Portal Wissen

The Research Magazine of the University of Potsdam

One 2019

ARTIFICIAL INTELLIGENCE

Contents

Imprint

Portal Wissen
The Research Magazine of the University of Potsdam
ISSN 2194-4237

Publisher: Press and Public Relations Department on behalf of the President of the University

Editors: Dr. Silke Engel (resp.), Matthias Zimmermann

Contributions: Petra Görlich, Antje Horn-Conrad, Heike Kampe, Karoline Schlegel

Translation: Monika Wilke, Susanne Voigt

Address of the Editorial Office:
Am Neuen Palais 10, 14469 Potsdam
Phone: (0331) 977-1474
Fax: (0331) 977-1130
Email: *presse@uni-potsdam.de*

Photos/Figures: AdobeStock 38/39 (bluedesign), 36 (Jale Ibrak), 12/13 (phonlamaiphoto), 34/35 (tuahlensa), 15u. (vegefox.com), 14u. (vexworldwide); DESY 31 (Milde Science Communication), 28/29 (Science Communication Lab); Fritze, Karla 90.li., 90.re., 110.li., 11u., 24(2), 27(3), 320., 32M., 33, 370., 37M., 440., 48/49, 50M.; G. Pérez, IAC, SMM 32u.; Gehendges, Marco 37u.; Hölzel, Thomas 500., 50u.(2), 510. li., 510.re.; Hopfgarten, Tobias 19, 200.(2), 96(4); Humboldt, Alexander von: Tagebücher der Amerikanischen Reise IV: Journal de la navigation sur l'Apure, l'Orenoque; le Cassiquiare et le Rio Negro (Voy. Par les Llanos de Caracas à S. Fernando de l'Apure). Statistique de Cumanas Pta Araya, S. 235–236 22/23; Kaczynski, Ernst 9u., 110.re.; Roese, Thomas 140., 150., 16, 17; Staatsbibliothek zu Berlin – PK, Carola Seifert 26; Thornton, Mike 40, 41u.re.; Töpfer, Andreas 1, 3, 4/5, 6, 7, 8, 10, 18, 20u., 21, 42, 43, 44u., 45, 46, 47, 56; Wigge, Philip 410., 41u.li.; Wikimedia/gemeinfrei 25; Zehbe, Dr. Kerstin 52/53

Layout/Design: unicom-berlin.de

Editorial deadline for next issue: 31. May 2019

Advertisements:
unicom MediaService,
Phone: (030) 509 69 89 -15, Fax: -20
Applicable price list for advertisements: No. 1
www.hochschulmedia.de

Print: Brandenburgische Universitätsdruckerei und Verlagsgesellschaft Potsdam mbH
Circulation: 1,500 copies

Portal Wissen online at
www.uni-potsdam.de/portal

ARTIFICIAL INTELLIGENCE

For a long time, there were things on this planet that only humans could do, but this time might be coming to an end. By using the universal tool that makes us unique – our intelligence – we have worked to eliminate our uniqueness, at least when it comes to solving cognitive tasks. Artificial intelligence is now able to play chess, understand language, and drive a car – and often better than we.

How did we get here? The philosopher Aristotle formulated the first "laws of thought" in his syllogisms, and the mathematicians Blaise Pascal and Wilhelm Leibniz built some of the earliest calculating machines. The mathematician George Boole was the first to introduce a formal language to represent logic. The natural scientist Alan Turing created his deciphering machine "Colossus," the first programmable computer. Philosophers, mathematicians, psychologists, and linguists – for centuries, scientists have been developing formulas, machines, and theories that were supposed to enable us to reproduce and possibly even enhance our most valuable ability.

But what exactly is "artificial intelligence"? Even the name calls for comparison. Is artificial intelligence like human intelligence? Alan Turing came up with a test in 1950 to provide a satisfying operational definition of intelligence: According to him, a machine is intelligent if its thinking abilities equal those of humans. It has to reach human levels for any cognitive task. The machine has to prove this by convincing a human interrogator that it is human. Not an easy task: After all, it has to process natural language, store knowledge, draw conclusions, and learn something new. In fact, over the past ten years, a number of AI systems have emerged that have passed the test one way or another in chat conversations with automatically generated texts or images. Nowadays, the discussion usually centers on other questions: Does AI still need its creators? Will it not only outperform humans but someday replace them – be it in the world of work or even beyond? Will AI solve our problems in the age of all-encompassing digital networking – or will it become a part of the problem?

Artificial intelligence, its nature, its limitations, its potential, and its relationship to humans were being discussed even before it existed. Literature and film have created scenarios with very different endings. But what is the view of the scientists who are actually researching with or about artificial intelligence? For the current issue of our research magazine, a cognitive scientist, an education researcher, and a computer scientist shared their views. We also searched the University for projects whose professional environment reveals the numerous opportunities that AI offers for various disciplines. We cover the geosciences and computer science as well as economics, health, and literature studies.

At the same time, we have not lost sight of the broad research spectrum at the University: a legal expert introduces us to the not-so-distant sphere of space law while astrophysicists work on ensuring that state-of-the-art telescopes observe those regions in space where something "is happening" at the right time. A chemist explains why the battery of the future will come from a printer, and molecular biologists explain how they will breed stress-resistant plants. You will read about all this in this issue as well as about current studies on restless legs syndrome in children and the situation of Muslims in Brandenburg. Last but not least, we will introduce you to the sheep currently grazing in Sanssouci Park – all on behalf of science. Quite clever!

Enjoy your read!
THE EDITORS

Illustration: Töpfer, Andreas

“Alexa, are you intelligent?”

Artificial Intelligence and What We Need It For

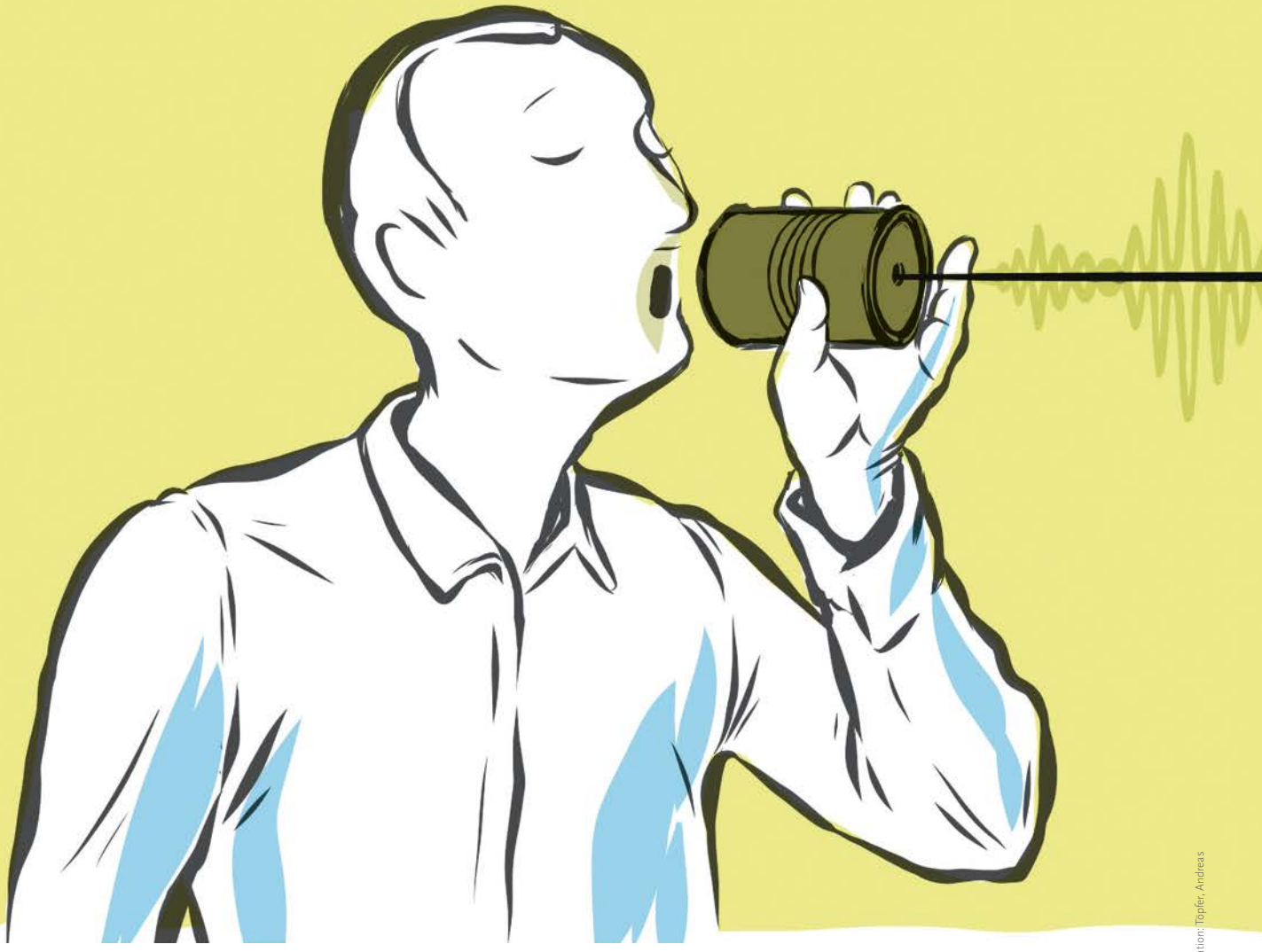
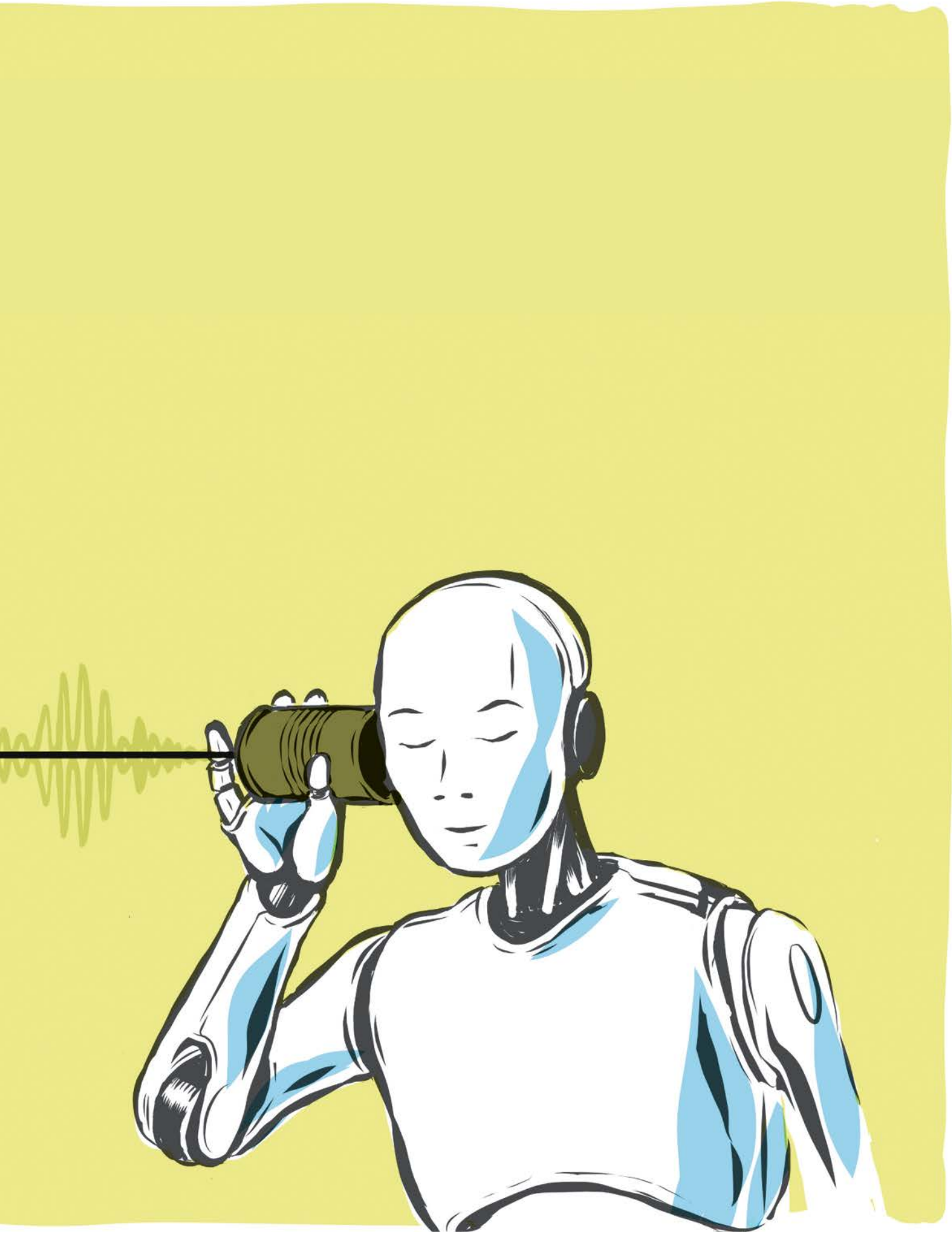


Illustration: Töpfer, Andreas



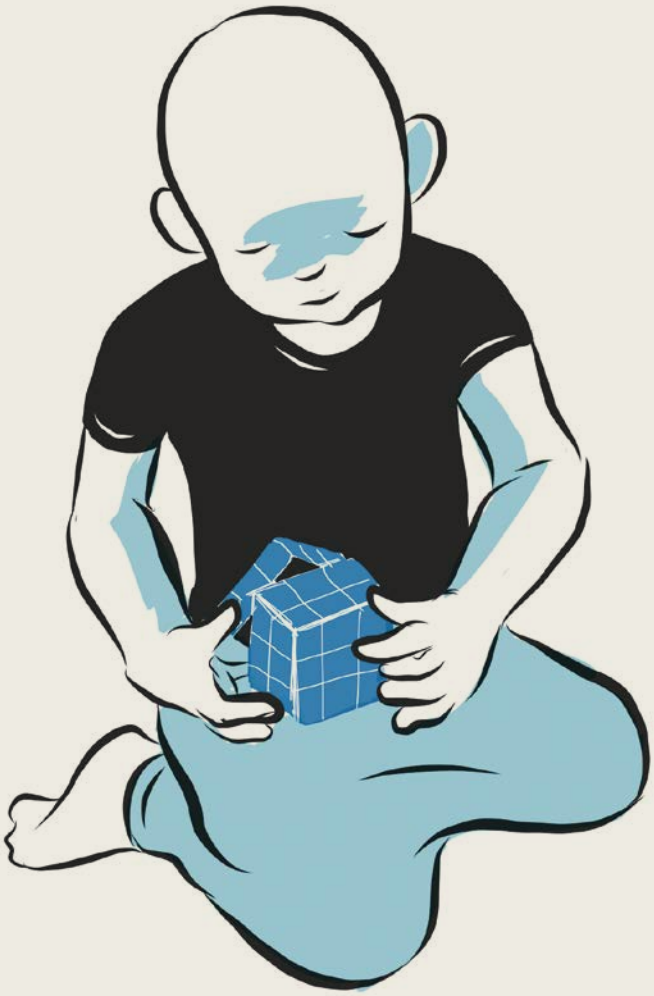
When you ask e-commerce giant Amazon's virtual assistant about its intelligence, you will hear, "Yes, I think, therefore I am." Alexa has learned this from eager employees of the world's biggest online retailer. But is there any truth in it? How intelligent are the systems being widely referred to as "artificial intelligence"? What actually is artificial intelligence (AI)? What makes it intelligent? And how much is AI changing our lives? For the cover story, Matthias Zimmermann interviewed cognitive scientist Prof. Reinhold Kliegl, educational researcher Prof. Rebecca Lazarides, and computer scientist Prof. Tobias Scheffer.

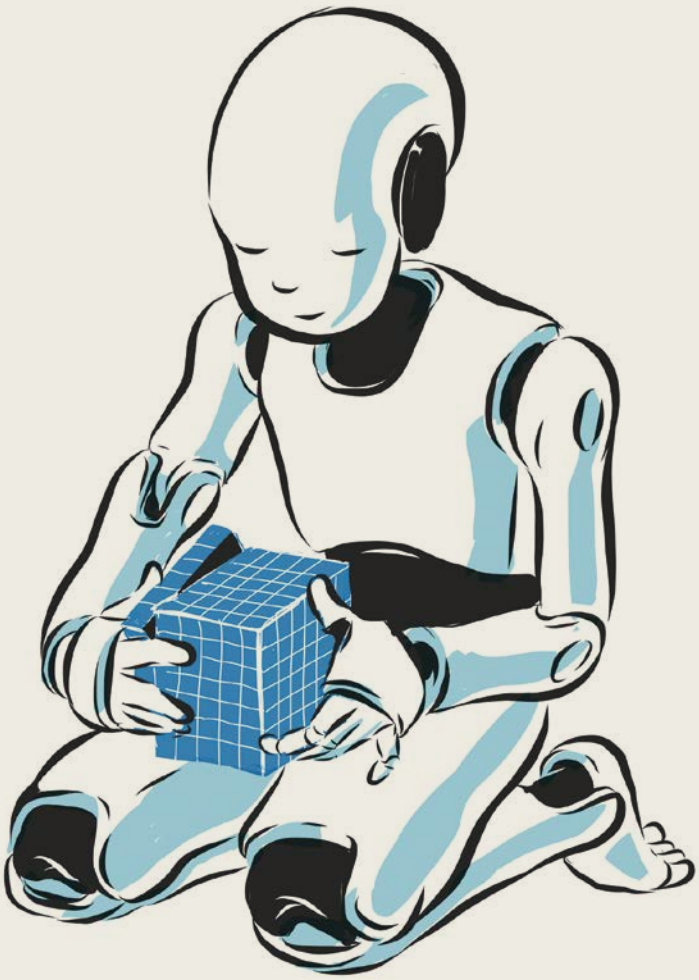
What actually is artificial intelligence, and what makes it different from human intelligence?

Lazarides: In general, it is related to development of computer programs or machines that behave in ways that we would call intelligent in humans. However, there is no single, clear definition of artificial intelligence but rather many different ones. It is similar when it comes to human intelligence – a report issued by the Board of Scientific Affairs of the American Psychological Association describes it as follows: "Indeed, when two dozen prominent theorists were recently asked to define intelligence, they gave two dozen, somewhat different, definitions."

Kliegl: Artificial intelligence is the area within computer science that constituted the cognitive sciences in the 1950s together with experimental psychology and some sub-areas of linguistics. The common goal of this "interdiscipline" was and is a theoretically grounded explanation of genuinely human achievements such as perception, memory, language, thinking, problem-solving, and the control of actions. AI is, thus, cognition implemented in a computer or robot that simulates complex human behavior. These sim-

Illustration: Töpfer, Andreas





ulations not only have to reproduce proper behavior but also typical human errors if they are to serve as an explanation of human behavior. In the application-oriented engineering context of AI, you don't want errors, of course. The goal is to build programs that work fast and error-free. These conflicting goals mean that AI and human intelligence research are very different. What they have in common is that they use well-defined maximum human performance as a benchmark (e.g., chess, Go, image and speech recognition). The cognitive sciences try to explain these types of performance; AI often takes such explanations as a heuristic starting point but tries to surpass them.

Scheffer: Broadly speaking, human intelligence is considered to be what is measured by an intelligence test, but Ms. Lazarides has already said that there is no real definition. The research field "Artificial Intelligence" deals with a variety of problems whose solution is considered to be intellectual performance in a person. Today's AI systems solve specific tasks, for example playing Go or comparing people in video recordings with their passport photos. A complete artificial intelligence would be a technical system that is at least equal to a human with regard to all intelligence achievements.

Lazarides: In the "Science of Intelligence" Cluster of Excellence at Technische Universität Berlin and Humboldt-Universität zu Berlin, we define intelligent behavior as goal-oriented, cost-efficient (e.g. physical, calculative costs), and behavior that can be transferred to a real-life environment. From an interdisciplinary perspective, we analyze the overriding principles of such behavior. We use our research to better understand the intelligent behavior of humans and to create new intelligent technologies. In my sub-project, I am interested, for example, in how intelligent tutorial systems and learning robots (social learning companions) can be used to support social learning processes in school.

Illustration: Töpfer, Andreas

Is that comparison helpful or an obstacle?

Scheffer: With its visionary goal of transferring intelligence to technical systems, artificial intelligence defines itself as an ambitious field of research. This has helped AI to attract attention and ambitious young researchers since the 1950s. Bruce Lee reportedly said that you need not necessarily achieve every goal, but the goal could also serve as something to strive for.

Kliegl: We need computer models to understand the dynamics of complex cognitive processes that underlie human intelligence. Technical hardware and software developments in AI provide increasingly better tools for these models. I definitely see advantages in that AI and human intelligence research have common benchmarks.

What is AI able to learn from human intelligence and vice versa?

Lazarides: To answer exactly this question, our cluster uses a synthetic approach. We combine the research of "analytical disciplines" like sociology and educational science with the research of "synthetic disciplines" like robotics and computer science. Unlike humans and animals, synthetic artifacts such as robots can be manipulated and modified more easily. This enables us to monitor different behaviors closely as part of such manipulations. Robots, for example, can be programmed to solve tasks very slowly, regardless of the environment. Other robots can be programmed to do things very quickly. With these robots, we can then test specific teaching-learning techniques and, thus, find out more about learning processes that also help us better understand human leaning. On the other hand, we observe behavior in humans that we don't find in AI experiments and have to expand certain concepts that we use for our work with AI systems.

Scheffer: I think that the ability to learn is the core of intelligence. Today, for example, AI systems use the data we leave behind to learn how to translate texts from one language to another, identify pedestrians and their intentions in traffic, or to assess credit default risks. One of the few AI systems that cannot learn anything from humans anymore is the Go program AlphaGo Zero. While earlier software versions learned from databases of human Go games, the current version learns only from games against itself. Human players are far behind and describe AlphaGo as "supernatural". The world's top Go player Ke Jie even declared AlphaGo the God of Go.

Kliegl: In comparison, humans are characterized by their ability to generalize and adapt to new situations. A weakness of AI programs compared to human intelligence is their specificity. So far, almost all of them have worked for only very narrowly described applications. Humans are characterized by their ability to generalize and adapt to new situations. This is certainly an area in which AI can learn from humans. An example of how this weakness is currently being overcome has recently been published. There is now AlphaZero, which beats AlphaGo Zero in

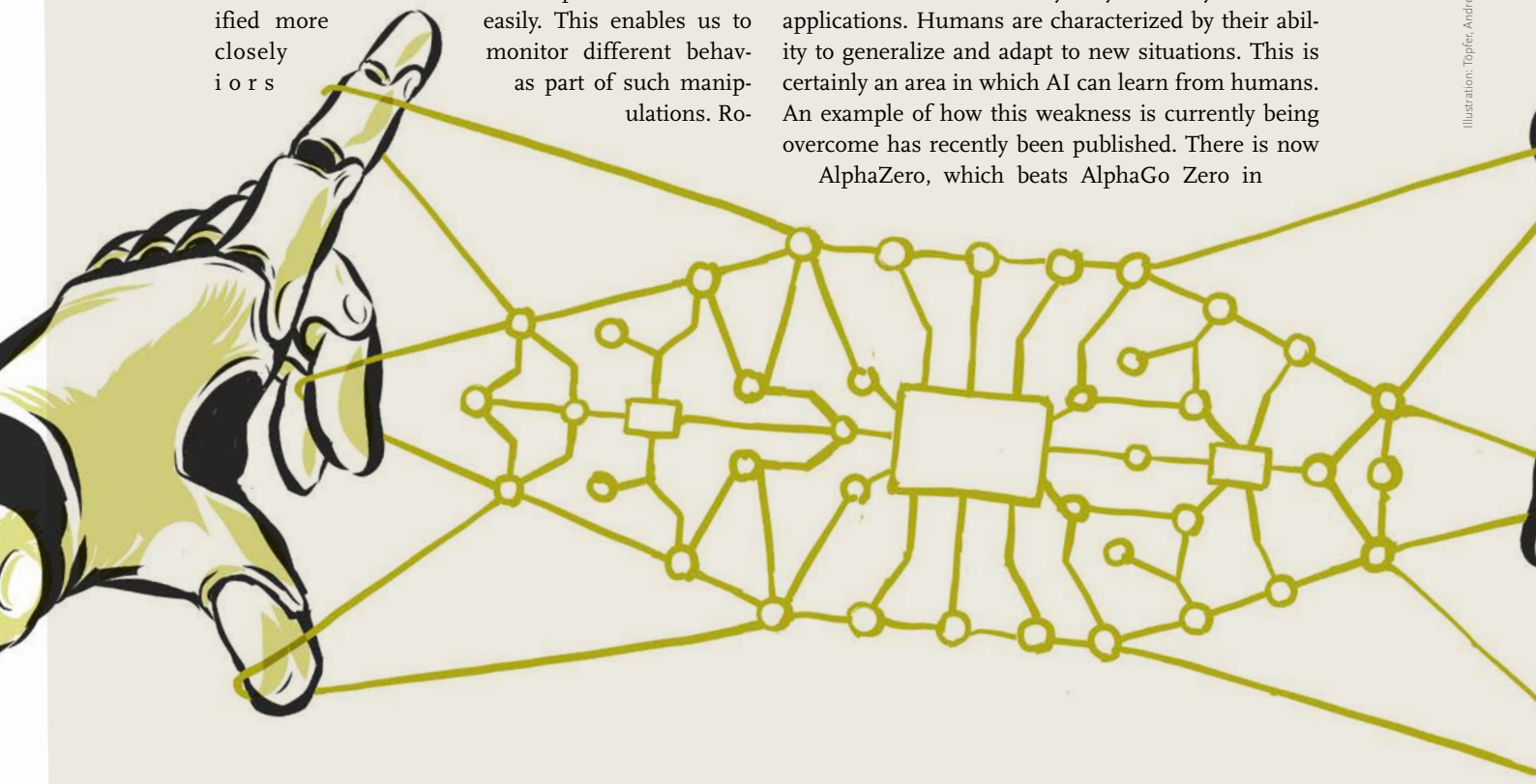


Illustration: Töpfer, Andreas

Prof. Dr. Tobias Scheffer.

Prof. Dr. Reinhold Kliegl.

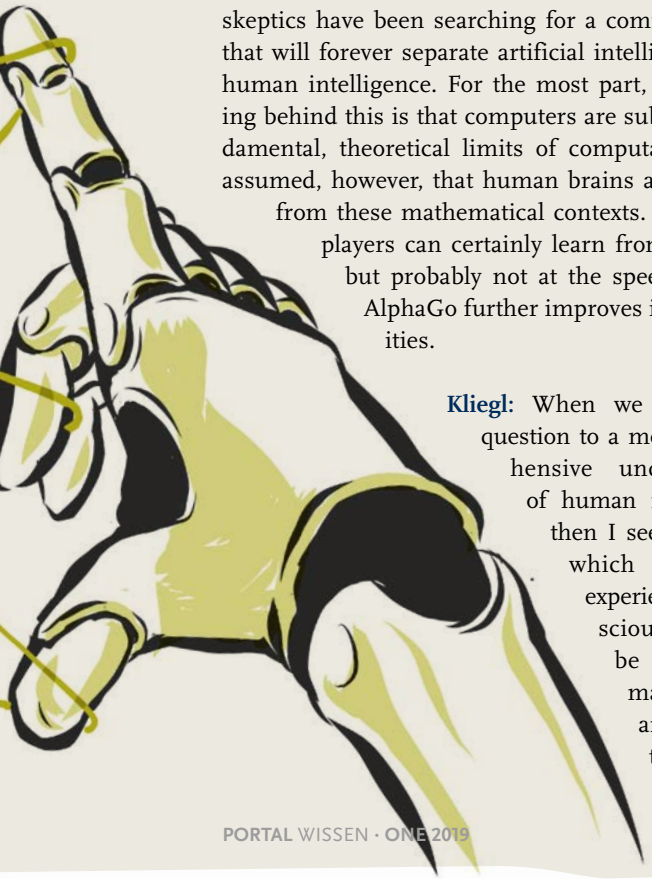
Prof. Dr. Rebecca Lazarides.

Photos: Kaczynski, Ernst (o.); Fritze, Karla (2)

Go, the best chess program, and the best Shogi (Japanese chess) program. AlphaZero not only learns nothing from humans but by combining a very general learning principle with the search algorithms used for the Go program, the Go performance was able to be transferred to the two chess variants. The general learning principle (reinforcement learning) "rewards" goal-oriented moves.

What is AI not able to learn from human intelligence and vice versa?

Scheffer: Since the birth of this field of research, skeptics have been searching for a common thread that will forever separate artificial intelligence from human intelligence. For the most part, the reasoning behind this is that computers are subject to fundamental, theoretical limits of computability. It is assumed, however, that human brains are excluded from these mathematical contexts. Human Go players can certainly learn from AlphaGo, but probably not at the speed at which AlphaGo further improves its own abilities.



Kliegl: When we relate this question to a more comprehensive understanding of human intelligence, then I see no way in which subjective experience or consciousness can be plausibly mapped onto artificial intelligence. I can't really imagine that a computer program that claims to be very happy because it solved a problem feels the same as a human. I also don't know how we could possibly know that.

Does AI need humans, and do humans need AI? And, if so, what for?

Scheffer: Today, AI needs humans. With each CAPTCHA we solve, we create new training data for image processing models. The Watson AI system, which won the Jeopardy! game show in 2011, learns from books written by humans, and now also from medical publications. On the other hand, humans benefit enormously from AI. The equivalent of a Google search used to be an afternoon in the library. With the help of automatic translations, we can now also understand Chinese texts to some extent.

Kliegl: In most cases, the performance of the currently best-known AI programs for voice and image recognition are often based on gigantic databases of human behavior that are indispensable for training the algorithms that underpin AI performance. However, as I said, this is no longer the case for chess, Shogi, and Go. We use AI products – often unknowingly – in our everyday life. Without AI, we will probably not be able to get to grips in the future with the current problems facing humanity, which we have also generated with technological progress.

Lazarides: I see a mutual relationship between humans and AI, which interests me particularly with regard to research processes. As researchers we benefit a lot from working with AI, for example when we want to find out more about learning processes. AI is very useful for answering questions concerning human learning. On the other hand, by dealing with human learning processes we learn more about effective learning of AI systems. In this respect, we use – and need – it in our everyday life but also in research.

How will AI change our lives – now and in the future?

Lazarides: As a junior professor of school pedagogy, I am particularly interested in this question with regard to education processes in school. This includes the question of what significance AI will have on school education in the future. One of the challenges of educational research is to explore the role of AI in supporting human teaching and learning in the classroom. On the other hand, there is the question as to how schools can impart the skills to children and adolescents that will allow them to engage in the self-determined and responsible use of AI. It also means discussing and reflecting on related opportunities and challenges.

Scheffer: Artificial intelligence has yet to come close to reaching its potential. For example, AI is part of search engines, voice input, music recommendations, and facial recognition. In the foreseeable future, it will drive vehicles autonomously. In precision medicine, it will replace chemotherapy with more compatible, personalized therapies. In precision agriculture, it will help produce healthier foods with less energy, water, and pesticide.

Kliegl: These examples show that our lives are already permeated with AI in many different ways and that this is only the beginning. A challenge for the future will be ensuring that AI-based decisions are fair and transparent and offering ethically responsible options for action. There are coordinated efforts to make AI technologies fruitful for very many and

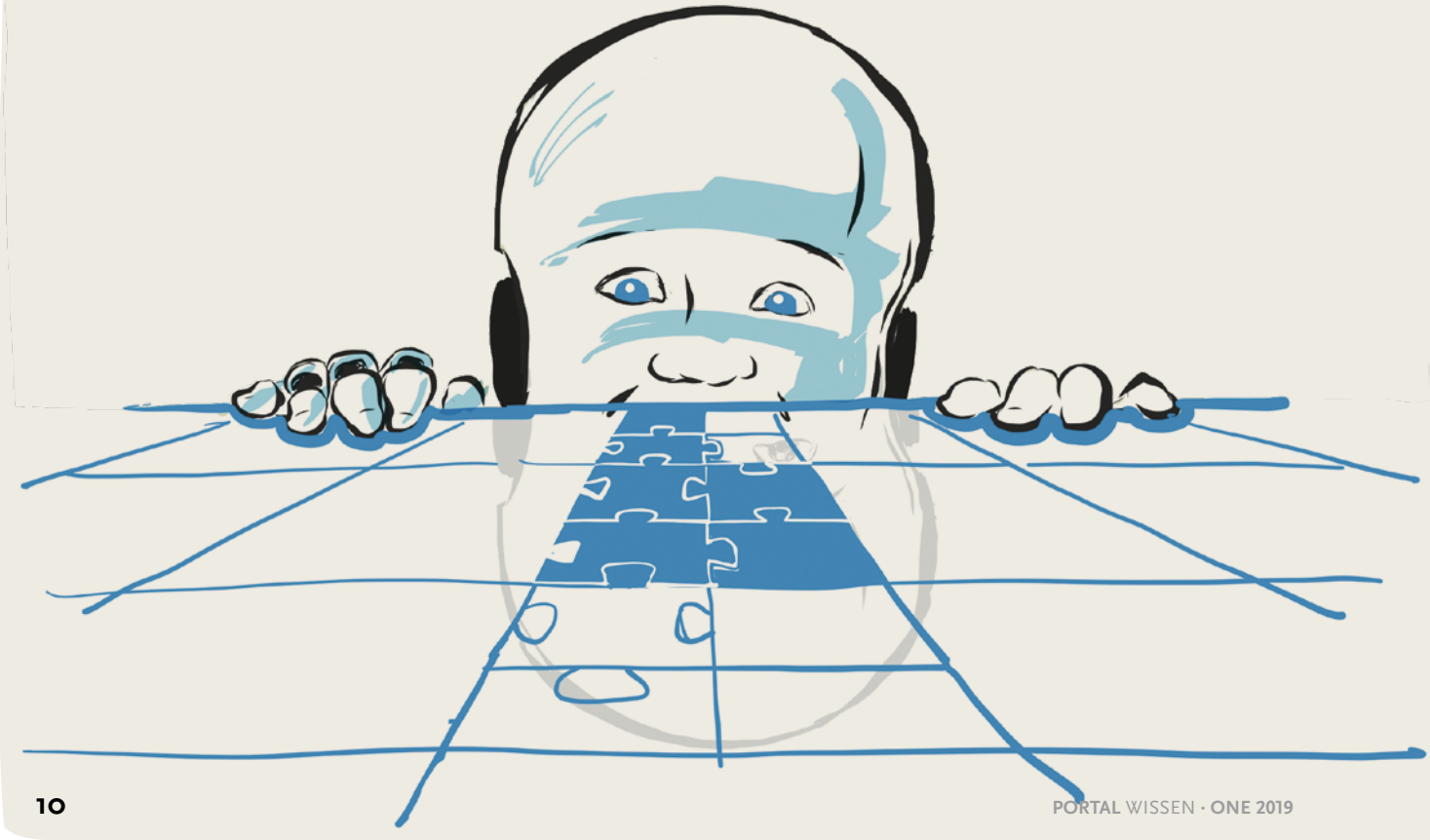


Illustration: Töpfer, Andreas

THE RESEARCHERS

Prof. Tobias Scheffer is Professor for Machine Learning at the University of Potsdam. He was coordinator of the Emmy Noether Junior Research Group at Humboldt-Universität zu Berlin and was head of the Machine Learning working group at the Max Planck Institute for Informatics in Saarbrücken. In a joint project with the Max Planck Institute for Molecular Genetics, he is working on machine learning methods for cancer therapies. Together with Cisco, he is developing learning methods for the detection of computer viruses and attacks on networks. In other projects, he is developing learning methods for on-board diagnostics in cars and modeling credit default risks. He is a member of the Collaborative Research Center "Data Assimilation" at the University of Potsdam.

✉ scheffer@cs.uni-potsdam.de

Prof. Dr. Rebecca Lazarides is Junior Professor of School Pedagogy (equivalent to Assistant Professor) with a research focus on learning and instruction at the University of Potsdam. After studying educational science at Freie Universität Berlin, she earned a doctoral degree at Technische Universität Berlin. Her PhD thesis dealt with the role of instruction for student motivation in mathematics. Her research interests include learning and instruction processes, particularly with regard to the classroom dynamics that optimally promote the motivational and affective development of students in secondary school. In this context, Lazarides, who is Principal Investigator of the "Science of Intelligence" Cluster of Excellence at Technische Universität Berlin and Humboldt-Universität zu Berlin, examines the role of robot-based learning companions in increasing classroom motivation.

✉ lazaride@uni-potsdam.de

Prof. Dr. Reinhold Kliegl is Professor of Experimental Psychology with a research focus on cognition. After earning his doctorate at the University of Colorado, he worked at the Max Planck Institute for Human Development. Since 1993, he has been working at the University of Potsdam. He focuses on how the dynamics of language-related, perceptual, and oculomotor processes influence reading, spatial attention, and working memory tasks and examines neural correlates and age-related differences in these processes. In the CRC "Limits of Variability in Language", Kliegl researches whether borders in syntactic variability can be shifted with training. His current research also focuses on the modeling of the relationship between cognitive and physical fitness and individual differences in children and older adults in these processes.

✉ kliegl@uni-potsdam.de

very diverse problems facing humankind. The program of the "AI for the Social Good" workshop at the 2018 NeurIPS conference, for example, provided an overview.

How is AI changing your life and your research?

Scheffer: Machine learning has been my main research interest from the very beginning.

Lazarides: In my research, I address the question of how to implement AI in pedagogically meaningful and goal-oriented teaching-learning settings. By dealing with the role of AI systems for teaching and learning processes, I am also changing my own research, which is becoming more interdisciplinary. In the Cluster of Excellence, for example, I collaborate with researchers from the fields of computer science and robotics. In general, it is still important to effectively support students in their learning according to their individual needs and to empirically investigate related theoretical questions. What the explicit benefit of AI systems will be, however, plays a greater role.

Kliegl: Artificial intelligence provides methods that are very important for my research. I hardly see any possibilities for us to test theories about the dynamics of complex cognitive processes and the behavior they control or by which they are controlled without modeling experimental and observational data. Take eye movement control when reading or looking at images as an example of the interplay of perception, knowledge, memory, speech, and programming and the execution of eye movements. AI methods are indispensable for understanding how these processes are orchestrated. But it is important that we do not confuse the methods of AI that we use to test our theories with the theories themselves.

TRANSLATION: SUSANNE VOIGT

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

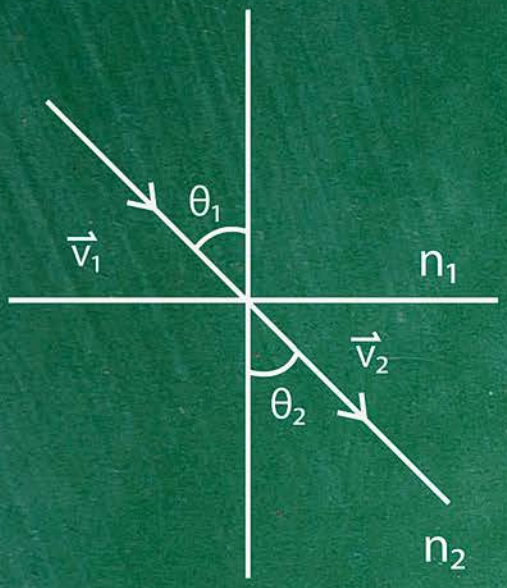
$$ab+ac = a(b+c)$$

$$a\left(\frac{b}{c}\right) = \frac{ab}{c}$$

$$\frac{\left(\frac{a}{b}\right)}{c} = \frac{a}{bc}$$

$$\frac{a}{\left(\frac{b}{c}\right)} = \frac{ac}{b}$$

$$\frac{a}{b} + \frac{c}{d} = \frac{ad+bc}{bd}$$



$$\bar{x}_1 = \frac{1+3+3+6+8+9}{6} = 5$$

$$\bar{x}_2 = 2+4+4+8+12 = 30$$

$$\bar{x}_3 = 4+7+1+6 = 18$$

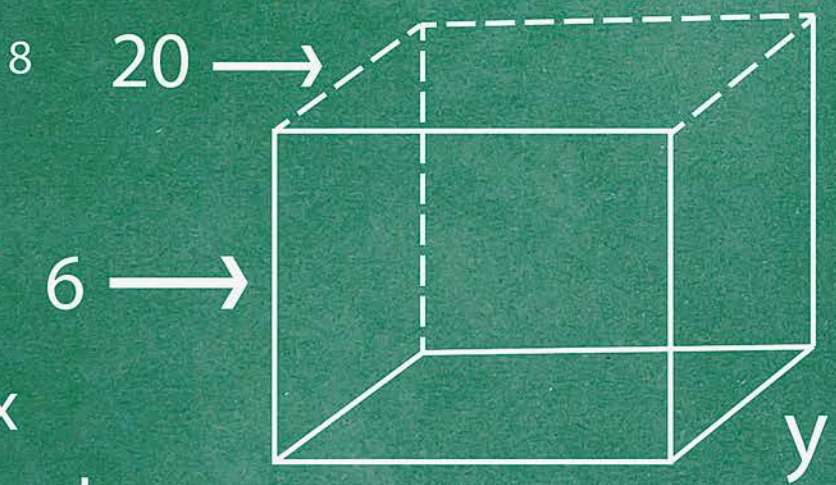
$$\log_b b^x = x$$

$$\log_a x = \frac{\log_b x}{\log_b a}$$

$$\log_b (x^r) = r \log_b x$$

$$\log_b (xy) = \log_b x + \log_b y$$

$$\log_b \left(\frac{x}{y}\right) = \log_b x - \log_b y$$



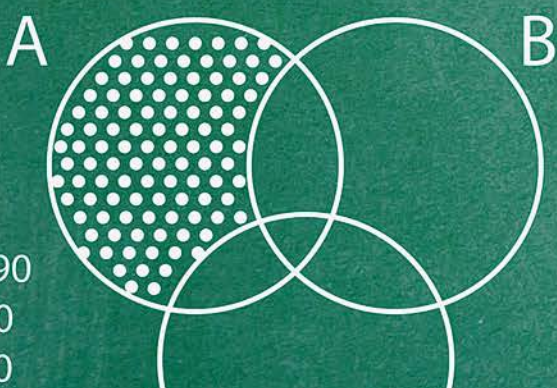
$$a(bc) = (ab)c$$

$$a+b = b+a$$

$$a(b+c) = ab+ac$$

$$126 = 6xy$$

$$2x + 2y = 20$$



$$(x)\ (2x+3) = 90$$

$$2x^2+3x-90 = 0$$

$$(2x+15)\ (x-6) = 0$$

$f(x)$

$X^2 - 4X + 5$

$X^2 - 4X$

$n(B \cap C) = 22$

$n(B) = 68$

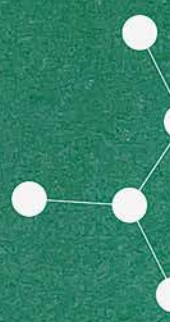
$n(C) = 84$

$n(B \cup C) = n$

He =

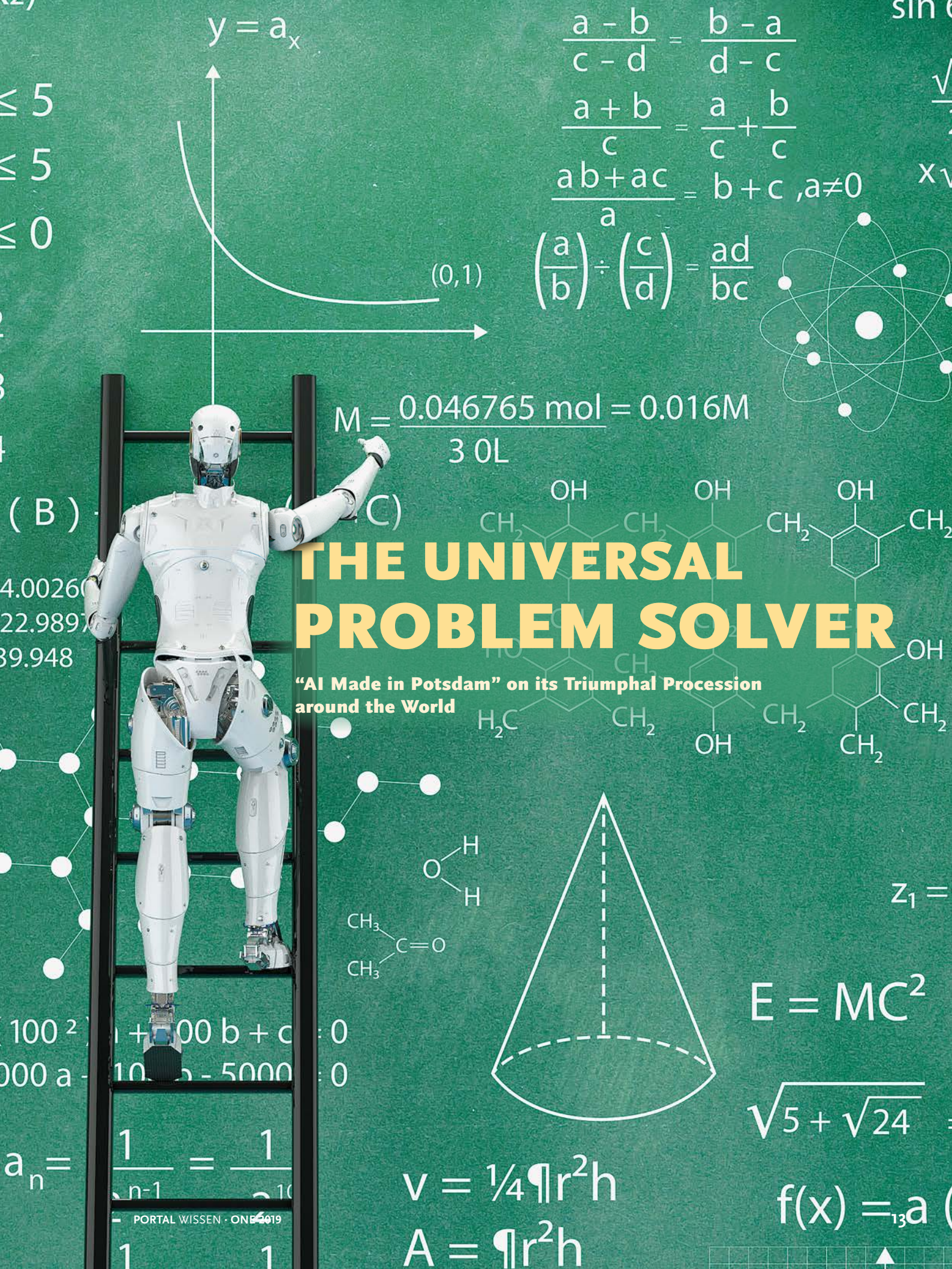
Na =

Ar =



100

Illustration: AdobeStock/phonlamaiphoto



THE UNIVERSAL PROBLEM SOLVER

"AI Made in Potsdam" on its Triumphal Procession around the World

People have always had to solve tricky problems. But with the accumulation of more and more data, new challenges have emerged that are often too complex for us. This is where Clasp comes in – a computer program developed by Potsdam computer scientist Torsten Schaub and his team. For Clasp, problems can hardly be difficult enough: From the best possible course schedule for an entire university or the optimal organization of a huge warehouse, to the autonomous composition of musical works, there is little the program cannot do. The trickier the problem, the better.

Torsten Schaub is Professor of Knowledge Processing and Information Systems at the University of Potsdam. It was by mere coincidence that he learned of his program's biggest success so far: At the annual Artificial Intelligence Conference in New York in 2016, researchers of the Canadian University of British Columbia presented a highly complex problem – and the tool they intended to use for its solution, Clasp. The researchers had been commissioned by the US Federal Communications Commission (FCC) to organize the redistribution and auction of broadcasting licenses in the United States. What sounds quite straightforward turned out to be an enormous challenge: Existing frequencies had to be split up into new ones while avoiding interferences. In addition, the large number of frequencies had to be available at almost the same time to be put up for auction. The resulting mathematical formula contained millions of variables. Just the thing for Clasp, as it turned out!

THE RESEARCHER

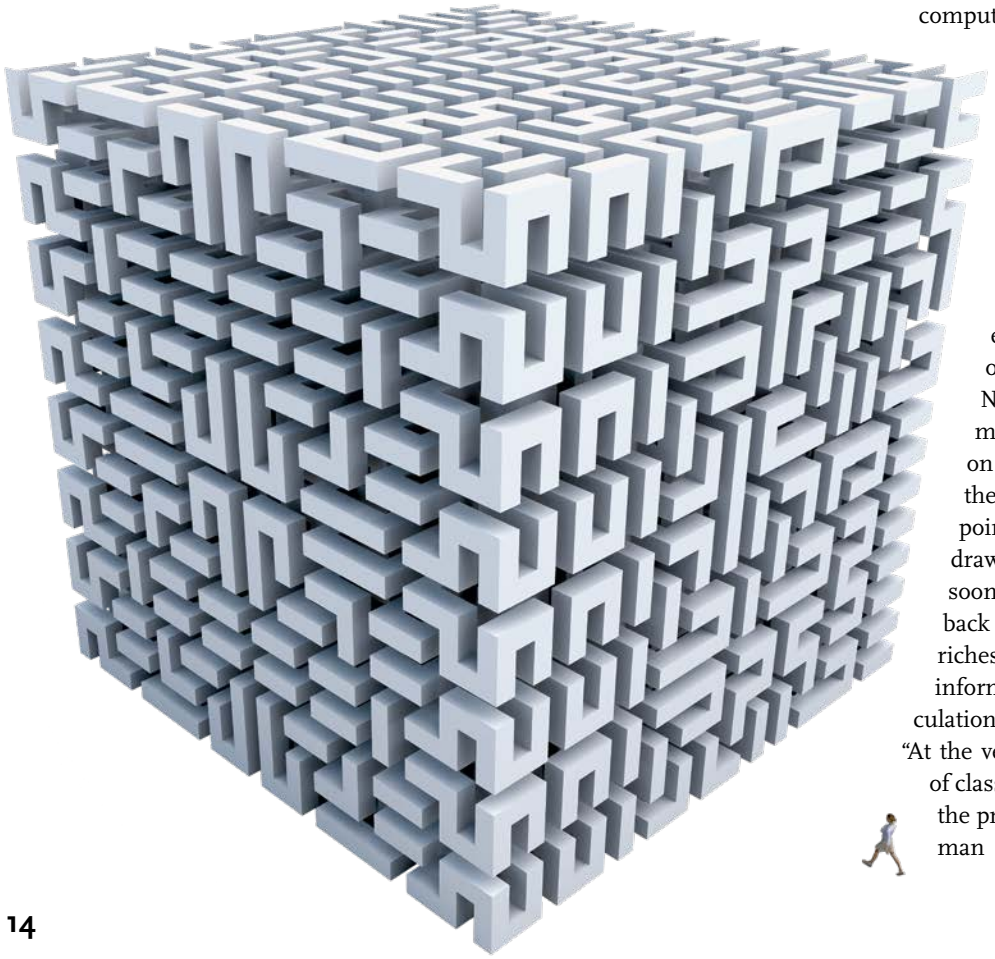
Prof. Dr. Torsten Schaub studied computer science at the Technical University of Darmstadt, where he also earned his doctorate. He has been the Professor of Knowledge Processing and Information Systems at the University of Potsdam since 1997.

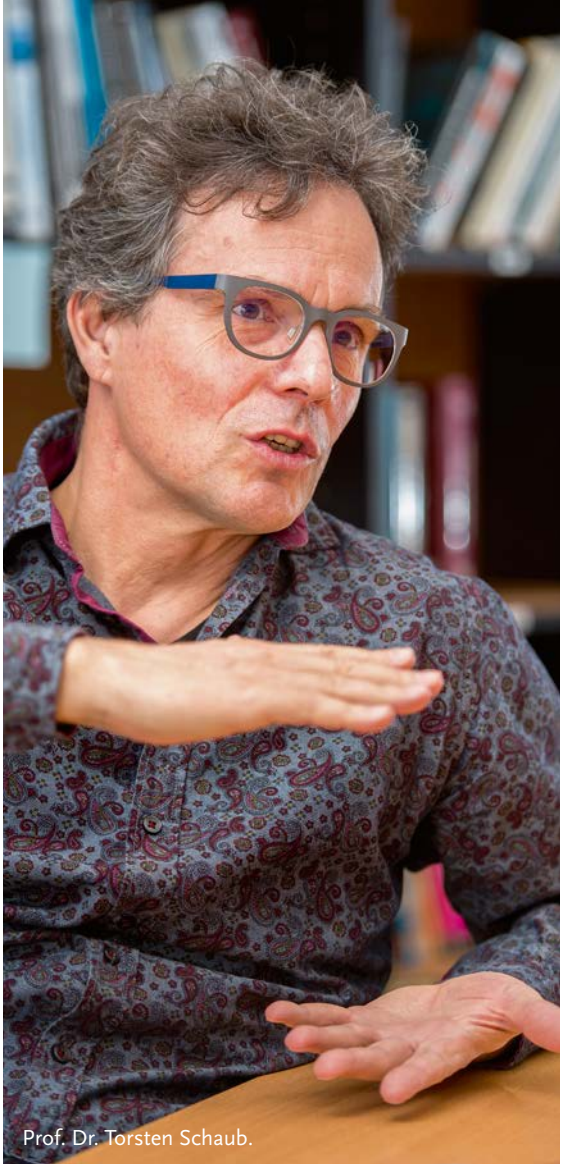
✉ torsten@uni-potsdam.de

AI searching for conflicts

Clasp is a conflict-driven answer set solver. "A universal problem solver," as Schaub puts it. "It solves the most diverse combinational optimization problems, the ones that are particularly knowledge-intensive and contain many variables." That is why Clasp is considered artificial intelligence. While for a long time, software did only exactly what it had been programmed for, AI systems such as Clasp unfold their full potential when "fed" with a problem. "A normal computer program isn't intelligent, it doesn't make decisions, as the solution path is laid down in its program code," Schaub explains. But Clasp is different. "We just define the problem, the solution path is found autonomously." This is possible because the system consists of mathematical algorithms capable of learning from mistakes. Not only can Clasp deal with mistakes, it actually depends on them. "When solving a task, the system starts at an early point to look at conflicts and draw conclusions from them. As soon as a conflict occurs, it jumps back to the root of the conflict, enriches the problem with the new information, and continues its calculations," Schaub says.

"At the very beginning, we used a lot of classic combinatory tasks such as the problem of the travelling salesman (see box)." We also included





Prof. Dr. Torsten Schaub.

Sudoku puzzles among the early training tasks. Today, this example is used to introduce students to the topic. "They can easily relate to it, since everyone is a Sudoku expert in one way or another," Schaub says with a smile. But soon the first real applications began. For instance, information scientists at the University of Potsdam teamed up with biologists in the analysis of biological networks. With the help of Clasp, the researchers drew up timetables for entire universities that had to combine rooms, times, and professors for several thousand courses. And the results outdid those of any other program to this day. Over the years, students, PhD candidates, and staff members have applied Clasp in more and more fields to solve problems as diverse as the control of robot swarms, optimum shelf space allocation, route-planning for logistics operators, the design of embedded systems in vehicles, or the autonomous composition of musical works. Some years into its development, Schaub and his team began to stabilize the system. It was ready for everyday applications.

Now in worldwide use

Since Clasp and some "related" solver systems were developed as part of a project funded by the German Research Foundation (DFG), they have been open-source and free since the beginning. Over the years, they have been downloaded more than 160,000 times. "Today, our software is so popular that I can't even tell who is using it," Schaub states. In any case, it is well-known for being used in the configuration of the open-source operating system Linux. Clasp makes the decision on what versions of what components may be uploaded to a certain computer to make it run smoothly. But it did not take long before businesses discovered the potential of the system. In the redistribution of net frequencies in the US in the summer of 2016, it did a good job and helped save several billion dollars.

The success of Clasp is based on two important features: First, the system is among the world's most

The **traveling salesman problem** is one of the best-known combinatorial optimization problems. The task is to find the shortest possible route for visiting several cities, while ensuring that no city is visited twice and the salesman returns to the original city. If you do not take the terms "city" and "route" literally, but mathematically, they describe a widespread mathematical problem that appears in many contexts, from route planning to the design of microchips and genome sequencing. The more additional conditions are added to the "route", the more complex the problem gets. By the way, there are 43,589,145,600 possibilities for the traveling salesman to visit the 15 largest cities in Germany – and only one of them is the correct solution to the problem.

THE PROJECT

Since 2007, **Clasp** has been developed within the framework of two DFG-funded projects as a solver for answer set programming, or ASP. ASP is a descriptive problem-solving paradigm with a focus on compact knowledge representation. Over the years, it has been developed into a universal problem solver. For one of the key publications on Clasp in the Artificial Intelligence Journal in 2012, Torsten Schaub and his co-authors Martin Gebser and Benjamin Kaufmann were presented with the "Prominent Paper Award 2018". The award recognizes papers that have had a substantial impact over the past seven years.

Development of highly efficient sequential and parallel systems for model-based problem solving by result set programming (2008–2012)
Advanced Solving Technology for Dynamic and Reactive Applications (2012–2018)
The systems are freely accessible under:
https://potassco.org

efficient, as Schaub explains. It is now able to solve problems containing several million conditions and variables. Second, it has a modeling language that precedes the actual program which enables the user to formulate the task for the AI comparatively succinctly and comprehensibly. The problem definition by which Clasp solves Sudokus is just seven lines long. "When the problem to be solved by the system is formulated well, Clasp becomes a powerful tool," Schaub explains. "It is predestined for such tasks as it combines knowledge representation with processing."

An intelligent pocket calculator

What exactly makes AI intelligent? For Schaub, this is a matter of perspective. "When I was 4 or 5 years old, my dad gave me a pocket calculator. To me, it seemed highly intelligent," he says with a smile. "At the end of the day, the AI we program works like a pocket calculator. A very good one, of course."

Schaub first encountered what is making headlines as AI today in his first year as a student of computer science at the Technical University of Darmstadt in the 1980s. A summer program in logic programming

Photo: Roese, Thomas

got him hooked. The fact that he stuck with it is now paying off. "For me, it is highly satisfying that we have moved from basic ideas to industrial production. When I came to Potsdam in 1997, we discussed basics, how to deal with incomplete information, for instance. Today, we develop systems that can be practically applied," Schaub proudly reports. "In 20 years from pure theory to practice. That's a giant leap." Despite all that, AI research is still in its infancy. It has not yet reached industrial production. Developers again and again face major challenges when adapting systems developed in theory for practical applications. This is why contacts to the business community that actually uses Clasp are so important for Schaub and his team. "Our research is application-driven, as this is where new fundamental questions arise," he says. "After all, our task is to make the technology suit a large variety of users, from big corporations to small enterprises."

Starting a business to facilitate practical application

It is for this very reason that Schaub und his team founded "Potassco Solutions" in early 2018. "As we saw more and more companies using Clasp, we as its developers of course wanted to be involved," Schaub says. For two reasons the company is a matter very dear to his heart: It offers former students, PhD candidates, and staff at the chair a career perspective. But first and foremost, it provides an opportunity to bring the development of Clasp forward while continuing relevant basic research beyond the DFG project. "Synergies with the research group inspire work at 'Potassco Solutions', and vice versa."

One of the first projects was to set up a shift schedule for a major railway company – with 6,000 employees working morning, afternoon, and evening shifts. In doing so, Clasp had to incorporate numerous parameters: full-time and part-time work, holidays, workloads at various times of the day, and many more. After about a month, all conditions had been collected and the problem formulated. Then Clasp came in. It took the system half an hour to put together what an employee had been working on for a whole week. "The final plan was absolutely correct, even the work guidelines were factored in," Schaub says. And it opened up many more possibilities. To give just one example, proposals were made on how to improve the shift system to reduce accumulated overtime.

Right from the outset, "Potassco Solutions" was designed as a global company. It now has eight branch offices on three continents. "We want to spread our knowledge – as we took Clasp out into the world from the very beginning," Schaub says. But sooner or later, regional cooperation should follow, he underlines. After all, Potassco, the name of the platform on which AI systems like Clasp run and where the company got its name from, stands for "Potsdam Answer Set Solving Collection".

MATTHIAS ZIMMERMANN
TRANSLATION: MONIKA WILKE

THE COMPANY

"Potassco Solutions" was founded by Torsten Schaub and some of his colleagues and former staff members in early 2018. The company's objective is to market Clasp and refine the AI system through concrete application problems.

https://potassco.com

Photo: Roese, Thomas

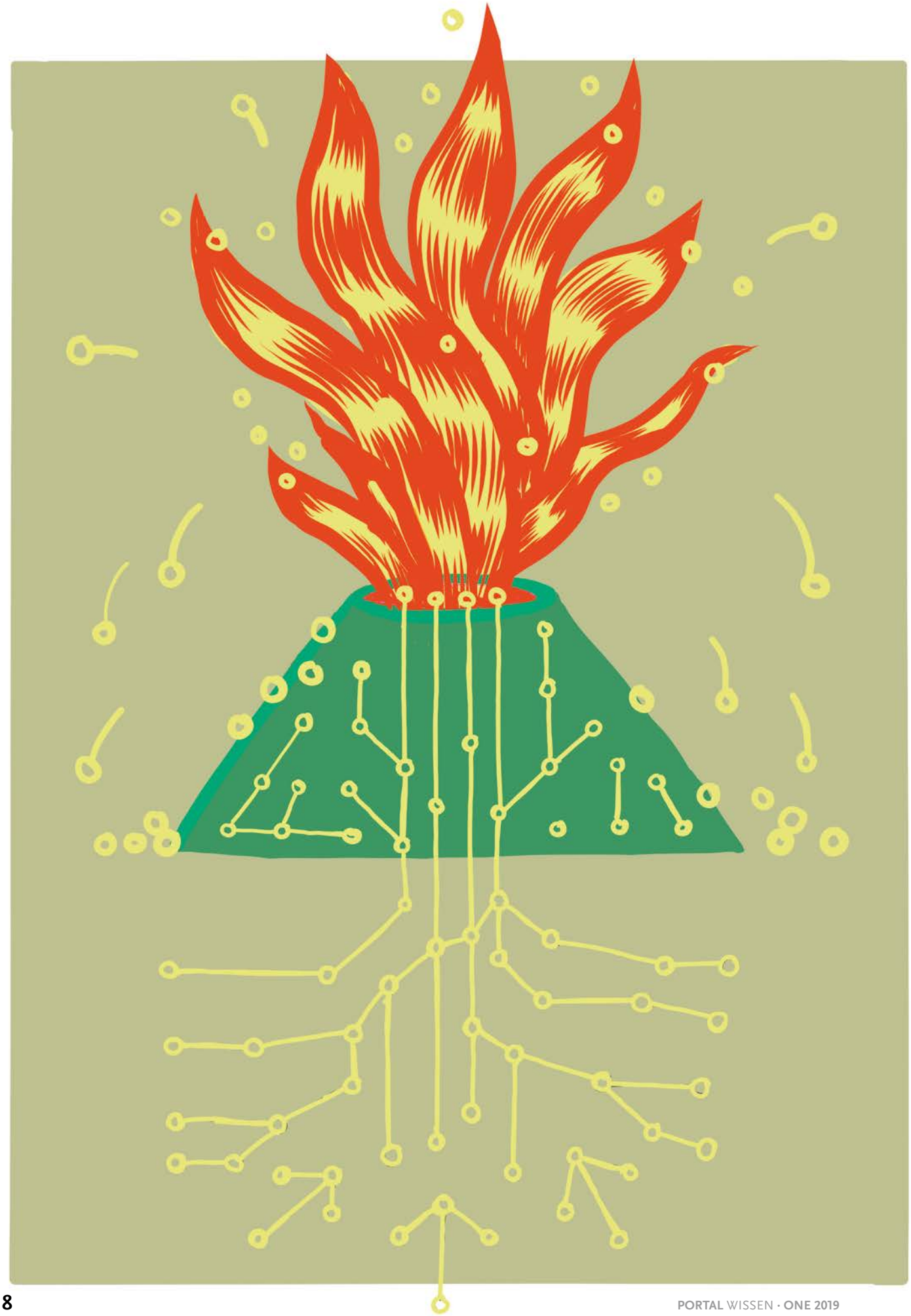


Illustration: Töpfer, Andreas

EXEMPLARY

How Artificial Neural Networks Can Revolutionize Georeseach

Geoscientists have a problem: The phenomena they research are so complex that it is difficult to track them down. New sensor technology, satellite surveillance, and computer models of the processes in the earth's interior bring them closer to these phenomena but create another obstacle: Even the most modern high-performance computers take a very long time to calculate the complex models. Artificial intelligence (AI) may provide a remedy. Dr. Hannes Vasyura-Bathke is developing a system that will take only a few second to complete modeling that normally keeps a computer busy for weeks – and will even do a more accurate job.

Hannes Vasyura-Bathke is a geoscientist. His research focuses on the physics of earthquakes and volcanoes. This is a field of research that has significantly benefited from technological developments in recent years. Computer programs are used to model processes and phenomena that cannot be detected directly because they sometimes happen several kilometers deep into the earth's crust. Meanwhile, the researchers are able to draw initial conclusions about what happens in the earth's interior when there is a quake on the surface. Where do rock masses break? Where and how far do they move? The extent, displacement, and magnitude of seismic events can be simulated on the basis of measured data. Despite the new opportunities that big data and computer models have opened up, geo-researchers are already bumping up against new limits. And they are technical in nature: mathematical modeling on the computer, i.e. the search for seismic source parameters and their inaccuracies, which explain the measurement data similarly well, is complex and can sometimes takes weeks because millions of models with slightly different parameters have to be calculated over and over again. "This is a bottleneck hampering our progress," says Vasyura-Bathke. "Actually, you do not want to do the same calculation over and over again; you want to get straight to the solution."

THE RESEARCHER

Dr. Hannes Vasyura-Bathke studied geophysics und earned his doctorate in geophysics at the University of Potsdam in 2013. Since 2017, he has been research assistant at the Institute of Geosciences.

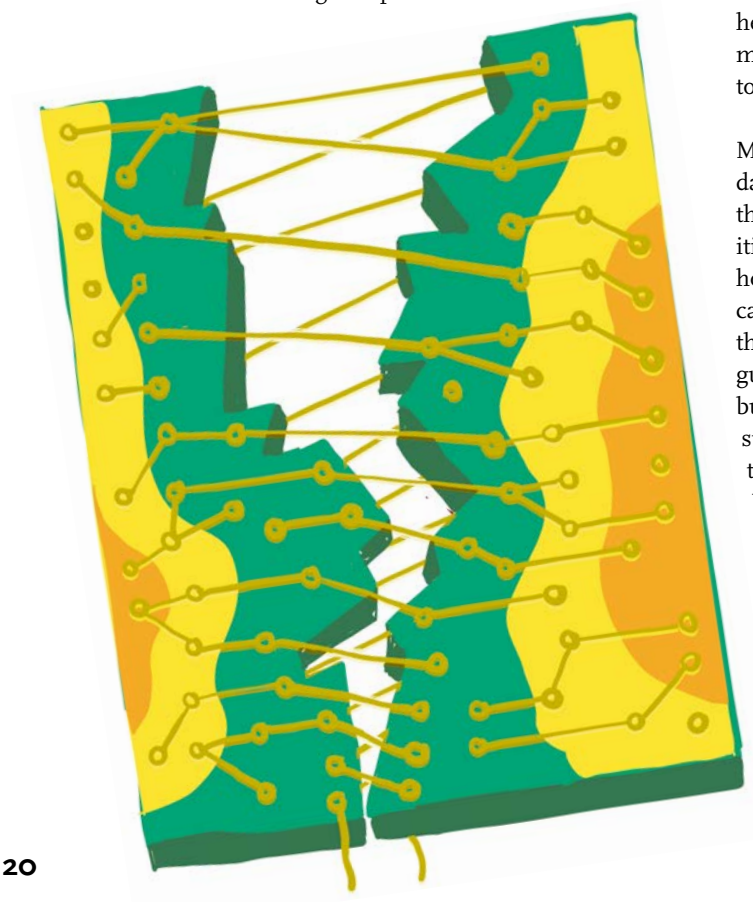
✉ hvasbath@uni-potsdam.de

Photo: Hopfgarten, Tobias

Dr. Hannes Vasyura-Bathke.

The AI is learning to recognize patterns

Vasyura-Bathke is developing an AI system that performs the modeling and gets smarter with each run. "We do not calculate other solutions. We model the same physics but faster," he says. If the method is successful, a few seconds might be enough to create a model from new data. The "system" is an artificial neural network. "Imagine it as a small brain," explains Vasyura-Bathke. The system's special feature is that the AI does not save the millions of calculations it performed to retrieve them when needed. Instead, it learns to recognize patterns



in the data. "To identify a banana, we do not need 30 pictures of a banana, but the banana's characteristic features." It is exactly these criteria that the network should identify and remember – and that it has to learn.

Technically, the AI consists of mathematical algorithms, filters that are being applied to measured data. Only when there are many filters stacked behind one another do they form a neural network. It works in a way similar to the face recognition tool on Facebook or the tool to unlock smartphones, only with satellite images and seismic wave recordings. The AI system has to be trained to learn the patterns. "For the methods currently in use, the measurement data is entered into a program and then we check to see if the calculated model fits the measurements. To train the AI, we turn this process around," he explains. To begin with, he "feeds" the system with validated data, i.e. pairs of measured data and calculated models that are known to be correct.

"We actually have only a few hundred of these." Many more are needed. Therefore, they simulate the data and add a "noise" – sources of error, deviations that always occur and affect the measurements. "Initially, the system is often wrong. But then you tell it how much it is off, and it corrects the filters." The AI calculates millions of slightly varied models based on the known data pairs and gradually refines the filters guided by its coach. This process takes a long time but will ultimately save a lot of time because when successfully trained, the AI can match the data to the physical quantities of an earthquake. In the end, Vasyura-Bathke is not training a room-filling supercomputer, but a computer program that is barely more than a few megabytes.

At the intersection of different disciplines

Vasyura-Bathke came up with the idea while studying. "Nowadays you have to program

everything yourself anyway. If you look around the relevant forums, sooner or later you will inevitably come across 'machine learning'." Only now is the technical development mature enough for such a project, he explains. "Machine learning has made significant progress in recent years, for example in terms of how the AI is able to remember patterns." The project breaks new ground, and not only for Vasyura-Bathke. It is difficult because it requires expertise from a wide range of subject areas. Ideally, one would be a geodesist, geophysicist, and computer scientist all in one. It took Vasyura-Bathke years to work through all these fields, he says. At the same time, he found competent partners: at the University of Potsdam, the Machine Learning Group headed by Prof. Dr. Tobias Scheffer at the Institute of Computer Science and the geophysicist Dr. Matthias Ohrnberger from the Institute of Earth and Environmental Sciences, as well as the working group for seismology led by Prof. Torsten Dahm at the GFZ German Research Center for Geosciences. They are all helping him to develop and train his AI system.

Like every student, the AI also has to overcome learning difficulties. Currently it is 'struggling' with the complexity of the task. "The network has difficulties with concurrent learning parameters with different mathematical units," says Vasyura-Bathke. While the orientation of an earthquake surface in space is measured in degrees, displacements of rock masses are quantified in meters. Combining these units is a challenge. The researchers do not know yet how many modeling algorithms can be combined in an AI system. "We're the first to try something like this – the combination of geoscience and machine learning is just in its infancy. It is entirely possible that different networks will be developed for different problems. But it might also be conceivable that in the end one network will do everything."

Locating earthquakes faster and more accurately

Together with the two PhD students Marius Kriegerowski and Gesa Petersen, Vasyura-Bathke has taught the AI system to find a location based on the three spatial coordinates – latitude, longitude, and depth. In its first test, it had to evaluate data for the localization of earthquakes in the Vogtland region, where seismic waves have been recorded over long periods at various measuring stations. Their analysis allows conclusions about where and when earthquakes occur. So far, the evaluation still requires a lot of "manual work" and uses standard methods that have a success rate of barely 60 per cent, according to Vasyura-Bathke. "Our neural network was able to accomplish the task not only faster but also more accurately, with an accuracy of 95 per cent!" Vasyura-Bathke is now sending another network 'back to school' because every scientific question requires the training of a new network. The researcher estimates, however, that it will probably take years until one of them is ready for automated, operational use. But then they should be able to model more complex phenomena – and continue learning.

MATTHIAS ZIMMERMANN
TRANSLATION: SUSANNE VOIGT

THE PROJECT

Artificial Intelligence support for rapid analysis of earthquakes and volcanic activity

Duration: 2017–2019
Funding: Geo.X The Research Network for Berlin and Brandenburg
Participants: University of Potsdam; Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

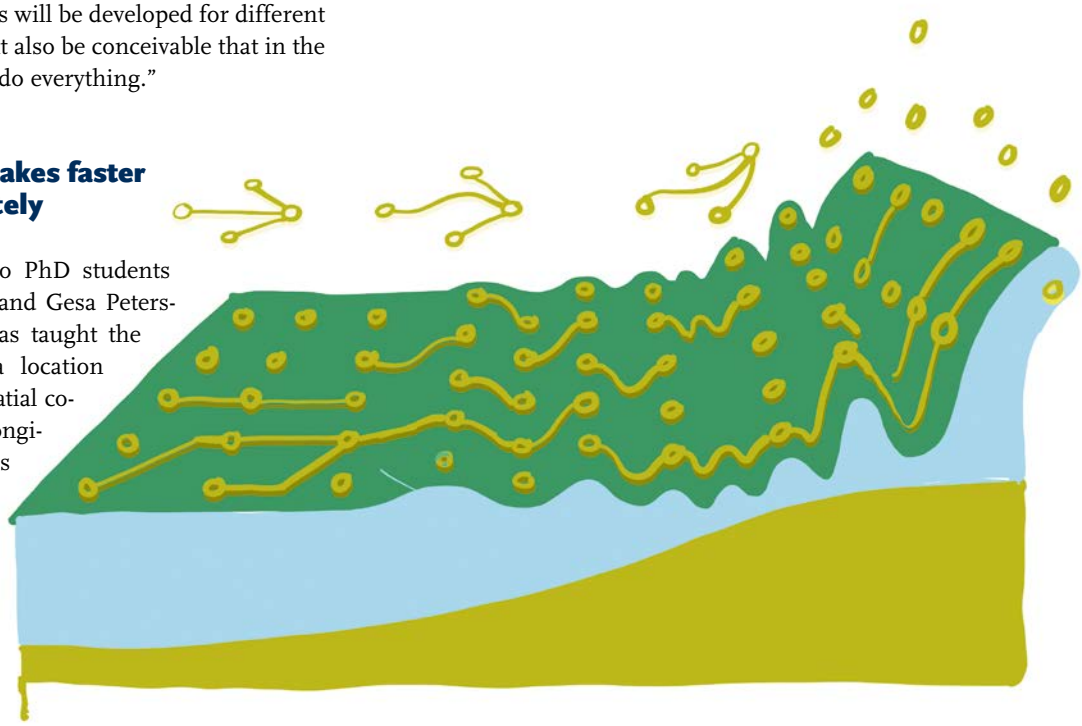
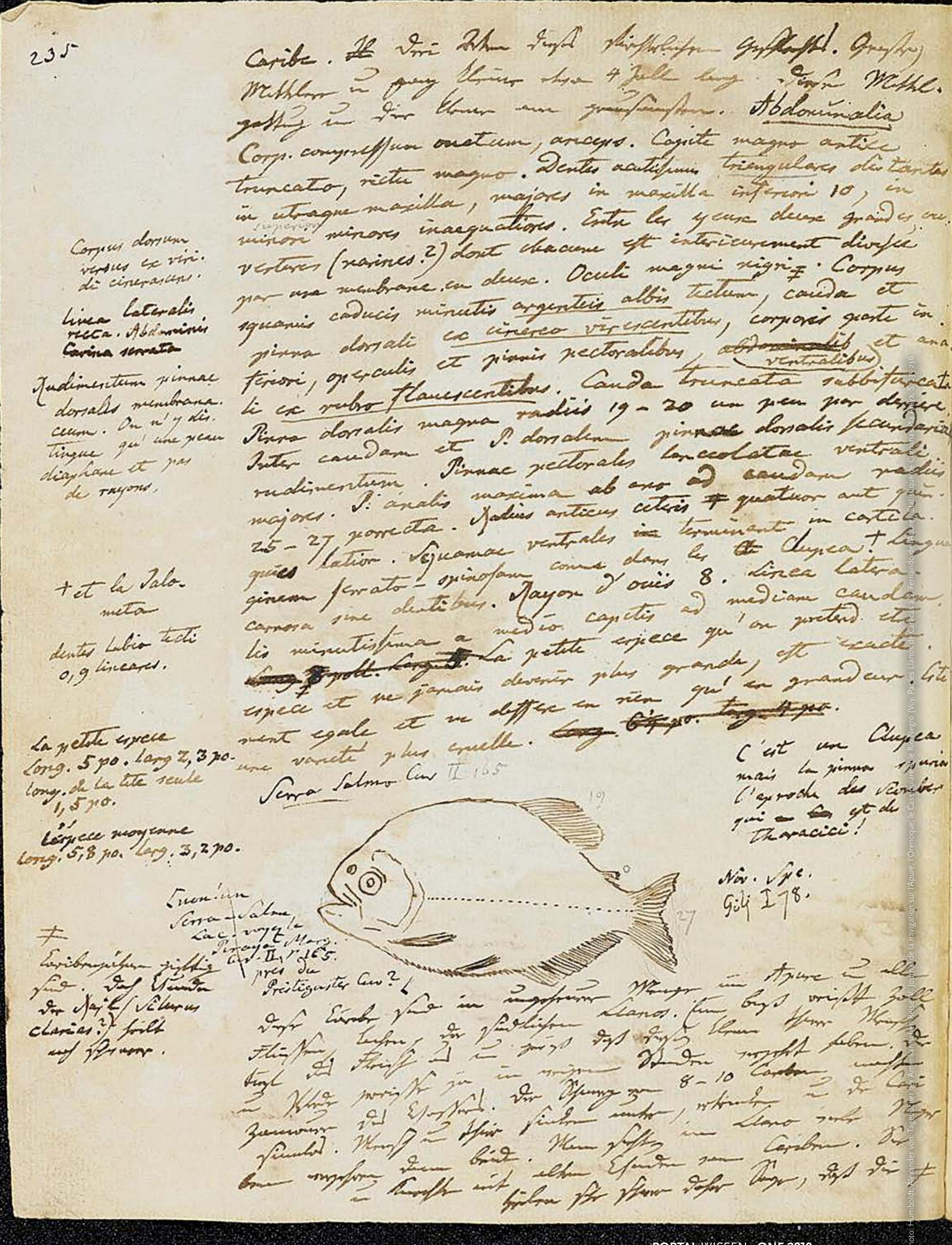


Illustration: Töpfer, Andreas



235

Caribe. [illegible] Abdominalia

Corp. compressum ovatum, anceps. Capite magno antice truncato, rictu magno. Dentes acutissimi triangulares distantes in utraque maxilla, majores in maxilla inferiori 10, in minori minores inaequaliores. Entre les yeux deux grandes ouvertures (narines?) dont chacune est intérieurement divisée par une membrane en deux. Oculi magni nigri. Corpus squamis caducis minutis argenteis albis tectum, cauda et pinna dorsali ex cinereo virescentibus, corporis parte inferiori, operculis et pinnis pectoralibus, ventralibus et anali ex rubro flavescentibus. Cauda truncata subbifurcata. Pinna dorsalis magna radiis 19 – 20 un peu par derrière. Inter caudam et P. dorsalem pinna dorsalis secundaria rudimentum. Pinnae pectorales lanceolatae ventrali majores. P. analis maxima ab ano ad caudam radiis 25 – 27 porrecta. Radius anticus ceteris quatuor aut quinques latior. Squamae ventrales terminant in carinam serrato-spinosam comme dans les Clupea. Rayon d'ouïs 8. Linea lateralis minutissima a medio capitis ad mediam caudam. La petite espece qu'on pretend etre [illegible] ne jamais devenir plus grande, est exactement egale et ne differe en rien qu'en grandeur. C'est une varieté plus cruelle.

Corpus dorsum versus ex viridi cinerascens.

Linea lateralis recta. Abdominis Carina serrata

Rudimentum pinnae dorsalis membranaceum. On n'y distingue qu'une peau diaphane et pas de rayons.

+et la Palometa

dentes labio tecti 0,9 lineares.

La petite espece long. 5 po. larg 2,3 po. long. de la tête seule 1,5 po.

L'espece moyenne long. 5,8 po. larg. 3,2 po.

C'est un Clupea mais la pinna spuria l'approche des Serrasalmes qui [illegible] est de Characini!

Serra Salmo Cuv II 165

Nov. Spec. Götz I 78.

[illegible]

Humboldt's Journey into the Digital World

From a Hand-Written Diary to a Digital Edition and Back to Printed Paper

2019 marks Alexander von Humboldt's 250th birthday – a good reason to look at the comprehensive academy project of editing his travel diaries. Romance scholar Ottmar Ette, who is scientific director of this project, and Tobias Kraft, the project coordinator, talk about the new perspectives that are opened up for research by digitizing Humboldt's writings. They also explain why there is no way around the printed book.

"Caribe. Three types of this terrible species. Big middle and very small, about 4 inches long. This middle genus and the small one the cruelest," wrote Alexander von Humboldt in his journal in 1800. In ink, he added an image of the "caribe fish" called piranha, and took the pencil to add the animal's sharp teeth. A deluxe edition published by Prestel brings together all the drawings and sketches that the explorer made on his great American expedition for the first time. Romance scholars Ottmar Ette and Julia Maier have arranged and annotated the illustrations in the original format according to subject areas. A graphic treasure, printed on fine paper, carefully stowed in a decorative slipcase.

But why a book? All the pages of Humboldt's travel diaries acquired in 2014 have been digitally recorded and are freely accessible on the worldwide web. Ette explains the motivation. "It is a collector's edition for classical readers who love the feel of printed paper, who want to delve into the pages and follow a linear narrative style." The Berliner edition humboldt, led by Ottmar Ette, publishes Humboldt's writings and travel journals to the Americas and Siberia not only online but also in print. When it comes to concentrated, persevering reading, the book is superior to the digital reception, he says. The digital version meets other needs. As a freely accessible research platform, it primarily serves research and academic exchange across disciplines and national boundaries.

Into unmapped territory

The 18-year project of the Berlin-Brandenburg Academy of Sciences and Humanities started in 2015. The Cuban journal fragment "Isle de Cube. Antilles en general" was published as a pilot project, thanks in part to the Biblioteka Jagiellońska in Krakow, where part of Humboldt's written legacy is located. It is a first example of a digital edition giving an idea of the possibilities offered by this type of publication. When the computer mouse moves over unknown plant names, places, or units of measurement, an explanation appears next to the text. You can also click on Humboldt's margin notes, calculations, and pasted notes. The scientific classification is based on a research dossier with annotations by specialists. For this pioneering achievement, the project team received the Berlin Digital Humanities Award in 2017. "We are honoring the will, the preparation, and the beginning of a journey into the digital world," said the Berlin philosopher Gerd Graßhoff in his laudatory speech. "This journey leads from the homeland of the classical edition to the hybrid digital edition. It leads – to stick to this metaphor – across dangerous fords into partially unmapped new territory."

Science for the digital age

One who does not shy away from the imponderabilities of terra incognita is Tobias Kraft. He completed his doctorate in Potsdam at the chair of Ottmar Ette on "Tropes of Science: Essay, Tableau, and Atlas in Alexander von Humboldt's Opus Americanum." Today, he coordinates the edition humboldt digital, which he describes as a "work-in-progress publication". Every six months, they publish new texts and letters and develop functions that make the books, which are in fact not really books, more readable. "We work accumulatively, so the edition is getting bigger, wider, and more profound." Kraft and his team see themselves following Humboldt's footsteps, whose journals do not follow a strict chronology, but are a collection of nature observations, sketches, series of experiments, calculations, scientific essays, and literary reflections, which were later rearranged and annotated. "Hum-

THE RESEARCHERS

Prof. Dr. Ottmar Ette is director of the research project "Travelling Humboldt – Science on the Move" at the Berlin-Brandenburg Academy of Sciences and Humanities. He is Professor for French and Spanish Literature at the University of Potsdam.

✉ ette@uni-potsdam.de

Dr. Tobias Kraft studied Romance and German literature and languages, and media studies at the universities of Bonn and Potsdam, where he also earned his doctorate. Since 2015, he has been research coordinator of the academy project "Travelling Humboldt – Science on the Move" at the Berlin-Brandenburg Academy of Sciences and Humanities.

✉ kraft@bbaw.de

Photos: Fritze, Karla (2)

boldt's way of writing is relatively concise," says Kraft. The "text islands" that he has connected with each other correspond to today's data structure and could be taken over in exactly the same way. "A science for the digital age," Ette confirms. It is possible to visualize the complexity of the manuscripts very well in the online publication. Depending on their needs, readers are able to delve deeper into a topic and create new connections opening up completely new perspectives for Humboldt research. This represents Humboldt's dynamic and networked thinking, where everything is related to one another. Ette sees how young researchers around the world take up this network idea and address the scientist's work from the perspective of art, mathematics or even climate change. The digitization of his travel journals gave the research on Humboldt a new impulse, says Ette, and is pleased that coming generations perceive Humboldt not as a "scientist of the past" but as a contemporary due to his global perspective. His multilingualism certainly contributes to this.

Which in turn is a challenge for the digital edition. In addition to German, French, and Latin, Humboldt's manuscripts contain Spanish, Portuguese, Italian, Greek, and English entries. There are also notes in Chinese, Persian and various Amerindian languages. "A complex system of text segments. That will take a long time," says Kraft, who sees this as a field for using artificial intelligence. Every translation is qualitatively inferior and can only approximate the original. A radical multilingualism, however, would produce a different understanding of the text. "Artificial intelligence is a promise. It will open more doors."

"TRAVELLING HUMBOLDT – SCIENCE ON THE MOVE"

The project of the Berlin-Brandenburg Academy of Sciences and Humanities comprises the complete edition of Alexander von Humboldt's manuscripts related to his travels. It focuses on the American and Russian-Siberian travel diaries. The edition will have eleven volumes that will be published as a hybrid project both as a print version and digitally. In addition, extensive material from Humboldt's legacy at the Berlin State Library – Prussian Cultural Heritage and the Biblioteka Jagiellońska in Krakow will be indexed by content and edited according to main topics. The research and editing project is performing its tasks in cooperation with the University of Potsdam, the Berlin State Library – Prussian Cultural Heritage, Technische Universität Berlin and other research institutions in the region of Berlin-Brandenburg.

Start: January 2015 (planned duration: 18 years)

The last portrait of Alexander von Humboldt by Julius Schrader (1859). In the background the Chimborazo.

Photo: Wikimedia

Open science in Humboldt's tradition

Kraft frequently uses the metaphor of the house with many doors when it comes to making knowledge public and freely accessible. Humboldt already strongly advocated the open science concept, says Kraft, reminiscent of Humboldt's overcrowded lectures at the Berlin Singakademie. Knowledge was not to be locked up in archives, but available to everyone. "In Humboldt's tradition, we feel very comfortable," explain Ette and Kraft in unison. Since they do not just want to reach a professional audience with the digital edition, they also provide access at different levels. The easiest way is to follow the chronology of travel. "Today we are able to reconstruct what Humboldt did and where he was on almost any given day." Jürgen Hermes, a colleague at the University of Cologne, developed a Twitter robot (@AvHChrono) in a seminar on digital information processing together with students that reported every day in Humboldt's life more than 200 years ago, says Kraft. That does not seem so far-fetched. If Humboldt went on an expedition today, he would surely keep an online blog.

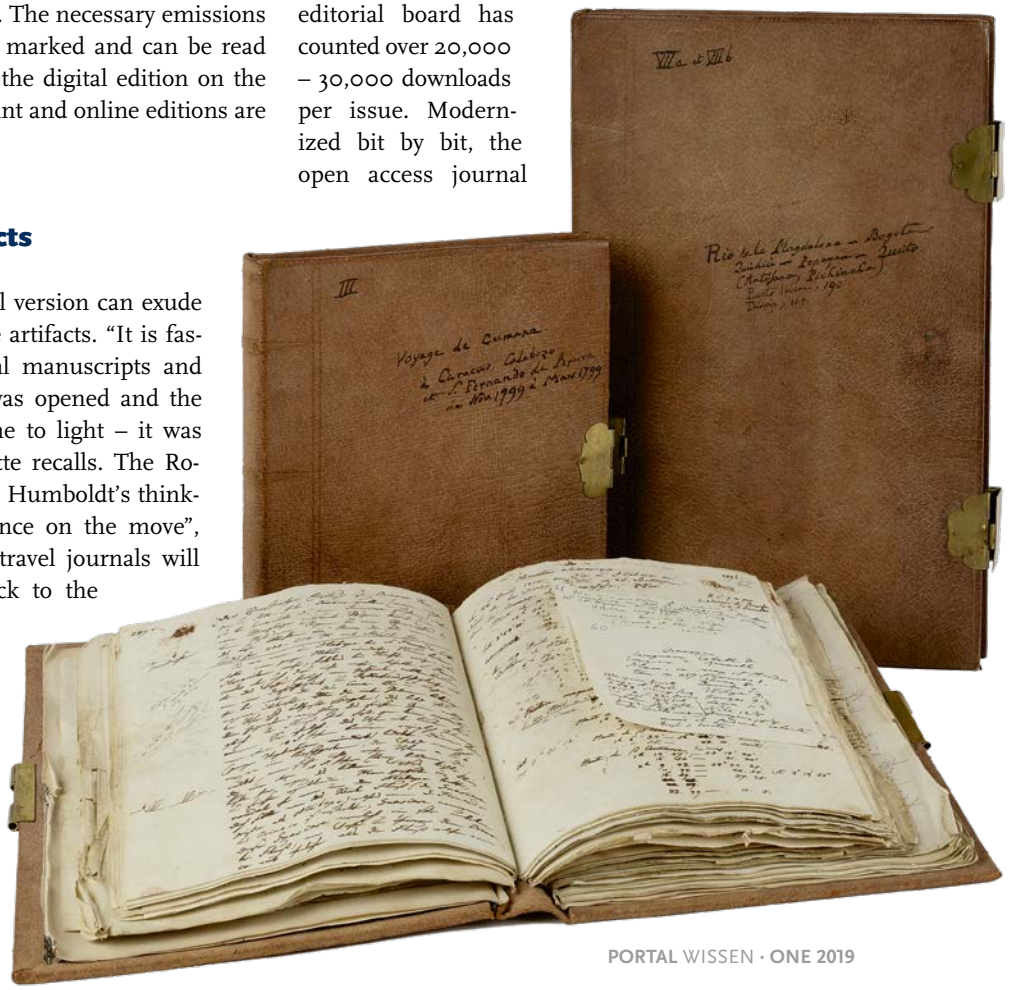
The original journals are repeatedly interrupted by anticipations and recourses, inserted essays and page-long digressions, and were bound together by Humboldt only much later, towards the end of his life. The printed version of the edition humboldt tries to reconstruct the chronology of the journeys – among other things, for better readability. The necessary emissions in the print edition will be marked and can be read in their original context in the digital edition on the Internet. This is how the print and online editions are usefully combined.

The aura of the artifacts

Neither the print nor digital version can exude the aura that surrounds the artifacts. "It is fascinating to see the original manuscripts and drawings. When the box was opened and the leather-bound journals came to light – it was a very special moment," Ette recalls. The Romance scholar, who regards Humboldt's thinking and writing as a "science on the move", wishes that the American travel journals will once go on a journey, back to the sources of their origin, for example to Mexico. Currently, they are securely locked in the Berlin State Library and a smaller, unbound part in Krakow. But perhaps they will soon find a home in the new Humboldt Forum in Berlin's city center. Hermann Parzinger, President of the Prussian Cultural Heritage Foundation, has already declared them to be its "communicative center". Fortunately, they are now completely digitized, which takes the pressure off the original, Ette says. On the State Library's website they are available as digital facsimiles for the worldwide research community.

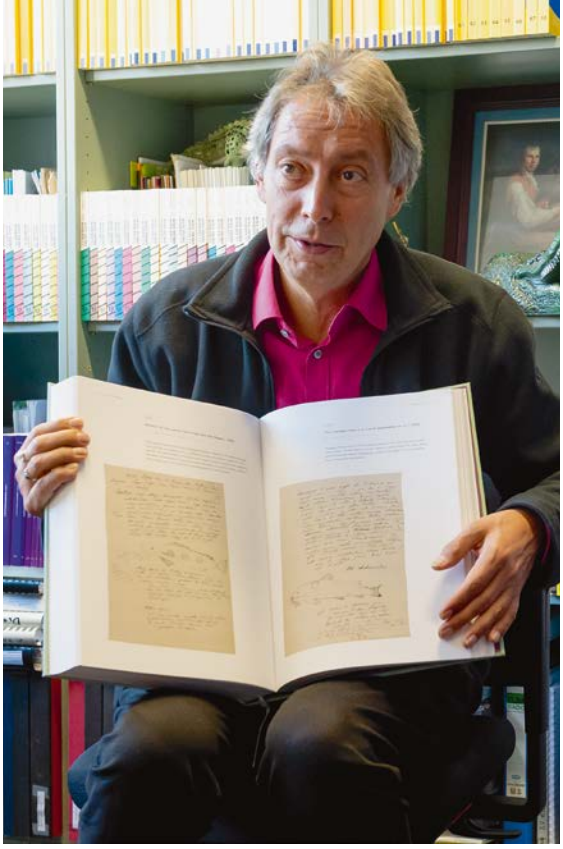
For almost 20 years "Humboldt in the Net"

For a long time, the Potsdam Romance scholar had used the unrestricted possibilities of academic discourse on the Internet like almost no other. In 2000, Ette founded the digital journal "HiN – Alexander von Humboldt in the Net", demonstrating his courage to take a risk. Initiated as a low-budget project, it was first published in cooperation with the Haus der Kulturen der Welt, later with the Berlin-Brandenburg Academy of Sciences and Humanities. It publishes the latest current studies in the field of Alexander von Humboldt research twice a year in four languages – English, German, French, and Spanish. "An advantage, particularly for our colleagues in Latin America, who are able to access up-to-date material free of charge at any time," explains Ette. So far, the editorial board has counted over 20,000 – 30,000 downloads per issue. Modernized bit by bit, the open access journal



Humboldt's travel diaries.

Photo: Staatsbibliothek zu Berlin – PK, Carola Seifert



Prof. Ottmar Ette (left) and Dr. Tobias Kraft.

has become increasingly elaborate and professional. "It not only reflects the development of Humboldt research, but also the history of digitization," says Kraft, who "has grown into" the topic through his work on the journal and has brought about several changes over the years. The open-journal system they use not only enables the desired multilingualism and the uploading of metadata but also a web-based editorial system. Each article goes through a three-stage review process, Kraft explains. What is more, the layout has changed, became more reader-friendly and clearer.

Digital journal goes to press

When Ette views himself in the mirror of the publication, it still amazes him how they managed to gather contributions from all over the world and establish an international team of authors with an "unbelievably small" editorial staff, which has sometimes consisted of only two persons. Currently the 37th issue is being published. This time, not only digitally but also as a printed booklet – 100 pages to touch, browse, study, and to look at. Almost 20 years after its founding, the online journal is now taking the opposite route: from the Internet to print. A gift for the Humboldt Year 2019. Thanks to a grant from the President of the University, the digital data could be translated into print versions – a collection of 35 volumes, published by the Potsdam University Press. "The people are surprised and are happy to suddenly hold the things they know from the Internet in their hands," Ette describes the reactions, and proudly presents the big slipcase. As much as he appreciates the advantages of the digital periodical, the concentrated reading of a book and sinking into the printed text are irreplaceable.

ANTJE HORN-CONRAD
TRANSLATION: SUSANNE VOIGT

HIN – ALEXANDER VON HUMBOLDT IN THE NET. INTERNATIONAL REVIEW FOR HUMBOLDT STUDIES

HiN is an international open-access journal and, since 2000, has regularly published current studies in the field of Alexander von Humboldt research in German, English, Spanish, and French. The digital periodical is published twice a year by the University of Potsdam and the Berlin-Brandenburg Academy of Sciences and Humanities. Since 2018, the journal has been published online and in print (ISSN online 1617-5239, print 2568-3543).

Photos: Fritze, Karla (3)

Artistic depiction of the active galaxy core. The supermassive black hole at the center of the accretion disk sends an energized, sharply focused particle beam vertically into space.

THE PROJECT

Development of an Alarm System for CTA

Duration: 2017–2020
Funding: Federal Ministry of Education and Research (BMBF)

Photo: DESY, Science Communication Lab

SIGNALS EVERY SECOND

Astrophysicists Develop Telescope Alarm System for Next-Generation Gamma-Ray Observatory CTA

It is a step into a new dimension. The search for time-dependent phenomena in space is in full swing and, with it, the search for cosmic sources of high-energy gamma radiation. Researchers have already identified exploding stars, black holes, and pulsars. But they are sure that there are many more. The universe is full of extreme particle accelerators producing gamma rays and other phenomena. However, researchers still know little about how exactly the processes by which charged particles are highly energized work and what the time frame for them is. But help is on the way: A new observatory, the Cherenkov Telescope Array (CTA), is being prepared by a number of universities and research institutions, including the University of Potsdam.

They are not visible to the naked eye: energetic particles raining down on Earth. But they are there, millions of them, everywhere, in the Milky Way and beyond. Among other things, they become visible by gamma rays that can actually be measured by telescopes, albeit only indirectly, since gamma rays cannot penetrate our planet's atmosphere. But when they hit the earth's atmosphere and collide with atoms and molecules, they produce particle showers that can be investigated using certain detectors. In the future, CTA will be one such detector. "The observatory will allow us to explore the cosmos with unprecedented precision," explains Dr. Kathrin Egberts, head of the "Experimental Astroparticle Physics" team at the University of Potsdam. Her team is involved in the large-scale project bringing together some 1,400 researchers and engineers in 30 countries. In the coming years, more than 100 telescopes of three different types will be erected and in operation for at least two decades on Cerro Paranal (Chile) and the Canary Island of La Palma. "The first of these in the northern hemisphere has been built," Egberts reports. Together with her team, she has long concentrated on the HESS experiment for research purposes (see box on page 43). "The technologies developed here can now be used for CTA," she explains. Their special expertise in developing automated warning systems for telescopes is very much needed for CTA, too. The main focus is on the criteria according to which the telescopes automatically switch to other parts of the cosmos where very scientifically interesting events are taking place.

CTA is the acronym for **Cherenkov Telescope Array,** an observatory for gamma-ray astronomy. Its methodology is based on the fact that gamma rays produce particle showers when entering the earth's atmosphere. These particle showers emit Cherenkov radiation, i.e. short flashes of light measured by telescopes. The obtained data are used to determine the energy as well as the direction of the incoming gamma-ray particles. Because the electrically neutral rays are not deflected by a cosmic magnet field, the direction from which they arrive leads directly to their source. For the next two decades, the CTA observatory will be the most important observation instrument for very high energy gamma-ray astronomy. Its planning and construction are supervised by a major international consortium. A central role in the planned observatory will be played by the Zeuthen-based DESY (Deutsches Elektronen-Synchrotron) research center, with which the University of Potsdam cooperates and is connected via a number of joint appointments. In the future, part of the project will be coordinated at its Science Data Management Centre.

Proven technology becomes more flexible

"The alarm system we 'built' for HESS is a good basis for the new project," explains Egberts' colleague Clemens Hoischen, "even though it cannot be transferred one to one." The challenge is that CTA is an observatory and not purely experimental like HESS. A system for CTA, therefore, requires a higher level of professionalism, including easier configurability and higher flexibility. Aspects such as monitoring the stable operation of the autonomously acting system as well as an environment in which alarm responses can be simulated need to be expanded. This is a major challenge. "We are currently in the design stage, which is a critical one. The focus is mainly on architectures," Hoischen explains.

Just like its predecessor, the new system will be able to receive, process, and send alarms. Incoming parameters include positioning data of a current event, but also information on measurement parameters of the delivering telescopes. These form the basis for the decision whether to switch to the respective phenomenon. To ensure that this can be done, a processing pipeline will be set up which will play a central role in the entire technology. Inside the pipeline, very complex process steps are carried out: alarm prioritizing, alignment with celestial maps, and calculation of optimum observation positions. Next, the alarm reaches the central data acquisition system, which will then manage the observation.

That's a lot of theory, and before it can be applied in practice, the researchers have to do a lot of detailed work. CTA key systems need to be combined and basic criteria for the research program defined. "This is what we are doing now," Hoischen describes the situation. What other components does the alarm system need to be connected with? Which alarms should be reacted to and under what conditions? And what happens if several alarms come in at once? These are

CTA array at night with two particle showers.

Gamma-ray astronomy focuses on high-energy processes in nature. The unit of measurement is electron volt (eV). Sources in space that can be made visible by gamma radiation can accelerate particles much faster than, for instance, the largest particle accelerator on Earth, the Large Hadron Collider at the European Acceleration Center (CERN) near Geneva. Here, protons reach a maximum of 6.5 TeV, whereas researchers using modern instruments measure 100 TeV or higher for particles reaching the earth's atmosphere. So the key question is: How does nature do it? Gamma-ray astronomy will help find answers.

Photo: DESY, Milde Science Communication

THE RESEARCHER

Dr. Kathrin Egberts studied physics at the University of Heidelberg, where she also earned her PhD in 2009. She has been head of the working group "Experimental Astroparticle Physics" at the University of Potsdam since 2013.

✉ kathrin.egberts@uni-potsdam.de

Dr. Clemens Hoischen studied physics at RWTH Aachen and obtained his doctorate from the University of Potsdam in 2018. He is a research assistant in the working group "Experimental Astroparticle Physics".

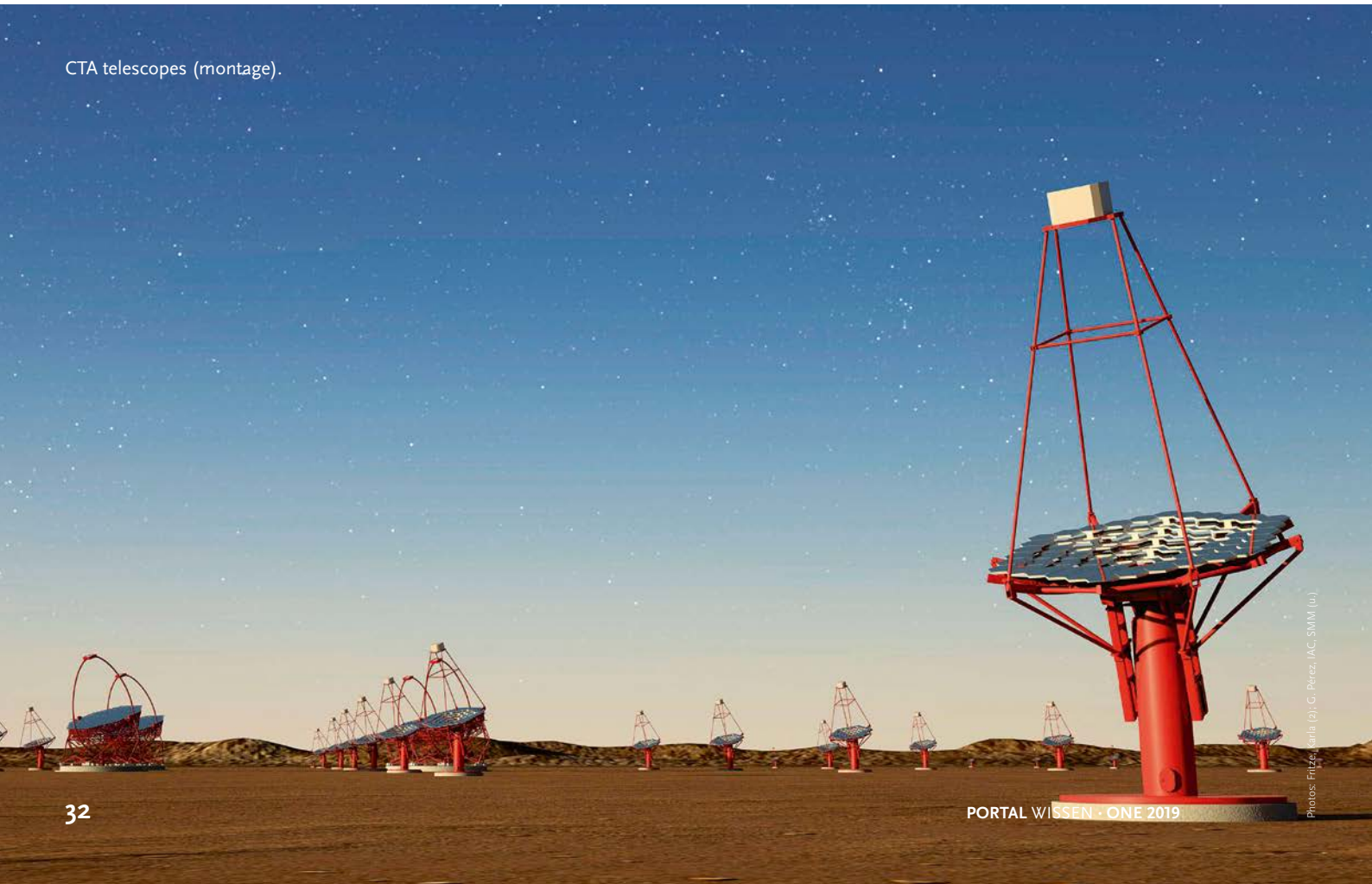
✉ clemens.hoischen@uni-potsdam.de

some of the questions that need to be clarified, yet it is quite clear what the CTA alarm system is able to pass on to the experiments connected with it: everything discovered by its own telescopes. The systems searching other wavelength ranges could then focus on them. "Another possibility is to communicate 'findings'. You quote the original alarm and the result," Hoischen explains. "The community is already doing this, and it facilitates each other's decision whether to point the telescope to the event."

Meanwhile, Hoischen is pushing to speed things up. "We must finish the planning stage now and design a prototype system," he says. "It should demonstrate that it can do all that CTA requires." But important interfaces have yet to be sufficiently defined, and responsibilities need to be made clear. Ultimately, a handover process will determine whether the Potsdam system will be adopted.

Alarm systems on the rise in astrophysics

Alarm systems are not new in the world of observational astronomy. However, experts see a rising demand for them in astrophysical research. The systems are capable of receiving and sending thousands of signals a night in rapid succession which requires efficient selection and processing. Events were also filtered in the past, but filtering has improved with new technologies offering more differentiated solutions.



CTA telescopes (montage).

Photos: Fritze, Karla (2); G. Pérez, IAC, SMM (u.)

Dr. Kathrin Egberts and
Dr. Clemens Hoischen.

Photo: Fritze, Karla

Even today, a large global community uses warning systems to follow phenomena in the shortest possible time. The existence of alarm systems is due to a simple fact: The fields of vision of HESS – and the planned CTA telescopes, too – are limited to the size of ten full moons on average. Therefore, they depend on information from wide-angle instruments capable of capturing a larger section of the sky to observe events they would otherwise miss.

HESS heightens expectations of CTA

Major hopes are resting on the Cherenkov Telescope Array. Comprising many more than the 5 telescopes used at HESS and distributed across both sides of the globe, CTA could actually become a game changer in space research. After all, the comparatively small HESS, with its integrated alarm system, has demonstrated what observations modern systems are now capable of. For instance, its gamma telescopes reacted quickly when alarms indicated the upcoming merger of two neutron stars in 2017. In fact, HESS was the first ground-based instrument to have the decisive spot at the sky in its field of view, yet without discovering a gamma-ray source. Still, it was a key element in what was probably the biggest observation campaign in modern astronomy. Soon after, the detection of a neutrino from the direction of a known gamma-ray source attracted similar attention in the community. Again, HESS received an alarm – and observed the object for weeks, like all Cherenkov telescopes did, to study its behavior. “The results of the worldwide research found their way into many publications and events, which testifies to the strong interest in observations in the time domain,” Hoischen underlines. “Systems like the one we are developing here in Potsdam open the doors to these kinds of observations.”

PETRA GÖRLICH
TRANSLATION: MONIKA WILKE

The **High Energy Stereoscopic System (HESS)** is one of three key projects in gamma-ray astronomy today, the other two being MAGIC and VERITAS. It went into operation in 2002 and is located in Namibia. Altogether, HESS consists of five Cherenkov telescopes measuring cosmic gamma radiation in the range of 30 GeV and 100 TeV. The major result of the three experiments is the demonstration of a multitude of different gamma-ray sources. So far, over 200 have been detected, but researchers are sure that this is just the tip of the iceberg. In order to discover significantly weaker sources and study them in detail, CTA is needed, for which experts from all three experiments have joined forces.

Photo: AdobeStock/Kruthiensa

In Search of Islam

Where do Muslims Live in Brandenburg?

Thousands of migrants and refugees come to Germany every year. As a result, the diversity of faith in Germany is greater than ever before. Despite this, we know little about the religious affiliation of these people. There is especially little data about the number and distribution of Muslims in Germany. To change this, the Ministry of Science, Research, and Culture (MWFK) of the state of Brandenburg commissioned a survey on the number of "Muslims in Brandenburg". A team of researchers and students at the University of Potsdam headed by Prof. Johann Ev. Hafner hit the street.

THE PROJECT

Muslims in Brandenburg

Funding: Ministry for Science, Research, and Culture of the federal state of Brandenburg (MWFK)
Duration: 2017/18
Participants: Prof. Johann Ev. Hafner (lead), Seyit Arslan, Burak Güleryüz, Kadir Sancı as well as six students, among them Marco Gehendges

The project kicked off with a lecture by Prof. Hafner together with the political scientist Seyit Arslan and Kadir Sancı from the Department of Jewish Studies and Religious Studies in the winter semester 2017/18. One of the six students who enrolled for the mapping project was Marco Gehendges. "Although I have been in contact with Muslims since my youth, mostly at school, I have never participated in their religious life," he says. "In this project I now have the chance to witness it firsthand."

That's easier said than done. First of all, they had to find the Muslims. The researchers took up the search in a total of twelve cities across the country: Cottbus, Potsdam, Frankfurt / Oder, Brandenburg on the Havel, Rathenow, Neuruppin, Luckenwalde, Wittenberge, Senftenberg, Forst, Guben, and Spremberg. It quickly became clear that Muslims were quite reluctant and their willingness to articulate themselves in public was rather low. "This does not mean that they are hiding," Hafner explains. "They are just usually busy with other things like submitting applications or looking for housing and work. In addition, they simply lack the appropriate mouthpiece."

People of Islamic faith have not only lived in Germany since the migration movements of the 21st century. Already 250 years ago there were **Muslims in the region of today's state of Brandenburg.** At first, they had only simple prayer rooms. In 1915 the first mosque was built on German soil in Wünsdorf near Zossen. Since autumn 2015, the number of people of Muslim faith in the Federal Republic of Germany has steadily increased. The current admission procedure stipulates that only the home country has to be stated when registering. The Federal Office for Migration and Refugees (BAMF) rarely gets information about religious affiliation. If they do receive it, it is by voluntary self-disclosure.

Muslim communities do not have a strong public presence

But who actually is a Muslim? Is the cultural background a decisive factor, or is it rather the participation in annual and weekly cyclic rituals such as Ramadan and Friday prayers or being involved in community activities? Estimates of the number of believers vary a lot. Hafner suspects that the information available to the public is widely overestimated. Moreover, it is not properly taken into account that many refugees dissociate themselves from their own religion, he argues. Also in Christianity, people call themselves Christians, but rarely or never go to church or even leave the Church. Therefore, it is necessary not only to interview individuals, but to examine how Muslim communities are developing and how many people are active in these communities.

When preparing the project, the data collection process was discussed with a social geographer, as was the best way to get in contact with the communities. Ultimately, the researchers established contacts with the communities through integration commissioners, NGOs, newspapers, and social media. Once this first hurdle had been overcome, communication went smoothly. The respondents were open for discussions and the language barriers were limited. The average number of 400 to 500 weekly participants in the Friday prayers showed that Potsdam is home to the largest community in the state of Brandenburg, followed by Cottbus with 300 to 500 participants. To collect

The communities lack suitable premises.

Photo: AdobeStock/Jale Ibrak

more detailed data, however, the researchers spoke on-site with the Muslims of different communities and participated in Friday prayers.

The researchers experienced open-mindedness and sporadically also wariness

Not all communities have their own premises, some share local multifunctional rooms with other initiatives and groups. "One community used a gym," Gehendges remembers. "This is not easy because depending on the season it is too hot or too cold." But those interviewed were usually happy about every available space; in some cases even a carpet is sufficient. "During my visits, the interviewees were always friendly and open," says Gehendges. "Some were even interested in our study and curious about the results." Only in one community did he experience distrust of outsiders; the first two talks here took place in a rather tense atmosphere.

To obtain comparable information, the team used three different questionnaires that were used to close the initial distance. The questions referred to the communities' offers, the number of visitors and cooperation with other local stakeholders. "The questionnaires are meant to help us understand how many people visit the community, how the social structures within the community are developing, and how they are externally networked," he says.

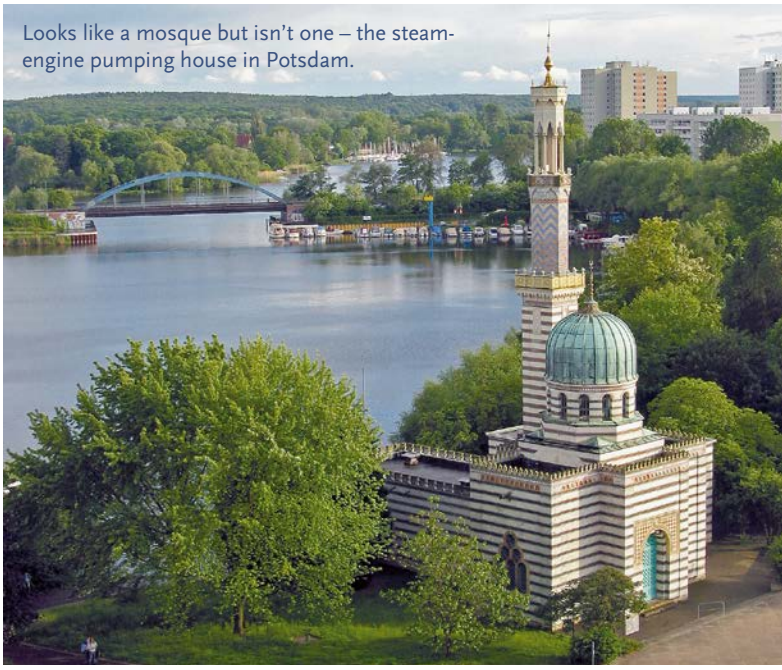
"Premises are crucial"

Prof. Hafner sees two big problems for the integration of the Muslims living in Brandenburg. Above all, the Muslim communities in Brandenburg lack suitable premises. They need them not only for prayer but also for common social activities. Only a few, like the Muslims in Potsdam, whose mosque is located in an apartment block, have their own permanent prayer and meeting space. It is already evident that in those cities where space is small, fewer participants come to the prayers. In order to change that, many communities are dependent on donations. This is usually difficult because a large number of the members are refugees and receive benefits under the Asylum Seekers Benefits Act or unemployment benefits (ALG II).

Yet they also lack suitable people who would permanently assume the leadership of a community, says the scholar of Religious Studies. Accordingly, the future of Muslim communities will significantly depend on whether there are enough imams who preside over the mosque community and maintain contacts with the majority society. So far, these functions have been performed in many places by individuals who can only rely on little commitment from the community.

With their study, Hafner and his team not only want to find out more about the Muslims in Brandenburg, but also want to help them, as Gehendges emphasizes. "I hope that our project can improve networking between the stakeholders by informing them about where communities are located so that they become contactable. It is also important to us to show the needs of people in these communities. "The results of the survey will be published in a brochure in 2019. The explicit aim of the project is to convey the findings to society in order to maintain interest in promoting Muslim communities.

KAROLINE SCHLEGEL
TRANSLATION: SUSANNE VOIGT



Looks like a mosque but isn't one – the steam-engine pumping house in Potsdam.

THE RESEARCHER

Prof. Dr. Johann Ev. Hafner is Professor of Religious Studies with a Focus on Christianity at the Department of Jewish Studies and Religious Studies of the University of Potsdam.

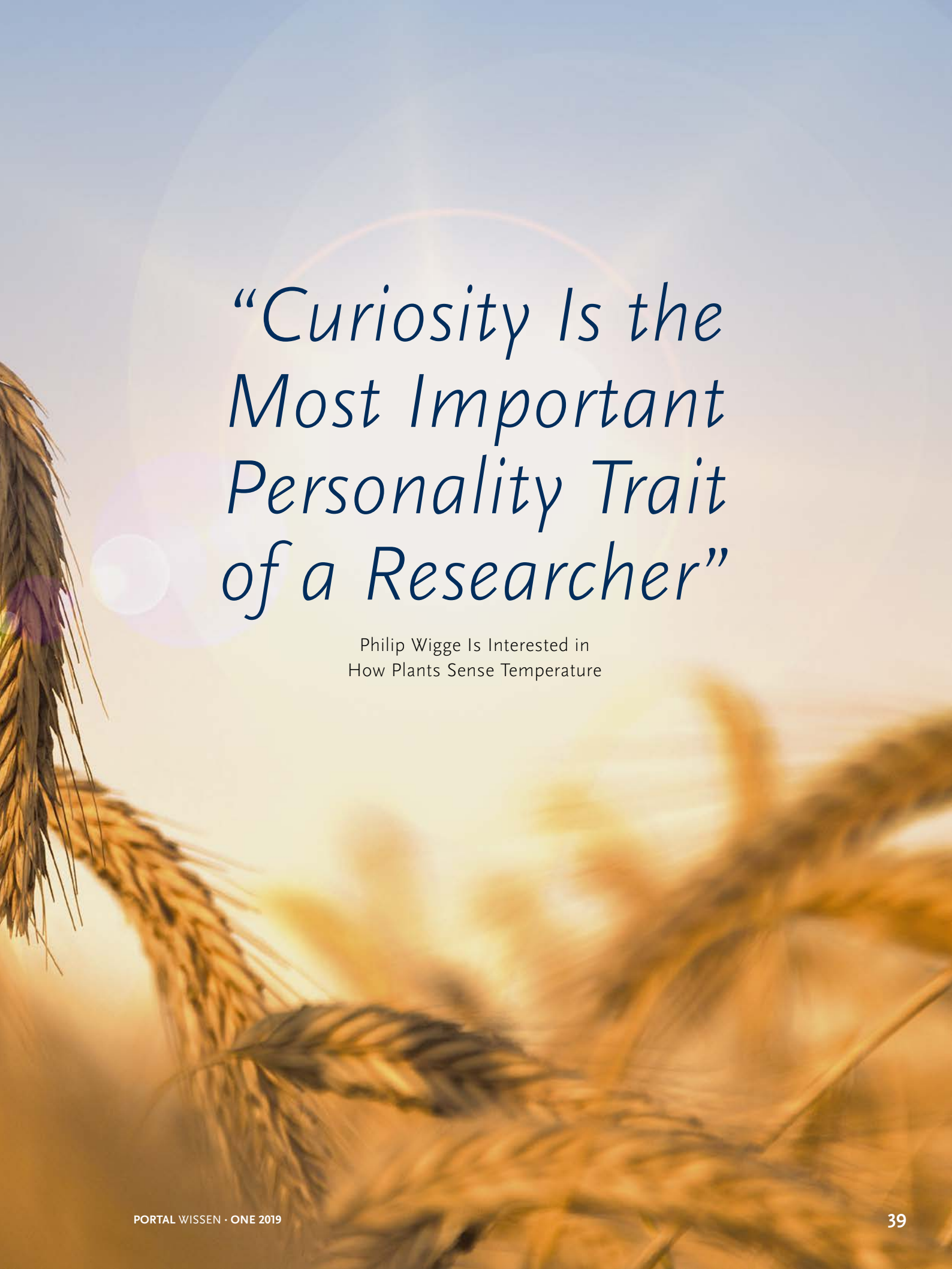
✉ hafner@uni-potsdam.de

Marco Gehendges is a student in the dual-subject Bachelor's degree program (B.A.) Religious and Jewish Studies of the University of Potsdam.

✉ gehendges@uni-potsdam.de

Photos: Fritze, Karla (2); Gehendges, Marco (u.)

Photo: AdobeStock/bluedesign



"Curiosity Is the Most Important Personality Trait of a Researcher"

Philip Wigge Is Interested in
How Plants Sense Temperature

When we feel cold, we get goosebumps and put on warm clothes. When it's very hot, we start to sweat. Plants, too, sense the temperature and use this information to adapt to their environment. Researchers are puzzling over the mechanisms behind this and the way plants adapt to heat or cold. One of these researchers is Professor Philip Wigge, who recently accepted a chair at the University of Potsdam.

This visit to Germany will be a brief one for Philip Wigge. He will be giving a lecture on temperature sensitivity in plants at Freie Universität Berlin and taking care of some bureaucratic matter before flying back to his home country of Great Britain. He won't be staying there for long, however. In a couple of weeks, the biochemist and plant researcher will be relocating from Cambridge to Potsdam, where he will become Professor of Plant Nutritional Genomics, and to Großbeeren, where he will be heading a department and working with his research team at the Leibniz Institute of Vegetable and Ornamental Crops (IGZ). How do plants sense and measure temperature, and how do they adapt to climate change? This is the big question guiding Wigge's research.

Climate change means lower crop yields

"In agriculture we have known for centuries that plants are highly sensitive to temperature," Wigge explains. A farmer knows their wheat needs a certain number of warm days to blossom and ripen, enabling them to anticipate the harvest date. Plants are therefore able to measure temperature across many scales, from minutes to days and months, and integrate this information to make key decisions, such as when to flower. Remarkably though, we don't know the sensors by which plants measure temperature and pathways that enable plants to respond. "The underlying molecular mechanisms of many signaling pathways in plants remains unknown," Wigge says.

He has been studying these mechanisms for years. His work is particularly relevant as climate change reveals the extent to which temperature affects vegetation. Over the past years, the temperature of the earth's atmosphere has risen by about one degree Celsius. "By the end of the century, we are currently on track to see changes of as much as 4 °C that will cause major disruption to natural and agricultural systems," Wigge anticipates.

The consequences of this warming are already clearly visible: Many plants are starting to bud and blossom earlier, growing in new habitats that used to be too cold for them, or are being driven out of their natural habitats by other species. "These are dramatic changes," Wigge underlines. Not only for wild plants, but for agriculture, too.

Agronomists estimate that with every degree of warming, global crop yields fall by 10%. Rice, wheat, corn, and other crops are already growing at their temperature limits in the world's granaries. There is also an increasing danger of plants and their pollinators desynchronizing. Rising temperatures mean that plants will blossom too early, while their pollinating insects are still hibernating. Consequently, early bloomers will produce less fruit and seeds. For Wigge, this is a major motivation to encourage more research in this field and to understand these processes at the molecular level.

Photo: Thornton, Mike

New genetic engineering technologies facilitate new breeding methods

Not least, the objective of the research is to breed new crops that are better adapted to higher temperatures. Here, Wigge focuses mainly on breeding methods using new genome editing technologies such as CRISPR. The so-called genetic scissors can be used to modify the plant genome selectively and very precisely. "Classical breeding methods are very time-consuming and have to rely on trial and error," Wigge says. "If we can combine precision agriculture, molecular biology, and genome editing with more conventional breeding methods, we will have great opportunities. This is particularly important in the context of climate change, because we will continue to experience rising temperatures and more extreme heat events."

Wigge is just about to equip his future workplace at the IGZ in Großbeeren. "Plant science is developing into a more predictive than descriptive science," he ex-

Philipp Wigge's second home: his lab.

Arabidopsis thaliana is easy to breed and examine.

plains. Next-generation sequencing enables researchers to quickly analyze the entire genome of a plant and study the way in which genes are regulated. This helps predict how plants will react to certain stimuli like temperature at the molecular level. The current revolution in sequencing technology is occurring in parallel with a massive expansion in bioinformatics. Where it was customary to study one gene at a time, increasingly tens of thousands of genes are analyzed simultaneously. This requires new computational skills, but is greatly increasing our understanding and predictive ability.

Many researchers, one goal

Currently, Wigge and his team are searching for the proverbial needle in a haystack: A plant cell has about 30,000 proteins. Some of them are thought to be involved in the perception of temperature. One class of proteins is of particular interest: "Some proteins undergo a phase transformation, which means that a certain stimulus switches them from inactive state to an active one," Wigge outlines. The researchers hope to identify exactly those proteins in the plant cell for which the phase transformation is triggered by temperature. In addition, they want to find out how DNA and proteins regulate each other.

This type of research requires an interdisciplinary team: Plant physiologists, geneticists, biophysicists, biochemists, and bioinformatics experts will all be bringing their resources to the table. Many of them have never worked with plants before. For the team leader, this mix is a great opportunity as well as a challenge. "All of these people need to work together, understand each other, and pursue a common goal." And there is something else which he thinks is absolutely essential: "Curiosity is the most important personality trait of a researcher."

Wigge himself is curious to find out more about plants as living beings that actively sense and respond to their environment and by no means "passively wait for the weather to get warmer". Plants are able to sense their environment very precisely, anticipating the approaching seasons. Another point that fascinates the researcher is that "many of our festivals and holidays originate from key dates for farmers, reflecting the plant lifecycle. After all, our entire social development is based on agriculture. It was because a fraction of people were able to produce enough food for all that others could turn to the arts, medicine, or sciences."

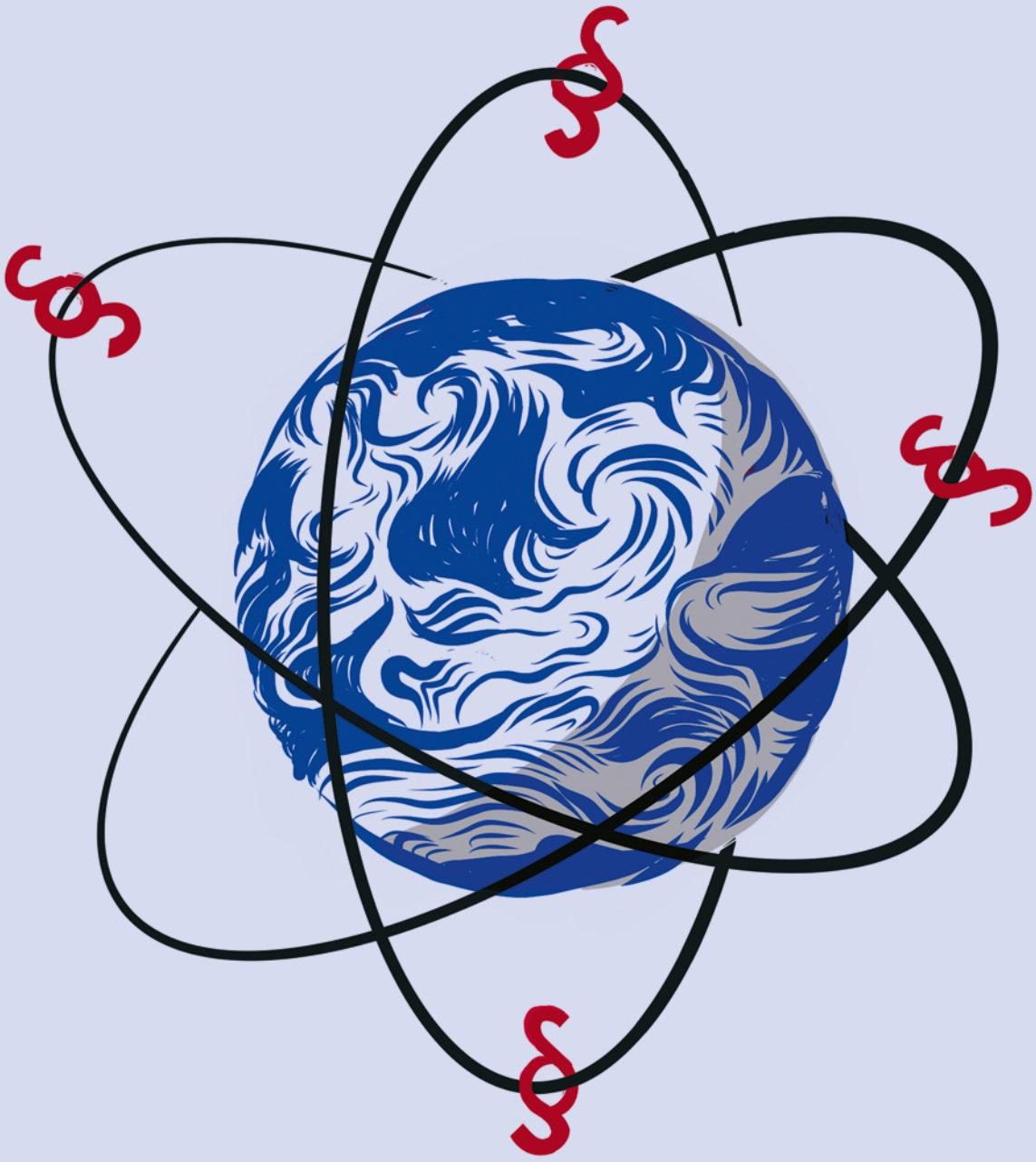
HEIKE KAMPE
TRANSLATION: MONIKA WILKE

THE RESEARCHER

Prof. Dr. Philip A. Wigge studied biochemistry at the University of Oxford (GB) and earned his doctorate at Cambridge. In 2019, the Leibniz Institute of Vegetable and Ornamental Plants (IGZ) and the University of Potsdam appointed him Professor of Plant Nutritional Genomics.

✉ wigge@igzev.de

Photos: Wigge, Philip (2); Thornton, Mike (u. re.)



Articles in Orbit

How a Treaty Ensures That Outer Space Is Used for the Benefit of All

Illustration: Töpfer, Andreas

There is room for everything: crewed Soyuz rockets, the ISS, many satellites, the Hubble Space Telescope, and astronauts daring a spacewalk. Outer space has been a huge sphere of activity. For over 50 years, whatever goes on there has been regulated by the Outer Space Treaty. So what does it actually say, how did it come about, and how up-to-date is it? Petra Görlich asked these and other questions to jurist Marcus Schladebach.

Prof. Schladebach, where does your interest in outer space come from?

Well, my father sparked my interest in it. He was an astronomy teacher and showed me at an early age how fascinating celestial objects and phenomena are.

When did outer space legislation first come about?

Actually, there are two birth dates. One is set in the National Socialist context. On 4 October 1942, Wernher von Braun, a pioneer in space flight, successfully launched the first V-2 rocket from the Army Research Center in Penemünde. It flew about 85 kilometers high, thus grazing the front yard of outer space. This led to the first deliberations on introducing state regulations on outer space. Later, when the Russians launched their first artificial earth satellite Sputnik 1 into orbit in 1957 and the Americans reacted by launching their artificial earth satellite Explorer 1 in February 1958, the need for such regulation became even stronger. During the ensuing space race, the United Nations Committee on the Peaceful Uses of Outer Space was established in 1959. From then on, it was not only technical matters that were studied, but also legal ones.

Years later the Outer Space Treaty went into effect.

Yes, it was signed in London, Moscow, and Washington and remains the main legal basis for outer space legislation. It has been ratified by 98 states and signed by 27. By the way, it went into effect relatively late in Germany, in 1971.

What are the greatest benefits of the Treaty?

The greatest benefit is that it put into writing excellent fundamental decisions on the exploration and utiliza-

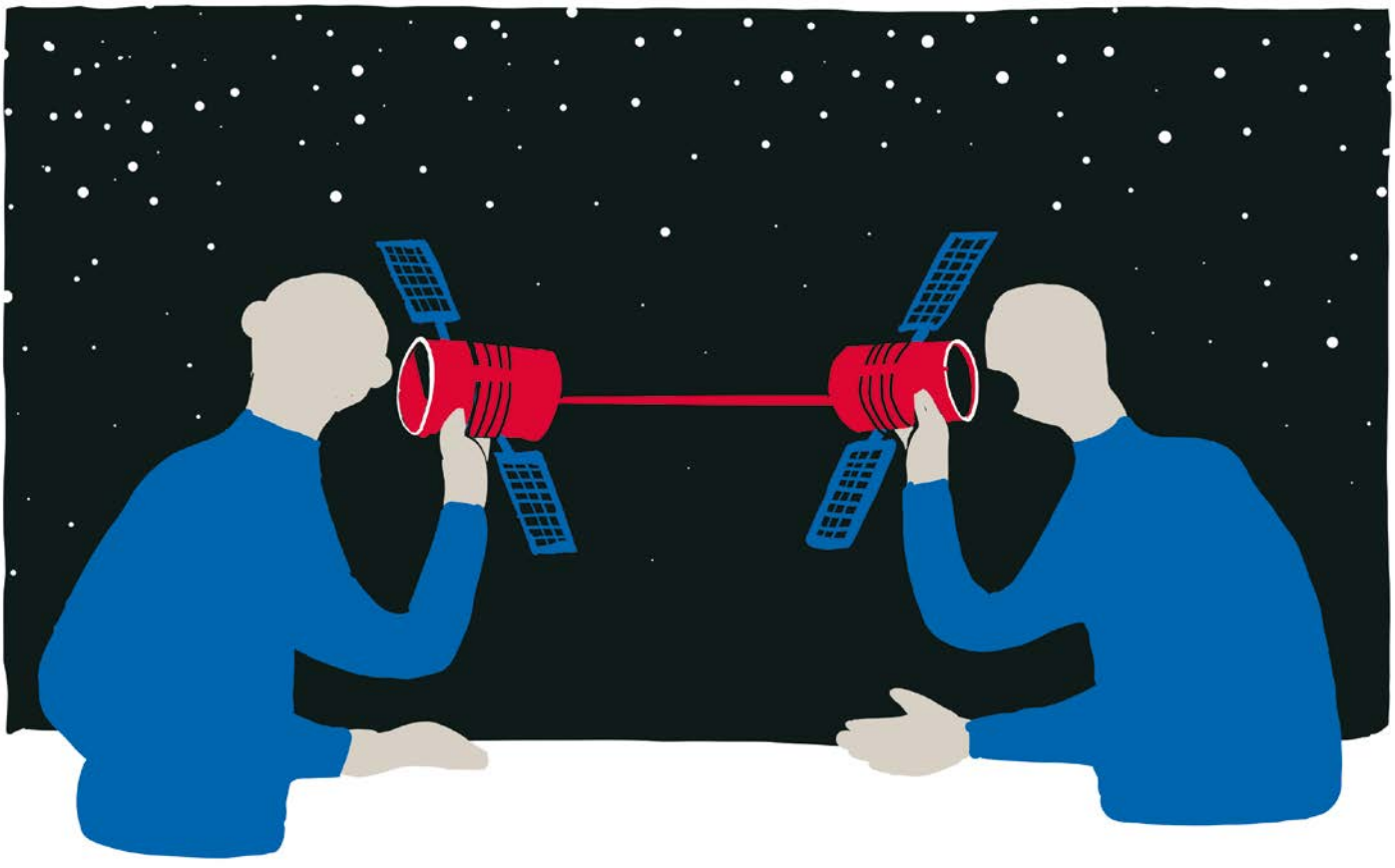


Illustration: Töpfer, Andreas

tion of outer space, which have proven over the past decades to be very wise. Another positive feature is its forward-looking design, in that it rules fields that became relevant only much later. For instance, Article 6 includes private aerospace companies.

What do we actually mean by "outer space"?

There is no legal definition of it. The Outer Space Treaty has just one paragraph on the status of outer space. According to it, outer space is not under the jurisdiction of any state – just like the high seas, the deep sea, and the Antarctic. It belongs to all states, including those not engaging in space travel.

Where does outer space begin, and where does it end?

From a legal perspective, nobody has ventured a guess as to where outer space ends. Where it begins, though, is a disputed issue between air traffic and outer space legislation. This line is important, since it defines the legal limit of national legislation.

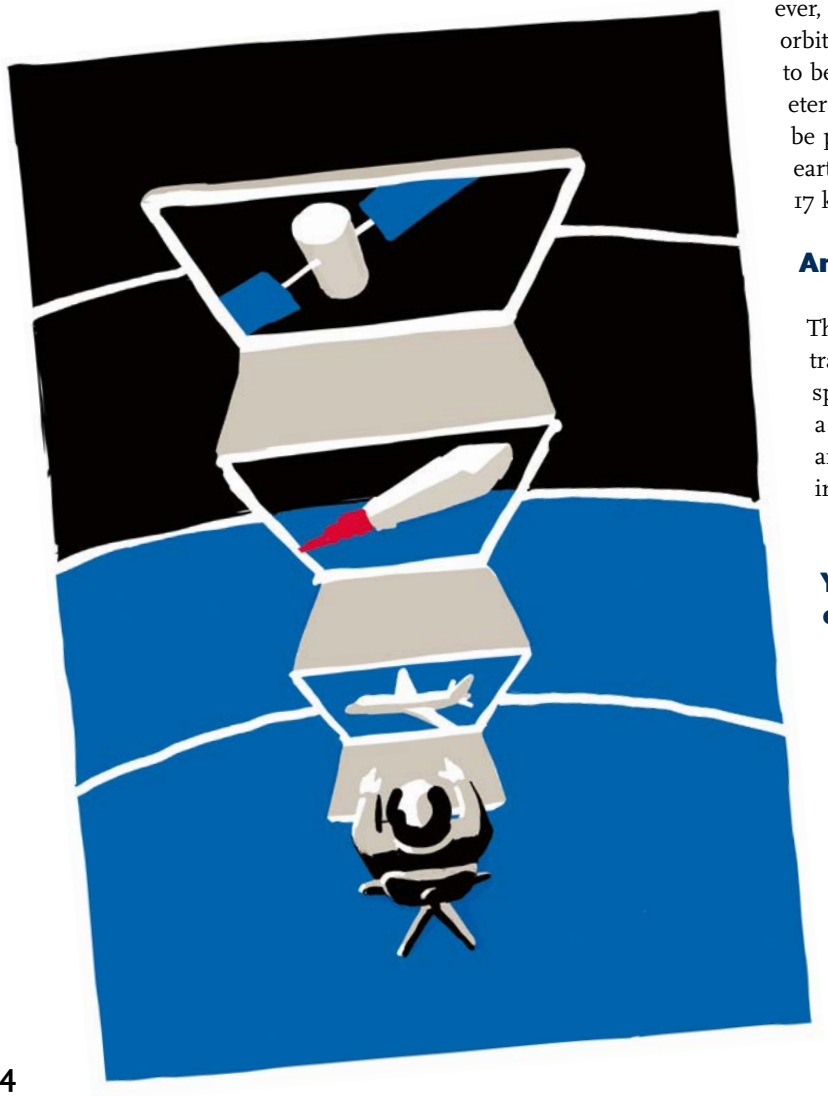
THE RESEARCHER

Prof. Dr. Marcus Schladebach studied law at Humboldt-Universität zu Berlin where he also earned his doctorate. He habilitated at the University Augsburg and has held the chair of Public Law, Media Law, and Didactics of Law at the University Potsdam since 2017.

✉ marcus.schladebach@uni-potsdam.de

Where do you personally define this limit?

My position is that outer space begins at 100 kilometers, and air space ends at 83 kilometers. Due to aerodynamics, i.e. air buoyancy, aircrafts cannot fly higher than 83 kilometers. In space flight, however, space vehicles need centrifugal force to orbit the earth. Scientific evidence shows this to be possible only at an altitude of 100 kilometers. A vehicle flying at a lower altitude would be pulled by the – then lower – gravity of the earth. So I allow for an intermediate layer of 17 kilometers.



And what legal status applies here?

That depends. If the vehicle is on a vertical trajectory heading for outer space, national space legislation applies. For a vehicle on a horizontal trajectory, independent of the airspace and thus the territory of a state, international outer space legislation applies.

You are not alone in this opinion …

There are similar positions. They build on the fundamentals of the much older Law of the Sea, which uses the concept of horizontal sovereignty. The further away from the coast you get, the lower the sovereignty of the coastal state. If you take this picture and fold it up, so to speak, you get a legally justifiable zone. The further away from my own territory I fly into air space and outer space, the lower the sovereignty of my state. The Law of

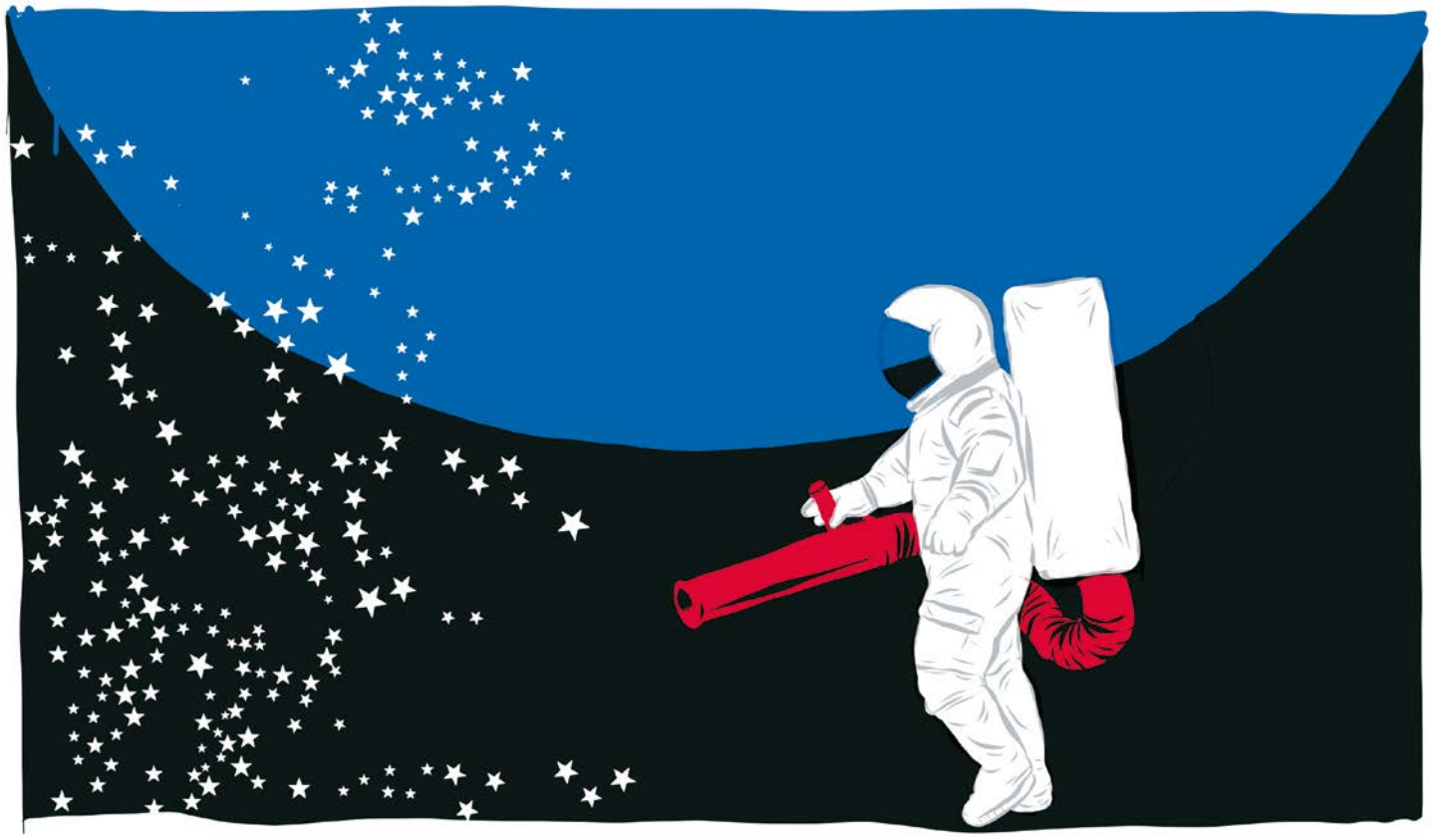


Illustration: Töpfer, Andreas

the Sea also has an interesting intermediate layer: the exclusive economic zone (EEZ). It is neither part of the coastal state nor the high seas.

Let us come back to the Outer Space Treaty. It even includes environmental protection measures. Does it go far enough?

No, even though it was progressive at the time to include this aspect in an international treaty. The text states, among other things, that contamination in outer space has to be avoided.

There is a lot of debris in outer space. Why is there no legal obligation to remove it?

The major space-faring nations stress that no incident has happened yet, so there is no urgent need to take action. Besides, the related financial issues are very complex. There are projects like the Clean Space One cleanup satellite developed in Lausanne. Switzerland is planning to use it to remove its own debris, but refuses to make the patent available to other countries. Another idea is to blow space debris into pieces. In my opinion, this cannot be a solution, as it would only reduce particle size. Yet another idea is to shoot debris into a higher orbit, so their fall would affect people who live much later. This is not what I would call acting responsibly.

The Outer Space Treaty has ensured that there is no military use of outer space. How sure can we be that it will remain like this?

Here we have to differentiate: While a militarization ban applies to the moon and the other celestial bodies, military personnel are allowed to research there. In open space it is prohibited to put nuclear weapons or other means of mass destruction into orbit. However, the ban does not apply to other kinds of weapons. To a certain extent, this regulatory gap has been filled by arms control agreements with limited claim.

Speaking of the moon, experts are already considering using it once the earth has run out of resources. Has this field been legally regulated yet?

In 1969, when the first human walked on the moon, it was clear that a legal regime for the moon was needed. The Moon Treaty was ultimately signed by several countries in 1984 and was later ratified by some of them. Today, however, it is deemed to have failed, given

that it is very difficult to implement. Article 11, which regulates the extraction of natural resources, is a very good example indeed. Problems result from the special status of the moon as a "common heritage of mankind". As things stand now, this means that if a state extracted natural resources, it would have to have them administered through a fund to make sure all other countries benefitted as well. Most countries reject this. Nevertheless, I'm seeing a kind of renaissance. One thing is clear: Somewhere along the line, people on Earth need to be supplied with raw materials and resources from other celestial bodies. Our resources are limited, and the moon is an alternative. That is why researchers in international law are discussing ways to modernize the moon regime, that is, the distribution mechanism, and to make it more acceptable. The tendency is to return to the original terminology and modify it wisely.

Outer space legislation is based on international law. The challenge jurists are facing today is to develop it further, not least because there are plans for the private exploration of the moon and of asteroids. The intention of private aerospace companies to transport travelers into outer space adds to this urgency. As of now, several agreements and treaties contain regulations on the use of space, among them five major international agreements and five UN resolutions specifying important applicable principles.

Let's leave the earth's satellite and look at the problem of possible accidents in outer space. What does the Open Space Treaty regulate, and what does it not?

In the case of an accident of a space vehicle involving imminent danger for its occupants, the Open Space Treaty obliges other states to render assistance. This is an expression of the humanist rationale of space legislation and, in my opinion, a matter of course. Space travelers are considered "messengers of humanity", so their rescue should be a task of the entire world community. However, active assistance requires space vehicles of other states to be around and prepared to help. This will rarely be the case. The Open Space Treaty does not include a legal obligation to launch a dedicated mission for the rescue of space travelers. Apart from that, such mission would probably not be able to be accomplished in an extremely short time frame.

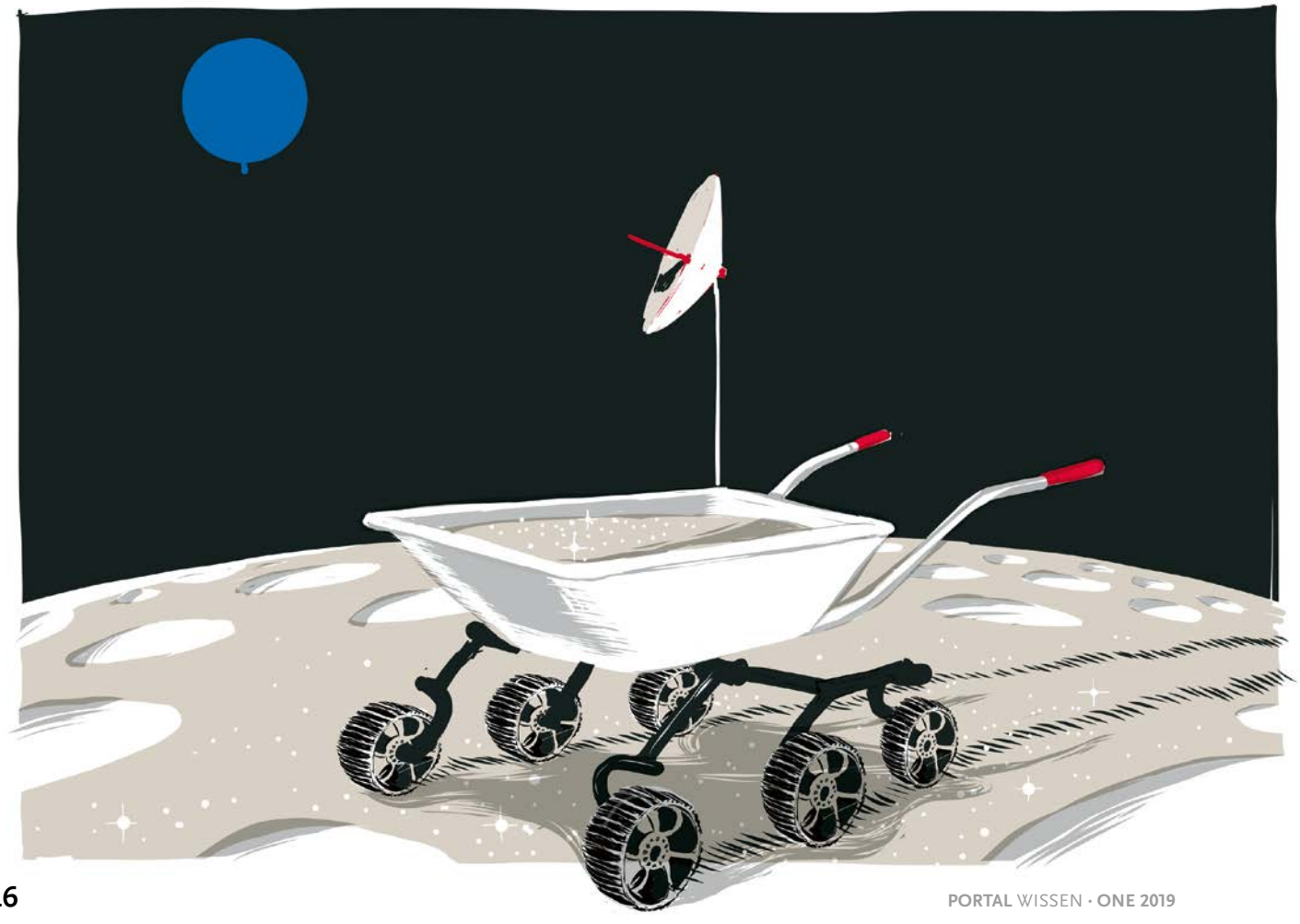


Illustration: Töpfer, Andreas

When the Treaty was signed, the International Space Station ISS was unthinkable. To what extent are its limits now becoming visible?

I would not see it as a defect that the Open Space Treaty signed in 1967 does not provide for joint space stations. After the fall of the Iron Curtain, Presidents Clinton and Yeltsin proposed combining the vast experience gathered with their space labs Skylab and Mir in a joint space station. Initially, it was to be named "Alpha" but ended up just being called "International Space Station (ISS)". In my opinion, the cooperation between ISS partners of the US, Russia, ESA (European Space Agency, including Germany), Japan, and Canada is gratifying proof of the constructive way in which states with often very different views on Earth are able to cooperate in outer space.

In 1998, the governments involved in the space station project signed a dedicated document, the Space Station Intergovernmental Agreement. It regulates, among other things, the legal responsibilities for the existing modules, the protection of intellectual property, and the legal regime in criminal matters. Could you tell us a bit more, especially about the last point?

You are referring to the legal problem of which state has jurisdiction and, thus, control over the various ISS modules. According to the ISS Agreement, responsibility for each module lies with the partner who provides and operates it. In the case of the ESA-built module "Columbus", things are a bit more complex. ESA is not a state, but rather an intergovernmental organization of several European countries. In the case of a criminal offense in connection with the ESA module, the jurisdiction of the home country of the offending astronaut applies. However, I would like to make it very clear that the idea of criminal offenses at the ISS is a completely unrealistic scenario. All astronauts aboard the ISS underwent tremendously difficult training, so any intention to commit a crime on board the ISS can be ruled out.

To this day, no agreement has specified on what basis an encounter between astronauts and intelligent beings in space could take place. Suggestions on the table include Immanuel Kant's categorical imperative, the Charter of the United Nations, and the Bible's Ten Commandments. What are you advocating for?

I have put forward ideas on what the correct criteria could be in a number of papers. For me, the basic requirements of the UN Charter are most appropriate. They are oriented toward the imperatives of peacefulness, a prohibition on the use of force, and cooperation; are universally consented to; and, in my opinion, are a suitable set of guidelines for potential encounters with other intelligent beings.

But the UN Charter is based on our way of thinking on Earth. Could this be a problem?

In our search for suitable criteria, we should, in my opinion, really bear in mind that these are the behavioral and moral norms laid down in UN regulations that reflect our motivation on Earth. Perhaps we cannot yet fully understand whether and, if so, which other guiding principles are conceivable and could be central for extraterrestrial beings. Therefore, advocating for the application of principles applied on Earth, like those of the UN, could mean that we might be accused of taking a superior, even arrogant position.

One last question: How optimistic are you that Germany – like other states – will soon have its own space legislation?

The objective to create such legislation is laid down in the coalition agreement of the current government. The numerous aerospace companies in Germany have long felt the need for more legal and investment certainty. I myself would like to provide scientific backing for this process. We need the law very urgently. It's high time.

PETRA GÖRLICH

TRANSLATION: MONIKA WILKE

Illustration: Töpfer, Andreas

Fighting Stress with the Right Gene

A European Graduate Program Researches Crop Resistance to Stress

THE PROJECT

CropStrengthen is a European Industrial Doctorate Network funded by the Marie Składowska-Curie Program of the European Union. It aims to increase crop strength and resistance to stress by developing new breeding methods and identifying the relevant genes. Participants: University of Potsdam, Department of Molecular Biology, BioAtlantis Ltd., Ireland, and Enza Zaden Beheer B.V., the Netherlands.

Photo: Fritze, Karla

Dr. Katrin Czempinsky (center) with "CropStrengthen" PhD students in the greenhouse.

Five researchers from five countries, a German university, a Dutch and an Irish company – this is what a graduate program can look like today when funded by the European Union. CropStrengthen is a European Industrial Doctorate Network of the Marie Skłodowska-Curie Program. It is a molecular biological project with the objective to increase crop strength and resistance to stress.

What stress does to plants became clear on arid fields in summer 2018: Barley, corn, and potatoes barely stood a chance after months without rain. "The urgency of our project is beyond dispute," says Katrin Czempinski, who coordinates the graduate program CropStrengthen. "We try to identify the genes that make grains and vegetables more resistant to drought but also to excessive wetness. The most stress-tolerant plants possessing these special genes will then be bred systematically." What gardeners and farmers achieve by patiently crossing and testing plants over several generations will be done in a fast-track procedure by using molecular biological methods. And time is of the essence: The climate is changing and crop failures are increasing worldwide.

Basic research focusing on applications

Katrin Czempinski immediately knew that she wanted to get involved in this project. Its international approach as well as collaborating with operators in the industry piqued her interest. She underestimated, however, how much her own tolerance for stress would be required. The PhD students came from India, Pakistan, China, and Colombia. Two of them were employed by the participating companies BioAtlantis Ltd. in Ireland and Enza Zaden Research and Development B.V. in the Netherlands, and the other three at the University of Potsdam. During their doctoral studies, all early-stage researchers had to conduct research on-site at the industrial partners for 18 months. "This was one of the program's conditions," Czempinski explains, who did not know at the start of the project three years ago what was involved in ob-

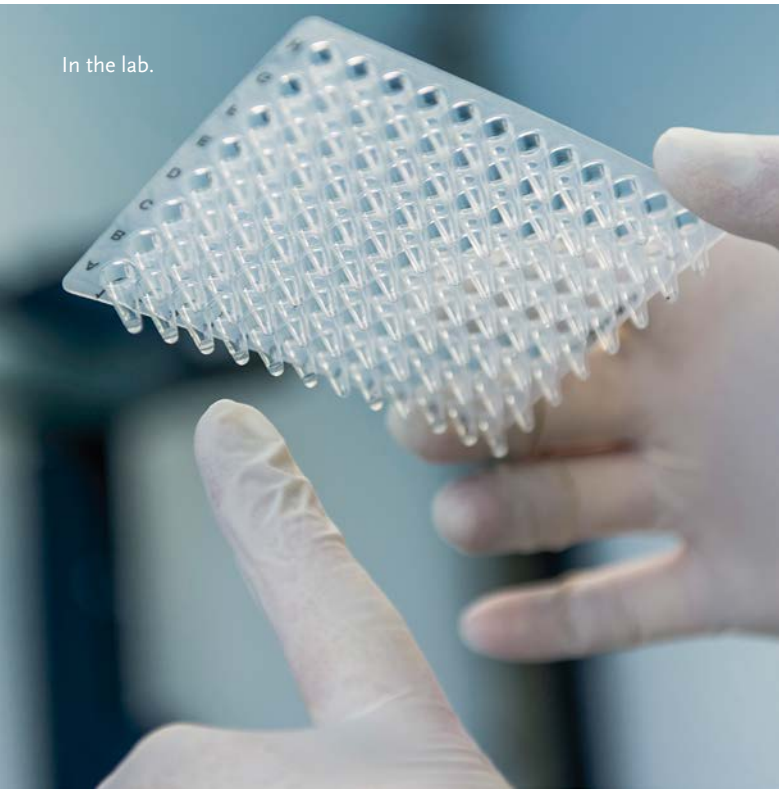
THE RESEARCHERS

Prof. Dr. Bernd Müller-Röber studied biology and philosophy in Tübingen and Marburg. Since 2000, he has been Professor of Molecular Biology at the University of Potsdam.

✉ bmr@uni-potsdam.de

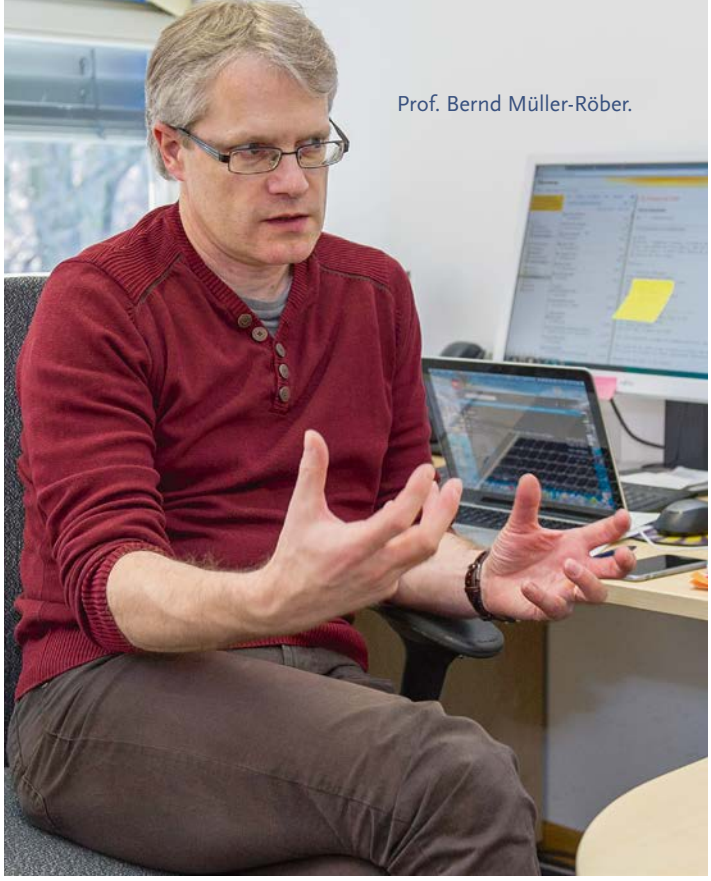
Dr. Katrin Czempinski is a biotechnologist and coordinator of the European Graduate Program CropStrengthen at the Institute of Biochemistry and Biology.

✉ katrin.czempinski@uni-potsdam.de



In the lab.

Photos: Hölzel, Thomas (5); Fritze, Karla (M.)



Prof. Bernd Müller-Röber.

Model plant
Arabidopsis thaliana.

taining residence and work permits for five non-Europeans in three European countries, organizing constant changes of residence, and resolving insurance issues. She sometimes thought she would never do this again. Deadlines, taxes, approvals – nothing went together. At the same time, the experiments in the Potsdam greenhouses operated under their own laws. "Plant growth and experimental procedures don't care about residence regulations," says the doctor of biotechnology, who is familiar with the constraints of scientific work from her own experience. In retrospect, she is astonished how things eventually fell into place. "I would not have managed without the help of the Welcome Center and the university's HR department," she is sure. With patience and creativity, they found new answers to even the most complicated questions. Only in this way were the PhD students able to take advantage of the program's special opportunities and to relate their basic research topics to those of the industry. This was an important experience that will help them to find the right career path after graduation.

Biostimulants increase drought tolerance

All five PhD students are now about to complete their doctoral studies. They were invited by Prof. Bernd Müller-Röber – a molecular biologist and scientific coordinator of the project – to present their results in a poster session at the international Plant Stress Symposium in November 2018. The scientific committee of the symposium selected PhD researcher Lorena Romero Prada to give a talk. She reported on her analysis of a stress-tolerant wild tomato from the Andes. "These exciting results were extensively discussed," says Müller-Röber. Over 50 experienced researchers as well as many young ones came to Potsdam from 16 countries to discuss the current state of research.

The projects of the graduate program provided important data for a better understanding of the response of model and crop plants to environmental stress and adaptation. One of the most notable results is the discovery that certain biostimulants made from brown algae significantly improve the resilience to drought stress. "Several genes with similar functions are involved in the model plant Arabidopsis thaliana and the cultivated plant tomato. How exactly the biostimulants activate the genes is still unknown."

That the biostimulants used increase the drought tolerance of plants is in itself an important finding. In the future, such products will likely be used to cultivate other plants that need to be protected against drought, but this must still be tested in detail, as the molecular biologist explains. "It is also important that we learn more about the genes that provide such protection by looking at the effect of biostimulants. In the future, this knowledge can be used in breeding." Initially, this will require an in-depth analysis of the identified genes, the cellular signaling networks, and molecular mechanisms. Promising candidates that improve stress tolerance when influencing and changing their gene activities would then serve as new breeding markers to cross this trait into new varieties, says Müller-Röber. "In the medium term, it could be particularly interesting to breed our crops so that they react even better to biostimulants."

ANTJE HORN-CONRAD
TRANSLATION: SUSANNE VOIGT

Photos: Hölzel, Thomas (2)

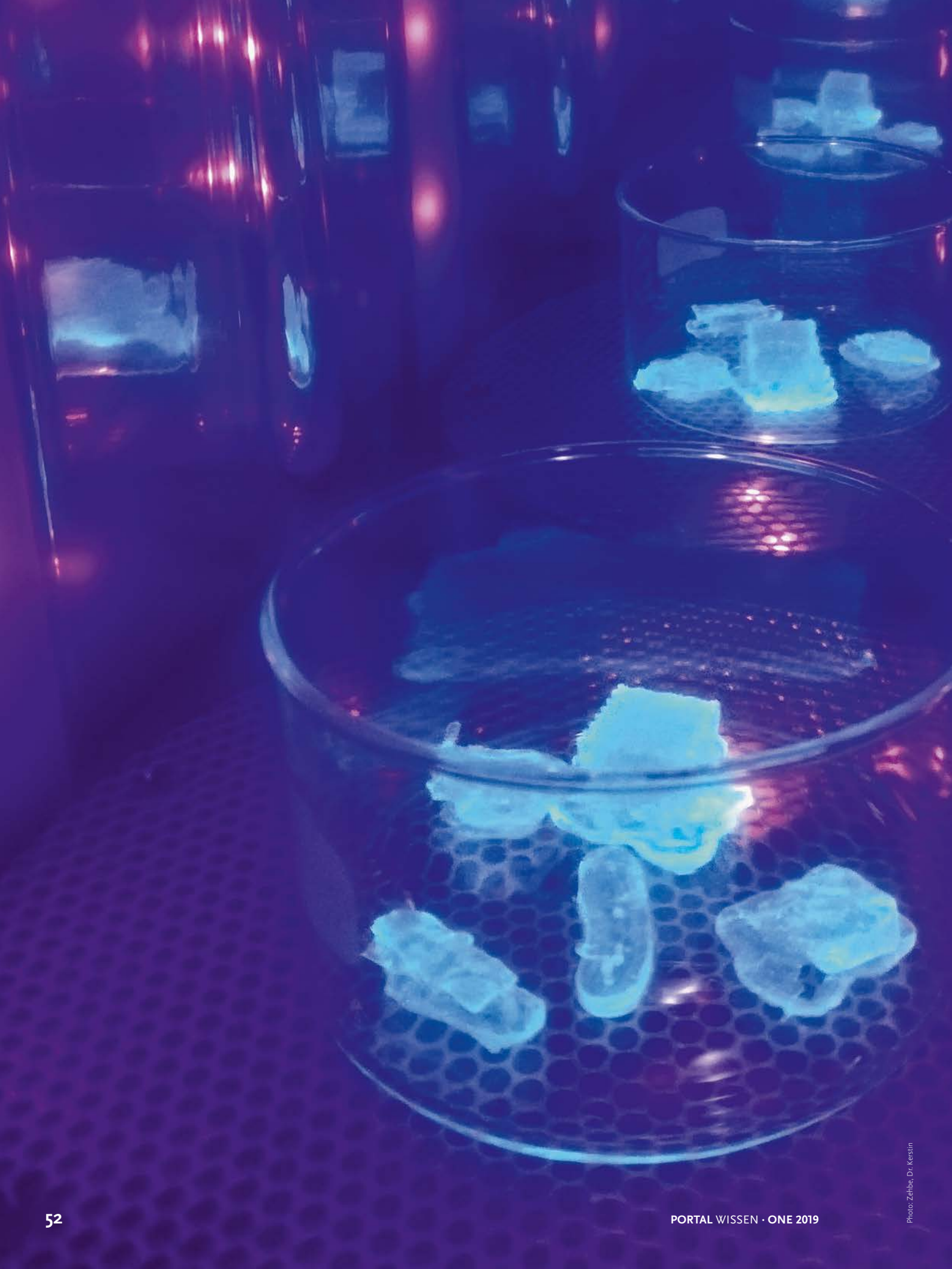


Photo: Zehbe, Dr. Kerstin

Batteries from the Printer

Chemists from Potsdam and Karlsruhe Are Developing Novel Electrochemical Storage Systems

Powerful batteries are in demand as never before. They are not only the key to electromobility and energy supply for our everyday electronic companions. Research on and into energy storage systems is also booming because they are essential for the energy transition. The Potsdam-based researcher Kerstin Zehbe is developing a battery concept based on novel gels and 3D printing.

Kerstin Zehbe is holding two small, round glass flasks filled with liquids in her hands. In one she is swirling a deep blue solution, in the other a pale yellow. More pistons containing other substances are standing under the fume hood of the chemical laboratory: some are crystalline, others colloidal. There are even some that contain compounds that luminesce under UV light. Although the substances look different, they have one thing in common: they are so-called ionic liquids. The chemist is pursuing an ambitious goal with these starting materials. In a joint research project with the Karlsruhe Institute of Technology (KIT), she intends to develop novel batteries that are stronger, more efficient, and more stable than all previous ones – yet are still inexpensive.

Alternatives to lithium batteries

"The principle of a battery is quite simple," Zehbe explains "You need two electrodes and an electrolyte in between to allow charge transport." Up until now, mainly systems based on lithium ions have been used. But these are not without problems: If a lithium battery is damaged or heated by sunlight, it can catch fire or even explode. "That's why we're looking for alternatives."

The chemist is counting on ionic liquids, which are also suitable for use in battery systems. "In principle, they are salts that are usually liquid at room temperature," Zehbe explains. These salts consist of positively and negatively charged ions. By choosing the ions, the researcher can influence how the substance behaves. Like choosing from a modular system, she selects which negatively and positively charged particles to mix and thus determines which characteristics the final product has. "The way I need it," she says.

Adaptable by using 3D printing

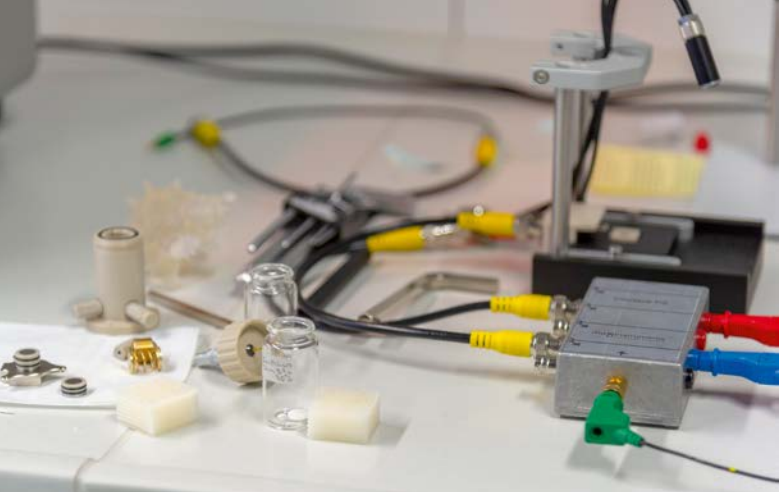
In her battery model, the ionic liquids act as the charge-conducting electrolyte. But the real clou of her research approach lies elsewhere: Kerstin Zehbe is developing gels from these liquids in order to connect

THE PROJECT

Universally shaped Batteries from Printable Ionogels (UniBat)

The researchers are developing a novel process for batteries based on ionogels. The aim of the novel battery concept is to overcome current technical problems such as unwanted chemical side reactions or thermal decomposition.

Participants: University of Potsdam, Karlsruhe Institute of Technology (KIT)
Funding: German Research Association (DFG)
Duration: 2017–2020



Dr. Kerstin Zehbe.

Printed batteries of different shapes and structures.

them with a carrier matrix. For this, she mixes the ionic liquids with a synthetic resin or with silicone and prints out the mixture on a 3D printer. Laser irradiation hardens the material during the printing process.

With this method, the resulting ionogel can take any conceivable form. Zehbe's prototypes, for example, are hard, circular discs that contain fine holes – like a sieve. A second model is cylindrical and soft, it has pores like a sponge. A third one has honeycomb pores that traverse the blank from one end to the other. "We are trying to print structures that are macroscopically optimized," she explains. The finer, the better, so that it enables a good connection to the electrode and a faster charge transport.

The desired properties of the ionic liquids are retained by the procedure. At the same time, the gels reduce undesirable characteristics of the fluids. These are very corrosive and can attack the electrode material in a battery.

Not far from achieving the perfect mix

The scientist has been experimenting with various liquids and resins in her laboratory for a year determining the conductivities and testing numerous types of the ionogel. The products are to be chemically and thermally very stable, highly conductive and as efficient as possible. Zehbe is looking for "the perfect mix". She sends the most promising prototypes to the Karlsruhe Institute where further tests will follow. She does not want to reveal too much about the components of her system. "Only so much: Our gels are based on fluorites and sulfates."

Kerstin Zehbe is still in the midst of research into her battery systems, which she will further optimize. Nevertheless, she is already hatching the next project, and she remains true to the topic of energy: "Fuel cells are another very large field that we want to tackle." Ionic liquids will play a role her as well, announces the chemist.

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

THE RESEARCHER

Dr. Kerstin Zehbe studied chemistry at the University of Potsdam and earned her doctoral degree at the Technischen Universität Berlin. Since 2014, she has been a postdoctoral researcher at the University of Potsdam and has researched ionic liquids, ionogels, battery systems, and fuel cells.

✉ kerstin.zehbe@uni-potsdam.de

Photos: Hopfgarten, Tobias (4)

Die Tageszeitung der Landeshauptstadt als E-Paper!

Einfach schneller informiert

Das PNN E-Paper informiert jederzeit über alles Wichtige aus Potsdam, Berlin, Deutschland und der Welt. Bequem auf dem Weg zur UNI vorinformieren, online oder offline, dank moderner Archivfunktion. Mit der SocialMedia-Funktion können wichtige News sofort weitergegeben werden. Moderner Zeitungslesen geht nicht.

Ihre Vorteile

- ✓ Für 5 Geräte parallel nutzbar
- ✓ Zugriff jederzeit online und offline
- ✓ Schon am Vortag ab 21.00 Uhr die kommende Ausgabe erhalten

30 Tage gratis

Jetzt bestellen

pnn.de/probe

Telefon: (0331) 23 76-100

Weitere Angebote im Paket mit Tablet oder Smartphone: pnn.de/epaper

JETZT BEI Google Play

Laden im App Store

TAGESSPIEGEL

POTSDAMER

NEUESTE NACHRICHTEN

Where **Knowledge** grows

www.uni-potsdam.de