacuum furnace. The dry layers of electrode and separator material, which are just 100 to 200 micrometers thick, are then pressed together. The actuators can then be trimmed to the desired size from the resulting semi-finished product.

The experts coat the small actuators with a thin polymer layer to make them harmless to humans and at the same time to protect them against environmental influences. They are then bonded to conductive threads which are sewn into the textile and supply them with energy. “This technology”, as Neuhaus emphasizes, “saves energy, is reliable and can be used in a wide range of applications”. A prototype membrane is already showing what it will look like in practice. A mini prototype is also scheduled to go into operation in 2020, which will consist of a room for a single person to test the effect of the intrinsically activated membrane. Neuhaus estimates that it will be some time before the new technology is market ready: “But many industries have already recognized the potential.” →

Raphael Neuhaus

“This technology saves energy, is reliable and can be used in a wide range of applications.”

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New supercomputer at the High Performance Computing Center

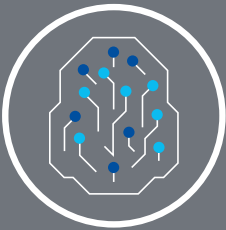


x 3,5

Hawk will be 3.5 times faster than the previous supercomputer at the HLRS, Hazel Hen.

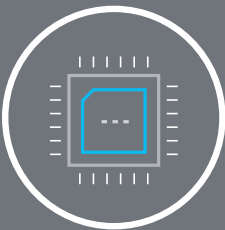
SWIFT AS A HAWK

A new era will dawn in early 2020 at the University of Stuttgart's High Performance Computing Center (HLRS) when construction will begin on the new "Hawk" supercomputer, which will soon be the fastest computer system for industrial production. Hawk is intended to support research in science and industry, predominantly in engineering. In particular, it will enable even faster computations and higher resolutions in simulations. For example, Hawk will be able to simulate the turbulence around a flying aircraft or show how molecules behave during combustion processes in an engine or power plant in a more realistic manner. Hawk will identify where the future hip joint will be exposed to particular stress even before an operation, and will allow climate researchers to make predictions for small regions or even specific locations.



27 peta-FLOPS

Is what Hawk's theoretical peak performance should be.



11,264 processors

the cluster that makes up the Hawk computer system will be distributed across 5,632 nodes.

44 million euro

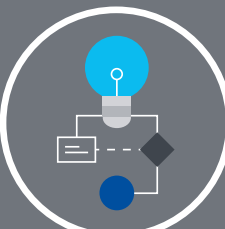


is what it will cost to manufacture and install Hawk.



today: 400 years tomorrow: 1 second

Hawk will need just one second for a computing application that it would currently take eight billion people about 400 years to complete.



EPYC

Hawk's speed will come from a new type of AMD EPYC processor, whose memory subsystem is particularly suitable for simulation algorithms.



19/02/2020

Hawk will be officially taken into operation on the 19th of February 2020, in the presence of Federal Research Minister Anja Karliczek and Baden-Württemberg's Minister President Winfried Kretschmann.



On the move: Marc-André Keip holds the Chair of Materials Theory at the Institute of Applied Mechanics (Civil Engineering).

The laboratory in the computer



In focus: an in-depth knowledge of the properties of intelligent materials.

TEXT: Jens Eber
PHOTOS: Sven Cichowicz

Intelligent materials hold the promise of countless application possibilities. However, researching them represents a major challenge. Simulations are one option.

“Materials”, says Prof. Marc-André Keip, “cannot think or be creative, so in this sense they also can’t be intelligent”. Initially, it strikes one as something of a contradiction that Keip is in fact researching intelligent materials at the Chair of Materials Theory. However, the 40-year-old immediately resolves the confusion: certain materials, he explains, react to physical or chemical stimuli in a controllable manner, which makes them appear to be quite smart after all.

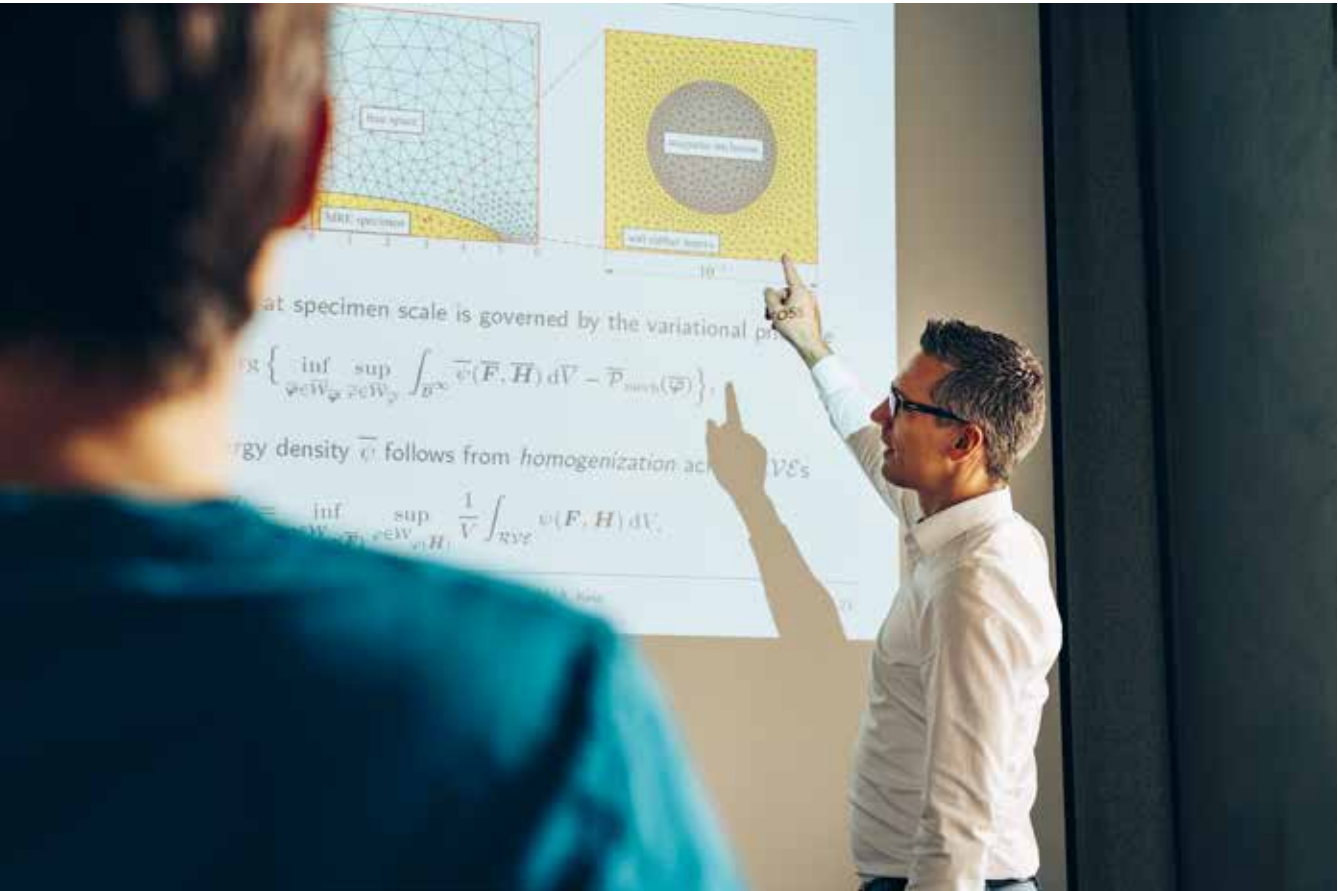
“Essentially, it’s about coupling various phenomena”, says Keip. Materials are considered to be “intelligent” when, for example, magnetic and mechanical forces interact within them. One classic example is found in many lighters, in which the ignition spark is created by a so-called piezoelectric quartz rather than a flint, which is energized by pressure from the user and thus generates a spark.

Of course, such rather mundane applications are of no interest to Keip and the other seven scientists in his research group. “We are not exclusively focused on applications anyway”, he says. “Often we are more interested in the fundamental phenomena. It’s the challenge of expressing these in mathematical models that attracts us.” “We”, he adds with a laugh: “often consider something to be practical if it can be represented on the computer”.

DIFFICULT TO RESEARCH IN LABORATORY EXPERIMENTS

Yet, in this way the Stuttgart-based scientists are providing the basis for practical development work, for example on magnetorheological elastomers, i.e., soft plastics that contain magnetic particles and deform when they interact with magnetic fields, enabling them, for example, to close valves or perform adaptive damping tasks.

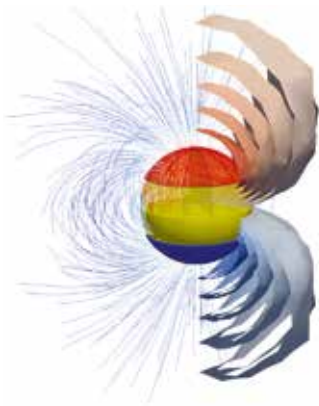
According to Keip, intelligent materials could enable many other technical applications, but some of them are difficult to research in laboratory experiments, due, ironically enough, to their otherwise welcome qualities. If a metal component is subjected to a tensile test in the laboratory, for example, external forces which are precisely adjustable from the outside act on it at all points inside. →



An excellent re-
searcher and teacher:
Keip received the
University of Stutt-
gart teaching award
in 2018.

MARC-ANDRÉ KEIP

“We are creating the theoretical foundations with which the behavior of materials can be modeled mathematically.”



In the picture: the
visualization of a
simulation result.

“A good simulation obviates the need to carry out certain experiments in reality.”

→ Soft magnetoelastic materials react in a much more complex way in experiments: when they are exposed to a magnetic field, an inhomogeneous state of forces is established inside of them. This, as Keip explains, makes it much more difficult for researchers to empirically determine reliable parameters for such materials. However, without an in-depth knowledge of the properties of intelligent materials and their reactions to external stimuli, their further development will also come to a halt.

The Stuttgart-based material theorists are showing the way out of this dilemma. “We are creating the theoretical foundations with which the behavior of materials can be modeled mathematically”, explains Keip. These theoretical models form the basis for numerical simulations, which can be used to investigate and optimize the behavior of materials as well as the structures created from them,

which, in turn, enables engineers to better assess whether a given application should be developed at all. “A good simulation obviates the need to carry out certain experiments in reality”, says Keip. One example is the expensive crash tests used in the development of motor vehicles. Simulations are cheaper, but they also have another advantage, Keip explains: practically any number of parameters can be tested in the simulation cycles. This, among other things, enables the composition of composite materials to be optimized in recurring simulation cycles, which is not easily possible in the laboratory. His team, explains Keip, is mainly working on the so-called continuum level, i.e., in the size range of connected material structures. “Many intelligent materials have a microstructure, which we investigate and try to draw conclusions about based on what is visible to the naked eye.”

A BETTER UNDERSTANDING OF POROUS MEDIA

The research group is also working on a better understanding of porous media in collaboration with the University of Stuttgart’s Collaborative Research Center 1313. Among other things, the researchers are looking into how cracks form and continue to form in rocks when liquids are used under high pressure. This knowledge is important, for example, in connection with fracking processes. For example, even if components develop cracks, simulations can provide information about how they could be avoided.

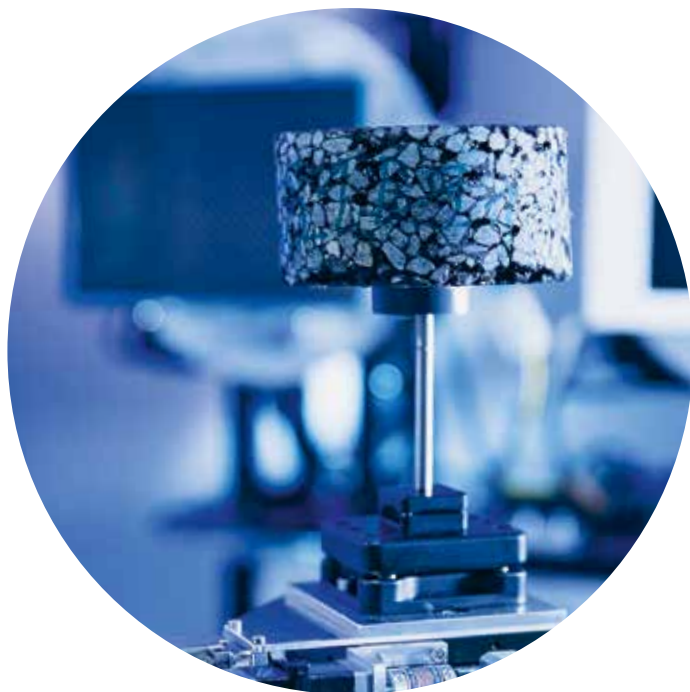
Keip was already looking at intelligent materials and the associated coupling phenomena during his doctoral studies at the University of Duisburg-Essen. When a junior professorship at the University of Stuttgart’s Institute of Applied Mechanics (Civil Engineering) (MIB) was announced in 2013, the Essen-born professor jumped at the chance. The University of Stuttgart was even more attractive to him because of the SimTech Cluster of Excellence. He has held the Chair of Materials Theory since January 2019. “One particularly attractive aspect of researching intelligent materials”, he says, “is that it links mechanics with many other related fields of research”. →

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HOLES IN THE CONCRETE

TEXT: Jens Eber
PHOTOS: Uli Regenscheit



Even impenetrable rock is full of pores. Scientists at the University of Stuttgart’s Porous Media Lab are researching the processes that happen within it.



Holger Steeb prepares an asphalt sample for the X-ray tomography scanner.

At first glance, the cylinders on Prof. Holger Steeb’s desk, each of which is about the same thickness as a thumb, resemble knick-knacks, holiday souvenirs perhaps. However, as the holder of the Chair of Continuum Mechanics at the University of Stuttgart’s Institute of Applied Mechanics (Civil Engineering) (MIB) explains, they are, in fact, important objects for his research, being sandstone drill core rock samples, lithographic limestone and high-performance concrete. They appear to be extremely solid and impermeable, but, as Steeb makes clear: “Each of these materials is porous and permeable to fluids. The only question is over what period of time?” And that brings him to the core focus of his research.

Since his appointment in Stuttgart in October 2015, Steeb has been building up the Porous Media Lab, which rather than being a classical laboratory to which samples are sent for analysis, functions as a partner for numerous research institutions in Germany and abroad. The laboratory is a central component of the University of Stuttgart’s SimTech Cluster of Excellence and the Collaborative Research Center “Interface-Driven Multi-Field Processes in Porous Media – Flow, Transport and Deformation” (SFB 1313). As Steeb explains: “we are working on creating links between experiments and models”.

One typical question of such fundamental research is what physical processes take place when rock is penetrated by fluids. Steeb’s group carries out experiments, but the knowledge gained also flows into simulations, which, for example, calculate the flow behavior of fluids in rock. This research is applied in connection with drilling operations for the exploitation of geothermal energy (the Mine water Project), in the development of intelligent road surfaces or water- and gas-proof construction materials. For example, asphalt and concrete are prone to cracking under the influence of water and other mechanical loads during their lifetime. To prevent this, researchers want to discover which processes take place at the so-called pore scale, which in the case of rocks, are areas with a typical length of 10 to 50 millionths of a meter. →

ALL MATERIALS ARE POROUS.
THE ONLY QUESTION IS OVER WHAT PERIOD OF TIME.

PROF. HOLGER STEEB

“Making it visible is a prerequisite for gaining any understanding of a material whatsoever.”

→ Steeb summarizes the scientific challenge as follows: “It’s not enough just to look inside porous media.” It is vital to understand what happens inside the pores under mechanical influences. Researchers in the fields of medicine and the geosciences are using ultrasound or seismic experiments to generate data of increasingly high resolution. But more detailed knowledge about porous media is required to interpret this with more precision and this is what the Porous Media Lab wants to provide.

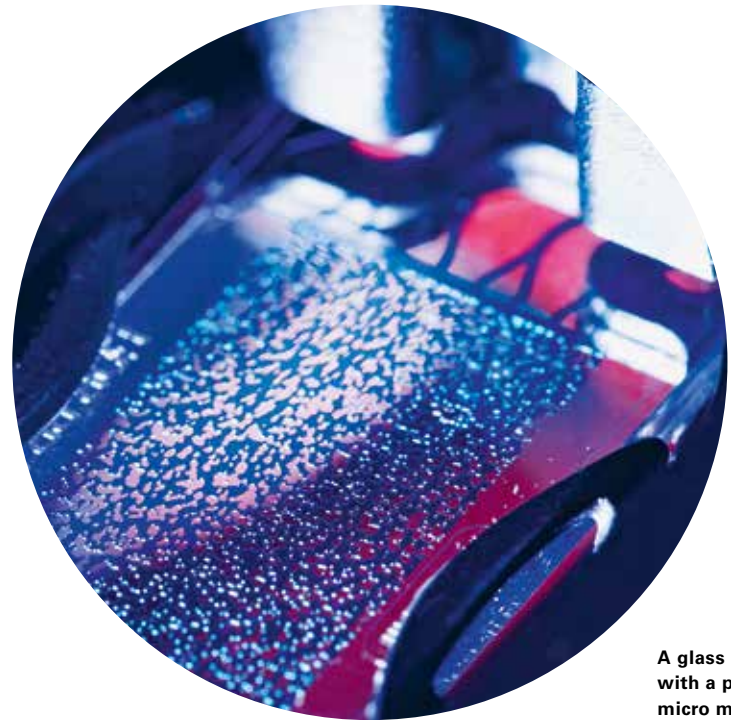
Steeb and his 15 colleagues are using X-ray tomography and other imaging techniques to look into the structure of pores and generate computational models of the porous materials as a basis for simulations. “Making it visible is a prerequisite for gaining any understanding of a material whatsoever”, explains Steeb. This understanding leads the researchers to multi-scale mathematical models and eventually to a wide range of simulation applications. ➔



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Working on dry and damp rock samples.



A glass plate with a porous micro model.



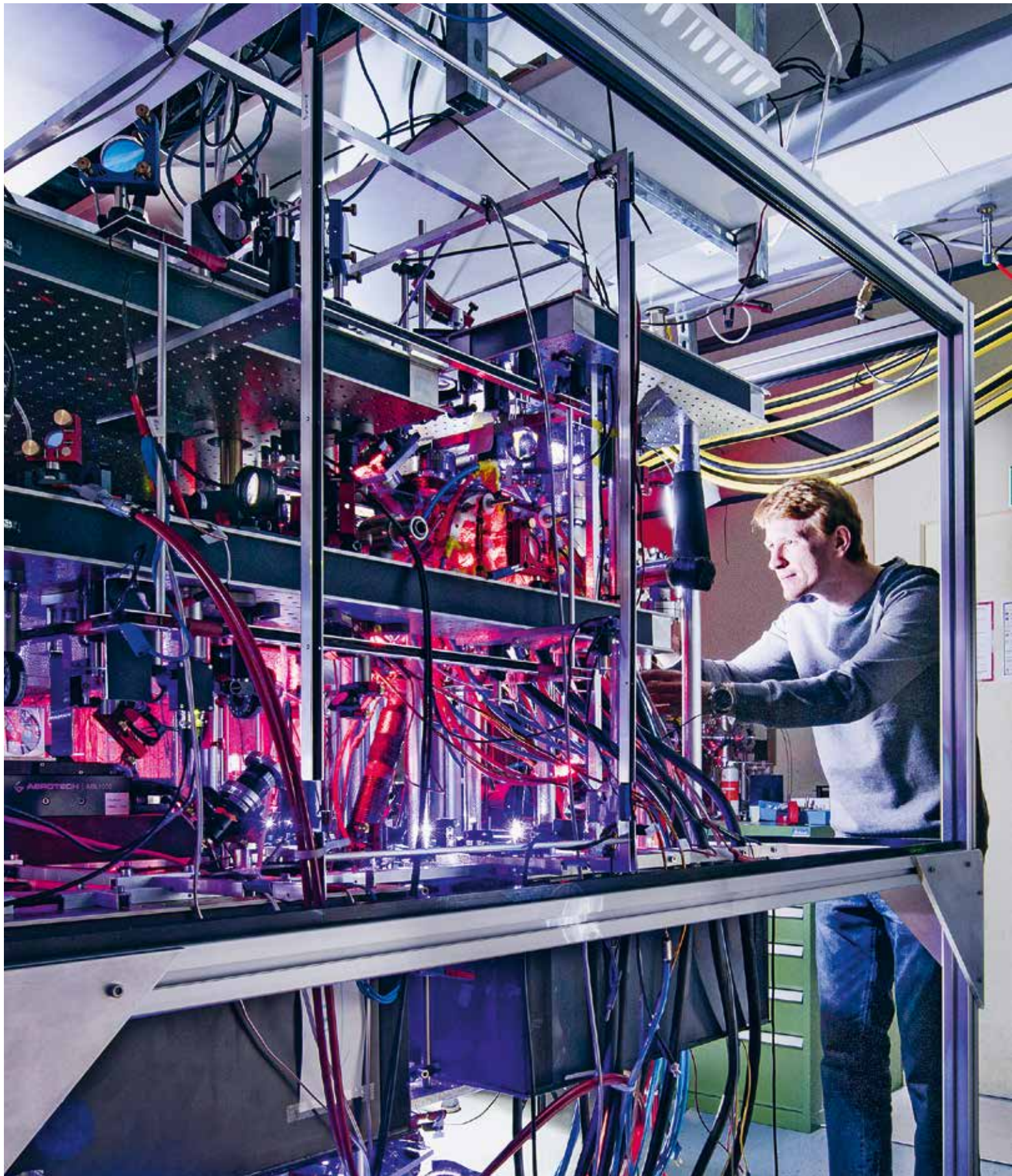
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Generation Education



A team of physicists based in Stuttgart detects new states of matter.

Photo: Wolfram Scheible

Hard as Honey

TEXT: Michael Vogel

A material that is a solid and a fluid at the same time: Stuttgart-based physicists prove the existence of supersolidity for the first time.

Prof. Tilman Pfau had to wait for almost 20 years for this, as he put it in retrospect, “special moment”. He was appointed as an experimental physicist at the University of Stuttgart in the year 2000, where he heads up the 5th Institute of Physics. Since then, he has been working on a question to which his team has now found a definitive answer: yes, supersolidity, a phenomenon first predicted in the ’50s, does actually exist!

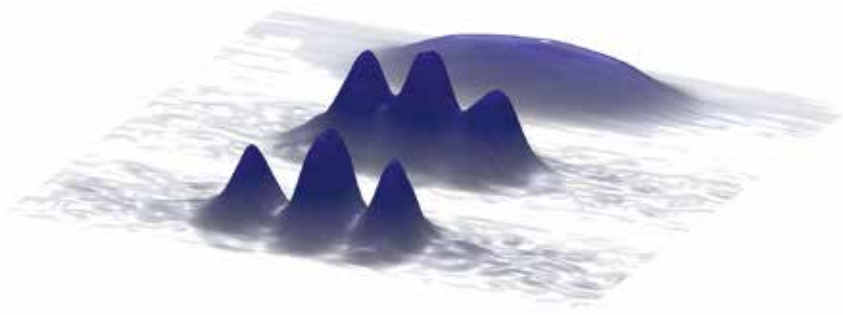
To understand the concept, one can picture familiar treats such as honey or ice cream: “As honey ages”, explains Pfau. “it begins to crystallize in the jar. So you have a mixture of set and liquid (clear) honey”. Anyone who eats ice cream too slowly will experience a similar situation: it will start to melt. Supersolid substances are similar; they exist simultaneously in solid and liquid forms. But, as the physicist points out, there is one important difference: “The individual atoms in honey and icecream are either in a solid or liquid state. In a suprasolid substance, on the other hand, each atom is in both states: the atoms are, so to speak, in a solid and liquid state at the same time.”

BASIC RESEARCH IN ITS PUREST FORM

The very fact that this – mind blowing – possibility exists at all is down to quantum physics. Atoms and other particles behave differently to what the laws of physics that apply, for example, to falling stones, would predict. Individual particles can be indistinguishable from one another at such microscopic dimensions: they are both particles and waves at the same time, and their location and speed can never be precisely determined at the same time. Although things happen in the quantum world that contradict common sense, they can explain many common phenomena, for example, why the sun shines. And, we can exploit quantum physics for technical devices such as lasers and LEDs. →

The existence of supersolidity was predicted in 1957.

Prof. Tilman Pfau and his team have now succeeded in proving its existence.



In the quantum world: atoms in crystal form (front), as a supersolid (center), and in a superfluid state (back).

→ “But”, as Pfau explains, “the quantum world also affects potential aggregate states of matter”. We usually distinguish between solid, liquid and gaseous states. However, physicists are familiar with other states of matter that they are able to create in the laboratory, which require low – very low – temperatures ; less than a millionth of a degree above absolute zero, which is -273.15 °C: nothing in the universe could get any colder. It was at this low temperature that Pfau and his team came across supersolidity: “Suitable materials consist of atoms with the properties of a crystal, i.e., a solid, and simultaneously that of a liquid.”

This is basic research in its purest form – it is far too early for questions concerning technical applications. This can be illustrated by comparison with a completely different, but also “cryogenic” field of research – the field of superconductivity. Since 1911, it has been known that at extremely low temperatures certain materials can conduct electricity without loss. However, only in recent times has there been any appreciable progress in the technical application of this knowledge. The situation concerning supersolidity could be similar.

In their search for supersolids, physicists around the world have long been using helium, a material which had already been shown to be good for another phenomenon in low-temperature physics. Since the start of the 20th century, physicists have been able to cool helium to a point where it becomes liquid at temperatures close to absolute zero. However, because of the quantum world, this liquid state of aggregation is a special one: in this state, helium no longer evinces any internal friction, which is expressed in such a way that it flows over obstacles, that it could not have overcome at all according →

→ to the laws of macrophysics. Physicists refer to this state of aggregation as superfluidity, in allusion to a fluid substance. So, strictly speaking, when Tilman Pfau talks in terms of supersolidity, he is referring to a state of aggregation in which atoms are simultaneously part of a crystal and a superfluid.

“However”, says Pfau, “helium proved unsuitable for this type of research, as super-solid helium doesn’t seem to exist”. So, researchers turned to other elements. Chromium was regarded as a source of hope for a long time, including in Stuttgart. “Two types of interactions between the atoms play a role at temperatures close to absolute zero”, says Pfau. “When two atoms come very close, they bounce off one another like billiard balls. At the same time, chromium atoms interact magnetically over long distances and can attract or repel each other.” However, one should not imagine the material sample with which the Stuttgart-based team is currently experimenting as a piece of metal. Instead, the objective is to combine the largest possible number of individual atoms in a controlled manner at low temperatures to form a condensate on which the actual experiments to find out whether it is a supersolid or not can be performed. All the atoms in such a condensate, whose density is lower than that of air, must move in perfect harmony: only then can the desired quantum effect occur, i.e., the indistinguishability of the atoms. This can be specifically adjusted by finding the right balance between short-distance billiard ball collisions and long-distance magnetic interactions. “However”, says Pfau, “this didn’t work. The chromium condensate kept collapsing: we couldn’t measure anything”.

IN A RACE WITH OTHER RESEARCH TEAMS

So, his team continued their search for alternatives. Their choice fell on dysprosium, a rare earth metal with even more favorable magnetic properties. This was the decisive turning point for the experiment in Stuttgart, as Pfau recalls: “In 2015, we succeeded in producing droplets of dysprosium that did not collapse. I had already stopped believing that it would work at all.” However, these droplets were still not suitable for proving the existence of supersolidity through empirical measurements – but they were stable, which was crucial.

The team continued to refine the process used to generate the dysprosium droplets. “In 2018, we succeeded in slowly and carefully combining the atoms into a condensate such that they remained still for the requisite measurements.” By then, time was running out, as the Stuttgart-based team was no longer the only one on the trail of supersolids. To be unambiguously considered a supersolid, a condensate must meet three criteria: a crystal structure must form, which must be embedded within a superfluid, and sound waves must propagate through the condensate in a characteristic manner. Measuring the speed of the sound waves, in particular, was a hard nut to crack, which nobody had been able to crack before. The Stuttgart-based team succeeded in doing so at the start of this year. “Ultimately, three or four droplets proved sufficient for the measurement”, says Pfau.

They immediately took their results to their colleague Prof. Hans Peter Büchler, head of the Institute of Theoretical Physics III. His job was to verify whether the experimental results actually corresponded with the theoretical expectations. “Only after extensive discussions with him was I convinced that we had actually proven the existence of supersolidity.” →

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NOTE^{PAD}



IMPROVED CONTROL OF TURBOCHARGERS

Turbochargers increase engine performance and efficiency significantly, which helps to reduce fuel consumption and pollutant emissions. A method has now been developed to make turbochargers more controllable, especially for gasoline engines, at the University of Stuttgart's Institute of Thermal Turbomachinery and Machinery Laboratory (ITSM), which is headed up by Prof. Damian Vogt. The basic idea of the Multiple Exhaust Duct with Source Adjustment (MEDUSA) control concept is to divide the turbine inlet into several sectors along the circumference and to use valves to control the inflow of the different sectors individually. This novel principle can be used to turbocharge both diesel and gasoline engines, and represents a cost-effective and mechanically robust alternative to conventional processes, particularly when it comes to downsizing gasoline engines.

14 ATOMS

In collaboration with an experimental group at the Institut d'optique in Palaiseau/France, a team at the University of Stuttgart's Institute of Theoretical Physics (ITP), which is headed up by Prof. Hans Peter Büchler), has succeeded for the first time ever in realizing a topological phase in a controlled environment in the form of a quantum simulator and in researching its special properties. The artificial system of matter under investigation consists of atoms trapped in individual traps and excited until they reach Rydberg states. Up to 14 atoms are involved in the experiment.

Photos: University of Stuttgart/ITSM, University of Stuttgart/IFKB, Christian Jogler/FSU Jena, whitehouse/stock.adobe.com

BRAKES FOR THE ENVIRONMENT

The University of Stuttgart's Institute for Manufacturing Technologies of Ceramic Components and Composites (IMTCCC) has developed a concept for a new high-performance brake disc. The brakes are particularly lightweight, have a better braking performance and are more environmentally friendly because they release fewer particulates. They are also especially attractive for use in electric vehicles. This concept involves the use of a basic aluminum rotor, whose friction surfaces are covered with a special wear-resistant ceramic coating. By means of this coating, the team has been able to prevent excess wear and tear on the aluminum alloy, thus making it possible to use this lightweight material at all. The University of Stuttgart's student racing team is currently using the new brakes in their racing cars, and plans are afoot to use the brakes in standard production cars.



MINUTE BRAIN SCAN IMPLANT

For the first time ever, a research group led by Prof. Klaus Scheffler of the Max Planck Institute for Biological Cybernetics and Prof. Jens Anders at the University of Stuttgart has developed an implant that provides researchers with high-resolution data on neuronal activity within the brain. The invention, which was presented in Nature Methods enables the combination of spatial data on brain physiology with insights into interactions between nerve cells in real time. This global first and unique innovation integrates the functionality of a magnetic resonance imaging (MRI) device on a tiny chip.

The hair-thin implant consists of a minute MRI scanner and combines the versatility of well known spatial MRI analysis with the accuracy of an implantable sensor that can measure neural events at a specific point within the brain in real time.



ANTIBIOTICS FROM THE OCEAN

Increasingly, currently available antibiotics are becoming less efficacious and more and more pathogens are developing resistance to them, so new antibiotics are urgently required. Yet, less than one percent of all known bacterial species are currently available for the search for active substances; the remaining 99 percent are considered uncultivable, so hardly any research has been done on them. A team led by Prof. Christian Jogler of Friedrich-Schiller University of Jena in collaboration with Prof. Franz Brümmer and Ralph-Walter Müller from the University of Stuttgart have now succeeded in cultivating several dozen previously neglected marine bacteria under laboratory conditions and identifying their functional characteristic thereby making them accessible for systematic drug screening. Their initial bioinformatic analyses and observations of their cellular biology indicate a potential for their use in the production of new antibiotics.

99
percent

of all known bacterial species are considered uncultivable, so hardly any research has been done on them, leaving less than one percent of the known bacterial species available for the search for urgently required new antibiotics.

Pure strains of 79 new planctomycetes were successfully cultivated from samples taken from the Mediterranean Sea, the North and Baltic Seas, the Black Sea as well as the Atlantic, Pacific and Arctic oceans.

The SECRET network encourages and promotes the mobility of doctoral students.



18 Partners
from eight European countries and Israel are collaborating in the SECRET network.

↓
15 Projects
are currently being carried out within the network.

↓
3 of these
are based at the University of Stuttgart's Institute of Cell Biology and Immunology (IZI).

NETWORK AGAINST BREAST AND COLON CANCER

TEXT: Helmine Braitmaier

The new international SECRET network for doctoral students connects cancer researchers from nine countries. The program is being coordinated by Angelika Hausser of the Institute of Cell Biology and Immunology (IZI).

Breast cancer is the most common cancer among women. Following their diagnosis, patients today usually live much longer than they did ten years ago. However, there are some major differences: women whose breast cancer cells have additional docking sites on their surfaces for the female hormones estrogen and progesterone or for a specific growth factor can now be treated with newer, more targeted drugs, which specifically block the growth signal that is transmitted from the receptors, or docking sites, via a signal chain to the tumor cells' control centers. Yet about one in five to ten breast cancer patients does not benefit from these therapeutic advancements, because the targeted drugs do not work if the tumor lacks any of the three receptors. This form is therefore known as triple negative breast cancer. Chemotherapy, which attacks all rapidly dividing cells in a non-specific way, remains the only drug treatment for these women.

18 PARTNERS FROM NINE COUNTRIES AND ONE COMMON OBJECTIVE
Young cancer researchers involved in the new research and training program SECRET, are now searching for new targets, specifically in breast cancer and colorectal cancers. Identifying suitable targets is crucial for the development of bespoke therapies that will specifically prevent cancer cells from communicating with their environment. 18 academic and industrial partners from eight European countries and Israel are collaborating in the SECRET network, which was launched in October 2019. →

“We’re networking expertise from various disciplines such as biology, medicine and mathematics.”

→ Among the participating institutions from Germany are the University of Stuttgart, the University of Freiburg, the Robert Bosch Hospital in Stuttgart and the Charité in Berlin. The network encompasses 15 projects and will receive almost four million euros in funding from the European Commission’s Marie-Sklodowska-Curie program over the next four years. Three of the projects, whose focus is on breast cancer, are based at the University of Stuttgart’s Institute of Cell Biology and Immunology.

The cancer researchers are primarily interested in secretions from cancer cells, i.e., the substances they release, which is how tumor cells communicate with their environment and other cells. This communication is of enormous importance to the abnormal cells, as it enables them to create the optimum conditions for uncontrolled proliferation and to spread to distant parts of the body. They can, for example, stimulate other cells to release growth-promoting substances, or they themselves can release substances, which then stimulate neighboring tumor cells to grow.

As network coordinator Dr. Angelika Hausser explains, normal body cells also communicate by releasing or absorbing various substances. “For example”, she says, “certain pancreatic cells receive signals that indicate that the blood sugar level has risen and then release insulin“. In another example, released signal substances stimulate immune cells to divide or lure them to the site of infection. However, in cancer cells, the secretome, i.e. the entirety of all substances released, differs from that of normal cells.

“The important thing now”, says Hausser, “is to understand which deregulated signaling pathways lead to the alteration of the secretome“. As with growth stimuli, the signal for the transportation of substances into and out of the cell is transmitted via a sequence of signaling molecules within the cell. Normally, these processes are strictly controlled. If the researchers are now able to create a kind of molecular map of all secretion signaling pathways within a cancer cell, they may also discover new ways of blocking them and thus of disrupting the communications of tumor cells. The scientists also specifically hope to identify proteins in the relevant signaling pathways of the tumor cells whose production is elevated or that are missing. These could serve as biomarkers that would indicate whether a therapy was working or could predict how aggressive the tumor is. →



Network coordinator
Dr. Angelika Hausser

**Funded by the
European Commission**

The researchers’ primary focus is on cancer cell secretions.

Photos: P. 58 private, p. 59 Dr. Cristiana Lungu/Institute of Cell Biology and Immunology/ University of Stuttgart

Profound insights

A fluorescence microscope image of tumor cells.



→ The idea of looking more closely at breast cancer cell secretions came to Hausser following a discovery made by her research group together with that of her institute colleague Prof. Monilola Olayioye. They discovered that triple-negative breast cancer cells have a particularly high number of molecules of a kinase known as PKD3, an enzyme that is an important signal transmitter for the discharge of substances. The new doctoral student network will now conduct further research into which specific substances are released and at which sites the signaling pathways in which the enzyme is involved could be blocked.

INTERDISCIPLINARY APPROACH TO NEW THERAPEUTIC STRATEGIES

Researchers in another project supervised by Hausser are looking into whether an altered extracellular breast tissue matrix transmits different commands to the breast cancer cells embedded in it, such that they are more likely to release tumor-promoting substances. For reasons as yet unknown, this meshwork of protein fibers and sugar molecules is particularly rigid around breast cancer cells. Hausser suspects that this leads to a mechanical stimulus on cancer cells, which activates signaling pathways, which in turn stimulate the tumor secretions.

Olayioye, a cancer researcher who specializes in molecular tumor cell biology, has also put out a tender for a project involving an important switching molecule in the transmission of signals, which is often miss regulated during cancer metastases. She is interested in finding out whether the overactive signaling chain causes the cancer cells to release substances that make it easier for the abnormal cells to break out of the cell complex and manipulate nearby connective tissue cells and immune cells for their own benefit.

All of these approaches are being brought together in an interdisciplinary manner within the SECRET network. “We are networking expertise from various disciplines such as biology, medicine and mathematics within this program, to develop new therapeutic strategies for breast and colorectal cancer”, says Hausser. This should not stop at national borders, so master’s graduates, for example, can only apply for network projects outside their home countries. The 15 doctoral candidates, who were selected from 300 applicants and will begin their research by March 2020, will also be expected to be highly mobile in other respects: at least two research visits with network partners, each of several months duration, are also planned, as well as various workshops and annual meetings between the network partners. “Our hope”, says Hausser, “is that by eventually sending these young people out into the wider world, they will continue to use their knowhow to make an important contribution to international cancer research”. →

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TUMOR CELLS IN CONTEXT

A holistic view:
Monilola Olayioye
is researching can-
cer as a system.



INTERVIEW: Helmine Braitmaier
PHOTOS: Günther Bayerl

Personalized therapy is raising hopes in the fight against breast cancer. Motivated by this, Monilola Olayioye of the University of Stuttgart's Institute of Cell Biology and Immunology (IZI) is researching the inner life and behavior of cancer cells. Olayioye Vice Rector for Young Researchers and Diversity is coordinator of biomedical systems a field with enormous potential.

Professor Olayioye, is any progress being made in the treatment of breast cancer?

PROF. DR. MONILOLA OLAYIOYE (MO) Certainly. New therapies have been developed based on a better understanding of the molecular processes that cause breast cancer, such as on monoclonal antibodies, for example, which are antibodies produced by a strain of cells that recognize target structures on the cells of certain breast tumors in a very specific manner, whereby the frequent occurrence of these target structures on the tumors is a prerequisite for therapy.

Breast cancer patients often have a good chance of surviving if it is detected at an early stage. Does that apply to all breast cancer patients?

MO That depends on the specific form of breast cancer a patient is suffering from. For example, patients suffering from one type of breast cancer, which is hormone receptor-positive, have a very good prognosis. They can be treated with an anti hormone therapy in addition to surgical intervention. Another form of breast cancer presents a lot of the HER2 growth factor receptor on the surface of affected cells, against which the previously mentioned blocking antibodies can be used. The so-called triple-negative breast cancer, in which both the hormone receptors and the HER2 growth factor receptor are absent or only present in small quantities, is a particularly aggressive form.

In general terms, how come normal body cells suddenly become abnormal and begin to proliferate in an uncontrolled manner?

MO Tumors develop when genetic changes accumulate within the cell over time, which affect both oncogenes, i.e., genes that promote growth, and tumor suppressing genes. Tumor suppressors slow down cellular growth. Mutations in tumor suppressors eliminate the mechanisms that control growth, repair errors or induce cell death.

Cancer cells can break away from the cell structure to form metastases in remote areas of the body. Why does that happen?

MO This stage can also be activated by genetic changes within the cancer cell. A cell's interactions with its environment, for example with connective tissue or the immune system cells, also has a major influence. On the one hand, the tumor cells manage to make themselves invisible to the immune system, but they can also reprogram immune cells in such a way as to facilitate metastasis.

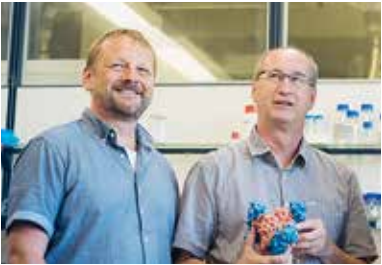
How does this interaction between cancer and immune cells work?

MO Tumor cells become particularly invasive in the presence of certain immune cells. Tumor cells release a growth factor that attracts these immune cells and reprograms them together with other factors, whereupon the immune cells release another growth factor, which in turn stimulates the tumor cells thus creating a self-reinforcing cycle that facilitates metastasis. We've mapped this circuit in our lab in three-dimensional, →



Co-working space lab: In her projects, Olayioye collaborates with other researchers at the University of Stuttgart.

“PREVENT THE GROWTH OF BREASTCANCER CELLS.”



Prof. Albert Jeltsch and Prof. Roland Kontermann (from the left)

Photo: Max Kovalenko

→ cell cultures similar to tissues in which breast cancer cells grow in conjunction with immune cells rather than in isolation. This enables us to map the situation within the body much better than is possible with conventional two-dimensional cell cultures. We have been able to elucidate a new molecular regulatory mechanism in the 3D system that further strengthens the reciprocal interactions between breast cancer cells and immune cells.

What other factors cause the progression of a cancer?

MO I’m extremely interested in cytoskeletal changes, the structure of cells, which also determines their shape. What we see is that cancer cells actively change their shape, especially during the process of metastasis. However, the cytoskeleton also influences the transmission of growth factor receptor signals, this interaction is precisely what I’m investigating in more detail with my team. As we’ve been able to demonstrate in several publications, not only does the loss of certain tumor suppressors, which regulate the cytoskeleton result in increased cell mobility, it also enhances the activity of HER growth factor receptors. We’re working closely with Dr. Angelika Hausser at our institute in relation to this.

A new project in collaboration with Prof. Albert Jeltsch of the University of Stuttgart’s Institute of Biochemistry and Technical Biochemistry (IBTB) is focusing on epigenetic changes in breast cancer. What’s that about?

MO Epigenetic changes are, usually reversible, chemical modifications in the DNA that influence which genes are turned on or off within the cell, which also creates different cell types. Epigenetic changes within cancer cells, for example, switch tumor suppressor genes off. One interesting therapeutic approach may be to reverse these epigenetic changes, thus inhibiting tumor growth. →



Modelled: The process of metastasis in breast cancer cells in three-dimensional tissue cultures.

→ **What exactly do you want to study in this project?**

MO We want to use specific fluorescent sensors developed in Prof. Jeltsch’s department to visualize epigenetic changes in living breast cancer cells. This will enable us to microscopically check whether certain tumor suppressor genes have been turned off. Conversely, we will also be able to find out whether the drugs that remove epigenetic changes from the DNA reactivate these muted tumor suppressor genes.

Getting back again the aggressive triple negative form of breast cancer, for which there are currently only a few treatment options: what targeted therapeutic approaches can you imagine for this subspecies?

MO Very often, another growth factor receptor, the HER1 or EGF receptor, is found in these tumors. By itself, simply blocking it is not enough to prevent the breast cancer cells from growing. If one signaling pathway is blocked, it often causes other compensatory signaling pathways to be turned on. But, in cell culture and in animal models, blocking two different growth factor receptors in parallel, the HER1 and HER3 receptors, inhibits triple-negative breast cancer cells. Together with Prof. Roland Kontermann from our institute, we were able to demonstrate this.

What other challenges are researchers who want to develop new breast cancer treatments facing?

MO Another difficulty is that even triple negative breast cancer can be divided into other subgroups. In fact, we will have to create a kind of molecular fingerprint of each individual tumor in future, which will be used to derive promising bespoke treatment programs. To do so, will require a holistic understanding of the modified signaling pathways in breast cancer as a system. As part of the University of Stuttgart’s Stuttgart Research Center Systems Biology (SRCSB), we are collaborating with colleagues from other faculties to develop mathematical models of the signaling pathways in cancer cells, the objective being to be able to predict the behavior of cancer cells and the efficiency of molecular treatments.

Do you think it will be possible to cure cancer in the future?

MO Due to the diversity of cancer forms, completely curing it will remain a challenge in the short term, but, by improving treatments, we will be able to ensure that it will become a chronic disease with which cancer patients can grow old. And this is where I see great potential in targeted therapeutics. →

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BRAIN ON HAND



Researchers at the University of Stuttgart have developed a novel hand-worn exoskeleton, which enables patients to move their paralyzed hands once more.

Photos: pp. 64, 65 Wolfram Scheible,
p. 65 bottom Fraunhofer IPA,
University of Stuttgart/IFF

Jonathan Eckstein (above), a biomechanics engineer and researcher in the Human-Technology Interaction department at the Institute of Industrial Manufacturing and Management (IFF), tests the finger modules of the hand-worn exoskeleton. Eckstein developed the innovative support structure in conjunction with researchers from “KONSENS NHE”, a joint project funded by the Baden-Württemberg Stiftung. In addition to the University of Stuttgart’s IFF and the Institute for Modelling and Simulation of Biomechanical Systems (IMSB), the University of Tübingen and Reutlingen University are also involved. →



→ Annette Dreher (left) a 52-year-old Computer scientist is able to reach for objects with her right hand and even use tools, which is by no means straight forward: she suffered a stroke at the age of 25, which left the right side of her body almost completely paralyzed. The new hand-worn exoskeleton was developed by the IFF and other partner institutes for people like her. The particularly lightweight support structure is made of a special plastic and comprises a central module and individual finger modules. In contrast to previous exoskeletons, this one, which was developed in Stuttgart, →

The exoskeleton is extremely lightweight: even with its motors and electronics it only weighs about **400 g**

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2018: A PATENT HAS BEEN REGISTERED FOR THE EXOSKELETON

→ gives patients a great range of movement options: they can spread their hands, move their fingers individually and receive tactile feedback. An open shell system allows patients to fit the modules individually on their own. These are then flexed and contracted by a motor. However, the final word has not yet been spoken when it comes to the control system. In the next phase of development, a combination of brain waves and eye movements will give the exoskeleton an additional means of control.

The project combines expertise in the fields of neurotechnology and mechanics, mechatronics, sensor and control technology, machine learning and 3D object recognition. →

HOLISTIC LASERS

An industrial 3D laser cutting system from Trumpf, one of the companies participating in the FastShape project.

Photo: University of Stuttgart / IFSW



TEXT: Michael Vogel

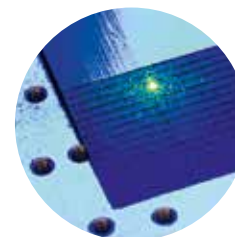
The German Research Foundation and Fraunhofer are, for the first time, funding trilateral projects for the transfer of knowledge to industry, one of which was entrusted to the University of Stuttgart.

Cutting, welding, drilling, soldering, polishing – increasingly, throughout the past decades, the laser has proved to be a real alternative to traditional material processing methods in the industrial sector. One of the reasons for this is that lasers can produce even complex geometries such as curved contours, rather than just straight edges meaning that entire assemblies, for which several individual parts had to be manufactured in the past, can now be made in a single piece.

However, despite its triumphant success, industrial laser technology is still far from being ready for every type of application, as Dr. Rudolf Weber, Head of the Process Development at the University of Stuttgart's Institute of Laser Technologies (IFSW), is also aware. "The rise of industrial laser processing began with the CO₂ laser", he says: "in retrospect, the choice of this laser was an absolute fluke". This is because CO₂ lasers use a wavelength, which in a favorable combination with several other factors, produces clean cut edges in sheet metal.

As has been shown over the past decade during which new types of material processing lasers came onto the market, this is by no means a matter of course. "These solid-state lasers", Weber explains, "use a much shorter wavelength at which the interplay between energy input, material and absorption characteristics no longer works so well. Instead, the machining parameters must be matched to one another with extreme precisions, and yet the results are often less than perfect. "When sheet metal is thicker than five millimeters, you have a problem with solid-state lasers", explains Weber. Producing weld seams of several millimeters depth in materials such as aluminum and copper, both of which are important for electro mobility, can also be problematic. Nevertheless, both industry experts and scientists are working hard to improve processing quality because solid-state lasers are significantly more efficient and cheaper than CO₂ lasers. →

Laser welding seams are only considered to be good if they do not need to be reworked. Achieving this is the aim of the FastShape project.



The use of green wavelength lasers is ideal for some metals (far right).

Carbon fiber reinforced plastic – widely used in lightweight construction (small photo).

Photos: Uli Regenscheit (left), Max Kovalenko (right)

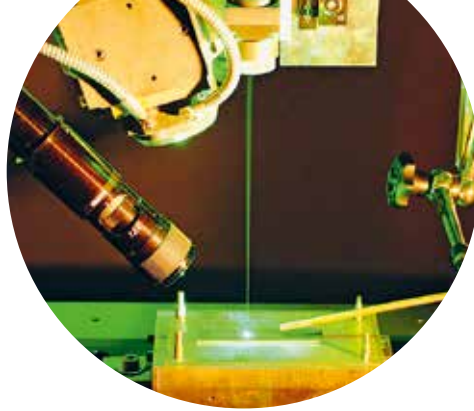
The Institute of Laser Technologies (IFSW) is able to record the processes that take place during laser tooling with an extremely high temporal and spatial resolution.

→ The FastShape project is also focused on this problem. The Fraunhofer Institute for Material and Beam Technology (IWS) in Dresden as well as Bosch and Trumpf are involved in addition to IFSW. FastShape is one of the first seven projects to benefit from a new research transfer funding scheme by the German Research Foundation (DFG) and the Fraunhofer Society. The seven trilateral projects were chosen jointly by the DFG and the Fraunhofer Society in the summer, who will fund them for three years. The objective is to convert research results into innovative applications more rapidly through collaborations between universities, companies and Fraunhofer Institutes.

“To get better results in laser processing”, Weber explains, “we need a better understanding of the complex interactions between laser radiation, material behavior and the geometry of the zone in which the light interacts with the material”. For example, if the laser beam, which is only 100 to 300 micrometers thick, remains in one place for too long, it causes problems with the processing quality. “Therefore”, Weber goes on, “the IWS has developed a method to continuously wiggle the beam back and forth a little to prevent too much local heating in the material. For our part, we at IFSW have some unique investigation technologies for, as it were, observing the laser beam in operation at high temporal and spatial resolutions”. The IFSW’s X-ray facility, for example, can capture 10,000 images of the interaction zone per second. Other measuring devices can measure changes in temperature, also depending on the geometry of the zone of interaction. →

Bottom: The high-speed X-ray system monitors laser welding processes.

Photo: Max Kovalenko



A vertical green laser beam hits a piece of copper.

Photo: University of Stuttgart/ IFSW

→ “The laser beam liquefies and partially evaporates the material”, Weber explains: The resulting complex flows are important in terms of understanding the machining quality and occur within a few hundred microseconds to milliseconds. “However, we need to be able to take measurements ten to a hundred times faster, to gain a real understanding of exactly how the individual process parameters influence the result, which is what we at IFSW want to achieve in the context of this project.” Bosch is contributing with a reference process for the laser welding of copper sheets, which is of industrial relevance, whilst Trumpf will be doing the same in respect of laser cutting. →

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Future know-how for small and medium-sized businesses

INTERVIEW: Michael Vogel

The purpose of PlanQK is to help small and medium-sized businesses to broaden their knowledge of artificial intelligence (AI) and quantum computing. Professors Stefanie Barz and Frank Leymann from the University of Stuttgart both have a significant involvement in the project.

Prof. Barz, Prof. Leymann, was the inclusion of two current buzz words – AI and quantum computing – in a single application helpful in terms of securing funding for the 19 million euro PlanQK project?

PROF. STEFANIE BARZ (SF) (laughs) Quantum computing has been developing rapidly in recent years, and AI has been an important topic for quite some time now.

PROF. FRANK LEYMANN (FL) In fact, we originally wanted to set up a project on quantum computing, but the German Federal Ministry for Economic Affairs and Energy, which is funding the project, wanted to link that topic to artificial intelligence. And it's a perfect fit.

Where do we currently stand with AI?

FL A lot has been happening; it is, after all, quite an old field of research in computer science. Processes, such as Deep Learning, are currently being used in computer applications. Large companies have expanded their AI skills, but smaller businesses often don't have anyone who knows anything about the subject.

And what about quantum computing?

SB Google recently demonstrated a new quantum processor for the first time which can solve special problems faster than traditional processors. Whilst this is an important research milestone, it doesn't mean that quantum computers can already be used to solve practical problems.

So why should businesses worry about this topic now?

FL The technology is developing much faster than anticipated. There are some areas in the field of AI that require a doubling of computing power every three and a half months. In the longer term, this will no longer be possible with traditional computers, but it is possible with quantum computers.

How might PlanQK be able to help with this?

FL The primary purpose of PlanQK is to offer small and medium-sized businesses the opportunity to learn more about quantum computing. IT professionals in particular, who currently have no experience of it at all should be able to familiarize themselves with it thanks to PlanQK. To this end, we are creating a platform through which we will make the relevant knowledge available.



Prof. Stefanie Barz heads up the Quantum Information and Technology Department at the Institute of Functional Matter and Quantum Technologies (FMQ).

Photo: Uli Regenscheit

Prof. Frank Leymann heads up the Institute of Architecture of Application Systems (IAAS) and worked for the IBM Software Group for 20 years.

Photo: private

SB First, we'll collate and standardize various quantum algorithms from scientific publications. The next step will be to present these in a standardized way. We quantum physicists involved in the project will then evaluate these algorithms with respect to their suitability for specific applications, especially in the field of machine learning.

FL We'll present the suitable algorithms on the platform in a format that computer scientists refer to as a pattern language. The algorithms will be implemented on quantum computers. Any platform user will then easily be able to find a solution to their current problem.

However, due to their more limited resources, small and medium-sized businesses become overstrained by these issues relatively quickly.

FL PlanQK users will not need to view any quantum algorithms, because many algorithms are implemented as normal programs, in a familiar programming language. To make this work, we will further develop a technology that was originally developed in Stuttgart to enable the software to run automatically on the quantum computer.

So users won't have to have any specific knowledge?

FL Not unless a user finds an algorithm that has not yet been implemented, they would have to play an active role themselves or else commission one of the consulting firms involved in the project.

PlanQK is supported by a consortium of companies and research institutions. Why?

FL The Ministry has funded a pre-project phase to put together a consortium and many participants presented their use cases and interests in various workshops. The consortium now covers the entire spectrum: Algorithm developers, quantum computer programmers, users and consultants.

How many quantum computers do you have access to?

SB PlanQK is independent of the actual quantum computer architecture: we'll be working with a number of different systems and will, for example, have access to IBM's system. We also want to use D-Wave's quantum annealer.

Is it certain that AI algorithms run faster on quantum computers?

SB There are several quantum algorithms that are known to be faster, particularly for optimization problems or for solving linear equation systems. But it always depends on the specific task at hand: general statements are problematic.

What is the intended deliverable or product at the end of the project in three years?

FL A public platform. The applications will be available as open source software. But we also have an industrial partner on board who wants to offer a commercial version of the platform. And the companies in the consortium were required to formulate a business case, according to the specifications of the Federal Ministry for Economic Affairs and Energy, to show how they plan to earn money in the future from any knowledge they acquire in the course of the project.

Can others still take part in the project?

SB Gladly, but we already have 15 partners in the consortium and over 40 other associated partners who want to participate in the workshops and conferences at their own expense. Any further participation can only be as an associated partner, because the consortium partners were included in the project proposal.

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LET

US

TEXT: Jens Eber

Several hundred students have already taken part in the "Let US start! Startup program. This forward-looking University of Stuttgart project familiarizes them with the methods and conceptual frameworks for entrepreneurial activities.

START!



Graduates of the “Let US start!” program can be trained as coaches and provide support for their successors as they take their first steps during the startup phase.

In the beginning is the concept: whether it works is not so important – making mistakes is part of it
Teamwork: participants also learn about agile project management and team leadership.



Intelligent parking space management: One of the Let-US-start! Projects is known as “Carlotta”

Photos: p. 73 Tomasso/unsplash, Andreas Dalferth, p. 74 University of Stuttgart, Shutterstock, Getty Images/EyeEm



Several deckchairs bearing the university logo are grouped around a cube-shaped table in a room in the former university bookshop on the Vaihingen campus. The walls are ablaze with colorful sheets of paper full of ideas and sketches. Dirk Sahlmer was one of the 30 or so participants who worked on their startup concept ideas there during the 2018 winter semester, which marked the launch of the “Let US start!” program. “I’ve known for a long time that I wanted to do something of my own”, says the 29-year-old master’s student of electro mobility, “but I lacked the basic know-how: how to validate an idea, how to put a team together, and how to find customers.” He was unable to answer these questions. Dr. Eric Heintze himself, a physicist and project manager of the “Let US start!” program, founded a startup in the field of artificial intelligence. In his view, the “Let US start!” program fills the gap he and other entrepreneurs had been all too aware of. “Whether the specific idea works is not so important”, he says: “it’s better for the students to make their mistakes in a protected environment”. The most important factors for participation in the program – as well as for founding a startup – are passion and motivation.

GENERATING A STARTUP FEVER

Participants acquire their know-how in such things as the intensive six-week AWAKE course, in which they draw up business plans, interview customers and present their visions to potential investors. “We know that the students have full schedules”, says Heintze. Which is why the approximately 30 attendance hours are scheduled for the evenings or Saturdays. How much time the teams put into it beyond that is up to them. Experience has shown that a kind of startup fever can be generated within the clearly defined framework of the “Let US start! program. Participating in the program also earns the students three credit points towards their degrees. The other elements of the program are not timed quite as strictly: Prospective entrepreneurs can attend workshops and develop ideas in the ACTIVATE course. Under the keyword ASK, established entrepreneurs talk about their own careers in a relaxed setting. “The biggest hurdle is reaching customers”, says Merve Emir, who took part in the “Let US start!” program in the 2019 summer semester. The process engineering master student and her team developed an existing product further: they worked on the business plan and project management plan for “SIMsalabim”, a simulation environment for autonomous driving systems, which had previously been developed by the “Driverless Greenteam”, a Formula Student racing team at the University of Stuttgart. Emir found the “Let US start!” program an intense experience that demanded a lot from her in addition to her studies and research and development job with a large corporation. “I learned a lot about time management”, says the 25-year-old with a laugh.

ESTABLISHING PRODUCTIVE NETWORKS

The “Let US start!’ program has helped me to clarify and expedite my plans for the future”, says Dirk Sahlmer, who, together with his team, worked on “Carlotta”, an intelligent parking management system. The software is now in operation in prototype form, but the market launch is not part of the “Let US start! program. “We want to convey a desire to found a startup and support the participants through the initial steps”, says Heintze. But even though not all of them wanted to get into the startup scene afterwards, he goes on, they all gained some important experience. “We teach them team leadership skills as well as about consistent, agile project management and innovative thinking”, Heintze continues. Participants could, he adds, just as easily benefit at a later date from the methods they have learned in relation to thinking through and planning complex projects, whether in the corporate sphere or in science.

The “Let US start!” program has met with a positive response, both from entrepreneurs and the University. Beginning with just 30 participants, the AWAKE course now caters to over 200, and about twice as many take part in the associated ACTIVATE workshops. “What I found is that the startup scene is a good target for me to set my sights on” says Merve Emir. Although her father had once founded a company, she only discovered her own ultimate passion for the adventure of self-employment through the “Let US start!” program, in the course of which she also established a productive network: “Before the program, I had known practically no one outside of research”, she says: “now I can reach someone for help with every question”. Eric Heintze believes that the University of Stuttgart has come a good deal closer to its goal of establishing a vital startup culture. “We’ve only just drilled a well.” Who knows how many success stories might bubble up to its surface? →

NANOBOTS FOR MEDICINE

TEXT: Michael Vogel
PHOTOS: Sven Cichowicz

Ambitious: Qiu studied mechanical engineering in Beijing before specializing in biomedical technologies.

The Chinese Tian Qiu heads up the new “Biomedical Microsystems” research group, which forms part of Cyber Valley, one of the largest research collaborations on artificial intelligence.

Dr. Tian Qiu doesn't like to talk about himself, but he does like talking about his research. He is hoping to develop new systems for biomedicine, systems so small that they could, for example, transport active ingredients directly to the right place within the body or transmit images from there. The success of such systems will be the clever combination of artificial intelligence (AI) and robotics. The 32-year-old scientist has been head of the newly founded “Biomedical Microsystems” since July 2019, a Cyber Valley research group based at the University of Stuttgart's Institute of Physical Chemistry. Its objectives fit perfectly within the Cyber Valley, one of the largest European AI research collaborations between business and science. The Cyber Valley is spread between Stuttgart and Tübingen.

The fact that Qiu was selected for the position almost seems like the logical next step in a scientific career marked by talent and determination. “There were no major gaps”, Qiu confirms dryly. At the age of 18 he was among the best in the highly selective entrance test for Tsinghua University in Beijing, China's leading technical university, where he studied mechanical engineering and graduated with a bachelor's degree. He first came into contact with biomedical technologies during his master's studies and was fascinated by so-called labs-on-a-chip, i.e., highly miniaturized systems with which proteins, cells and viruses can be analyzed automatically, which shortens the duration of biomedical tests and laboratory analyses dramatically. Qiu experimented with such a lab-on-a-chip, through whose microchannels sperm cells migrated, for his master's thesis. The autonomous movement of sperm also plays a role in his current research, but this time in miniscule robots.

FROM BEIJING TO STUTTGART

After completing his studies, Qiu, then 25, turned his attentions to Europe. “I'm an engineer”, he says, “and key processes to make biomedical micro- and nano systems a reality have been developed here in Europe”. He knew that Prof. Peer Fischer's group at the Max Planck Institute for Intelligent Systems in Stuttgart was researching nanorobots, so he emailed Fischer, who is also professor of physical chemistry at the University of Stuttgart, to ask if he could possibly do his doctoral studies in this field of research. One Skype interview later and Qiu had Fischer's approval. Having completed his doctorate in the spring of 2016, the young scientist joined Fischer's team as a postdoc.

He has already succeeded in piloting a nanobot through the vitreous body of a pig's eye, which was no easy task, as the corkscrew-like midget consisting of a biocompatible material had to be small enough to fit through the pores of the gel-like vitreous body but also large enough to prevent its progress from being hindered by the thermal movement of the molecules. The ideal dimension was found to be 500 millionths of a millimeter. “The nanobot completed the journey through the vitreous →



Dr. Tian Qiu

“Cyber Valley has a strong interdisciplinary focus and brings science and business into direct contact.”



**Precision engineering:
wireless ultrasound
actuators for a miniature
endoscope.**

A robot just 500 millionth of a millimeter long

**Tian Qiu has already succeeded in
piloting a nanobot through the
vitreous body of a pig's eye within
just 30 minutes.**

→ body within 30 minutes”, says Qiu. If it had been just a fraction smaller, it would have taken several days for the same journey. Qiu is currently planning to optimize systems such as this one to make them capable, for example, of transporting an active ingredient to a specific location within the body where it can then be biologically metabolized.

PHANTOMS FOR THE OP

Surgical training systems are another focus of Qiu's research. “At first glance, nanobots and surgical training systems appear to have nothing to do with one another”, he says: “But you need the most realistic environments possible if you want to test nanobots.” These are not available: tests on animal organs are laborious and the results are only partially transferable to humans, which is why Qiu and his team are also developing replicas of human organs. In itself, this is nothing new; such so-called phantoms, albeit of a poor quality, have been around for a long time. Qiu and his team recently presented a novel prostate phantom, which they had evaluated by doctors at the University Medical Center Freiburg. Their verdict: when a surgeon performs an endoscopic operation on this phantom, it feels almost the same as a human prostate. And what's more, surgeons can see from the phantom how well the operation went, which, currently, is not immediately clear, whether for training phantoms or for patients. “With our phantoms, we want to significantly improve training and surgery planning”, says Qiu, not just for the prostate, but for other organs as well. AI is an important aspect of this: Qiu can use the data obtained from the phantoms to train algorithms to optimize the surgical procedure and instruments. Ideally, it will even be possible to train a robot in future to perform these operations with the same quality every time →

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Internationally stronger

TEXT: Jens Eber

How can porous material be sealed so thoroughly that really nothing can get through? Together, researchers from Stuttgart and the USA are pursuing a promising approach: practical internationalization.

INTERNATIONALIZATION: AN EXAMPLE

The most impermeable rock possible is needed in many technical applications: concrete walls are meant to retain liquids, dikes are built from sand and larger rocks and stones, sandstone formations could help with sequestration of CO₂. However, one of the properties of stone, whether produced by artificial or natural means, is a certain degree of porosity, i.e., it is at least partially permeable to liquids and gasses.

An innocuous bacterium now represents a potential solution for sealing porous rock. *Sporosarcina pasteurii* forms large quantities of enzymes that are able to break down urea. It occurs naturally in soil where it is completely inconspicuous. However, if the bacterium comes into contact with large volumes of urea and calcium, it precipitates calcium carbonate, forming a solid mineral from the soft biomass of the bacteria.

Researchers at the University of Stuttgart’s Collaborative Research Center 1313 (Interface-Driven Multi-Field Processes in Porous Media – Flow, Transport and Deformation) want to exploit this phenomenon in an international project. Their idea is to introduce bacteria and reactive substances into rock such that the calcium carbonate precipitate seals the pores. Scientists from the Institute for Modelling Hydraulic and Environmental Systems (IWS) in Stuttgart and the Montana State University (MSU) in Bozeman, Montana, in the USA, are collaborating in the project. The teams complement one another through their different areas of expertise. “Our strength”, apl. Prof. Holger Class, Deputy Head of the Department of Hydromechanics and Modeling of Hydrosystems at the IWS, “lies in modeling, whilst our colleagues in Montana specialize in experimentation”.

Dr. Adrienne Phillips from the Center for Biofilm Engineering at the MSU confirms this: “The Stuttgart-based team is using our results to calibrate their models”, she says: “We then use their models to predict experimental results.” In this way, international collaboration is also contributing to the more effective planning of expensive and complex field trials.

What specific challenges are involved? According to Class, all of the processes involved in this project are actually relatively simple and have already been researched. “The difficulty”, Johannes Hommel adds: “is that they are coupled with complex fluid mechanics. Reactants can only react to form calcium carbonate at the location to which they are transported”. However, the area of the pore space and therefore the flow changes as soon as the calcium carbonate is precipitated. So, to seal a rock reliably, the reactions must be stimulated in a uniform manner across the desired area. The interactions that take place within the pore are “not trivial, and we want to understand them better” says Hommel. The researchers are also collaborating closely with the Porous Media Lab at the University of Stuttgart’s Institute of Applied Mechanics (Civil Engineering) (MIB). ➔



Researchers from the University of Stuttgart at a workshop on biofilms at Montana State University.



Prof. Rainer Helmig
Spokesman for the Collaborative Research Center 1313.

“Internationalization has resulted in a forward leap in research quality.”

INTERNATIONALIZATION THE STRATEGY

As an “intelligent system”, one of the University of Stuttgart’s strategic objectives is to be “internationally networked”. Together with Prof. Andrea Barth and Beatrix Becker Prof. Rainer Helmig has been working on the key “intelligent system” element within the framework of the excellence strategy.

➔ **Prof. Helmig, what is the significance of internationalization in science?**
PROF. RAINER HELMIG I am firmly convinced that internationalization has resulted in a forward leap in research quality. Researchers are given the opportunity to prove themselves in an international environment and also to learn to be tolerant of other cultures and approaches. This is of great scientific and socio-political importance. From my perspective, nothing can be achieved without internationalization.

Does internationalization also result in scientific added value?

RH Yes, because one gets to see other approaches. To give you just one example: all Collaborative Research Center 1313 employees are required to spend three months abroad, which provides them with different insights into the same topic. This benefits the researchers themselves, but also our research group. Experience has shown that such exchanges produce good results.

How does this manifest itself specifically in the field of biofilm research?

RH Our primary experience in Stuttgart is in the development of numerical concepts and models. We also need world-class experimental scientists to calibrate our methods in every detail. Our colleagues in Montana are just such partners. This has been in development for the past 25 years. We want to support this in future through exchange opportunities for young bachelor and master students.

How will internationalization be further developed?

RH Universities need strategic partners today. As teams drawn from the sciences and administration, they have to communicate with one another, carry out research and generate projects together. Universities with similar focuses can benefit enormously from one another. We cannot provide scientific solutions to such issues as the environment or water quality in Germany alone; we need to take a global approach. In this way, young people can develop their own networks and knowledge. We university lecturers should also go abroad, so that we can conduct research with our local colleagues. This is an extreme added value in terms of information exchanges and knowledge gains. ➔

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Photos: p. 80 University of Stuttgart,
p. 81 Uli Regenscheit



DR. TAREK ZAKI

THE INTERNET OF EVERYTHING

Actually, as Tarek Zaki remembers, he wanted to stay for a few years at most. “I’ve now been here for over ten years”, says the 32-year-old electrical engineer. “Here” in this context refers primarily to Stuttgart and its university. He has been living and working as a project manager at Bosch Sensortec, electronics company in nearby Reutlingen since 2016.

The journey from Egypt, his home country, to Germany began with a stay at the University of Stuttgart for his bachelor’s degree project. After that he enjoyed the University’s international INFOTECH masters program so much that he stayed on. There he had already met Prof. Joachim Burghartz, who heads up the Institute for Microelectronics Stuttgart (IMS CHIPS) as well as the University of Stuttgart’s Institute of Nano and Microelectronic Systems (INES). Burghartz became his mentor and doctoral supervisor. “That time holds a special place in my memory”, says Zaki. “Prof. Burghartz was one of the most important mentors of my life, not only academically, but also in terms of my own personal development.”

Zaki’s focus is on flexible and organic electronics, a field in which he has received awards and achieved outstanding results. For example, he was involved in a project, whose object was to develop the world’s fastest and smallest circuits from organic materials. The subject has always fascinated him: “I was looking for something that would be at the cutting edge of innovation and benefit humanity at the same time.” Flexible electronics is a technology that makes it possible to coat a wide variety of objects, such as glass, packaging or paper, with novel, electrically conductive materials. Solar cells, for example, could in future be mounted on window panes both invisibly and in a space-saving manner. “The applications are endless”, say Zaki enthusiastically. “Electronics are everywhere, from smartphones to medical engineering. It’s not for nothing that we’re already talking about the Internet of Everything.” ➔

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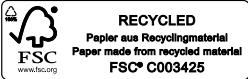
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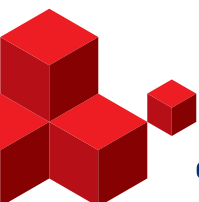
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