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The Research Magazine of the University of Potsdam

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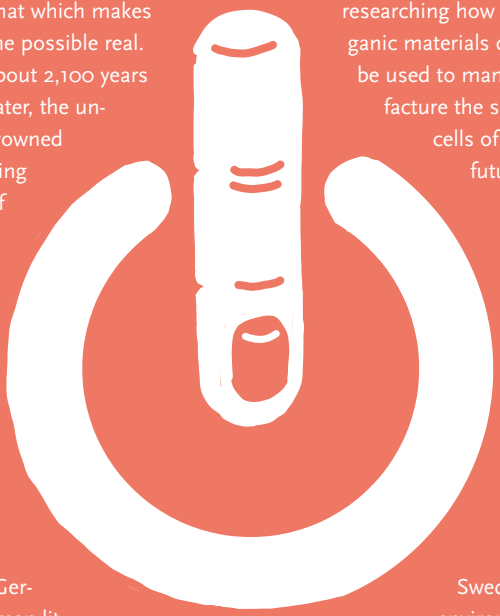
ENERGY

Energy – there is something to it. There is, of course, the matter-of-fact definition in every student encyclopedia: "the capacity to do mechanical work, transfer heat, or emit light." In this way, energy accompanies us, often undetected, all day long: getting out of bed, turning on the heat, switching on the lights, taking a hot shower, getting dressed, making coffee, having breakfast – before we have even left the house, we have already released, transformed, applied, and refueled a lot of energy. And we haven't even worked, at least not in the traditional sense.

But energy is not just a physical quantity that, due to its omnipresence, plays a key role in every natural science discipline, such as biology and chemistry, but also in almost every technical field. It is also indispensable when it comes to how we understand and describe our world and our activities – and it has been for a long time. How about an example? The Greek philosopher Aristotle was the first to speak of enérgeia, for him a rather nonphysical thing, a living "reality and effectiveness " – that which makes the possible real. About 2,100 years later, the uncrowned king of German literature Johann Wolfgang von Goethe declared it to be a humanistic essence. "What can we call our own if not energy, strength, and will!" And for his contemporary Wilhelm von Humboldt, energy "was the human's first and only virtue". Although physics began to dominate the concept of energy when it became the leading science in the 19th century, energy remained significant in many areas.



Reason enough for us to take a look at energy-related matters at the University of Potsdam. We found them in a wide range of disciplines: While Iranian physicist Safa Shoaee is researching how organic materials can be used to manufacture the solar cells of the future, Swedish environmental researcher Johan Lilliestam is focusing on the different dimensions of the energy transition to learn what makes it successful. Slavicist Susanne Strätling, on the other hand, crosses the boundaries of her discipline as she examines a complex conceptual history and tries to find out why energy electrifies us today more than ever. And physicist Markus Gühr is able to use ultrashort flashes of light to investigate how molecules change under its influence and convert energy in the process.

Of course, we have enough energy to highlight the diversity of research at the University of Potsdam besides the feature topic of this issue. A cognitive researcher, for example, explains why our brain processes both music and language according to its own respective rhythm, while an environmental researcher presents a method that uses particles from outer space to measure soil moisture. Educational researchers have also launched a study on hate speech in schools and we introduce a palaeoclimatologist who is one of twelve researchers in the new postdoc program at the University of Potsdam. We have spared no energy!

MATTHIAS ZIMMERMANN
EDITORIAL TEAM OF
PORTAL WISSEN

Illustration: Töpfer, Andreas

Illustration: Töpfer, Andreas

„ENERGY CONCERNS US ALL“

ENVIRONMENTAL SCIENTIST JOHAN LILLIESTAM IS CONFIDENT: A COMPLETE TURNAROUND IN THE ENERGY SECTOR WILL COME

The world is hungry! In some 20 years from now, it will devour a third more energy than five years ago. And there is no end in sight. At the same time, climate change is no longer a bleak scenario in scientific models, but has become a painful reality. If at all, this trend can only be stopped if we succeed in overcoming our dependency on fossil fuels. A complete shift towards renewable energy is required, as fast as possible. But how can it be done, what are suitable technologies and political means? This is the type of energy policy issue Johan Lilliestam is researching. He knows: The transition is well underway. What is crucial now is to speed up its progress.

"Energy concerns us all," Lilliestam says. "It is the backbone of our modern society and touches on all aspects of life. So we all have to work together to solve our energy problems." First and foremost, it is the responsibility of politicians, as a secure energy supply is the lifeline of the economy and thus a genuine political issue. Besides, the global energy industry has itself developed into a branch generating hundreds of billions in revenues every year. Those who control the energy supply, or the resources for it, have the upper hand and control entire countries, Lilliestam underlines. Traditionally, the oil and gas producing countries have had this role. But with the energy transition picking up pace, the balance of power begins to change. "Renewable energy – sun, wind, water – is accessible to everyone, although to different degrees. Therefore, the distribution of power is shifting in favor of countries developing the necessary technologies."

Making a contribution as an environmental scientist

However, an energy revolution that will have an impact on the climate can be completed through joint efforts only. Lilliestam researches how this can be done. Since 2019, he has been heading the "Energy Transition Dynamics" group at the Institute for Advanced Sustainability Studies (IASS) in Potsdam and also been Professor of Energy Policy at the University of Potsdam. But there was no telling he would end up doing this when he took his first steps, literally "on the other side": "At the beginning, I wanted to work in the field of nuclear energy," he says with a laugh. "But in the course of my physics studies I changed my mind. In 2002, my seminar group visited a nuclear power station. We were given a tour, and everything was presented to us as clean and emission-free. When I asked what the chimney was for, they said: 'Well, to release radioactive gases. But only at night, no problem.' Then I thought: This technology does not make sense."

Lilliestam changed majors and began studying environmental sciences at Göteborg. "This is my way of making a small contribution." Afterwards, he went to Germany where he obtained his master in environmental management at Freie Universität Berlin. "I wanted to have the chance to apply solutions," he says. In 2007, he took up research at the Potsdam Institute for Climate Impact Research (PIK), and in 2013 he earned his PhD at the Central European University in Budapest, "an inspiring place where people from the East and the West were coming together at the time." The topic of his PhD thesis was the inevitable link between politics, the economy, and science in the energy sector – using the example of solar thermal energy plants. Back then, they were competing with photovoltaics, which had not reached maturity yet, for the status of best technology for the use of solar energy. As they are most efficient in sunny regions, they also became known as Desertec. Lilliestam researched the potential challenges and risks of large-scale power imports produced by solar thermal energy plants to be built in Northern Africa for the European electricity market. What if terrorists destroyed such a power station or the respective power lines – would the European power system collapse? And would a Europe overly dependent on electricity imports become vulnerable to blackmailing? "I was able to demonstrate that such electricity imports involve few risks – provided they are not excessive. Energy supply needs to be structured in such a way that a part of it may collapse at any time without serious consequences."

But technology development took a different course. With solar cells becoming better and cheaper, solar thermal energy plants were cast aside. "The conclusion: There is no room for two solar technologies, apparently," Lilliestam says, "especially not in the minds of policy-makers."

THE RESEARCHER

Prof. Dr. Johan Lilliestam studied environmental sciences in Goteborg, and environmental management at Freie Universität Berlin. Since April 2019, he has been heading the "Energy Transition Dynamics" group at the Institute for Advanced Sustainability Studies (IASS) in Potsdam and held the Chair of Energy Policy at the University of Potsdam.

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THE PROJECTS

The transition to a renewable electricity system and its interactions with other policy aims (TRIPOD)
Duration: 08/2017–07/2022

The Sustainable Energy Transition Lab (SENTINEL)
Duration: 06/2019–05/2022
Interactive map "Possibility for Electricity Autarky": https://timtroendle.github.io/possibility-forelectricity-autarky-map/

Market Uptake of Solar Thermal Electricity through Cooperation (MUSTEC)
Duration: 10/2017 – 09/2020

Photo: Hopfgarten, Tobias

His current project TRIPOD, which is funded by the European Union, focuses exactly on this competition between political objectives and discourses. More concretely, it looks into "the transition to a renewable electricity system and its interactions with other policy aims". The spotlight is on the European states. Usually, their initial conditions, possibilities, and strategies in energy policy differ considerably. Besides, politics in Europe is caught between two stools: there is the national level, and there is the European Commission in Brussels. The Commission has decided that carbon emissions in the energy sector need to be cut by 93 to 99 percent by the year 2050. And it has more ambitious goals, such as raising energy efficiency and reducing demand. Besides, it plans to liberalize the market – with free competition for renewable energies – while at the same time Europeanizing energy policy, power grids, and the market. Lilliestam and his team hope to find out how these various political targets influence each other, what conflicts there are, how they could be solved – and how all this impacts the central goal: a complete transition in the energy sector.

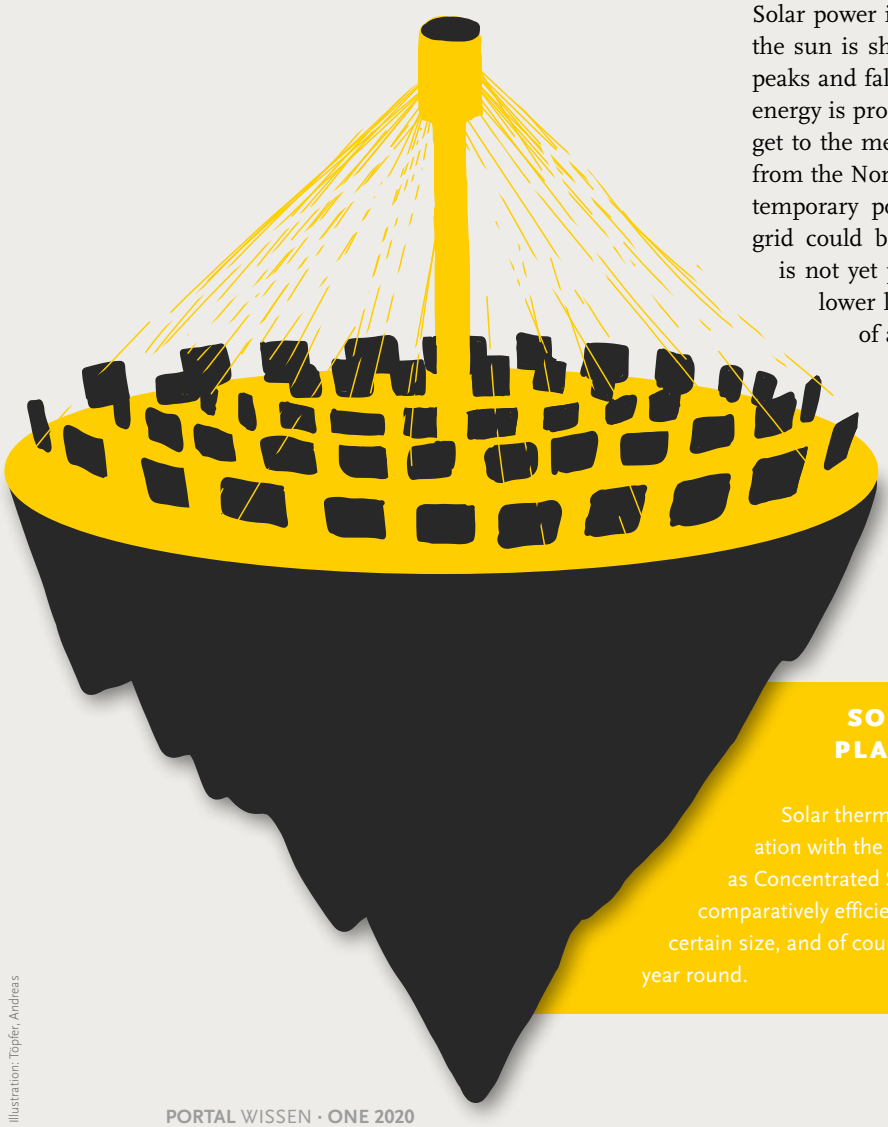


Illustration: Töpfer, Andreas

The technology for the energy revolution is ready

"These days, many experts – such as physicists, climate researchers, and geoscientists – speak about the energy transition and how climate change will get worse if we don't act," Lilliestam says. "From a technological point of view I would say: The transition is making good progress." There is no denying that, globally, emissions are still on the rise. But two crucial things have changed: Many technologies for the generation of renewable energy have improved over time and now involve lower costs. And the share of investments in renewables is going up everywhere. "Today, 95 percent of all investments in power generation in Europe go to renewables. Globally, their share still amounts to 70 percent," Lilliestam explains. "Renewable energies have become so affordable that they virtually blow up the existing system. With investments in old structures coming close to ceasing, the system will tip for economic reasons."

So the technology for the energy revolution is ready, but there are also some obstacles. First and foremost, the infrastructure and the market have not yet been adapted to the mechanisms of renewables. Solar power is available only during the day or while the sun is shining brightly, whereas energy demand peaks and falls in line with certain rush hours. Wind energy is produced in windy regions – but how can it get to the metropolitan areas hungry for electricity – from the North Sea to Bavaria, for instance? Efficient temporary power storage and an expansion of the grid could be the solutions. Furthermore, the grid is not yet prepared for the trading of electricity at lower levels – from the solar plant on the roof of a single-family home to the local grid, or even the neighbor. The mechanisms of the power market are another big obstacle: As electricity from renewables is available at certain times only, but then in abundance, its price would fluctuate on the free market at inefficiently high levels. Here, politics would have to jump in. "In this respect, politicians have to

SOLAR THERMAL ENERGY PLANTS / CSP-SYSTEMS

Solar thermal energy plants concentrate solar radiation with the help of mirrors. They are best known as Concentrated Solar Power, or CSP, systems and are comparatively efficient and profitable – provided they have a certain size, and of course only where there is a lot of sunshine all year round.

Prof. Johan Lilliestam

initiate a major transformation that will require a lot of political stamina."

Lack of political will

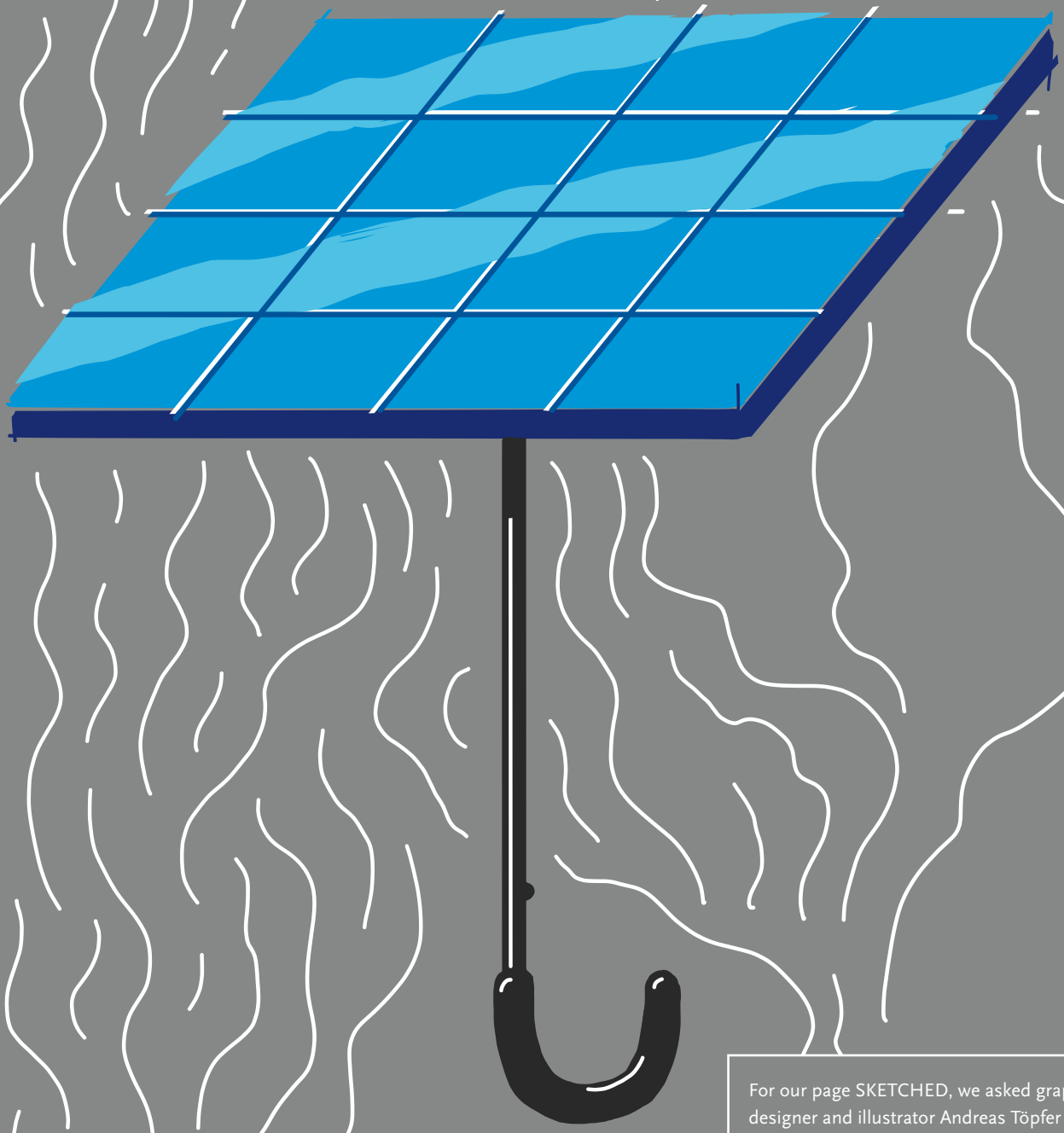
However, this is exactly where the problem starts. "There is a lack of understanding of how radical the target of the Paris Agreement actually is – and what needs to be done to attain it." For instance, carbon emissions have to drop by 100 percent to zero. "The EU has understood this, but not Germany. Here, there is still the opinion that a reduction of 80 to 90 percent would be enough – which would allow gas power stations to continue to operate."

As yet, only a few players focus on 100 percent renewable energy. In June 2019, Lilliestam and his team joined the "Sustainable Energy Transition Lab" (SENTINEL) which has set itself the task of providing political institutions and players with the necessary information and models to make the right decisions for the successful transition in energy policy. In SENTINEL, teams of researchers from the IASS and other institutions combine their efforts to develop and present models which capture the technological, geographic, societal, and political details that may be important for the transition. "The main point is that energy models are designed which are tailored to renewable energy systems, rather than adapting existing models to integrate the rising share of renewables in fossil-based systems." Their models as well as the data they are based on will be made available on an online platform. An interactive map of Europe has already been published where one can find out – down to the district level – where renewable electricity autarky would be possible. Potsdam, according to this map, is in fact likely to reach autarky, whereas Berlin – like most other big European cities – is not.

In any case, despite his focus on the European energy market, Liliestam still has a soft spot for photovoltaics and the CSP technology. In another project, he is developing very concrete ideas and proposals for politicians to help "concentrated solar thermal electricity" (MUSTEC) find its way to Europe in the end. After all, it might fill a supply gap: While photovoltaics "sleeps" at night, energy absorbed during the day by a CSP system could be fed into the grid.

MATTHIAS ZIMMERMANN
TRANSLATION: MONIKA WILKE

Photos: Hopfgarten, Tobias (2)



For our page SKETCHED, we asked graphic designer and illustrator Andreas Töpfer to interpret one of the research topics graphically. For this issue, he illustrated the the research on energy in various fields of science (pages 4–8 and 14–19). He also created the illustrations for several texts of this issue.

Illustration: Töpfer, Andreas

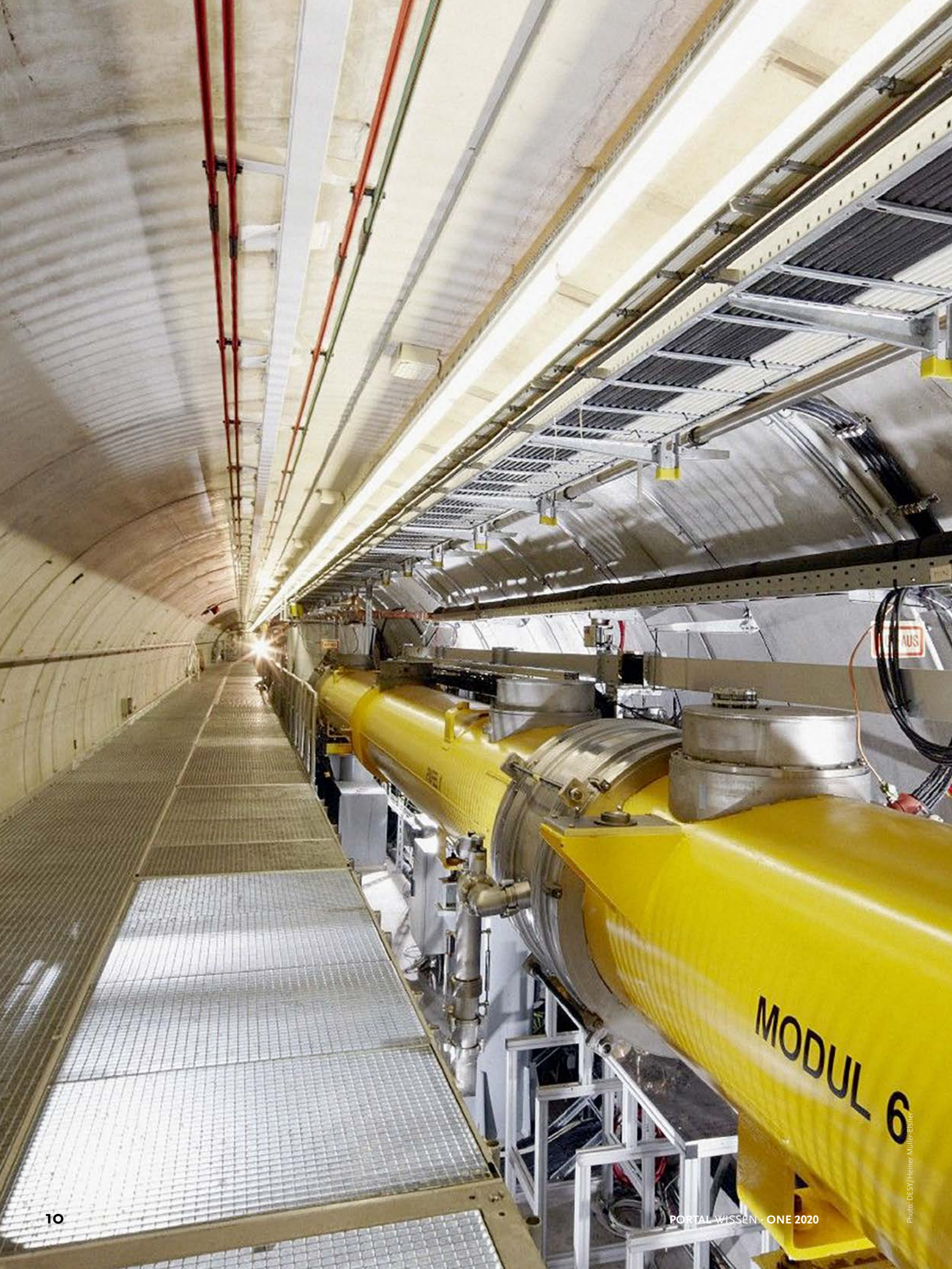


Photo: DESY/Heiner Müller-Elsner

View into the free electron laser at DESY, the German Electron Synchroton in Hamburg

Photo: Horn-Conrad, Antje

SNAPSHOTS FROM THE NANO COSMOS

How Markus Gühr uses flashes of light to probe the dynamics of molecules

Perhaps it was a sign: Markus Gühr grew up in Gießen. As a boy he used to play in the town's old cemetery, very close to the place where Wilhelm Conrad Röntgen was buried. That Gühr is a physicist himself and experiments with X-rays today makes him smile. A mere coincidence?

Anyone entering his laboratory at the Golm Institute of Physics must wear safety glasses – with light protection because here they use flash. Gühr examines how molecules change under the influence of light and in doing so converts energy. A process that often takes place in nature, for example during photosynthesis or when the sun warms our skin. The fact that the intense ultraviolet radiation does not damage our DNA is due to the special properties of the four nucleic bases of the double helix. They seem to have a protective mechanism that enables them to convert dangerous UV light into harmless heat. But how does it happen? And how can you observe such an energy conversion in real time? When photoexcited electrons interact with the core structure of molecules, it takes only femtoseconds, each one a mere millionth of a

THE RESEARCHER

Prof. Dr. Markus Gühr studied and earned his doctorate in physics at the Freie Universität Berlin. He was a researcher at SLAC National Accelerator Laboratory in Stanford before he came to the University of Potsdam as a Lichtenberg Professor.

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billionth of a second. Hardly much of a time window. And yet Gühr manages to get an insight into these extremely fast processes.

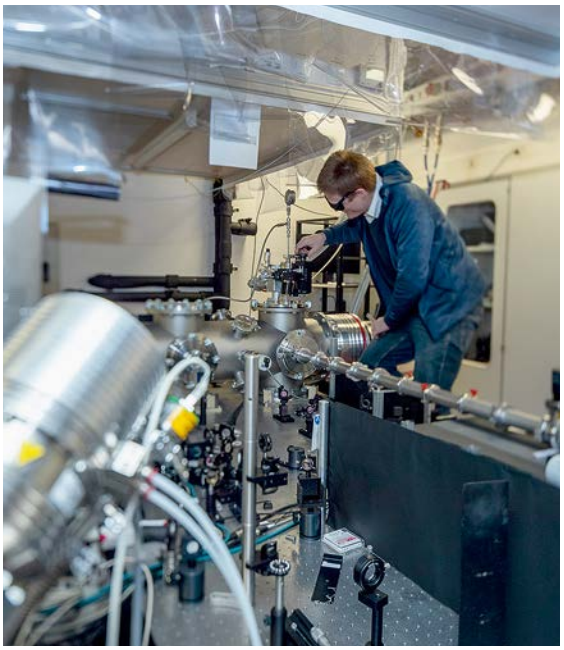
The experimental set-up in his laboratory in Golm does not initially reveal much: vacuum equipment, optical devices, and computers, all connected by a labyrinth of cables with building blocks and tools in between. There is, however, method to the madness. Here, Gühr's research group conducts experiments with ultrafast lasers that generate pulses within femtoseconds. The Potsdam quantum physicists are considered to be pioneers in using extreme ultraviolet light pulses which they flash at the molecules in a vacuum to literally shed light on their behavior.

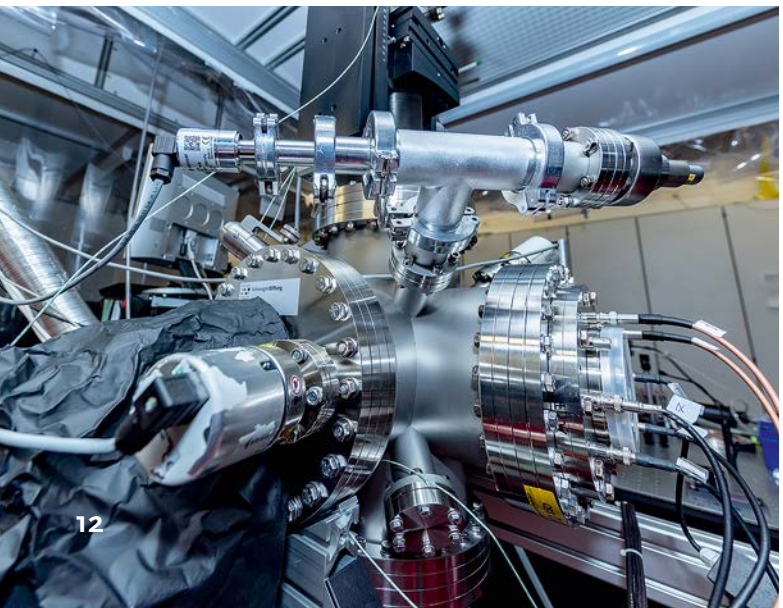
A movie about molecular processes

They also use ultrafast X-ray pulses in their research. Soft X-rays have a specific effect on the electrons of certain elements and are therefore particularly suited to tracking the movement of electrons in molecules. Such experiments, however, are not yet possible in Potsdam but only with the free electron laser at DESY, the German Electron Synchrotron in Hamburg. The aptly named facility "FLASH" generates extremely intense X-ray laser flashes within the femtosecond range, which can "take a photo" of these processes in molecules happening at the same high speed. In order to observe individual steps in a chemical reaction, for example, the researchers take countless snapshots that, when strung together, produce a "movie" that reveals the molecular process.

Scientists are extremely keen to experiment at FLASH. "The beamtimes are limited. You only have a few days for the campaign," Gühr says, who last had the opportunity to use the facility in spring 2019. At that time, he took a 700 kg apparatus with him that he and his Potsdam group had developed for the international research community at FLASH. For safety reasons, he drove the device, which was built by a specialized company, to Hamburg himself. "If you only have limited time, nothing must go wrong. It is not easy to repeat the measurement. Everything has to work," says Gühr and describes the exciting moment when the equipment was assembled and installed on-site. It worked. And so he and his team were able to record terabytes of data, which they are analyzing step by step.

Prof. Gühr is considered an expert when it comes to making nature's fastest and smallest phenomena visible in real time. Before coming to the University of Potsdam as a professor, he worked for many years at the SLAC National Accelerator Laboratory at Stanford





Photos: Hopfgarten, Tobias (3)

Prof. Gühr in his lab in Golm

University. Already during his time as a postdoc, he was able to gain experimental experience by using the LCLS free-electron laser. He belonged to the research team that developed a new instrument for ultrafast electron diffraction. With this high-resolution "electron camera", the researchers succeeded in taking the world's fastest images of atomic motions in gases. An unprecedented combination of detail and speed that makes it possible to film vibrating molecules and observe the breaking and reforming of bonds during chemical reactions.

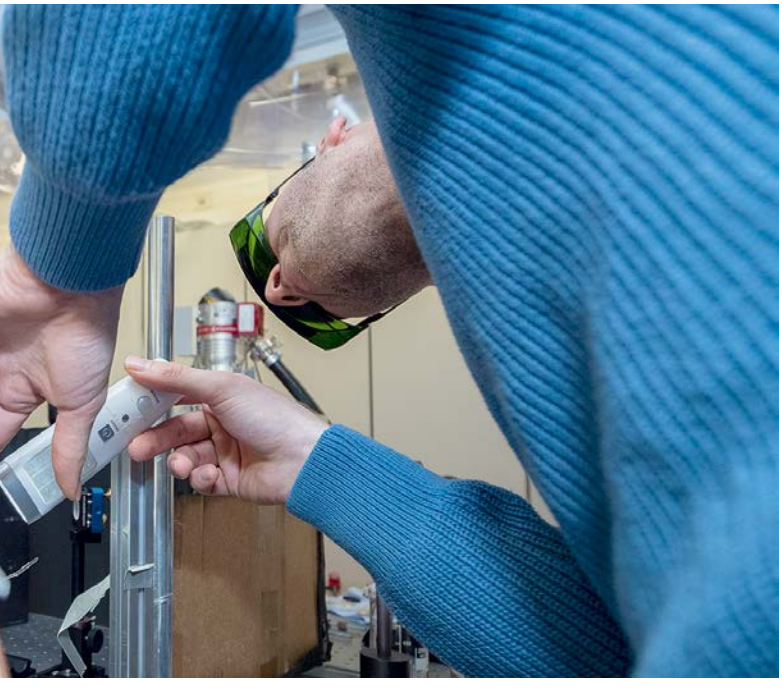
As the winner of the $ 2.5 million Early Career Award of the United States Department of Energy, Gühr took charge of a research group at SLAC that built on this invention. This new technology has the potential to lead to groundbreaking innovations in energy generation, chemistry and medicine, materials science, and many other areas of application.

Nevertheless, Gühr returned to Europe in 2016. The Volkswagen Foundation awarded him a Lichtenberg Professorship at the University of Potsdam and granted him 1.3 million euros to "research energy conversion in photoexcited states with extreme ultraviolet laser pulses". This gave the University of Potsdam the opportunity to establish a new interdisciplinary research field.

The word 'difficulty' should be considered non-existent

After the strictly programmatic work at the National Laboratory in the USA, Gühr perceives the freedom of research offered at a German university to be enriching. "Talking to colleagues who are doing something completely different constantly broadens one's own horizon," says Gühr, who has since established interesting links to physical chemistry and biology. When the Potsdam Leibniz Lectures turned their attention to the ultra-fast quantum world in 2016, the potential for collaboration soon became clear. While physicist Matthias Bargheer focused his presentation on the X-ray of solids, chemist Peter Saalfrank reported on how ultra-short laser pulses can be used to observe the extremely rapid processes in molecules. Markus Gühr appreciates "having such outstanding research groups nearby". In this enormously dynamic scientific landscape, it should soon be possible to apply for a Research Training Group or a Collaborative Research Center. This is reaffirmed by the extremely interested young researchers and the large number of doctoral students who are keen on experimenting. "Teaching and working together with the students is an exciting experience for me," says Gühr. "I greatly benefit from it for my own research," says the professor, whose lectures often flow smoothly into scientific experiments. "There is no big threshold."

Gühr considers the concept of research-based study to be the right way to encourage talented students. This is also why he took part in the discussion on the guiding principles of teaching, with which the University of Potsdam intends to set new standards in university didactics. Thinking critically, dealing with open processes, and solving complicated problems are intellectual skills that are indispensable for both science and society. Failure is part of it as well. "If you test something and it doesn't work, there is still something left that actually creates something new." Or as the physicist Georg Christoph Lichtenberg, namesake of the successful funding program for outstanding researchers launched by the Volkswagen Foundation, put it "A man of spirit must not think of the word difficulty as so much as existing. Away with it!"



THE PROJECT

Lichtenberg Professorship of the Volkswagen Foundation for "Extreme ultraviolet probing of energy-conversion in photoexcited states"

Duration: 2015 – 2019
Funding: Volkswagen Foundation

ANTJE HORN-CONRAD
TRANSLATION: SUSANNE VOIGT

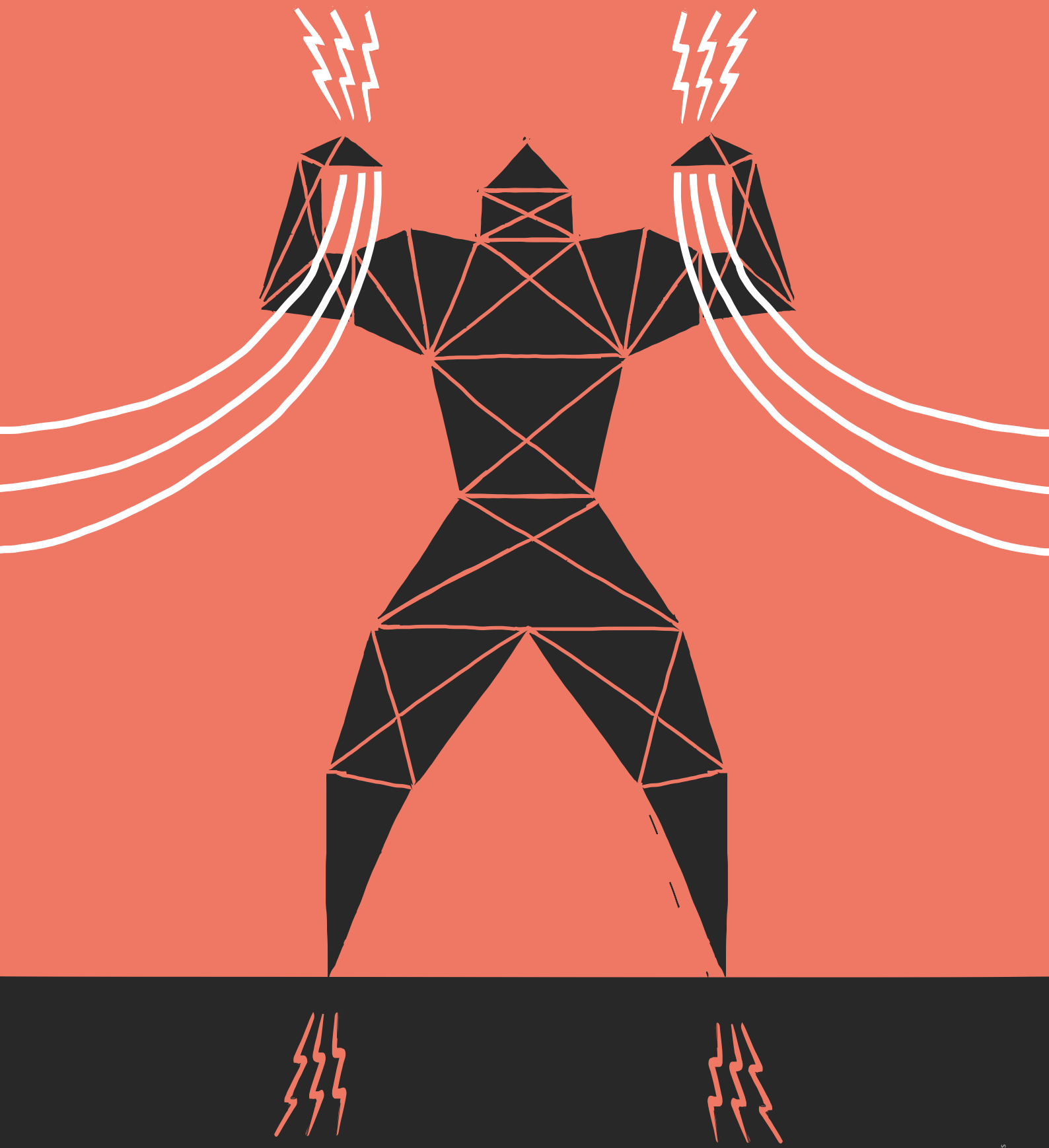


Illustration: Topfer, Andreas

ENERGY

Why one of the most popular terms of our time is so difficult to grasp

Energy dazzles, transmits, and moves. It comes in the shape of electricity, power, heat, and movement, too. It is in chemical compounds, and in high notes. But when you are full of enthusiasm, you are full of energy, too. When there's chemistry between two people, there is this special energy. If you have your way, you are energetic. Where there is energy, many things can happen. But why is that so? Slavicist Susanne Strätling researches the history of the term "energy" – and is fascinated by the energetic mess.

From metaphysics to thermodynamics

"Energy is a term that wanders around. It cannot be assigned to just one field," Strätling says. She is Professor of Eastern Slavic Literatures and Cultures at the University of Potsdam, and fascinated with energy . Even though today energy seems to be mainly a physical quantity other disciplines and knowledge domains have only borrowed, a look at the history of the term reveals that this is not so. The term it comes from, enérgeia (ἐνέργεια), was coined in Ancient Greece. Best known from the works of Aristotle, the philosopher, it described a vivid "reality and effectiveness" – something that makes the possible become reality. "In Ancient Greece, the term 'energy' was used in metaphysics as well as in physics and rhetoric. It never belonged to just one discipline."

It was not until the early 19th century that energy became one of the key concepts in physics. In 1800, the term was first used by British physician Thomas Young, but did not take hold. For many years, physicists used other terms, mainly "force". Hermann von Helmholtz, who was the first to finalize the famous principle of the conservation of energy in 1847, spoke of the "conservation of force". The 1848 edition of the legendary "Conversations-Lexikon", or encyclopedia, by Friedrich Arnold Brockhaus did not even include the term "energy", while its 1898 edition gave "willpower, spirit" as essential meanings, followed by "the ability of a body to do mechanical work". It was only Einstein's Theory of Relativity that coined the definition of energy as we know it today – and thus established the scientific dominance of the term.

"In fact, the term 'energy' had been used a lot in other fields such as philosophy, social sciences, and above all culture and the arts in the past as well," Strätling explains. Enlightenment figures such as Denis Diderot and Johann Gottfried Herder turned their attention to energy as did many romantic writers, among them E.T.A. Hoffmann and Novalis. "With the success story of thermodynamics, the literary and aesthetic examination of energy intensified, too."

Illustrations: Topler, Andreas (2)

Appetite for dynamics

The exciting thing is that the natural sciences and the arts see something completely different in the term "energy", Strätling says. "The sciences need energy as a clearly defined, stable unit that can be calculated with." After all, energy is what is conserved in a closed system in a physical process. It can be transformed from one form to another, but never generated or destroyed – according to the principle of the conservation of energy. "The arts discovered just the opposite in this transformability of energy: not stability, but flexibility. Energy fascinated them as an adjustable variable that can be used to describe both formal and semantic exceedances and transformations. While the sciences are interested in a delimitation of the term, the arts leave it open. For them, energy is not a term, but a metaphor."

This can be demonstrated in various dimensions, Strätling says, both with regard to the impact of art and its production, and from a media theoretical point of view. On the one hand, the relationship between a work of art and its viewer is often described as energetic. "For instance, when we say a painting, a theater play, or a novel 'electrifies' us." On the other hand, energy is applied to produce a work of art. This dimension is closely linked to the origin of the term as used by Aristotle, Strätling explains. "In his metaphysics, enérgeia and dynamis (δύναμις) form part of a conceptual pair also referred to as the actus and potentia model. Here, energy stands for what is not only possible, but actually realized – and thus becomes effective." In the media theoretical dimension, the references are particularly multi-faceted and intensive. In this vein, it is interesting to note that various energy potentials have been ascribed to different media time and again. For instance, Wilhelm von Humboldt was influential in the field of language as a medium. Humboldt spoke of the enérgeia of speech, meaning that spoken language – in

THE RESEARCHER

Prof. Dr. Susanne Strätling studied German philology, Slavistics, and Pedagogics in Münster, Volgograd, Prague, and Berlin. She has been Professor of Eastern Slavic Literatures and Cultures at the University of Potsdam since 2018.

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Illustrations/Photo: Töpfer, Andreas (2, top); Hopfgarten, Tobias (bottom)

contrast to written language – is forever in the making, never completed. By contrast, art historian Aby Warburg referred to pictures as "energy preserves", while performance artists like Marina Abramović are of the opinion that their art is based on the circulation of energy between performer and audience.

Energy as a hinge term

For Strätling, the fact that the sciences and the arts have used the term so differently does not suggest that there is an insurmountable contradiction. "I think, energy may well be a hinge term bridging the gap between the sciences and the arts, much like a clip connecting them." There are many examples of this: the Baltic German chemist and philosopher Wilhelm Ostwald – who received the Nobel Prize in chemistry in 1919 – developed the concept of energetics as cultural science. In it, he attributes not only material, but also awareness processes to the transformation of forms of energy. "His energetic imperative 'Don't waste energy, use it!' applied to all areas of life," Strätling explains. And the Russian theologian, philosopher, and mathematician Pavel Florensky combined various lines of tradition of the term energy from theology, philosophy, physics, and poetics to prove that words are units of energy, too.

In any case, the disciplines have alluded to each other again and again with regard to energy, mostly in a fruitful way. Especially in the modern age, humanistic and scientific perspectives illuminate each other. Take the Russian Projectionists: "For them, a work of art is an emitter radiating energy," Strätling explains. And as early as in 1923, Russian avant-gardist El Lissitzky conjured the visionary idea of an "electro-library" that overcomes the printed book.

As a literary scholar, Strätling is most interested in the role of energy in and for fictional texts. "Mostly, literature is available in written form. However, since Humboldt's time, written texts have been persistently denied energetic potential, only the spoken word is granted the privilege of having energy. Besides, a forgotten story of energy concepts of written text emerges that is worth discovering," – with enlightener Johann Gottfried Herder as prominent representative. He saw literature, in contrast to painting, as an energetic art

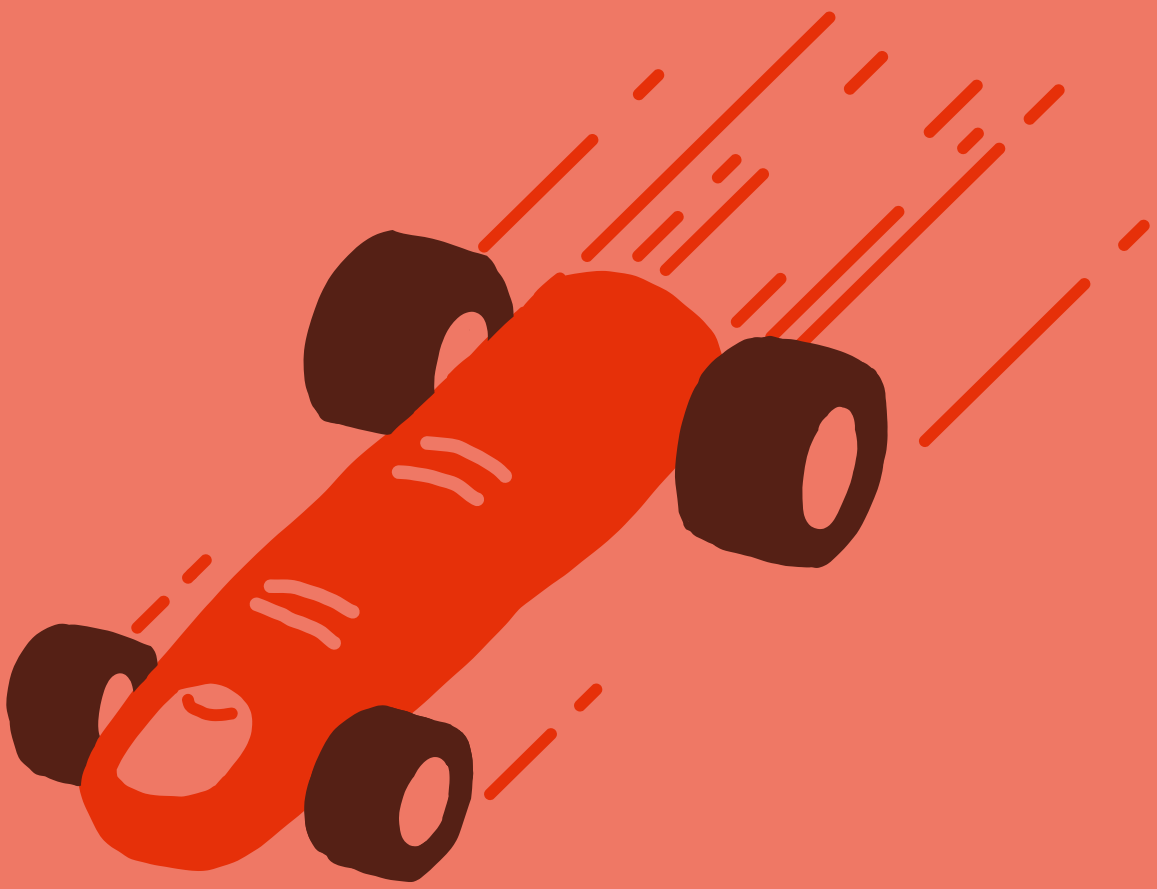


Illustration: Topler, Andreas

form since it allows a work of art to be seen in the process, as something open-ended and fluid. Strätling has a particular passion for the turn of the 20th century. In those years, not only the modern, scientific definition of energy developed and as such diffused into many other fields. “It also plunged into a deep crisis,” she explains. “More and more, the awareness developed that energy and entropy are inseparably linked. After all, energy is not infinite, but brings other associations to mind as well: exhaustion, relaxation, tiredness.” Torn between energy euphoria and energy anxiety, these are the poles between which the artists at the time moved, with the avant-gardists leading the way. “The utopia of the avant-gardists, the unfinished project of their discovery of energy between curse and promise, is highly fascinating and of continuing relevance.”

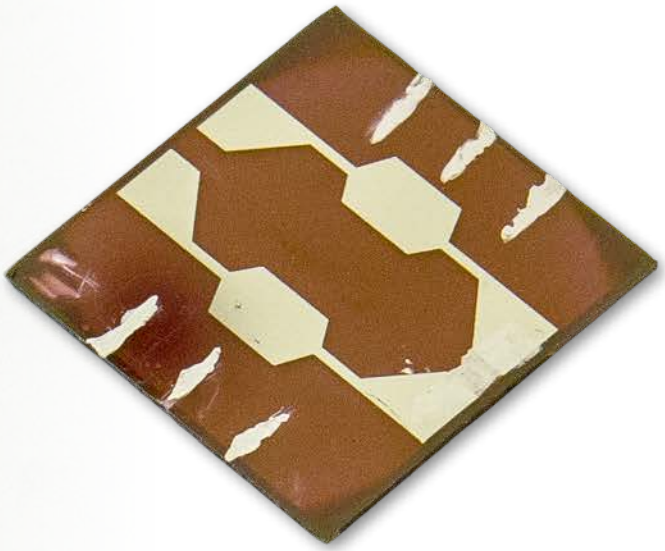
The dazzling complexity of the term means that it is not easy for Strätling to search for the paradigms of energy: She has to cross the boundaries of her own discipline and look around outside her field to find “energy enthusiasts” like herself who are interested in more than one dimension of the term – at meetings, in talks, through publications. “Over time, a network of researchers has emerged, cutting across disciplines, of course, as this is the only place where energy can be found.” One day, the activities of this network could generate a complex history of the term. “We would get a sort of cultural history condensed in a term, a cultural panorama.”

MATTHIAS ZIMMERMANN
TRANSLATION: MONIKA WILKE

Photos: Hopfgarten, Tobias (2)

Sample plates coated with different organic semiconductors have different colors. Thanks to their physical properties the can be used for a wide range of applications - for example in solar cells.

Photo: Fritze, Klara



New Paths to Solar Energy

Looking for the best material for novel solar cells

The solar cells of the future are made of organic material as they can be produced very inexpensively using printing technologies. Physicists at the University of Potsdam are investigating what properties these materials must have in order to achieve particularly efficient and long-lasting systems.

Optical lenses, mirrors, detectors, cables, and all kinds of technical devices: In Prof. Safa Shoaee's lab they are arranged in a complicated experimental set-up. This apparent mess, however, follows strict rules. At the heart of the experiment is a plate the size of a memory card. Its surface is coated in a bluish violet film made from an organic semiconductor material. The mysterious name of the substance is PM6: Y6. It has a property that makes it particularly interesting for Shoaee - it can convert light into energy. The researcher is interested in the underlying physical processes.

Also interesting for architects

The Iranian physicist has been working with organic materials for solar cells for 13 years. The Sofja Kovalevskaja award winner has worked as a scientist at the University of Potsdam since 2016. Her work at the university is funded by the Humboldt Foundation for five years. She shares her interest in organic solar cells with her host Dieter Neher, Professor of Soft Matter Physics. "Safa Shoaee brings special expertise to our working group," he says. They each focus on a different aspect of their field of research, complement one another and in doing so arrive at completely new findings. Clean energy at a reasonable cost - that is the ambitious goal of their joint research.

"Organic semiconductors are very versatile," Shoaee explains. "They can be used in solar cells, photodetectors, sensors, or LEDs." On the table in front of her are sample plates coated in a variety of these materials, their colors ranging from blue to pink to yellow. They all mainly consist of carbon, hydrogen, and oxygen. Their color not only makes them a po-

tentially attractive material for architects, who could integrate organic solar cells in the facades and roofs of buildings, but it also shows which color spectrum of visible light the respective material can use to generate energy. However, they are still inferior to the most commonly used inorganic silicon cells - which are always dark gray and quite heavy in comparison to organic cells: Although they absorb light better, they generate less energy and are less stable.

Safa Shoaee and her team are working on these flaws. With her experiments, she would like to find out how the chemical structure of the materials relates to their optoelectronic properties, which covalent bonding or combinations of elements ensure that light energy is captured particularly efficiently and converted into electrical energy. The results of her work are important for chemists who can produce substances with the desired properties. Step by step, physicists and chemists are jointly designing the basic building blocks for future solar cells.

THE RESEARCHERS

Prof. Dr. Safa Shoaee studied physics at the University of Manchester and physical chemistry at Imperial College London. Since 2016, the Sofja-Kovalevskaja Award Winner has been working at the University of Potsdam and is establishing her own research group in the field of optoelectronics.

✉ shoai@uni-potsdam.de

Prof. Dr. Dieter Neher studied physics at Johannes Gutenberg University of Mainz. Since 1998, he has been Professor of Soft Matter Physics at the University of Potsdam.

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Experimental setup in the lab that is used to examine the properties of organic semiconductors

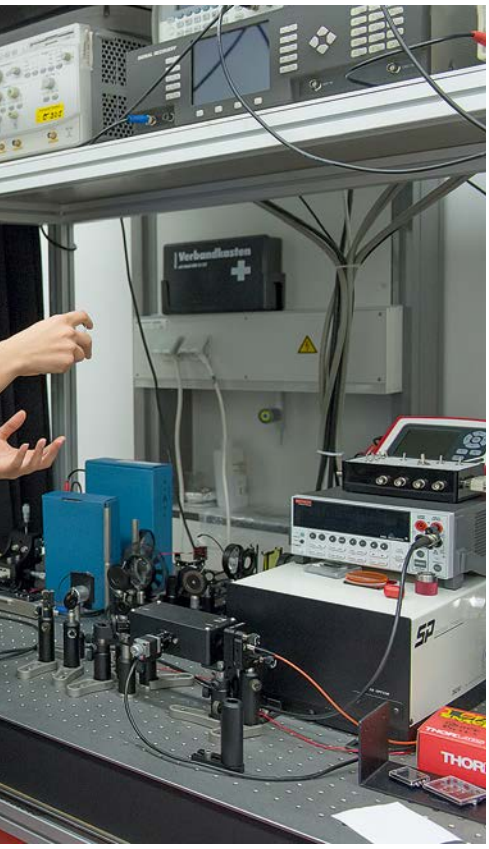
Lifespan and quantity are crucial

When light hits organic material, it initiates a whole series of complex physical processes, in which the negatively charged electrons are excited to higher energy levels, separated from the positively charged holes created in the process and ultimately transported to the electrodes. The research focus of Neher and Shoaee complement each other perfectly: They each investigate different aspects of the separation and transport of the charges created by light.

The two events frame the time period that is crucial for energy production: The lifespan of the resulting charges must be as long as possible in order for them to be transported out of the active layer to the adjacent electrodes. Only then can electricity flow. In this case, “long” means just a few microseconds. In Potsdam, Shoaee has developed a new method to capture this short time period. This requires hours of measurement in the laboratory. Meanwhile, rows and columns of numbers line up endlessly on the computer monitor. In the end, the researchers receive two values that tell them whether the material is suitable for organic solar cells: the lifespan and the number of charges. In addition, physical models that support the creation of new materials are developed from the data measured on various semiconductors.

Optimal optoelectronic properties alone, however, are not sufficient to successfully use organic semicon-

Photos: Fritze, Karla (4)



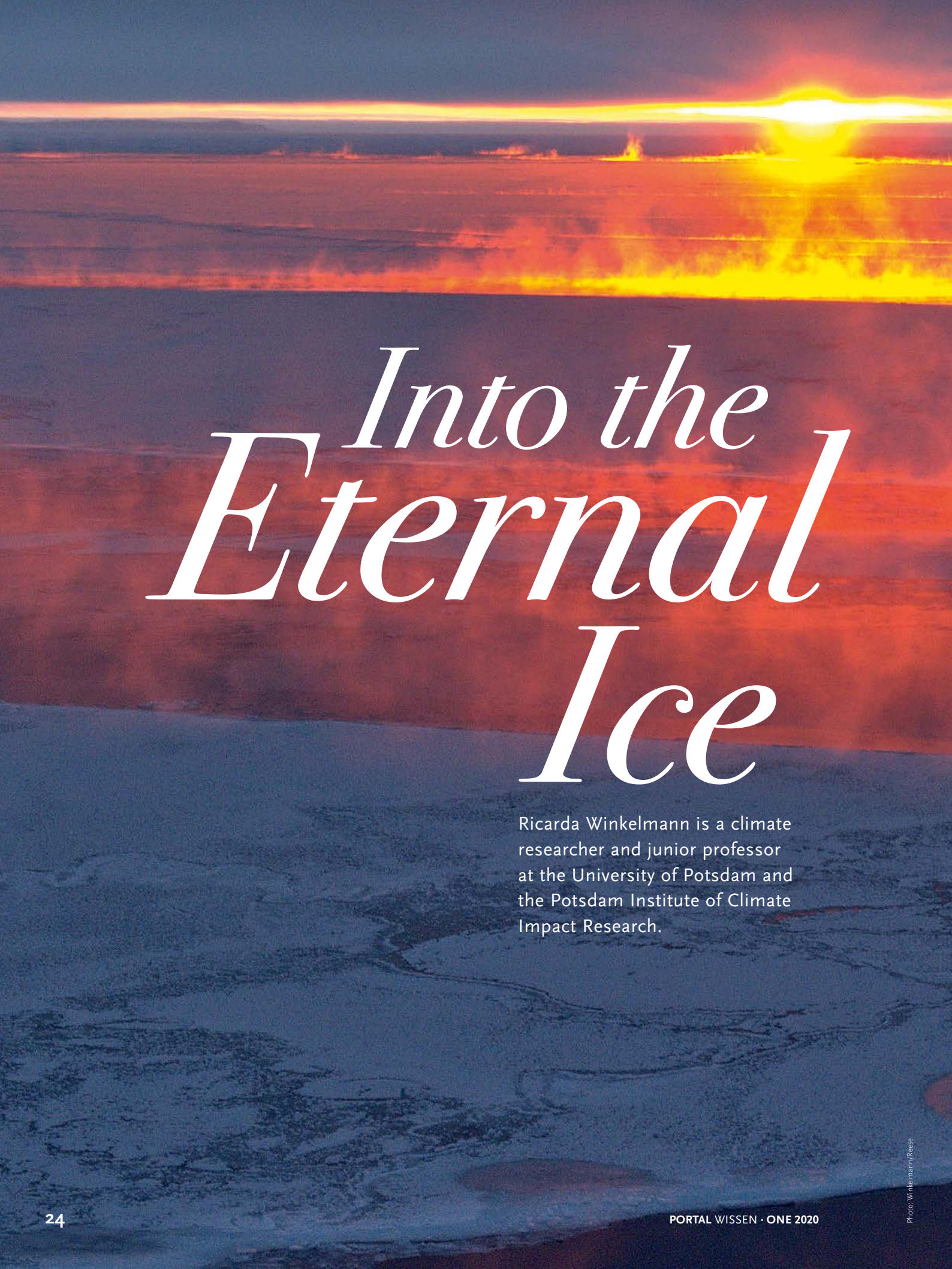
In the preparatory lab

ductors in solar cells. In order to be competitive on an industrial scale, it must be possible to produce them quickly and inexpensively. Organic materials already have a key prerequisite for this. "They can be dissolved in solvents and printed over a large area," explains Shoaee. Printing thin polymer layers is a well-established method and extremely fast compared to other coating processes. To avoid short circuits, the active organic layers of the printed solar cells have to be several hundred nanometers thick. Although this is still thinner than a single hair, there is a problem with the short lifespan of the photogenerated charge carriers: the thicker the layer, the more the charge carriers are lost on the way to the electrodes. Shoaee and her team are researching how they can optimize the crucial optoelectronic parameters to minimize these losses.

Physicists are constantly gaining new knowledge about materials that have so far not been well researched. Many of them behave physically differently from previously known systems. Although the learning curve has been steep, there is still a long way to go to find an organic solar cell that works as well as a silicon cell. "PM6: Y6 has some very good properties, but it is not yet perfect," says Shoaee, who is working persistently to clarify and optimize the physical processes in the solar cells. In any case, the potential of organic materials is enormous, a fact on which Shoaee and Neher can both agree, and their research is paving the way for their future use.

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

Photos: Fritze, Karla (2)



Into the Eternal Ice

Ricarda Winkelmann is a climate researcher and junior professor at the University of Potsdam and the Potsdam Institute of Climate Impact Research.

Photo: Winkelmann/Reese

Sea smoke in the Antarctic
floodlit by the sinking sun

Very few people have been here at all, to one of the world's most inhospitable regions, where the temperature is below the freezing point even in midsummer, which shines in white and blue all year round and, apart from some researchers, is only inhabited by penguins, whales, seals, birds, and microorganisms: the Antarctic. Climate researcher Ricarda Winkelmann knows this region well, both from her modeling work at the Potsdam Institute for Climate Impact Research (PIK) and from two expeditions. In 2010, Winkelmann, 25 years old at the time, was in Antarctica for the first time, and spent 68 days at sea. In 2018, she set off to Antarctica again on the research icebreaker "Polarstern" for several weeks to observe the ice and thereby learn more about climate change.

Ricarda Winkelmann studied mathematics and physics in Göttingen and California, earned her PhD in physics at the PIK and is now leading several large research projects on climate dynamics, including Antarctica and the so-called tipping elements in the earth system. Since 2015, she has been junior professor for climate system analysis at the University of Potsdam. The 34-year-old researcher is particularly fascinated by one thing about the polar regions. "They are a unique climate archive. Ice cores provide us with a look back in time through hundreds of thousands of years." The young researcher conveys this fascination and her extensive knowledge of the polar region in descriptive images and comparisons. Ice samples can be used like tree rings to count age segments. At the same time, the air entrapped in the ice hides a precious treasure: millennia-old air that reveals something about previous climatic conditions and allows conclusions about current changes. "The polar regions are therefore also a kind of early warning system for climate change."

Kilometer-thick ice layers cover Antarctica

Both Greenland and Antarctica are covered by a kilometer-thick layer of ice – making them the world's largest areas permanently covered by ice. Both regions are currently losing mass and thereby contributing to globally rising sea levels. The processes responsible for this change are very different, though, Winkelmann explains. "In Greenland, the ice is melting on the surface due to the comparatively warmer temperatures. In Antarctica, on the other hand, interactions between ice and ocean lead to the loss of mass." The Antarctic is surrounded by floating ice shelves, some of them larger than Germany. The shelf ice has a kind of buffer effect because it slows down the ice flow from the inland into the sea. If the shelves increasingly melt due to advancing climate change, this buffer

Photo: Winkelmann/Reese

will become weaker – more ice flows into the sea and the sea level rises. Winkelmann examines these processes with the Parallel Ice Sheet Model (PISM), which her group at PIK is developing together with the University of Alaska, Fairbanks (UAF).

But could warmer air, which can retain more moisture, not also lead to more snowfall and thus strengthen the ice layer? Winkelmann investigated this question in her dissertation at the PIK. "For a long time, it was assumed that more precipitation due to warming in the Antarctic could, paradoxically, counteract rising sea levels. Our study, however, has shown that this effect is largely compensated by an acceleration of the ice masses." Because additional snow raises the ice on the ground more than the floating ice shelves on the edge of the continent, it flows faster towards the coast, thereby contributing to rising sea levels.

Domino effects in the earth system

If the Antarctic ice were to disappear completely, this would raise sea levels worldwide by 58 meters. If Greenland's ice sheet melted completely, this would mean another seven meters of sea level rise. This would have fatal consequences worldwide and in the long term it would also affect the coastal regions of Germany. In the future, storm surges could also occur more often and cause a salinization of the groundwater. An increasing melting of Greenland would also have consequences for the global ocean. The Gulf Stream system, for example, which brings warm air to Europe, is driven by density differences between the polar regions and the equator. Additional fresh water from the melting ice sheet can slow this flow down – and, as a result, it could become colder on the European continent.

Winkelmann is especially interested in so-called domino effects in the earth system. For three years, the junior professor has been leading the project of

THE RESEARCHER

Prof. Dr. Ricarda Winkelmann studied physics and mathematics at the University of Göttingen and the University of California, Santa Barbara. Since 2015, she has been Junior Professor of Climate System Analysis at the University of Potsdam and the Potsdam Institute of Climate Impact Research.

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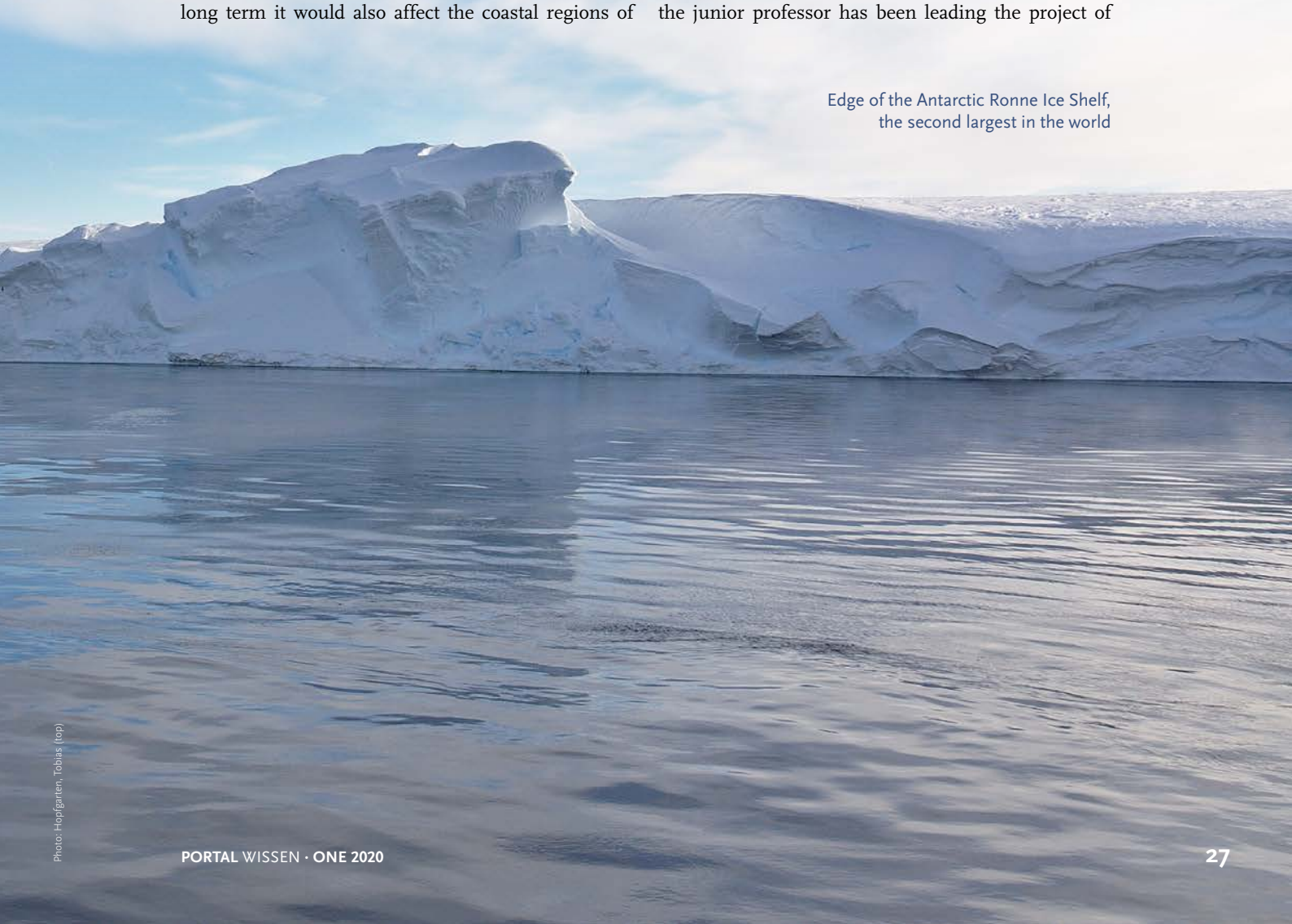

Edge of the Antarctic Ronne Ice Shelf, the second largest in the world

Photo: Hopfgarten, Tobias (top)

The research vessel "Polarstern" in the Weddell Sea

the same name jointly carried out by the PIK and the Leibniz Institute for the Social Sciences GESIS. "There are some interacting tipping elements in the earth system. They are comparable to a kayak: If you tip over in the water, it takes a lot of force to turn the boat around again." Because once you exceed a tipping point, a momentum develops that progresses without additional external influences – in other words, even if it was possible to stop emitting greenhouse gases overnight. Antarctica and Greenland are among these tipping elements researchers are focusing on, but also the Amazon rainforest, global ocean currents, and coral reefs. Their tipping would have far-reaching environmental impacts on the livelihoods of millions of people. Winkelmann examines the global context of such tipping elements at the PIK FutureLab "Earth Resilience in the Anthropocene" whose co-director she has been since 2019.

Research at freezing temperatures

During her expeditions to the Antarctic on the German research icebreaker "Polarstern", operated by the Alfred Wegener Institute for Polar and Marine Research (AWI), the researcher was traveling in partly unknown territory. "About 100 years ago, researchers set out to this region for the first time – to the eternal ice, as they say in German. Although this nice expression is actually not correct, as we unfortunately have to conclude from current observations." The work on board often started at four in the morning with checking the ice. "From the icebreaker, we recorded the snow cover, the thickness of the ice, and its concentration. This data is only a small part of the very extensive data sets that have been compiled over the past decades." This locally recorded information can be used, among other things, to better calibrate satellite images.

Together with her colleagues, Winkelmann investigated other properties of sea ice using so-called salt and light harps, which were developed at the Max Planck Institute for Meteorology in Hamburg. The harps, which have pairs of wire instead of strings, measure salinity, temperature, and light incidence across the entire depth of the floe. "This enables us to record the growth and melting of a floe throughout the year. The harps are inserted into the ice, frozen, and then they regularly send new measurement data via satellite." The aim is to find out how the sea ice in the Antarctic is changing. "For me as a mathematician, who otherwise works with the computer or paper and pencil, it is an incredible experience to examine the ice directly on an expedition," sometimes at temperatures of under 55 degrees below zero. "At such temperatures, you have to think about every

Photo: Hopfgarten, Tobias (top left)

Working with the ice core drill

Penguins walking across an ice floe

little movement, especially because you always wear thick gloves. So even tightening a screw can be difficult. ”

Climate change and climate targets

In addition to her research, Winkelmann has been a member of Junge Akademie at the Berlin-Brandenburg Academy of Sciences and Humanities and the German National Academy of Sciences Leopoldina for four years, and has recently become a member of its executive board. “We are celebrating the 20th anniversary of Junge Akademie in 2020. To reach as large an audience as possible, we are launching, in addition to events such as our public climate lectures, an online competition on the topic of sustainability and also a series of events on scientific topics in cinemas, museums, and pubs.” For the junior professor, teaching is just as important as research and its communication. “In my seminars and lectures at the University of Potsdam, I find it especially important to integrate current research topics.” She also develops new teaching formats with her students, such as a wiki on climate physics or SmartMovies on tipping elements.

The researcher has ambitious plans for the next few years, also as a member of the newly founded Earth Commission, an association of leading earth system researchers, which is headed by PIK director Professor Johan Rockström. The aim is to develop the scientific basis for sustainability goals that go beyond the Paris climate agreement, for example for the protection of the Amazon rainforest, the conservation of biodiversity, and environmentally compatible land use. “The work starts now and will keep me busy for the next three years. I am looking forward to it.”

Even if she constantly points out global dangers with her research, Winkelmann is a tenacious optimist, as she says. “Alexander von Humboldt once said that good ideas are only useful if they are brought to life in many people’s heads. At the moment I have the impression that climate change has reached the awareness of people at an international level.” And it has to. “If we want to meet the Paris UN climate target of limiting the rise of global temperatures to well below two degrees Celsius, we must make the turnaround now.”

DR. JANA SCHOLZ
TRANSLATION: SUSANNE VOIGT

Photos: Winkelmann/Reese (3)

Illustration: Töpfer, Andreas

„We don't want someone like that here"

First study on hate speech at German schools

Hatred and harassment threaten peaceful coexistence in our society. Not just on the internet, but in the analogue world, too. They are expressions of intolerance, marginalization and contempt of entire groups of the population. In how far schools are affected as well is the topic of a study by educational researchers Sebastian Wachs and Wilfried Schubarth from Potsdam, and Ludwig Bilz from Cottbus. In this first nation-wide study on hate speech at schools, they want to reveal risk factors and show what teachers and students can do.

A new pupil joins the class. A few months ago, his or her family had to flee their home country. Nobody in the room knows the reasons or knows anything about the family's past, the circumstances of their flight. Yet one of the pupils says, "We don't want someone like that here. My mother said they all just come for the money." "This is a strong message," Schubarth says. "It is an opinion expressed in public, in the public space of a school." In this concrete case, the harassment continued online. A racist WhatsApp group was formed in the class. A case of hate speech!

This is just one of the many examples teachers report more and more often from school life. Students are discriminated on the grounds of their homosexuality, physical impairment, or religious conviction. One might say that this is nothing new. And it has always been the task of schools to intervene. However, from their well-regarded study "How teachers act in case of violence and bullying" Schubarth and Bilz know that this happens all too seldom. Sometimes teachers feel they have no strength left with all the other tasks loaded onto them, sometimes they lack the respective knowledge or underestimate the consequences of turning a blind eye.

With hate speech on the rise – outside and inside schools – harassment has reached a new level, Schubarth underlines. He differentiates between hate speech, cyberbullying and verbal abuse. "Hate speech consists of words, pictures, and videos, and encourages the violation of someone's dignity. In contrast to bullying, it is always aimed at marginalized groups such as refugees or people with a handicap," Wachs explains. People may be attacked as representatives of the group they belong to. Hate speech generally includes a message, an invitation to discrimination. "This threatens democracy and has to be dealt with in class," Wachs demands.

Topics with conflict potential are avoided

Wachs has specialized in violence on the internet. Together with socialization researcher Schubarth from Potsdam and psychologist Bilz of the Brandenburg University of Technology (BTU) Cottbus-Senftenberg he has developed a socio-ecological model that is used for the first national empirical study on hate speech at German schools. In it, the problem is not viewed in isolation as an online phenomenon, but as overlapping with everyday school life. Especially at school, children and youths experience their otherness and conflicts resulting from it. "Consequently, school is the place where they should learn how democracy and living together in society work," Schubarth says. But today, teachers hardly speak about politics in class. "Often, there is a strong uncertainty about how to deal with the far-right Alternative for Germany party, AfD. Topics with conflict potential are avoided. Right-wing extremism has become a taboo issue, even though teachers should be very clear about their attitude towards it," criticizes Schubarth who has done many studies on value and democracy education at German schools.

To approach the topic of hate speech at school from various angles, the researchers are conducting qualitative interviews with teachers and students in Berlin and Brandenburg. The objective is to find out their reactions to hate speech and what factors influence their behavior: they may be rooted in their own personality, in engaging with others, the school climate, or society at large.

But before they could start their interviews, barriers had to be overcome which none of the team

THE PROJECT

Hate speech – a school problem? A combined student and teacher study on the relevance, frequency, and determinants of the hate speech phenomenon in schools and how to deal with it

Funding: German Research Association (DFG)
Duration: 9/2019–2/2022

Hate in classroom is real – also virtually

Photo: AdobeStock/Syda Productions

members had expected. The explosive nature of the topic made it complicated to obtain the necessary permissions from the Ministry of Education, the supervisory school authorities, the data protection officers, and the ethics commission. "What if, let's say, a student begins to realize in the course of the interview that she is victimized," Schubarth explains one legitimate objection. A second barrier had to be overcome by the schools themselves. "Who would admit that hate speech is an issue? It's not good for the image." In his questions, Schubarth brings up painful subjects: Is there violence at school? Are individuals or entire groups discriminated against and met with open hostility? How do teachers react? Has the social climate changed? To give honest answers to these questions takes courage and the realization that the problem will not disappear if you turn a blind eye to it.

"Trump Effect" at schools in the USA

In the USA, first studies on hate speech at school have already found a "Trump Effect" and were able to measure a direct influence on interaction and communication, Wachs reports. In a study initiated and led by him in 8 countries, 7,000 youths between 12 and 19 were asked about their experience in dealing with online hatred. Around the globe – in Spain, Cyprus, and Greece, as well as in Thailand, India, South Korea, the USA and Germany, young people said they were confronted with hate speech on the internet. "Social networks act like catalysts here," Wachs says. What used to be blared out at the regulars' table in the pub is now published on the internet. "They are only a few, but they are very noisy, and have lost all their inhibitions, protected by the web's anonymity." In concluding their international study, the authors call for programs that offer young people coping strategies, teach them media skills, and strengthen their self-assertion. This is the only way to prevent negative consequences and stand up against hatred openly.

But at the end of the day, schools are part of society. Therefore, the study currently conducted in Berlin and Brandenburg includes social factors, too: Who and what provides fertile ground for the spread of hate? Have violence and discrimination become socially accepted? Does hate reproduce itself at school? The researchers assume that children and youths are particularly vulnerable, because of their stage of development. "Haters generate hate with high emotionality and criminal energy," Schubarth explains. "There is a high risk of contagion. When youths witness hate speech among their peers, it becomes easier for them to join in as it gives them a sense of belonging and solidarizing."

THE RESEARCHERS

Prof. Dr. Wilfried Schubarth studied pedagogics and obtained his doctorate in Leipzig. After completing his habilitation in Dresden and doing research in Greifswald, he was appointed Professor of Educational and Socialization Theory at the University of Potsdam in 2004.

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Dr. Sebastian Wachs studied education and earned his PhD in Bremen. At the University of Potsdam, he was appointed deputy Professor of Media Education with a focus on teaching and learning processes at school.

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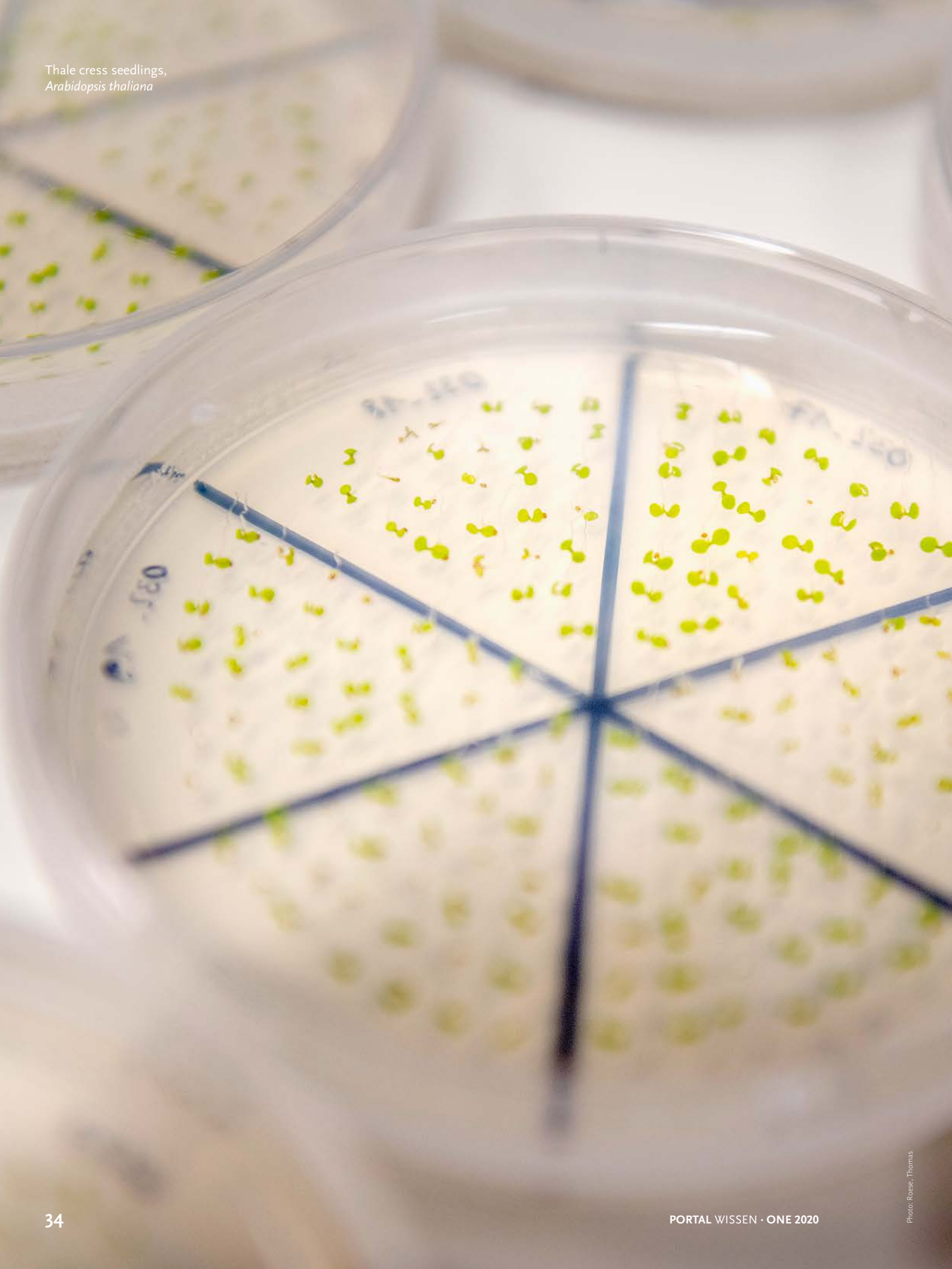
Prof. Dr. Ludwig Bilz studied psychology in Halle and earned his PhD in Dresden. He has been Professor of Pedagogic Psychology at the Brandenburg University of Technology Cottbus-Senftenberg since 2016.

From Berlin-Neukölln to Lusatia

The qualitative interviews will help the researchers to develop tools for a representative survey. In the coming two years, 2,000 girls and boys attending grades seven to nine at all types of public schools will be interviewed, together with some 500 teachers: in Berlin's districts of Neukölln and Prenzlauer Berg, as well as in Potsdam, and Lusatia. Thanks to the cooperation with BTU it will be possible to compare schools in Berlin with those in the area state of Brandenburg. The research team will include a number of master students writing their theses on the project, as well as two PhD students. This way, the results will flow directly into teacher training. As with the study on bullying, the outcome of the current research will also be published in practically relevant form and used for the further training of teachers. The aim is to give them powerful tools for countering hate speech attacks at school and thus accomplish their educational mission in this difficult field.

ANTJE HORN-CONRAD
TRANSLATION: MONIKA WILKE

Photos: Schubarth, Prof. Dr. Wilfried (top); Wachs, Dr. Sebastian (middle); privat (bottom)



Thale cress seedlings,
Arabidopsis thaliana

Photo: Roese, Thomas

When Plants Sound the Alarm

How genes and molecules protect plants from heat

THE PROJECT

"Chromadapt (The role of chromatin in the long-term adaptation of plants to abiotic stress)" is a project funded by the EU's HORIZON 2020 program and investigates the molecular mechanisms of the adaptation of plants to heat stress.

Duration: 2017 – 2022
Funding: European Research Council (ERC)
https://cordis.europa.eu/project/rcn/209923/factsheet/en

Isabel Bäurle is a biologist who researches the heat stress memory of plants at the molecular level. Her findings could give fresh impetus to the breeding of stress-tolerant crops.

The seedlings are only two weeks old. Evenly spread, they grow on the substrate in the round Petri dish. With their two seed leaves, they all look the same, but this impression is misleading: Even though the baby plants are all of one kind – thale cress, or Arabidopsis thaliana – PhD student Vicky Oberkofler has carefully placed plants with different genetic makeups due to mutations in the six sectors marked on the bottom of the dishes. Now she is going to experiment with the seedlings to find out how the plants react to heat stress.

First aid using heat shock proteins

When the sun beats down and temperatures are rising, plants cannot simply step into the shade. Yet plants are not entirely defenseless in hot conditions. Some protect themselves through leaf hairs or a thick wax layer, others by rolling in their leaves. But first and foremost, abnormally high temperatures trigger the production of certain proteins. Heat shock proteins are something like an emergency medication for heat-stressed plants. In the cells, they repair damaged proteins and protect intact ones from being damaged. "We are interested in the regulation of those genes that control the heat shock proteins," Bäurle explains. Other structures at the molecular level are also interesting to the researcher. She assumes that complexes of DNA and the proteins surrounding it – the chromatin – also determine how well plants can cope with heat.

Today a professor of plant epigenetics, Bäurle has been researching the genetic and molecular-biological mechanisms that make plants resistant to heat stress for a long time. In the future, her research findings will give fresh impetus to the breeding of crops. "Apart from drought, heat is one of the major factors leading to substantial crop losses even in our latitudes," Bäurle underlines. And with climate change, summer heat waves will become more frequent and more intense. So it is important to understand the molecular mechanisms that make crops more tolerant. More robust varieties will enable farmers to prepare better for the challenges of the future and produce stable yields. A crucial point in this regard is the heat stress memory Bäurle and her team are researching.

Photos: Roese, Thomas (2)

Plants with a memory

First of all, the seedlings of the thale cress need to be primed: To get used to higher temperatures, they are exposed to water with a temperature of 37 degrees for an hour. A few days later, the procedure is repeated, but this time at 44 degrees. Seedlings that did not undergo the priming are unable to survive this type of stress. Not so the experimental plants: They have developed a heat stress memory which allows them to react quickly to great heat – without suffering major damage.

Nevertheless, some of the plants will die in the experiment, despite the priming, whereas others will hardly be affected. The causes of this can be traced back to certain genes, some of which the researchers have already identified. Where these genes are active, the structure of the chromatin changes. Bäurle and her team assume that this is a precondition for plants developing a heat stress memory. With their experiment, the biologists want to find out what happens in the plants when these genes are deactivated and do not work properly due to mutations. For each mutation, they will then study which genes are active or inactive, what the chromatin state is, what proteins are produced, and how the heat stress was tolerated.

Next step: breeding

As these are complex mechanisms, the researchers move step by step. "Often, the answer to one question leads to three new questions," Bäurle says. "What we know already is that certain genes are switched on and off in hot conditions," she explains. Following a stress event, these genes remain active for some days. The plant stays in alert mode, so to speak, and can react quickly to hot weather spells with protective molecules if needed. Also, there are some genes that are switched off shortly after a heat event, but can be reactivated faster during a new stress period. Bäurle calls this the "molecular heat stress memory".

To find out whether individual genes are active or inactive, Bäurle and her team also use a substance best known from fireflies: In contact with an enzyme known as luciferase, the biomolecule luciferin begins to glow. In the lab, the molecular biologists engineered a luciferase producing gene into the plants. However, it is only active when certain other genes the researchers are interested in are switched on as well. So when being sprayed with luciferin, the experimental plants begin to glow where the respective genes are active. For the researchers, this is a simple method of testing genetic activity quickly and comprehensively.

In a next step, barley plants will be examined in the lab as the researchers have detected a certain gene involved in the heat reaction of the thale cress – FORGETTER 1 – in barley, too. They are planning to switch it off and monitor the reaction of the plant and the effect it has on its heat stress memory. Ultimately, the goal is to breed barley plants that are less sensitive to heat stress. The foundation for it is laid here.

HEIKE KAMPE

TRANSLATION: MONIKA WILKE

THE RESEARCHER

Prof. Dr. Isabel Bäurle studied biology and chemistry at the University of Freiburg. Following a junior professorship, she has been Professor of Plant Epigenetics at the University of Potsdam since 2019.

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Prof. Isabel Bäurle

Photos: Roese, Thomas (2)

Counting Neutrons for Environmental Research

Researchers measure soil moisture with the help of particles from space

Photo: AdobeStock/Goldengel

They are super-fast, rich in energy and are created when particles from space hit the Earth – neutrons are omnipresent and usually penetrate matter relatively easily. Only hydrogen and some other rare elements can catch them or at least slow them down. On this basis, researchers use the particles to find water in soil.

"I'm actually a physicist," says Sascha Oswald. It is therefore not surprising that the researcher is interested in cosmic radiation, particle showers, and neutrons. But what is special is that, as a professor at the Institute for Environmental Sciences and Geography, he cleverly combines physics and environmental sciences. He, his team, and many other cooperation partners, develop and optimize a method that measures on a physical basis how much water is stored in soil.

The method starts in space: Star explosions create super-fast, high-energy particles that, at some point on their way through space, also hit the Earth, just like the solar wind. Hundreds of them hit every square meter of the Earth's atmosphere every second where they collide with other particles trigging a particle shower of numerous, now somewhat slower particles. Many of them also reach the surface of the Earth. Oswald is interested in these particles – the neutrons – because these have interesting properties that the physicist can use for his measurements.

Soil moisture as an uncertainty factor in climate research

The DFG research unit "Cosmic Sense" deals with these investigations. The goal of the transregional

THE PROJECT

"Cosmic Sense" is a research unit funded by the German Research (DFG) that researches the hydrological variables at the land surface. Its goal is to better understand the complex water cycle between soil and atmosphere and provide findings for remote sensing and climate research.

Participating Institutions: Heidelberg University, Technische Universität Berlin, University of Augsburg, Helmholtz Centre for Environmental Research (UFZ), Forschungszentrum Jülich (FZJ), German Research Center of Geosciences (GFZ), Karlsruhe Institute of Technology (KIT).
Funding: German Research Association (DFG), FOR 2694, project no. 357874777
Duration: 2018 – 2021
https://www.uni-potsdam.de/de/cosmicsense.html

Photo: Oswald, Prof. Dr. Sascha

Non-invasive Cosmic-Ray Neutron Sensing (CRNS) – probe on a meadow during a comparative measurement with calibrator

research unit is to develop precise measurement methods and models to better understand the water cycle and hydrological patterns in landscapes. The path that water takes in the atmosphere, on the land surface and in the ground is an important factor of hydrometeorological models, which are currently still subject to substantial uncertainties. With the help of neutrons, the researchers hope to close a large part of the knowledge gaps.

Since 2008, research has been carried out on a new type of sensor. It is supposed to provide more precise data about the water stored in the soil. Experts speak of soil moisture. The amount depends on numerous factors: How much did it rain? Do forests or grass cover the surface that absorb and evaporate the water? Is the soil sandy, stony, or loamy? Soil moisture, which is an important basis of plant and soil organism life as well as of agriculture, also varies due to climate change and the form of land use.

More accurate data by using new methods

"Soil moisture varies a lot across large areas. Traditionally, this value is determined selectively with a soil probe. But a meter away, the value can be very different," explains Oswald. That makes it so difficult to get an accurate picture of it. Creating a meaningful model of soil moisture across a larger area is very expensive and requires a lot of measurements. At least it has been like this so far.

Particles from space should now help to measure the soil moisture on Earth with less effort. "A decisive factor is that water slows down the neutrons, catches or redirects them," Oswald explains. It is a mechanism that is also used in nuclear power plants to protect the environment from the neutrons generated in fuel rods. For their purposes, the researchers use this property of the naturally occurring particles found on land surface in small quantities.

They use a neutron detector – a box-shaped device that captures neutrons of a specific, medium energy range crossing its path. Their number indicates how much stored water is available in the soil of the surrounding area. After a few hours, each measuring device provides the researchers with a value that indicates the average soil moisture of about ten hectares of land. If you combine this information proficiently with meteorological data, remote sensing data, and other measurements, you get precise reference values of the soil moisture and how it changes over the course of days, weeks and months.

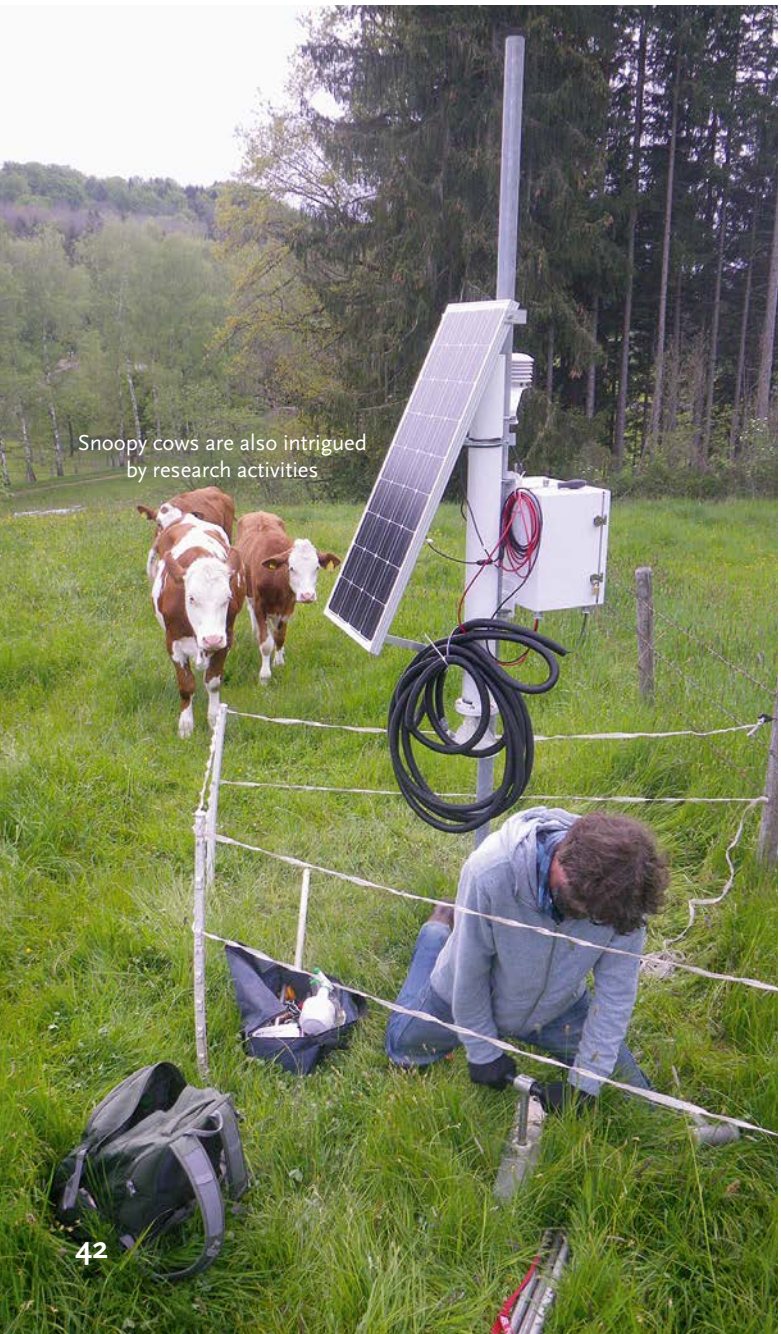
In 2019, the researchers examined the potential of this method in a first field campaign. At the research site of the Karlsruhe Institute of Technology (KIT) in the foothills of the Alps, they set up a dense network of

20 detectors in the catchment area of a small stream. For two months – from mid-May to mid-July – they collected a lot of data here in order to use these measurements to create a map of the soil moisture in the about one square kilometer large area. The research partners supplemented the measurements with vegetation mapping and aerial drone recordings.

Snow and cows – a source of error

"When we started, it poured for days," Oswald recalls. The weather became drier in the course of our campaign. "That was good for us because we wanted to see the differences." With the measurement campaign, the researchers received for the first time a temporally and spatially highly differentiated model of soil moisture. The sensors provided the required data every few hours – for eight weeks. "Such a comprehensive set of data has not been available before," emphasizes Oswald. In addition, the researchers were able to compare the values of the 20 different devices they had used and thus to calibrate the measurements even more precisely.

Now they must analyze the data. The main goal of the research group is to expand the possible applications of the detectors. In addition, some teething troubles have to be eliminated and the sensor sensitivity has to be improved. To obtain meaningful values, the devices capture the neutrons darting around for hours. Since their number is very small, natural fluctuations cause large measurement errors. In addition, water that is bound in plants as well as snow also af-



Snoopy cows are also intrigued by research activities

THE RESEARCHER

Prof. Dr. Sascha Oswald studied physics at the universities of Freiburg and Heidelberg. At the Institute of Environmental Science and Geography of the University of Potsdam, he is head of the working group for water and matter transport in landscapes.

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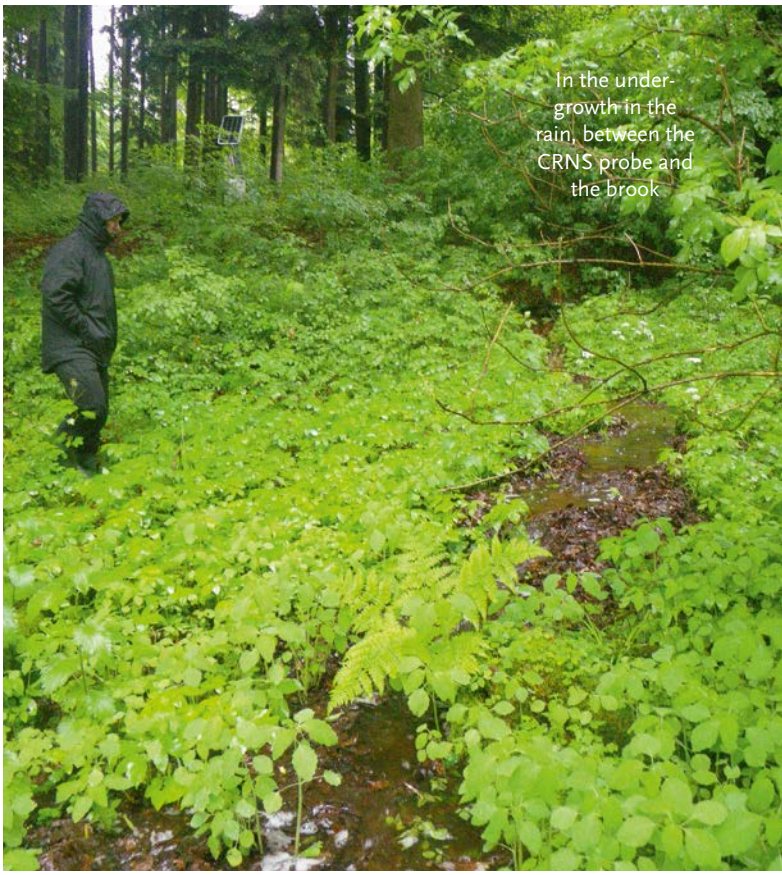


In the undergrowth in the rain, between the CRNS probe and the brook

Photos: Budach, Christian (bottom left); Scheiffele, Lena (bottom right); Hopfgarten, Tobias (top)

fects the measured values. Even cows that are curious about the installed sensors can be a source of error. “They also consist of 70 percent water. If such a herd of cows stands around the sensor, you will see that in the measurements,” says Oswald with a laugh.

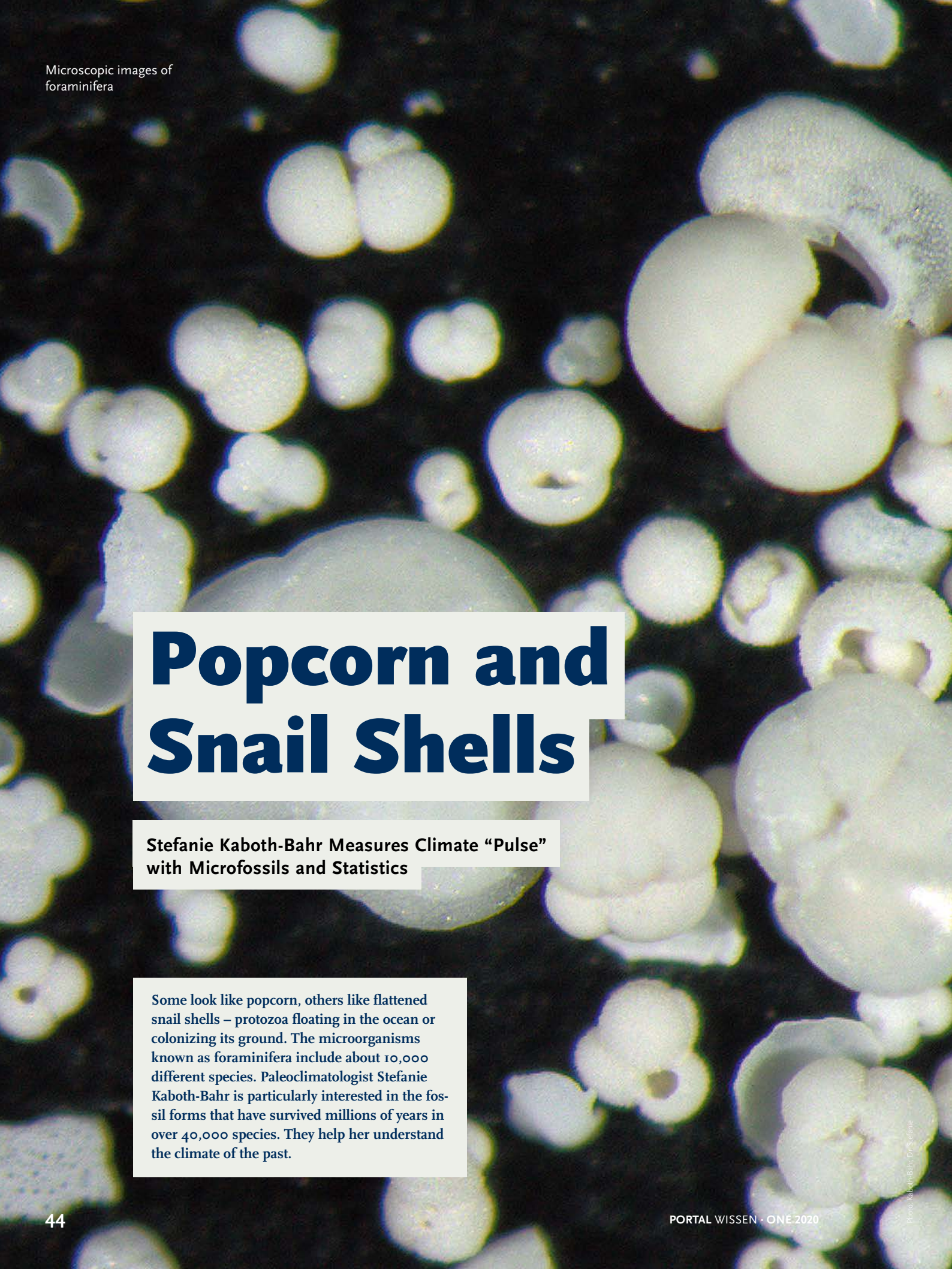
To get more reliable results, all these disruptive influences have to be eliminated. The researchers have plenty of ideas how to do this. They also test the integration of sensors in moving measuring stations to receive data for larger areas in less time.

If the environmental scientists around Oswald succeed in implementing their goals, it could also take climate research a big step forward. The water exchange between soil and atmosphere is highly complex. The results of “Cosmic Sense” can be used to calibrate, validate, and improve large-scale hydrological models. Research partners at the Helmholtz Center for Environmental Research in Leipzig (UFZ) are currently working on this, feeding the data on soil moisture into their hydrological models and making predictions about hydrological changes in the next 100 years. “What will happen in Europe and especially in Southern Europe is dramatic,” Oswald emphasizes. “The last two summers, which we experienced as exceptionally dry and very hot, will be normal in a few decades.”

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

Prof. Sascha Oswald

Photos: Hopfgarten, Tobias (2)



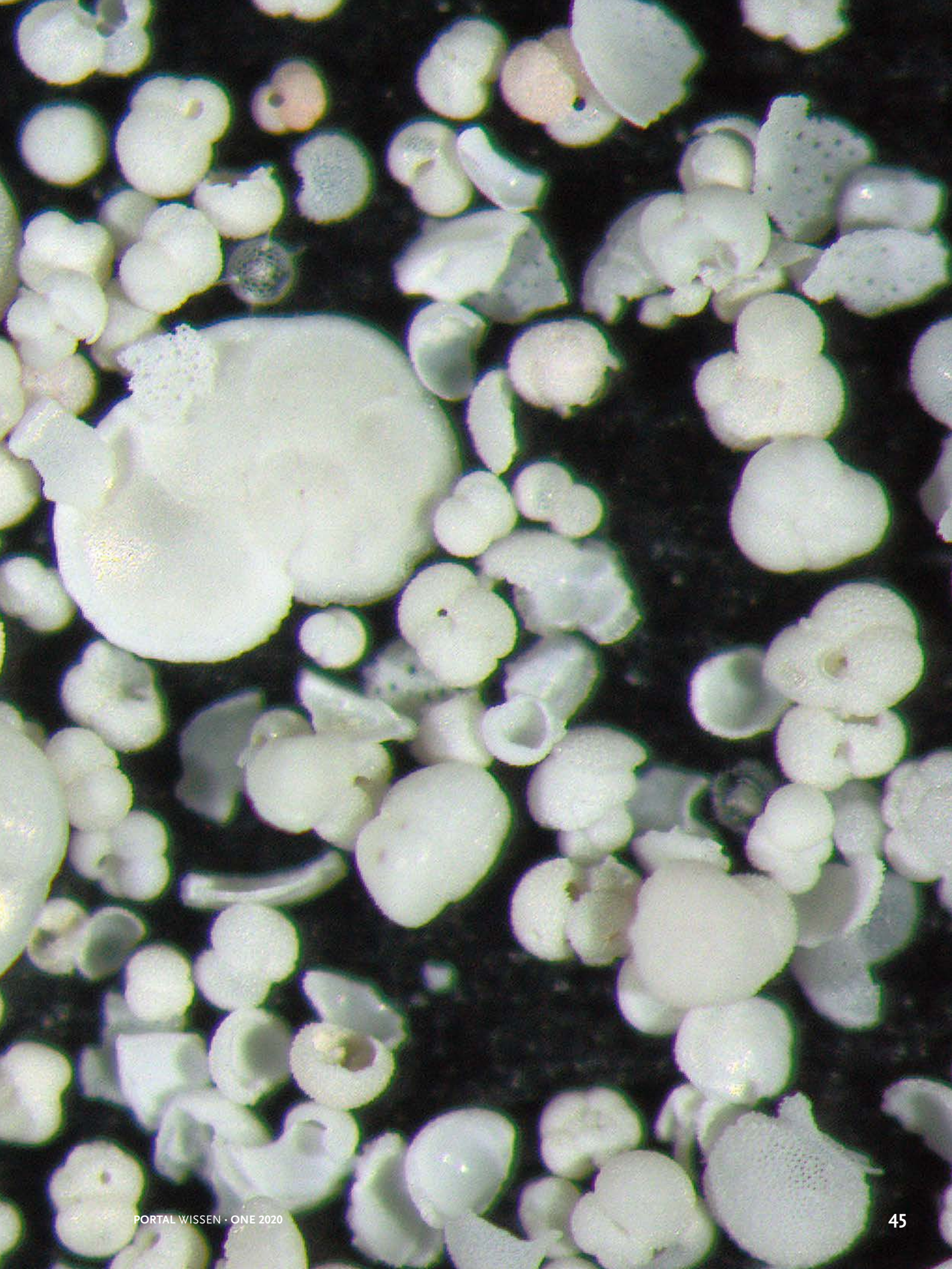
Microscopic images of foraminifera

Popcorn and Snail Shells

Stefanie Kaboth-Bahr Measures Climate "Pulse" with Microfossils and Statistics

Some look like popcorn, others like flattened snail shells – protozoa floating in the ocean or colonizing its ground. The microorganisms known as foraminifera include about 10,000 different species. Paleoclimatologist Stefanie Kaboth-Bahr is particularly interested in the fossil forms that have survived millions of years in over 40,000 species. They help her understand the climate of the past.

Photo: Kaboth-Bahr, Dr. Stefanie



When Stefanie Kaboth-Bahr studied geoecology at TU Bergakademie Freiberg, she did not know that her professional journey would soon take her across the oceans. But then she switched to the Alfred Wegener Institute in Bremerhaven for her diploma thesis, went on an expedition to the Arctic and took part in an expedition of the research icebreaker "Polarstern" to the North Pole. She learned from marine biologists and paleontologists how to examine microfossils and analyze them using geochemical methods to draw conclusions about the climate of the past. She screened sediments for everything larger than 63 microns and sorted out the multifarious foraminifera under the microscope. Then these microorganisms had to be crushed into even smaller particles, washed in an ultrasonic bath and dissolved in acid to be able to analyze the escaping gas by mass spectrometry. Based on the measured isotopes, statements can be made about how much ice there was in individual periods of geological history, the temperature, origin, and density of the water. "That was it," says Kaboth-Bahr. She had found her subject. There was no way back anyway: "I had lost my heart to marine research at sea," she says, raising her hands in a gesture of defenselessness.

... and next to a steam vent in Yangmingshan National Park in Taiwan.

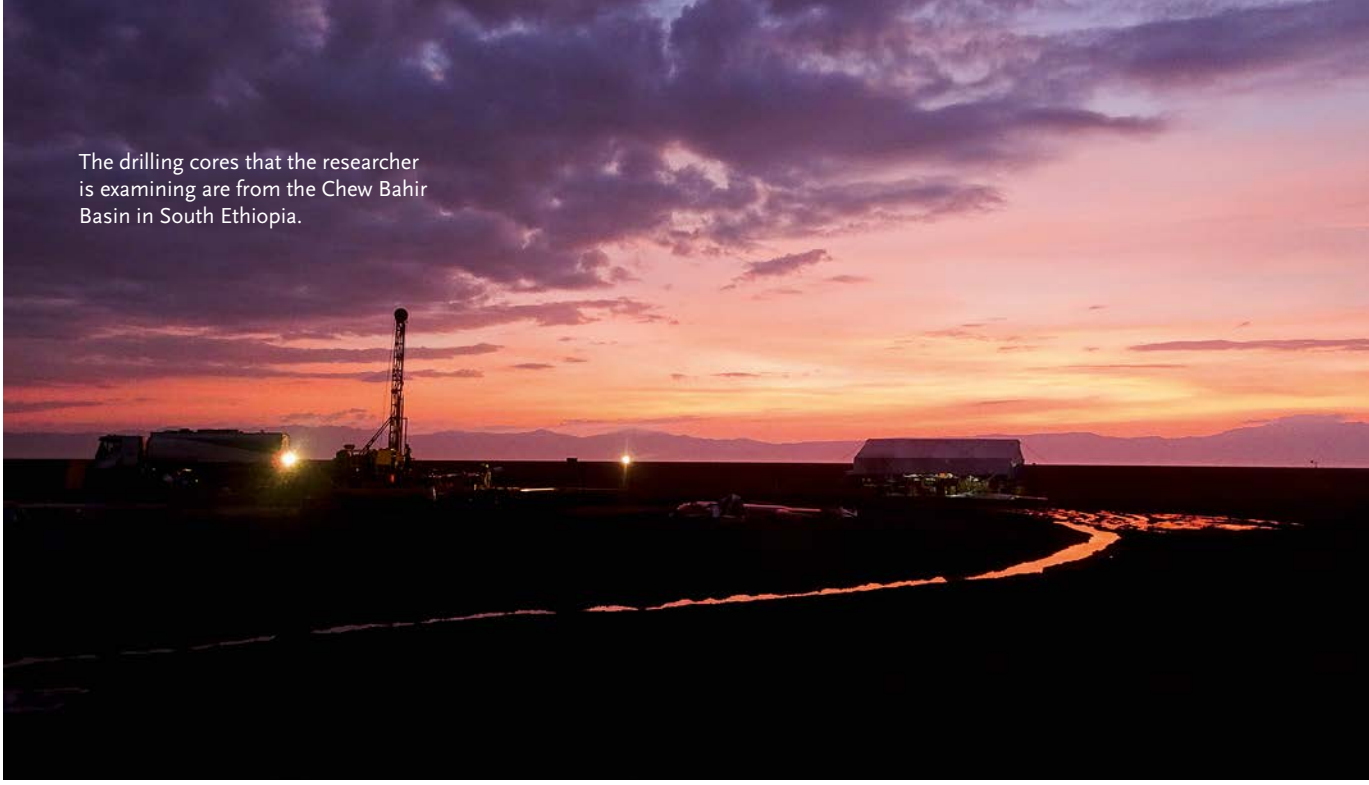
From North Pole to Mediterranean Sea

While she was still working at the Alfred Wegener Institute, she was accepted for doctoral studies in Utrecht, the Netherlands. She was standing in the polar suit in the cold room, working on her ice samples when the phone rang. She was very happy also because she was to go to warmer areas. In the Gulf of Cadiz, the doctoral student examined the outflow of the Mediterranean into the Atlantic Ocean. "The Mediterranean is considered a salt source for the North Atlantic and changes the ocean's density with the incoming water. This in turn affects the climate in Northern Europe," explains Kaboth-Bahr. In her dissertation, she was able to demonstrate that the African monsoon is an important factor in determining how much salt flows into the Mediterranean Sea and then into the Atlantic Ocean.

She is still fascinated by being able to establish such correlations using microfossils. As a postdoctoral

Stefanie Kaboth-Bahr on an Artic expedition, in the background the research icebreaker "Polarstern" ...

Photos: Kaboth-Bahr, Dr. Stefanie (2)



The drilling cores that the researcher is examining are from the Chew Bahir Basin in South Ethiopia.

researcher, she now brings this marine component to Martin Trauth's working group in Potsdam, who also did his doctorate in marine paleoclimate research but is now mainly working on the African mainland. "I'm now taking a step from the ocean to the land," she describes the changed perspective. She investigates over long geological time scales how the climate conditions on land and in the ocean influenced each other. Using geoscientific statistics and life science data sets, she looks far into the past, searches for recurring events and larger context. "I solemnly call it the 'heartbeat of the climate', but in fact, if you step back far enough and look at long periods of time, you can indeed recognize a rhythm," explains Kaboth-Bahr. Ultimately, the Potsdam researchers led by Martin Trauth want to find out how such climate changes affect the development of early humans, their migration routes and their cultural development. "How many climatic variations are needed for an evolutionary boost?", asks the researcher.

Now she is directing her attention to Africa

She likes the fact that geological processes are not researched in isolation at the University of Potsdam but in their interaction with biological developments. What attracted her to go to Potsdam, however, was above all the expertise of Martin Trauth, who is a specialist for statistical evaluations of the collected data. "I have come to the well-feathered nest. Everything has already been measured in Africa. The data is already available," says the young researcher, who recognized the opportunities of the open topic postdoc program. "Such an opportunity is quite rare in Germany and the University of Potsdam is a pioneer in this field." Kaboth-Bahr is happy to be able to take a big step forward in her academic career. Integrating statistics across long time scales is new to her. She wants to learn that here. In return, she contributes the marine component that has so far received too little attention in Trauth's group. "We put everything on the desk and see what fits," she says very pragmatically.

She can well imagine working in this field in the long term. As a postdoctoral researcher, she will first research in Potsdam for three years and then embark on a path to a professorship. And teach. She has only been at the university for a few months but already gives lectures on paleoclimatology. She will surely stop by the Alfred Wegener Institute on Telegrafenberg. She knows that the university is well networked and closely cooperates with the institutes there. She will make use of it. She does not feel like going on expeditions to arctic regions at the moment. Her attention is focused on Africa.

ANTJE HORN-CONRAD
TRANSLATION: SUSANNE VOIGT

THE RESEARCHER

Dr. Stefanie Kaboth-Bahr studied geoecology at TU Bergakademie Freiberg. Since 2019, she has researched at the Institute of Geosciences of the University of Potsdam within the Potsdam Open Topic Postdocs Program.

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Photos: Junginger, Annett (top); Horn-Conrad, Antje (bottom)

Photo: AdobeStock/WindyNight

FOR THE PROTECTION OF ALL PERSONS

Legal experts Andreas Zimmermann and Norman Weiß about the Human Rights Center at the University of Potsdam

More than 70 years ago, both the Universal Declaration of Human Rights, as well as the four Geneva Conventions dealing with international humanitarian law were signed. Since then, the two set of documents have existed side by side – and have been confronted with common tasks. The Human Rights Center, or MenschenRechtsZentrum (MRZ), at the University of Potsdam has done research on both fields for more than 25 years. Director of the MRZ Prof. Dr. Andreas Zimmermann and Prof. Dr. Norman Weiß, long-standing associate of the Center, spoke to Dr. Jana Scholz about the objectives of the MRZ and global challenges in the fields of international humanitarian law and human rights.

What are the intersections between international humanitarian law and human rights today?

Andreas Zimmermann: Historically, both fields developed independently of one another. International humanitarian law, formerly known as the 'laws of war', specifies which protective mechanisms take effect in an armed conflict. For instance, that war parties treat prisoners of war properly, tend to the wounded, and do not abuse civilians – the whole area of the laws of war, but with a humanitarian impetus. In contrast, human rights basically have nothing to do with armed conflicts. Simply put, human rights are primarily about the protection of a State's own citizens. For instance, that nobody may be subjected to torture in Germany, that the State has to guarantee freedom of expression, or implement the right to education. Interestingly enough, the Universal Declaration of Human Rights was adopted by the United Nations in 1948. Soon after, in 1949, the four Geneva Conventions were adopted providing a major codification of the laws of war. Even so, human rights and international humanitarian law have existed unconnectedly side by side for many years. However, more recently, there has been more overlap between them. Let us take a concrete example: Protests at the border between Gaza and Israel are principally covered by the freedom of assembly. But what if some protesters start shooting, or border installations are damaged? Could action against such acts be taken on the grounds of the laws of war? Do human rights apply in an armed conflict at all? And in what way do these two legal matters cross-fertilize each other? These are some of the topics we are researching at the MRZ.

Photo: Hopfgarten, Tobi

In September 2019, the University of Potsdam hosted the annual conference of the Association of Human Rights Institutes (AHRI), a network of university research institutions focusing on human rights. What are the main issues on the minds of human rights researchers these days?

Norman Weiß: Among other things, the conference dealt with new types of warfare that have emerged in the context of digitization and are presenting new challenges for human rights.

Zimmermann: Yes. This includes drones, but also completely automated weapons using artificial intelligence, for instance. It certainly becomes a human rights issue if robots decide whom to shoot on the basis of a uniform they recognize, or a badge displaying the national colors of the enemy – which is understood to be worn by a combatant of the enemy. It was interesting to see that representatives of both defense ministries and human rights organizations attended the conference, with considerably different perspectives. But I found they actually listened to each other surprisingly well. Of course, Germany does not hold such a prominent position in armed conflicts as, for instance, Israel or the USA who are more involved in concrete battle situations. Nonetheless, Germany also has to deal with challenges in the fields of international humanitarian law and human rights: During a stabilization operation by the German armed forces in Kosovo in 2004 acts of violence against Serbian institutions – including churches – occurred. The German army then used tear gas against the protesters as there was no local police force there at the time. Now, is the German army bound by German basic rights when operating abroad? May it use chemical weapons?

When it comes to AI, do you see legal gaps? Is there more possible today than would be good from the point of the protection of human rights?

Zimmermann: In Geneva, a dedicated working group of the United Nations' Conference on Disarmament is dealing with the topic of autonomous weapons. It will possibly develop fundamental principles, i.e. joint declarations, for States to adhere to. But in international law processes are rather slow. If everything goes well, we will have a treaty in ten years' time that will be ratified by big players such as the Russian Federation, the USA, and Israel as well. Given the current situation in international law and politics, however, it might also go badly, in which case negotiations would continue over the next 20 years without any significant progress.

THE RESEARCHERS

Prof. Dr. Andreas Zimmermann studied law in Tübingen, Aix-en-Provence, and at Harvard Law School. He has been Professor of Public Law, especially European and International Law, as well as European Economic Law and Economic International Law at the University of Potsdam since 2009, and director of the MRZ since 2010.

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Adjunct Prof. Dr. Norman Weiß studied law at Johannes Gutenberg University Mainz. He has been an adjunct professor at the law faculty since 2013, and a research fellow at the MRZ since 1994.

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The Human Rights Center was set up some 25 years ago. What were the founders' key objectives, and what has been achieved since then?

Weiß: In the early 1990s, the topic of human rights was not as present at universities and at law faculties in particular. In 1992, the University of Potsdam hosted an international conference on international human rights protection that was also attended by judges from the European Court of Human Rights. As it were, their task was to promote the establishment of human rights institutions in European States. In Germany, Potsdam seemed to be a suitable place, also because an academic elite institution – the GDR's Academy of State and Law – had been located here at Griebnitzsee, and where our campus is today, there used to be the Berlin Wall. Considering all this, Eckart Klein, then Professor of public and international law, established the MRZ as an interdisciplinary center in 1994. In 2001, it was merged with the Center of Research on Justice and became a central scientific institution. Since then, our organization has had a dual leadership: the director of the law faculty who also holds the chair of international law, and the director of the philosophical faculty, who is professor of ethics and aesthetics. Worldwide, there are many institutions like the MRZ doing research on human rights today. About 70 of them have joined forces in AHRI, the Association of Human Rights Institutes.

Photos: Hopfgarten, Tobias (2)

Zimmermann: I believe that we are now well established in the research landscape. The large conference last year has contributed to enhancing our national and international visibility. We are collaborating closely with the German Institute of Human Rights, the national institution working according to the United Nations Paris Principles. In teaching, we do quite a lot, both in the philosophical and the law faculty.

Weiß: The same is true for research, the MRZ's central task. A number of dissertations have been written here, and most of them were published in "Schriften des Menschenrechtszentrums der Universität Potsdam". Only recently, volume 46 appeared. Besides, MenschenRechtsMagazin, which is published twice a year, has a wide reach and is read in some ministries and by MPs in the Bundestag.

Zimmermann: All year round, we host one or two visiting researchers, for instance from Poland, Georgia, Israel, or Switzerland, who pursue their own research projects at our university. Besides, we prepared an expert opinion on the subsequent immigration of family members for the Bundestag in 2018. At the time, limitations on the right to family reunification were discussed, especially for Syrians. We always strive to involve the Potsdam population. For instance, we use the Wissenschaftsetage, or Research Floor, to popularize and discuss science and technology. In 2015, we organized an event on the Geneva Convention on Refugees – a hot topic at the time – which was very well attended.

Prof. Andreas Zimmermann

Prof. Norman Weiß

Can research have a concrete influence on the protection of human rights?

Zimmermann: It has an influence, but more on a meta level. For instance, one PhD student examined in her dissertation whether international law includes the right to conscientious objection. That is, not the laws of a country, say the German Basic Law, but whether the International Covenant on Civil and Political Rights legitimizes conscientious objection. And she found that there is such a right. This will ...

Weiß: ... change everything ...

Zimmermann: In a way, yes. Even though the research findings will not have a direct impact on the behavior of concrete States, they help to raise awareness. This is what research can do.

Which topics is the MRZ currently focusing on, and what projects will be on its agenda in the near future?

Weiß: For a number of years, we have been focusing on one major point, and that is to accompany the work of the UN Human Rights Committee of which Mr. Zimmermann is currently a member, as an independent expert.

Zimmermann: We are living in a difficult geopolitical environment characterized by a rollback of inter-

Photos: Hopfgarten, Tobias (2)

national law. Attempts are being made to challenge established human rights standards. Independent monitoring institutions such as the Human Rights Committee are also being affected. Currently, I am supervising a doctoral thesis on these treaty bodies and how to strengthen them in politically difficult times. And, as has already been mentioned, new global developments lead to new questions: What are the implications of digitization for human rights? After all, there is the right to free assembly – and according to international law this applies to cyberspace, too. But what does the right to privacy mean in cyberspace? Where does surveillance begin? Currently, you live in Germany and a foreign state or secret service can spy on you without ever entering German soil. Yet, are they bound by human rights law?

Another hotly debated issue in the United Nations is whether corporations have to comply with human rights obligations. Can globally operating corporations such as Esso, Shell or even German textile companies be obliged to fulfil human rights standards? At present, the United Nations is preparing an international treaty on the matter, and it remains to be seen whether it will materialize.

Are you saying corporations are not obliged to respect human rights?

Zimmermann: Usually, there are treaties on the protection of human rights signed by States. As a result, Germany, for instance, is required to protect human rights.

Weiß: On the other hand, there is Bangladesh, for instance.

Zimmermann: According to these human rights protection treaties, Bangladesh has to ensure that companies in Bangladesh comply with minimum human rights standards. But the question is whether Germany is obliged to act on German companies doing business in Bangladesh to meet certain human rights standards. This way of thinking is by no means accepted by all countries. After all, human rights are the responsibility of States. So the question arises whether States are obliged to act on companies, even more so since delivery chains today are complex and 60 percent of a company's shares may be held by German investors, whereas the remaining 40 percent are foreign-owned.

Weiß: Such situations lead to well-known conflicts that are difficult to resolve not only in theory, but also in practice. When it comes to major international corporations, developing countries are not in a position to insist on the compliance with particular rules.

HUMAN RIGHTS CENTER (MRZ)

The **Human Rights Center** was set up in 1994. Today, it is a central research institution of the University of Potsdam. It promotes interdisciplinary research, teaching, and continuing education and provides policy consultations on human rights issues.

https://www.uni-potsdam.de/mrz/

Zimmermann: These countries do not have the necessary bargaining power.

Weiß: But what if the corporation itself was obliged to respect human rights or Germany would compel it to do so? Over time, the situation in Bangladesh might change.

Zimmermann: In a globalizing world, such developments have become particularly virulent. In the supermarket, we buy t-shirts made in Bangladesh for just two Euros – overlooking the fact that they were made by someone who is paid one dollar a day, in a factory with no air conditioning or fire precautions.

TRANSLATION: MONIKA WILKE

Illustration: AdobeStock/jhnuer

SOUND BY SOUND TOWARDS WORDS

LOLA Makes Language Learning Visible

Photo: AdobeStock/VictorSpboya

Human language is a fairly complex thing. But the same applies to the way it is spoken. Lungs, vocal cords, tongue, lips – many "tools" in our body must cooperate precisely so that in the end a simple word leaves our mouth. The linguist Dr. Aude Noiray is interested in this mechanism, but above all in how children learn the motor, lexical and phonological skills necessary to speak their native language fluently. To carry out this research, she founded the "Laboratory for Oral Language Acquisition", or LOLA in short. Here, she uses the most modern scientific methods to uncover how spoken language is acquired, its solution being actually on the tip of our tongue and yet so difficult to decipher.

In the beginning was the Word? It's still an empirical question. When babies start communicating with their caretakers, they may first produce simple vowel-like sounds. A simple coo that may even sound like screaming is sometimes the first step into oral communication: "Little by little, they then learn to coordinate their lungs with the speech articulators such as the jaw, lips, and tongue," Noiray explains. "They are exploring the possibilities of their new tools. And they seem to have a lot of fun doing it!" Only when they have become familiar with these processes do babies begin to combine sounds with one another. Dadada, bababa – for parents, their children's babbling brings great happiness and they often perceive for the first time that someone is practicing speaking. "It has been shown that this transition begins in many children, regardless of the languages they grow up with, around six to ten months of age," Noiray says.

Looking into babies' mouths

Aude Noiray has long been fascinated by the "attunement" of the motor system to language. She, however, faced two problems: Until a decade ago, it was difficult to examine what happened in the child's mouth. "We owe most of what we know about child articulation today to the acoustic analysis or transcriptions of sound recordings," she explains. To observe the oral cavity non-invasively, she combined established audio and video analyses with ultrasound imaging technology that had hardly been used in linguistic research on young children and never on babies. Since there were not any method for experimentally examining

Dr. Aude Noiray explains a mobile ultrasound device for testing babies

Photos: Hopfgarten, Tobias (2)

Experiment with ultrasound probe

the vocal tract using ultrasound imaging, Noiray and her team designed the method themselves: the Sonographic and Optical Linguo-Labial Articulatory Recording system, or SOLLAR in short. They mounted an ultrasound head, the so-called transducer, which emits the ultrasound waves, on a spring-mounted frame. The participants place their chin on the sensor head so that it moves up and down with the lower jaw when speaking. As a result, it is below the tongue and can record an optimal picture of the tongue movement while children speak. The ultrasound data are transferred to a monitor, as known from medical examinations, and of course, the data are saved for evaluation.

The device has already proven its value in various projects for language development in young children. "We were not sure whether we could examine three-year-olds," says the researcher. "One of the biggest challenges was to stimulate their attention. We have created a space journey to the stars as a background story. We brainstormed to develop ideas, optimized the process – and it worked!"

Noiray and her team now go one step further – in fact a step back. "When I wrote my first research proposal for a project with three-year-olds, colleagues told me, 'This will never work.' Today this has become completely normal. Thanks to the technical possibilities and the experience we built with young children, we are able to start at an increasingly earlier stage in language development. And that starts in the first months of life." In a current project, funded by the German Research Foundation (DFG), the LOLA researchers are investigating the phase during which the first dadada develops out of curious cooing, and simple sounds turn into the first attempts at spoken language articulation. "At the moment, we are primarily interested in what influence the first speech attempts of babies, when and how they process what is articu-

THE RESEARCHERS

Dr. Aude Noiray studied English, Language, Letter and Foreign Civilisation as well as Language Sciences at the Université Stendhal, Grenoble (France). Since 2012, she has been researching at the University of Potsdam – and is the group leader of LOLA, which was founded in January 2015.

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Photos: Noiray, Dr. Aude (top); Hopfgarten, Tobias (bottom)

lated by others." The starting point of the investigation is an observation: During the first six months of life, children mainly look at the eyes of those around them. But at some point, between the eighth and tenth month, research has shown they focus more frequently on people's mouth, especially when the mouth is moving. "In fact, some babies even look at the mouth even before the first sound is produced – as if they were anticipating and understanding, 'This is an important place that can help me learn to speak myself,'" says Noiray.

Reading language from the mouth

The project aims at finding out whether there is a connection between the children's change of gaze from the eyes to the mouth area and their spoken language development. "It is quite conceivable that babies who start watching the mouth very early are more likely to start babbling earlier," says Noiray. The main challenge in this study is not just to observe what happens in the mouth but also the eyes. In addition to audio, video and ultrasound analyses the team also integrated eye tracking to record the eye movements into the experiment. And again, the little test subjects prove to be a great challenge, as Noiray says. "Some children are distracted very quickly; others are fascinated by the ultrasound screen that they look there or notice the transducer and no longer look at the video presented. Then the recordings are of course useless. We also can't keep most of them at it for more than five minutes. That's really short – and has forced us to adapt the whole procedure." All babies are "warmed up" together with their parents in a 30-minute playing phase before they are shown videos in which people begin to speak at some point. If the young participants allow it, their spoken communication is extensively documented – with a video camera, the ultrasound device, and a microphone. As soon as enough data is collected, the researchers will evaluate it. "We are curious which connections we will find," says Noiray. "Does the gaze 'shift' from eyes to the mouth indicate the beginning of a new developmental stage of speech production? Or is it rather the other way around – the children first start babbling, then discover the mouth of their interlocutor and prefer looking at the mouth instead of the eyes?"

So far, about 100 babies have been recorded, some even several times over a period of months. "A real stroke of luck," Noiray says. "Because we can follow their language development in detail and relate it to the findings of our study." This is also very important for potential applications of the research results, for example when treating language development disorders. "The more we know about how babies learn to speak, the better we can deal with delays or even disruptions to this development – perhaps even before they have a negative impact."

MATTHIAS ZIMMERMANN
TRANSLATION: SUSANNE VOIGT

THE LAB

The researchers of the **Laboratory for Oral Language Acquisition (LOLA)** research the development of language – from infancy to puberty. Research topics include the development of speech motor control, perceptual, phonological, and lexical development, the relationship between language planning and language production, and reading comprehension. In their experiments, they work with audio and video recordings, eye tracking, ultrasound and various speech and reading evaluations.

https://www.uni-potsdam.de/lola/index.html

Photo: Noiray, Dr. Aude

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