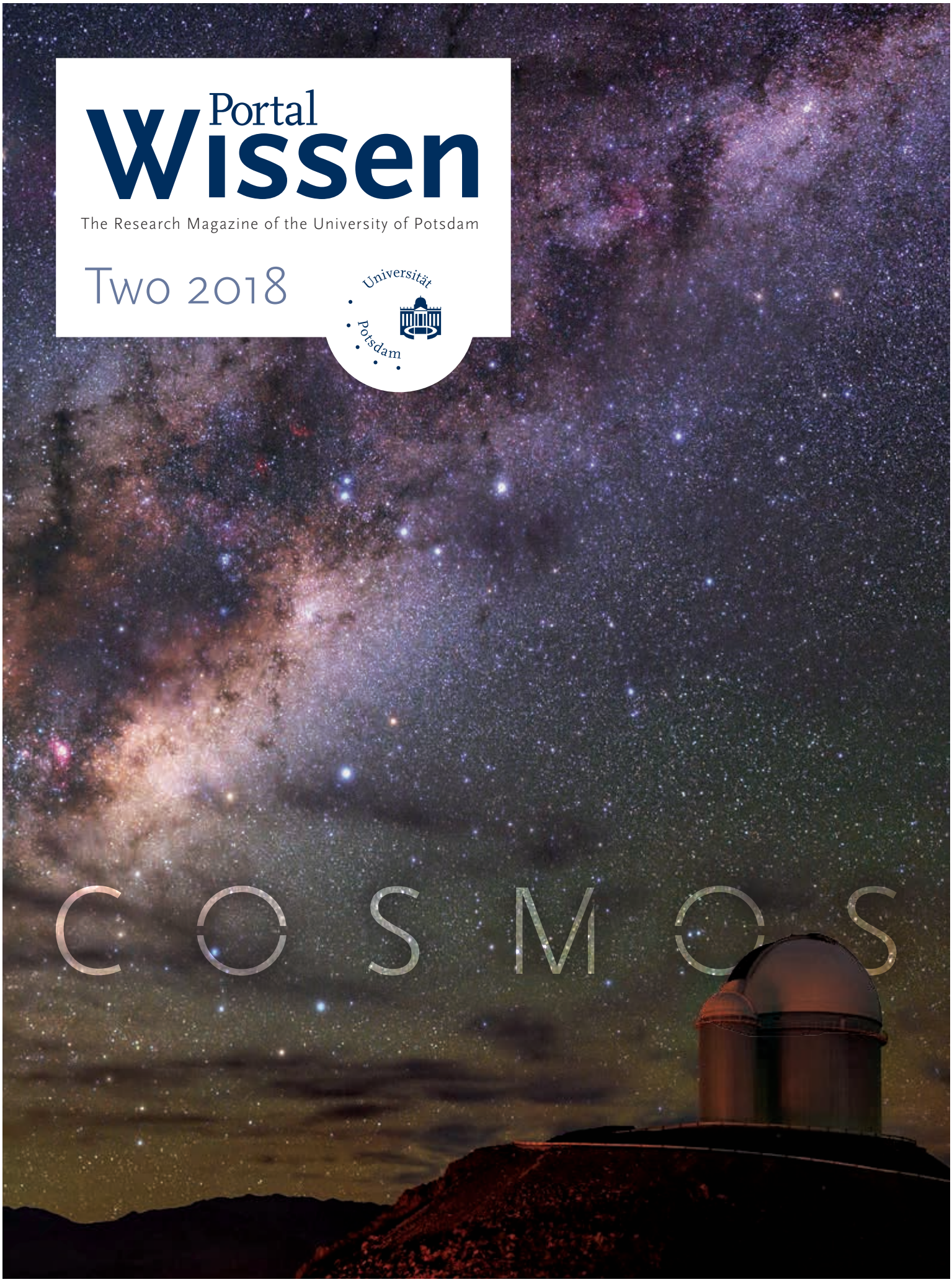
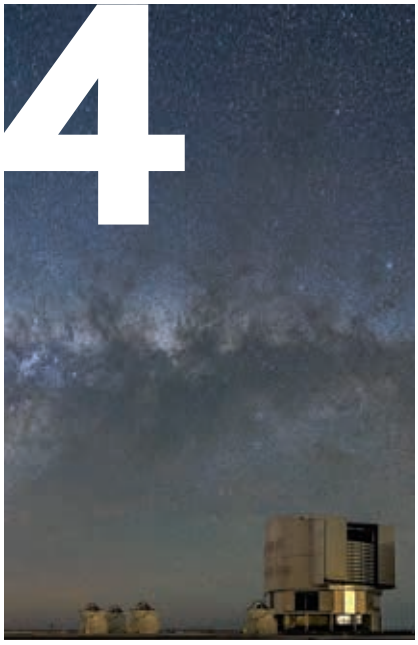
Portal Wissen

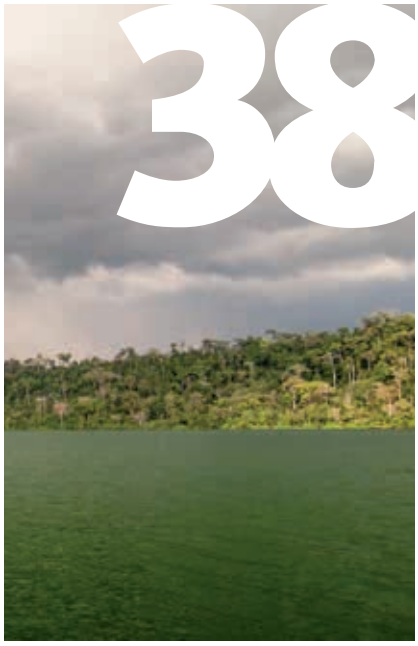
The Research Magazine of the University of Potsdam

Two 2018

Universität Potsdam







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COSMOS

Speaking of the cosmos means speaking about nothing less than everything, about the entirety of space filled with matter and energy. We only see a tiny fraction of it from Earth: planets like Venus or stars like the Sun. There are at least 100 billion stars in our home galaxy alone. Bound by gravity, these luminescent celestial bodies of very hot gas form a system visible from Earth as a whitish ribbon, which we call the Milky Way. The observable cosmos contains at least 100 billion such galaxies with stars, cosmic dust, gas, and probably dark matter as well. The universe is 13.8 billion years old; crossing it once would probably take 78 billion light-years.

Given these dimensions, it is hardly surprising that for us humans, the mystery of the properties of the cosmos is connected with questions of being. Where do we come from? Where are we going? Are we alone in the universe? Such questions are in the wheelhouse of astrophysicists, who explore the vastness of the cosmos through physical means, even though they, of course, deal with physical laws, mathematical formulas, and complicated measuring methods. In this issue of Portal Wissen, we talked with astrophysicists at the University of Potsdam about their research and everyday work.

Lutz Wisotzki showed us a 3D spectrograph, which he has developed in collaboration with colleagues from the Leibniz Institute for Astrophysics (AIP) and six other European institutes. This technical masterpiece enables scientists to look deeply into space and to "journey" through time to galaxies shortly after the Big Bang. Philipp Richter introduced us to the astrophysics research initiative and demonstrated how the University of Potsdam is working together with the AIP, the Albert Einstein Institute (AEI) and the Deutsches Elektronen-Synchrotron (DESY) to train junior researchers. The newly appointed Professor of Stellar Astrophysics, Stephan Geier, presented us with stars so close together to each other that they appear to be one to the naked eye. The physicist, who is also a historian, researches their turbulent relationships.

We have not confined ourselves to cosmic themes, though, but also questioned rather earthly matters such as modern consumption. We have thought about potential love relationships with robots and testimonials in literature and art. We learned why the rainforest in Central Africa disappeared 2,600 years ago, how to produce knee prostheses on a production line, and how animals in the field benefit from big data.

But back to the cosmos. The writing of late astrophysicist Stephen Hawking fundamentally shaped our concepts and knowledge of the universe. And that is because he was both an important physicist and a literary genius. Hardly anyone has been able to capture difficult facts in such a clear, understandable, and beautiful language. With this exemplary understanding of science in mind, we hope to offer you a stimulating read.

THE EDITORS

Photo: NASA/Goddard

LUMINOUS GAS HALOS

ASTROPHYSICISTS RESEARCH GALAXY ENVELOPES IN THE YOUNG UNIVERSE

The four towers of the Very Large Telescope in the Atacama Desert

Photo: ESO/John Colosimo

THE PROJECT

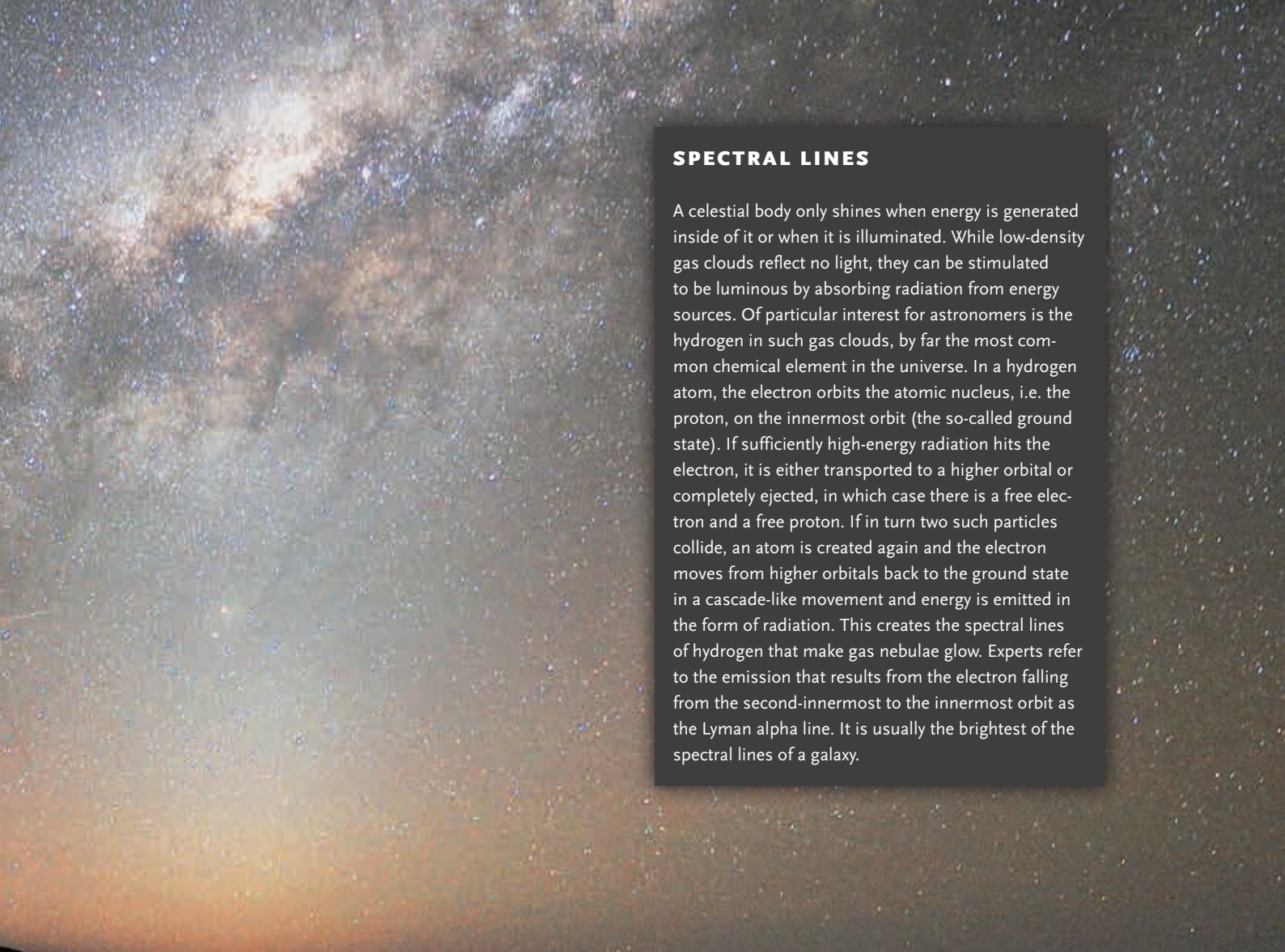
The infancy of normal galaxies revealed with MUSE

Funding: Leibniz Association
Funds: approx. 1 million euros
Duration: 2015–2019

La Silla Observatory of the European Southern Observatory in the Atacama Desert

It is a journey to the beginning of our being. The hunt for galaxies in the young universe and for what surrounds these heavenly worlds is in full swing. Science still knows very little about them. The space around stellar systems is not empty at all; it contains large amounts of so-called circumgalactic gas. But how is this gas distributed? How does it move around? What are the differences between the galaxies? Lutz Wisotzki and his teams at the Leibniz Institute for Astrophysics Potsdam (AIP) and at the University of Potsdam investigate such phenomena. Deciphering them is important to better understanding how galaxies are born and evolve.

They are invisible to the naked eye. Even the pictures taken by large telescopes reveal them only as tiny specks of light: galaxies at unimaginable distances. They are stellar systems in the young universe, whose light has taken billions of years to reach us. A new door to them has been opened now by a technological innovation called the Multi Unit Spectroscopic Explorer (MUSE), which was installed in 2014 at the Very Large Telescope (VLT) in the Atacama Desert in Chile. This 3D integral-field spectrograph – equipped with 24 identical spectrographs – makes it possible to look back almost to the origin of the universe. The telescope delivers much more than just beautiful pictures of the sky, though. With a single exposure, MUSE records more than 90,000 spectra of astronomical objects in a single go. It disperses the light into colors or wavelengths so that its intensity can be simultaneously measured at all frequencies. Wisotzki is particularly interested in the spectra, especially the so-called Lyman-alpha line, which reveals a lot about the circumgalactic medium surrounding young galaxies. This gas emits a substantial portion of its light in certain spectral lines. The Lyman-alpha line originates from hydrogen atoms, i.e. the most common element in the cosmos.



SPECTRAL LINES

A celestial body only shines when energy is generated inside of it or when it is illuminated. While low-density gas clouds reflect no light, they can be stimulated to be luminous by absorbing radiation from energy sources. Of particular interest for astronomers is the hydrogen in such gas clouds, by far the most common chemical element in the universe. In a hydrogen atom, the electron orbits the atomic nucleus, i.e. the proton, on the innermost orbit (the so-called ground state). If sufficiently high-energy radiation hits the electron, it is either transported to a higher orbital or completely ejected, in which case there is a free electron and a free proton. If in turn two such particles collide, an atom is created again and the electron moves from higher orbitals back to the ground state in a cascade-like movement and energy is emitted in the form of radiation. This creates the spectral lines of hydrogen that make gas nebulae glow. Experts refer to the emission that results from the electron falling from the second-innermost to the innermost orbit as the Lyman alpha line. It is usually the brightest of the spectral lines of a galaxy.

In collaboration with a consortium of six European research institutes, Wisotzki and his Potsdam colleagues at the AIP have developed a "magical machine". They provided the data reduction software that filters the scientific signal from the noise, eliminates the influence of instrument properties and the atmosphere, and then compiles the complex data, the AIP also developed and built the calibration unit as a hardware contribution. "The performance of MUSE is unique and unrivaled," Wisotzki enthuses about it. The spectrograph combines detailed images, spectra over a wide range, and high sensitivity. "Instead of creating a picture of the region and then selecting objects that were extensively and individually spectroscopically reobserved as had been done in the past, the device delivers data of high spectral quality for all objects in the field of view in a single step," Wisotzki explains. It offers an observing method that allows a very deep look into space and a journey through time to galaxies shortly after the Big Bang. For the first time, galaxies previously only visible to the Hubble Space Telescope can now be studied in much greater detail from the VLT with MUSE. And MUSE has even revealed galaxies so small and faint that they had escaped Hubble.

Photo: ESO/G. Hüdepohl (atacamaphoto.com)

DISTANCES TO GALAXIES

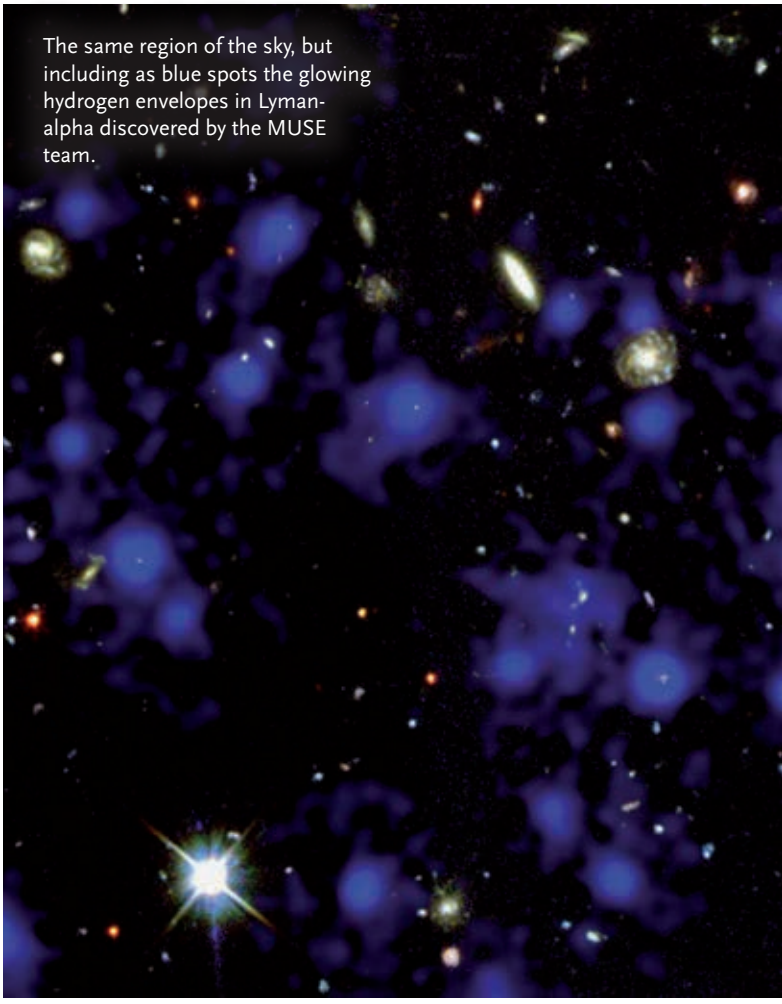
The distance to a galaxy cannot be measured directly but can only be indirectly determined or estimated. For distant galaxies, however, the universe provides the researchers with a "trick" based on a discovery by Edwin Hubble 90 years ago that allows them to infer distance from observations. Light waves passing through the expanding universe are involved in the expansion, which causes the radiation to shift to longer wavelengths. The further away a galaxy is, the faster it seems to be moving away from us. This is however no real movement in space, but only the immediate consequence of the expansion of the universe. Experts denote this effect as "cosmological redshift". In order to determine distances, astronomers first measure the redshift in a spectrum of the galaxy and then calculate the distance based on a relation established by Hubble.

The observed young galaxies are surrounded by hydrogen halos

Lutz Wisotzki, also Professor for Observational Cosmology at the University of Potsdam, and his team have studied the spectra of many galaxies in the young universe in the so-called Hubble Deep Fields, regions where the Hubble Space Telescope had previously obtained supremely sharp images. "We expose for as long as possible," Wisotzki reports. "The final result is then assembled on the computer." Two of the pointings alone combined data from 30 hours exposure time per field. The effort was worth it. In each of these fields, the researchers were able to measure redshifts from nearly 300 galaxies – a huge step forward, as only 10-20 redshifts per field had been previously known. Since redshifts can be converted directly into distances, it became possible for the first time to reconstruct these fields in three dimensions. While the images deliver the positions of the galaxies in the sky, the spectra provide redshifts and thus distances.

Photos: Wisotzki, Lutz (2)

Image obtained by the Hubble Space Telescope, showing approximately 600 galaxies.



The same region of the sky, but including as blue spots the glowing hydrogen envelopes in Lyman-alpha discovered by the MUSE team.

Lutz Wisotzki

Moreover, based on the redshifts the astrophysicists at the AIP and the University of Potsdam were able to classify the galaxies into cosmic epochs, thanks to MUSE.

The researchers also achieved a breakthrough by observing the so-called Lyman-alpha spectral line of the most distant galaxies. They were able to demonstrate that all observed stellar systems of this cosmic age are surrounded by very extended hydrogen envelopes, many times larger than the galaxies themselves. No astronomical instrument before MUSE had been able to detect these Lyman-alpha envelopes; there had only been statistically averaged values. How did this discovery happen? "We had previously found that the systems observed with MUSE in the Lyman-alpha light were slightly diffuse and definitely larger than in the Hubble images. After this initial visual impression, we analyzed the light distribution and applied statistical methods that confirmed this impression," Wisotzki explains. "We realized that we had seen not only radiation from inside the galaxies but also from the circumgalactic medium." This discovery will likely have consequences for astrophysics. Conventional wisdom on the ecosystem of galaxies must now be put to the test.

According to Wisotzki, the fact that the glow of the gaseous halos is detectable despite their extremely low density can only be explained if standard assumptions concerning the structure of the circumgalactic gas are revised. "Presumably, the gas in the vicinity of galaxies is much less uniformly distributed than previously believed," says the Potsdam astrophysicist. The circumgalactic gas appears to consist of many small clumps or filaments reprocessing the radiation from the central galaxy. Whether this is actually the case will become clear once these effects have been more accurately calculated.

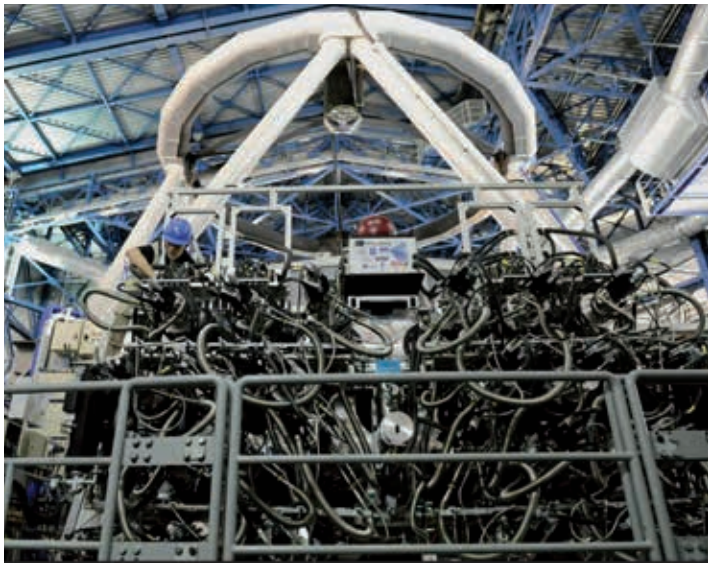
The insights gained will be incorporated into the next generation of numerical simulations, which need to take into account the newly discovered properties of circumgalactic nebulae. Possibly, theory and observations may get into alignment in about five years. It would be a big step in better understanding the environmental properties of young galaxies – and in understanding the evolution of galaxies in general – because the circumgalactic gas is both reservoir and catch basin. On the one hand, it supplies new

COSMIC TIME MACHINE

Given the finite nature of the speed of light, researchers observe each a distant galaxy as it was at the time its light was emitted. The observable universe is, so to speak, a perfect time machine but only into the past. This phenomenon is the prerequisite for astrophysicists to explore the state of the universe at very different cosmic times with a single observation – all the way back to the early stages when a large part of today's stars and galaxies did not exist or were only just coming into existence.

Photo: Roese, Thomas

VLT control room



The Multi Unit Spectroscopic Explorer (MUSE)

gas from the outside, which results in the evolution of new stars in the galaxy. On the other hand, it also absorbs material ejected from the galaxies, much of which then returns to the galaxies. One of the biggest unresolved questions in astrophysics is how this complicated chaos of so many processes is self-regulated. The new observation results from MUSE provide an essential component in solving this problem.

The **MUSE** consortium consists of 7 major European research institutes: The Centre de Recherche Astrophysique de Lyon (CRAL, France), the Leibniz Institute for Astrophysics Potsdam (AIP, Germany), the Göttingen Astrophysics Institute (AIG, Germany), NOVA/Leiden Observatory (NOVA, the Netherlands), the Laboratoire d'Astrophysique de Tarbes-Toulouse (LATT, France), the Department of Astrophysics at the Zurich Polytechnic Institute of Technology (ETH, Switzerland), and the European Southern Observatory (ESO).

The Very Large Telescope in the Atacama Desert is a very special place

The research successes of Wisotzki and his team were the outcome of numerous observation nights at the VLT. While the property rights of the MUSE instrument have been transferred to the European Observatory (ESO), the Potsdam researchers and their colleagues received 255 nights of "Guaranteed Observing" for the project, as "remuneration" for their work on MUSE. The researchers still have about 100 nights remaining for their investigations. On average, three researchers travel to Chile for a week, several times a year. When in South America, not only their

Photos: private (top); Bacon, Roland (middle)

THE RESEARCHER

Prof. Dr. Lutz Wisotzki studied physics and astronomy at the University of Hamburg. Since 2009, he has been Professor of Observational Cosmology at the University of Potsdam, a joint chair with the Leibniz Institute for Astrophysics Potsdam (AIP). At the AIP, Wisotzki heads the "Galaxies and Quasars" program area. He is also scientific coordinator of the overall MUSE project.

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work hours change but also the duration, with a night length of 8-10 hours. "We start preparing in the afternoon," Wisotzki reports. Work at the telescope then starts as soon as it gets dark.

During these nights, the experts from Brandenburg are not alone in the control room on the edge of the platform. Astrophysicists from all over the world are observing the sky. "It is a strangely sober atmosphere with dim light and a strict ban on music," the much-traveled professor describes the situation. "Only low partition walls divide the work areas." The place is still very special for Wisotzki, especially at sunset. "When the sun is low and the landscape is glowing in an impressive orange light, it's hard to believe that such a thing exists," he says. The area's barrenness and solitude are sublime.

In all likelihood, Wisotzki will soon be traveling back to Chile. Even after the current project funding ends in 2019, the questions remain: Where do the hydrogen envelopes get the energy from that makes them glow? What are the mechanisms for the observed Lyman-alpha radiation? Do the young, hot stars play the dominant role, or are external influences more important? Each discovery raises new questions. "MUSE has catapulted us to the scientific forefront in research on the young universe," says Wisotzki. "We want to maintain this position." The hunt for the unknown continues.

PETRA GÖRLICH
TRANSLATION: SUSANNE VOIGT

Photos: Roese, Thomas (top left); ESO/G. Gillet (bottom)

FROM THE DARK INTO THE LIGHT

Research initiative spotlights astrophysics in Potsdam

Potsdam is one of the four most important astrophysics research sites in Germany. Besides the University of Potsdam, three internationally leading institutes are located here, which conduct research across an unparalleled range of topics in this field. Joint appointments and working groups underpin the university's teaching. In an interview, astrophysicist Prof. Philipp Richter speaks about the advantages of this network, the attractiveness of the degree program, and promoting young researchers.

Photo: NASA/JPL-Caltech

Astrophysics in Potsdam has a long tradition. In the 19th century, several observatories were built on Telegraphenberg. Visible from afar, the domed building of the large refractor towers over the city's silhouette. The last German Emperor had it built on the hill in 1899. Why in Potsdam?

They wanted to have a place outside but not too far from Berlin. The lights of the big city would have prevented seeing anything in the sky. In addition, the site had already been structurally developed for the old optical telegraph line.

Potsdam also has too much light now, doesn't it?

Yes, without a doubt. Large telescopes now used for scientific observations are found around the globe: for example, in Chile, in Antarctica, and even in space.

Large refractor

Photo: AIP/Rainer Arlt

We rarely make observations personally on-site; instead, we evaluate data that has been recorded for us. Some of the topics we deal with today, however, have their origins on Telegraphenberg. My own research field, for example, – the interstellar medium – was discovered here in 1904.

Potsdam's days of being in the dark are definitely over. The city has become a hotspot of astrophysics. What is so special here?

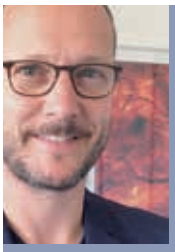
It is the density of major extramural research institutions and their close collaboration with the university. There is the Leibniz Institute for Astrophysics, which belongs to the world's leading institutes in instrument development. In Golm, there is the Max Planck Institute for Gravitational Physics. In 2015, it was involved in the first measurement of gravitational waves, for which a Nobel Prize was awarded. Last but not least, the German Electron Synchrotron (DESY) in Zeuthen is an internationally renowned center for astroparticle physics. Thanks to the joint appointments and the good collaboration with these institutes, we can now cover virtually all areas of modern astrophysics in our courses at the University. This is unique.

Some time ago you started a new research initiative. What is your objective?

We wanted to be able to better coordinate our collaboration, increase the visibility of Potsdam astrophysics, and act more concertedly, also to show prospective students and young researchers what and how they can study and research here. We also have a professionally designed joint website that offers a good overview of our activities. In 2016, we started offering the international Master's program "Astrophysics" as well as a structured graduate program with excellent conditions for doctoral studies.

How has the new Master's program been received?

Word has spread! The students come from all over the world: India, Pakistan, the US, and Canada but also from European countries like Italy, Spain, and Great Britain. We only have 20 places available every year in the Master's program, because the studies are very research-intensive and supervising theses takes a lot of time. We attach great importance to this. Accordingly, many are highly interested in doing a PhD afterward.



THE RESEARCHER

Prof. Philipp Richter studied physics and astronomy in Marburg and Bonn. Since 2007, he has been Professor of Astrophysics at the University of Potsdam.

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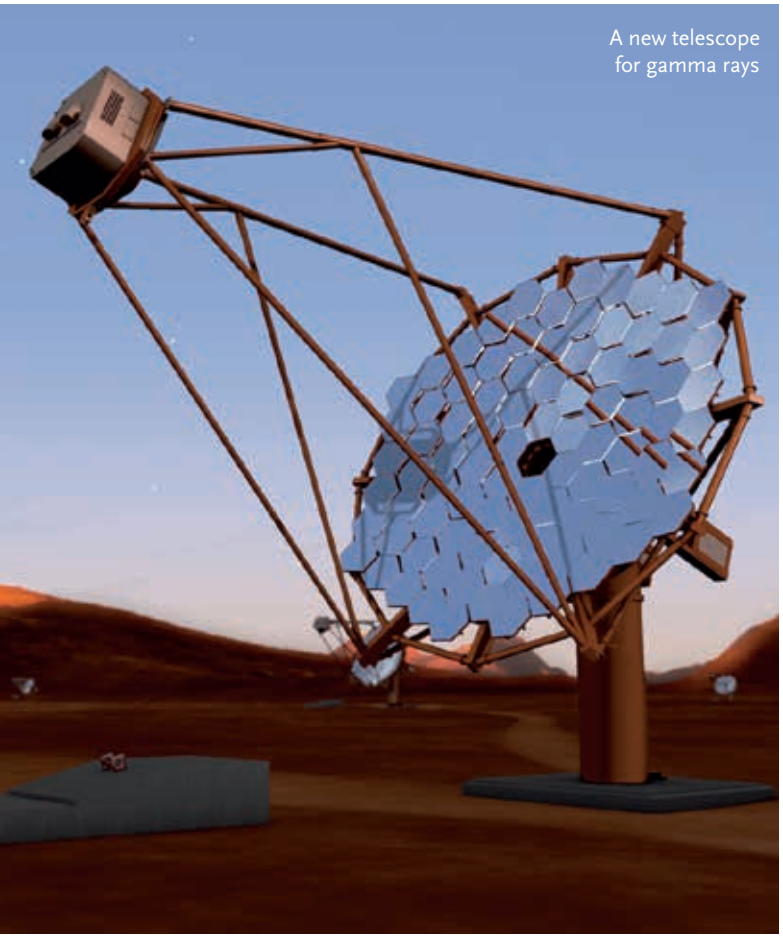
What makes it especially attractive?

The opportunity to already specialize during your studies and to do research at the extramural institutes for the Master's thesis. Students can engage in a variety of topics, such as galaxy clusters and large-scale structures, interstellar and intergalactic gas, stellar winds, or solar physics. Cosmic magnetic fields, planets, astroparticles, and gravitational waves can also be examined in the context of a Master's thesis. Together with our jointly appointed colleagues, we have now a team of 15 professors teaching courses. There are also post-doctoral candidates, honorary professors, and other lecturers who intensively advise students.



A new telescope for gamma rays

Has this changed scientific collaboration as well?

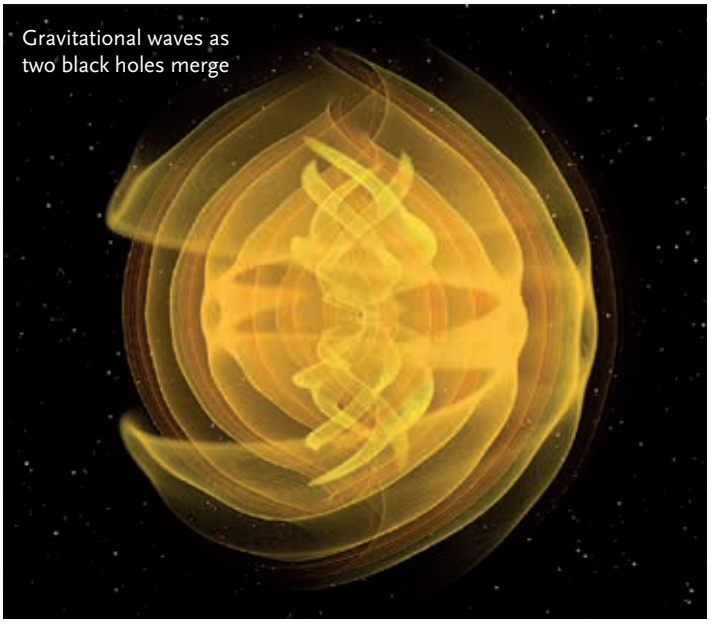
Today, we work together much more closely than we did 10 years ago. We formed a joint working group with DESY at the University, for example, which means that astroparticle physics is also represented here in addition to stellar and interstellar astrophysics and planetology. Our research initiative also includes joint applications for major projects. In the not too distant future, we want to initiate a DFG Research Training Group.

What role does promoting young female researchers play? There are still not that many women in astrophysics.

It's like in other subjects. There are many successful female scientists, but when they reach the doctoral stage – at the time of starting a family – it is getting difficult. We need to improve the conditions so that they are able to continue their research at this stage and consistently pursue their scientific careers. But we have made good progress. In the past seven years, we jointly appointed two female professors in astrophysics and a third female colleague is expected to take up a professorship later this year.

A path you have taken yourself. What attracted you to astrophysics?

It was the question of the origin of the laws of nature and the fact that they apply in the cosmos as they do on Earth, albeit in different spatial dimensions. You



Gravitational waves as two black holes merge

Photos: Richter, Philipp (top); DESY/Milde Science Communication (bottom left); S. Ossokine, A. Buonanno (AEI), Simulating eXtreme Spacetimes Projekt, W. Benger (bottom right)

need a lot of imagination for astrophysics. You cannot actually touch anything or verify things experimentally. I have to draw my conclusions with the help of physics from the properties of the radiation received. I particularly like this creative aspect of my work.

You explore the interstellar medium, clouds of gas and dust. How do you proceed? What counts as observation, calculation, and simulation?

Observations, in the very traditional sense... being alone at a telescope – I have not done research in this way for a long time. Today we get the data electronically from the large observatories in Chile or, especially in my case, the Hubble Space Telescope. Evaluating the data requires a lot of experience and intuition. It would be a mistake to only evaluate this data automatically. If you leave everything to the computer, you only get what the computer knows. Instead, you have to critically inspect the data yourself, look at the spectra of light with your own eyes, and develop an intuitive feeling. We sometimes spend entire days making sketches and thinking about how to approach and observe things. These thought experiments, the creativity – these are what this field of research lives on.

Do you find it regrettable that astronomy is hardly taught in schools these days?

I actually think one can use the unbroken enthusiasm for the universe, the fascination for black holes and dark matter to make the subject of physics more interesting for children. Astronomy does not, however, need to be taught separately in schools. Astronomy is part of physics and should be much more integrated into it. We often have physics teachers in the continuing education programs at the university. Teacher-students taking astronomy as an elective subject come to our training observatory but so do high school students doing an internship. Of course, it is great when we see these students again a few years later.

The training observatory on the roof of the physics building in Golm was once again an attraction on the Potsdam Science Day...

Yes, and there were not only well-informed amateur astronomers but also many prospective students with questions about the studies and programs. Our bachelor students learn to use the telescope in the observatory to take their own pictures. Later, during the Master's program, they focus more on the physical evaluation of the images, for example when we determine the age of star clusters.

Is it dark enough in Golm? Returning to the beginning!

Unfortunately not quite. The light from the large window of the library next door sometimes considerably disturbs the observations.

Maybe you should move to the biological research station of the university in Gülpe in Westhavelland, supposedly the darkest place in Brandenburg.

Yes, we have thought about that, but unfortunately the logistics would not be so easy...

THE INTERVIEW WAS CONDUCTED
BY ANTJE HORN-CONRAD
TRANSLATION: SUSANNE VOIGT

A strong network

Visit **www.astrophysik-potsdam.de** to learn more about the variety of research and teaching activities of the Astrophysics Network Potsdam. Students and researchers share information on the discoveries and puzzles of astrophysics, their own scientific work, and the observation campaigns in remote locations in the world.

INSTITUTIONS IN THE NETWORK:

The **University of Potsdam** researches stellar, galactic, and extragalactic astrophysics, planetology, and astroparticle physics.
The **Leibniz Institute for Astrophysics Potsdam** (AIP) researches Cosmic Magnetic Fields and Extragalactic Astrophysics as well as the development of future-proof instruments and software for large-scale projects.
The **Deutsche Elektronen-Synchrotron** (DESY) in Zeuthen researches high-energy neutrinos and gamma rays from cosmic sources and participates in constructing and operating observatories worldwide and experiments in astroparticle physics.
The **Max Planck Institute for Gravitational Physics** (Albert Einstein Institute, AEI), whose range of activities include basic research on the theory of general relativity and quantum gravity as well as experimental and theoretical aspects of gravitational waves, which were directly measured for the first time in 2015.

The Cosmic Carousel of

Interactions

Stephan Geier researches binary star systems

They orbit each other, swallow the other, or tear off their partner's shell (or "envelope") – stars have turbulent relationships with each other. The universe is full of multiple star systems in which the celestial bodies come so close together that they end up influencing each other. Astronomer Stephan Geier explores what these stellar connections look like in aging stars.

As soon as it gets dark and the sky is clear, they slowly become visible. At first, only a single point shines but eventually more and more start revealing themselves. "Can you count the stars that brightly twinkle in the midnight sky?" says a well-known German lullaby. But even if we were able to count all the points in the sky, we still would not know how many are really there. Appearances are deceiving: A single luminous point is rarely only one star but usually two, three, or even more.

"Stars are usually not alone," Geier says. The reason for this phenomenon lies in star formation. The cradle of the luminous celestial bodies are gas clouds that are gradually condensing. The gas molecules attract each other, and the distance between them decreases. Ultimately, a star is formed out of this gas cloud, with hydrogen fusing in its core. The centrifugal forces within the rotating cloud ensure that this usually happens in several places. This is how multiple star systems come into being. Binary stars can sometimes be seen with the naked eye: The light flickers when the orbiting stars cover each other.

Photo: ESO/L. Calçada

THE RESEARCHER

Prof. Stephan Geier studied physics and ancient history, classical archeology and modern history. Since April 2018, he has been Professor of Stellar Astrophysics at the University of Potsdam.

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Geier has long explored the relationship governing such constellations. The astronomer, who was recently appointed Professor of Stellar Astrophysics at the University of Potsdam, focuses on one category in particular: double star systems that are nearing the end of their relationship, because one of them has started engulfing the other and losing its envelope in the process. The mechanisms behind these events can reveal a lot about the formation and evolution of stars.

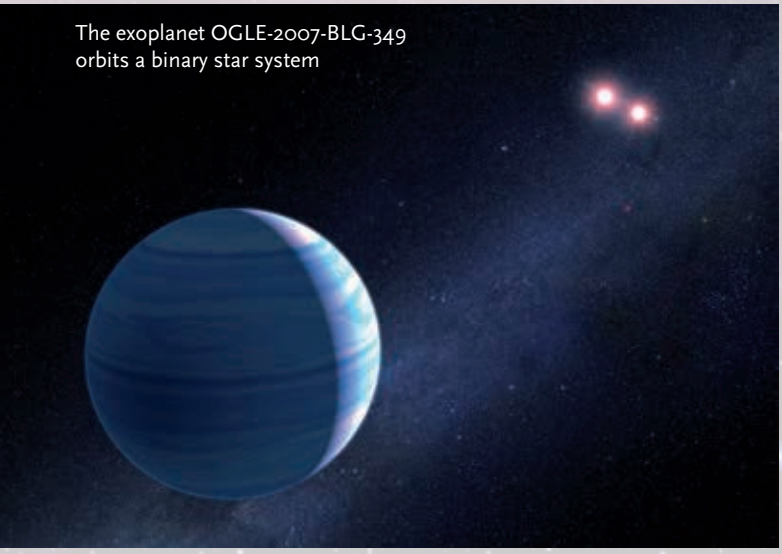
Aging stars have quite a few surprises in store. Once they have exhausted all of their hydrogen through fusion, they expand to giant stars, which range from about 10 to 100 times the size of our sun. When two stars very tightly orbit each other, the envelope of such a giant star can absorb its partner. Two cores orbit in one envelope. The researchers call this phenomenon a "common envelope". "In this common envelope, the nuclei of the two stars lose energy and slow down. They continue to approach each other and become very, very close binary star systems," explains Geier. It takes only a few hours or even minutes for these stars to orbit each other.

In the vastness of the universe, Geier searches for remnants of star interactions

Researching these systems poses some difficulties for astronomers. "These interactions cannot be observed live," Geier explains. What he sees in the night sky is always just a snapshot. "We are able to observe certain phases of stellar evolution but not others. Our problem as astronomers is that the lifespan of stars is much longer than ours," he says. Geier, therefore, searches for remnants of stellar interactions in the vastness of the universe – the "world's largest laboratory", he says, which can reveal more about their evolution than has previously been known.

Hot subdwarfs are just the kind of remnants Geier is looking for. This hot, yet compact type of star is very rare. To date, only a few thousand hot subdwarfs have been identified in the Milky Way: an insignificant number considering that there are billions of stars in it. They are the remnants of red giants that have lost their outer layers. While the reasons for this are unclear, Geier surmises that this event takes place in the common envelope phase of a binary star system. In theory, which is plausible but not yet sufficiently documented by measured data, the envelope of the two star cores heats up due to their interaction. At some point, the envelope dissolves, leaving behind the star cores, which are still closely orbiting each other.

With enormous ground telescopes and space probes, astronomers are now able to observe the rare hot subdwarfs. Some of them were discovered by chance, others tracked down and observed systematically. Geier and his team travel to the Chilean Atacama Desert, Argentina, and southern Spain. The



The exoplanet OGLE-2007-BLG-349 orbits a binary star system

The multiple star system HD 98800 consists of two binary star systems

Photos: Fritze, Karla (top); NASA Goddard (bottom left); NASA/JPL-Caltech/T. Pyle (SSC) (bottom right)

Stephan Geier

observation times for the telescopes in these places are highly coveted among astronomers and strictly limited. If you are lucky, your proposal will be granted a few days of that valuable time. Then you need to do night shifts in front of the many monitors of the observatory; coffee consumption is high. "We start our observations as soon as night falls. We record the spectra and light curves of the stars we are interested in," Geier explains. "It is somehow meditative," he adds, laughing.

The astronomers analyze hot subdwarfs using computer models

Once the data for a particular star is available, the real work begins. Astronomers use the spectral lines of the celestial body to analyze how hot the star is, how it moves, and which chemical elements comprise its atmosphere. The spectra of the stars are compared with models on the computer. There is a problem though: hot subdwarfs still lack suitable models, which the researchers first have to develop. The analysis is, therefore, very individual and difficult and can take months or even years.

The astronomers also look eagerly at the data of a current mission of the European Space Agency (ESA). Since 2013, the Gaia spacecraft has been systematically scanning the entire sky, capturing approximately one percent of all stars in our galaxy: the Milky Way. It is a mammoth project that measures over two billion stars with high accuracy and is the first to do so. The Potsdam researchers hope that the mission will also provide information on the number of binary systems in our galaxy, how they move, how many hot subdwarfs exist, and which star interactions take place.

Stephan Geier is an astronomer with heart and soul. Apart from stars, the 40 year old has a completely different, earthly passion: history. Due to "youthful foolishness", he studied this subject in addition to physics, he says with a wink. This youthful spontaneity led not only a degree, but also a second doctorate on German foreign policy after World War II. Even today the researcher is very enthusiastic about history. He is sure that some of this will be incorporated into his teaching. "There are many examples of how science and technology intervene in history; just think of nuclear fission," Geier says. "I would like to take up these examples." He has already reached out to historians at the University of Potsdam but will not reveal any concrete ideas yet. "We will cross that bridge when we come to it." His students have every right to be excited.

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

Photo: Fritze, Karla

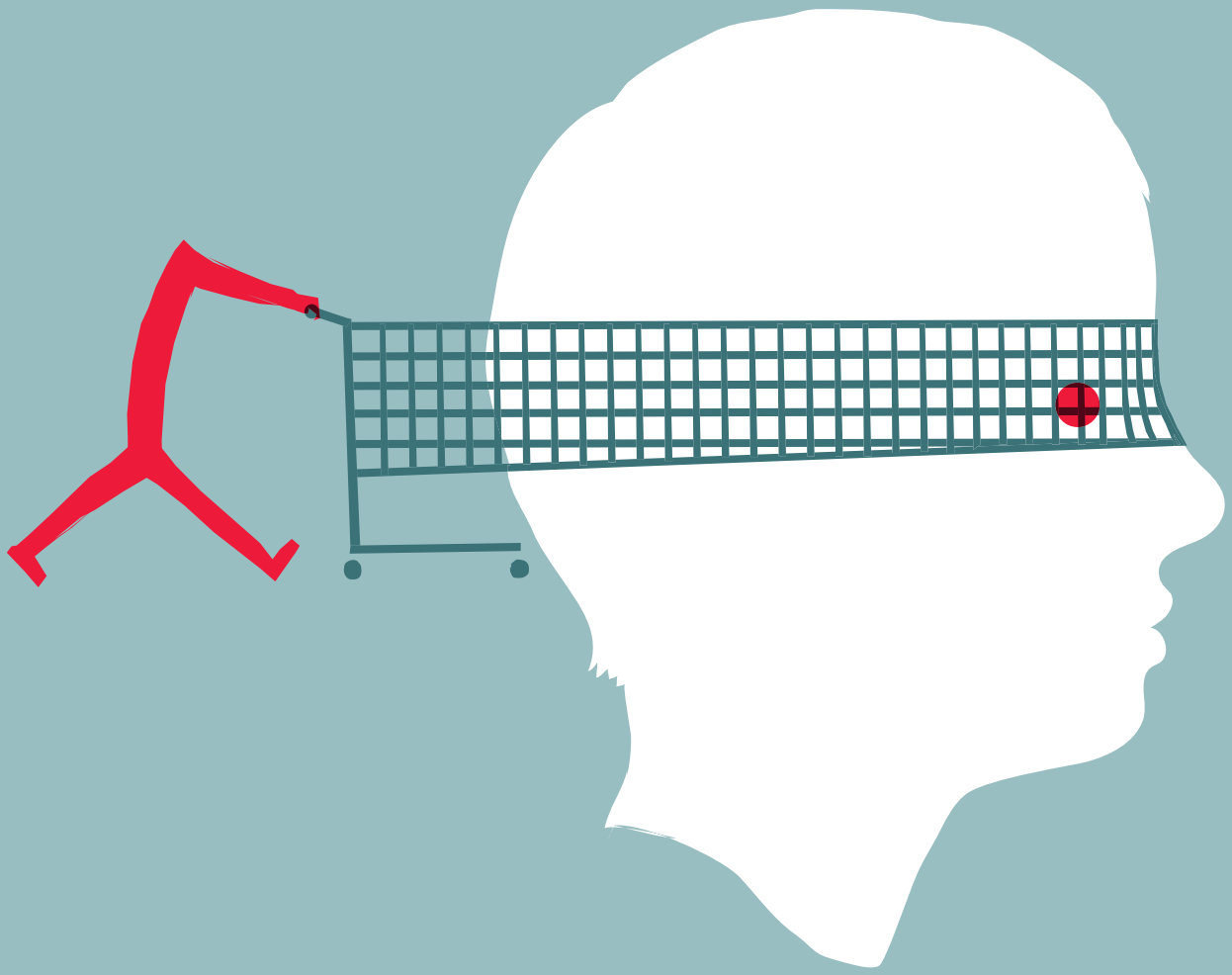


Illustration: Topler, Andreas

LESS IS MORE!

... AT LEAST WHEN IT COMES TO CONSUMPTION

Economists want to raise awareness of sustainable consumption

THE PROJECT

SPIN – Strategies and Potentials to Initiate and Promote Sustainable Consumption (joint research project)

Subproject: "Promoting modest, collaborative, and debt-free consumption styles and consumer-oriented training to promote sustainable consumption competence"
Participating researchers: Prof. Ingo Balderjahn, Dr. Barbara Seegebarth, Dr. Stefanie Sohn, Alexandra Hüttel, Florence Ziesemer
Duration: 2015–2018
Funding: Federal Ministry of Education and Research (BMBF) within the Socio-Ecological Research (SÖF), funding code 01UT1429

Every year the latest phone model, the fifth pair of stylish brand sneakers, an expensive bottle of wine every night. Consumption can take many forms today but rarely is it sustainable. Does consumption at least make us happy and satisfied? Researchers at the University of Potsdam want to find out what drives consumers' behavior and why so few care about acting sustainably. Their current project aims to raise awareness among school children regarding sustainable consumption and the environmental, social and personal benefit of doing so.

Klara stands up, walks over to a clothesline set up in the classroom, and hangs a photo of the smartphone she recently bought. Her classmates do the same – photos of tablets, jackets, game consoles, bikes, jewelry, and more. The students are asked to talk more about the items – where they bought them and why and what they know about where and how the products were made. This scene is the introduction to a lesson titled "Sustainable Consumption in School Education", which was tested at several Brandenburg schools early last school year. The lesson was developed by a research group led by Professor Ingo Balderjahn. The goal is to motivate school children to think about the consequences of their own consumption. "The high level of consumption in the rich countries of the world is one of the central problems for the preservation of the earth and the protection of the climate and resources," says Balderjahn. "Excessive, unsustainable consumption is destroying the climate and nature. Furthermore, it has the potential to further increase global social injustice."

One of the main causes for the disastrous consequences of over overconsumption is the widely shared view of many economists and governments that economic growth alone guarantees the prosperity western industrialized countries. "Leading economists warn almost daily of the consequences of a economic decline and foresee a diminished quality of life. But this view is far too simple. The global challenges we face cannot be solved with these traditional economic concepts," Balderjahn says. In fact, gross domestic product (GDP) is not an indicator of individual well-being.

Sustainable consumption also requires some frugality

"The crux is to consume only as many renewable resources as Earth can provide every year," says Balderjahn, economist and marketing expert. In order to leave a livable world for future generations, we have to consume so as not to permanently damage nature and also social communities. While science was already dealing with environmentally conscious consumption in the 1980s, the concept of socially sustainable/fair consumption started to be included only at around the turn of the millennium. The idea behind this is to buy things that have verifiably been produced under decent working conditions and at fair wages. Fair trade is a worldwide accepted movement that aims to secure the rights of producers and workers in developing countries and thereby helps to reduce global poverty.

Sustainable consumption includes, not least, a certain view of simplicity and simple living standards, Balderjahn emphasizes. "Getting by with less consumption protects not only our purse but also the environment and the climate. We also know that many people who want to free themselves from the prevailing consumption pressures of consumerist societies and live a more self-sufficient life feel better and perceived their simple living not as a sacrifice."

But why do some people consume sustainably but not others? What motives are behind particular consumption styles? What distinguishes people with a high income, who buy organic yogurt and fair-trade shirts, from the environmentally conscious consumer who grows vegetables in the neighborhood garden and shares his or her car with a neighbor, or from the penny pincher who takes

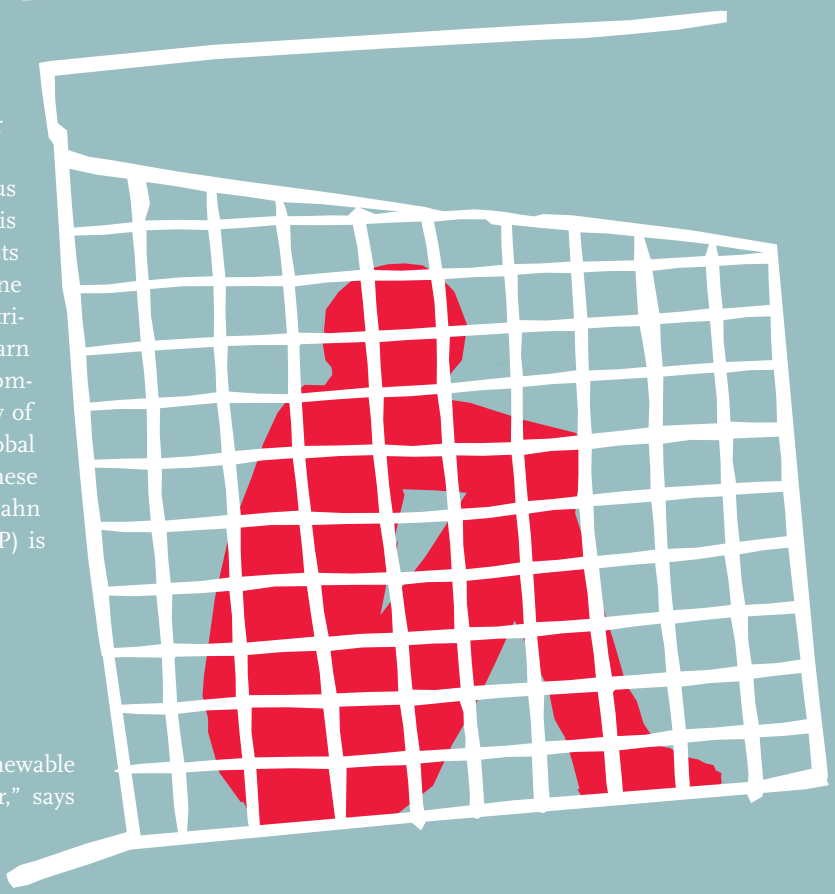


Illustration: Topler, Andreas

The Potsdam team: Alexandra Hüttel, Florence Ziesemer, and Ingo Balderjahn

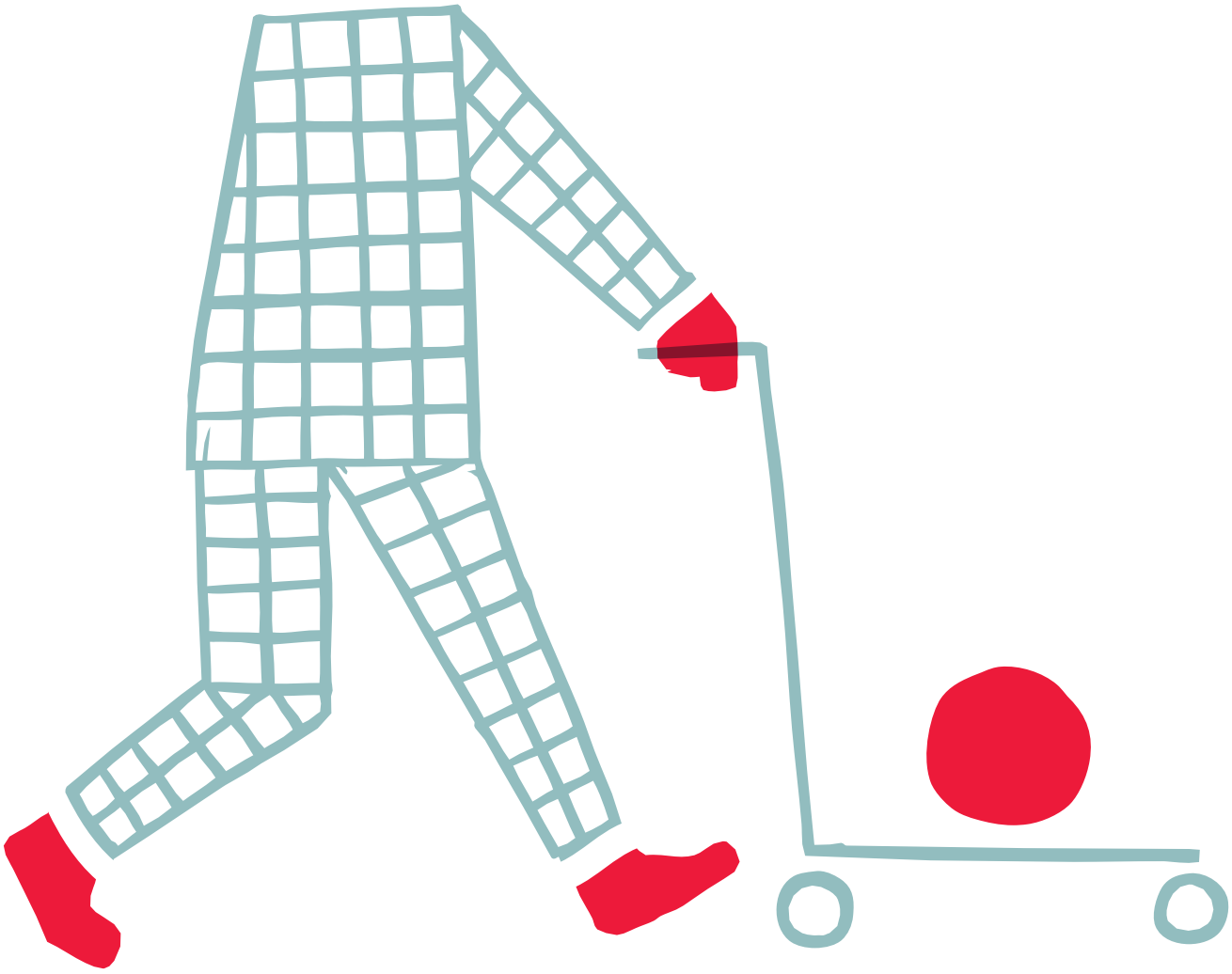
the train every day because it is cheaper? Prof. Balderjahn, his colleagues, and a team around Dr. Barbara Seegebarth from TU Braunschweig set out to identify what consumption means for people today. They study the drivers that motivate sustainable consumption and what hinders it. Following up on this, the researchers have developed a school lesson unit to raise young people's awareness for sustainable consumption.

For Balderjahn, it is not a contradiction that a marketing expert is addressing this topic. "Anyone who thinks that marketing only serves to make commercial products successful is wrong. Non-Governmental organizations, for example, often do a good job in marketing." The core of good marketing is the ability to understand the consumers' behavior in its economic and social backgrounds. Why not use this knowledge to stimulate environmentally, economically, and socially sustainable consumption?

The economists interview people about their buying behavior

The Potsdam researchers first talked with those who are likely to be considered particularly sustainable: people involved with car sharing, those who live frugally or without money, and consumer debt consultants. For three months, the researchers also mingled with people waiting at Potsdam Central Station and asked them about their consumption behavior. They were less interested in what or how much people consumed than in their motives and goals. "For this study, we conducted structured, in-depth psychological interviews," Alexandra Hüttel explains. She conducted a total of 167 interviews together with Florence Ziesemer. "We were interested in finding out which overarching values – such as health, sustainability, freedom, and self-determination – people connect with their buying behavior."

Photo: Fritze, Karla



When evaluating the results, the two researchers identified four types of consumers: the "conscientious simplifiers" who value independence and seek not to waste time, space, and resources, whereas the "precautious frugals" want to set money aside, to make provisions for the future. The "spendthrifty belongers" buy in order to gain social recognition but pay attention to their scarce financial resources, while the "hedonic squanderers" enjoy consuming and have the income to do so. It was noticeable that those who consume more frugally do so especially with regard to themselves and for their own benefit. They want to be self-determined, make provisions for the future, save time, space and, of course, money. "Ecological and altruistic-social aspects, however, seem to be of minor importance," the team concluded. Furthermore, it became clear that low consumption primarily aims at avoiding negative consequences such as debt or stress. On the other hand, excessive consumption is mainly connected to people striving for instant happiness. "When people become aware of personal benefits through more sustainable consumption, they change their non-sustainable habits more quickly," says Ziesemer, summarizing the research so far. "Only then can we even enter into a discussion and encourage a change in awareness."

The group developed a teaching unit for secondary school students

The second step on the team's agenda was to initiate this conversation – and not just anywhere. They wanted to change awareness in the classroom. "At present, these are mainly older, well-educated people who are consuming sustainably. To create long-

Illustration: Töpfer, Andreas

THE RESEARCHERS

Prof. Dr. Ingo Balderjahn studied industrial engineering and management at the Technische Universität Berlin. Since 1992, he has been Professor of Business Administration with focus on Marketing at the University of Potsdam. Since 2018 he has been senior professor in Potsdam.

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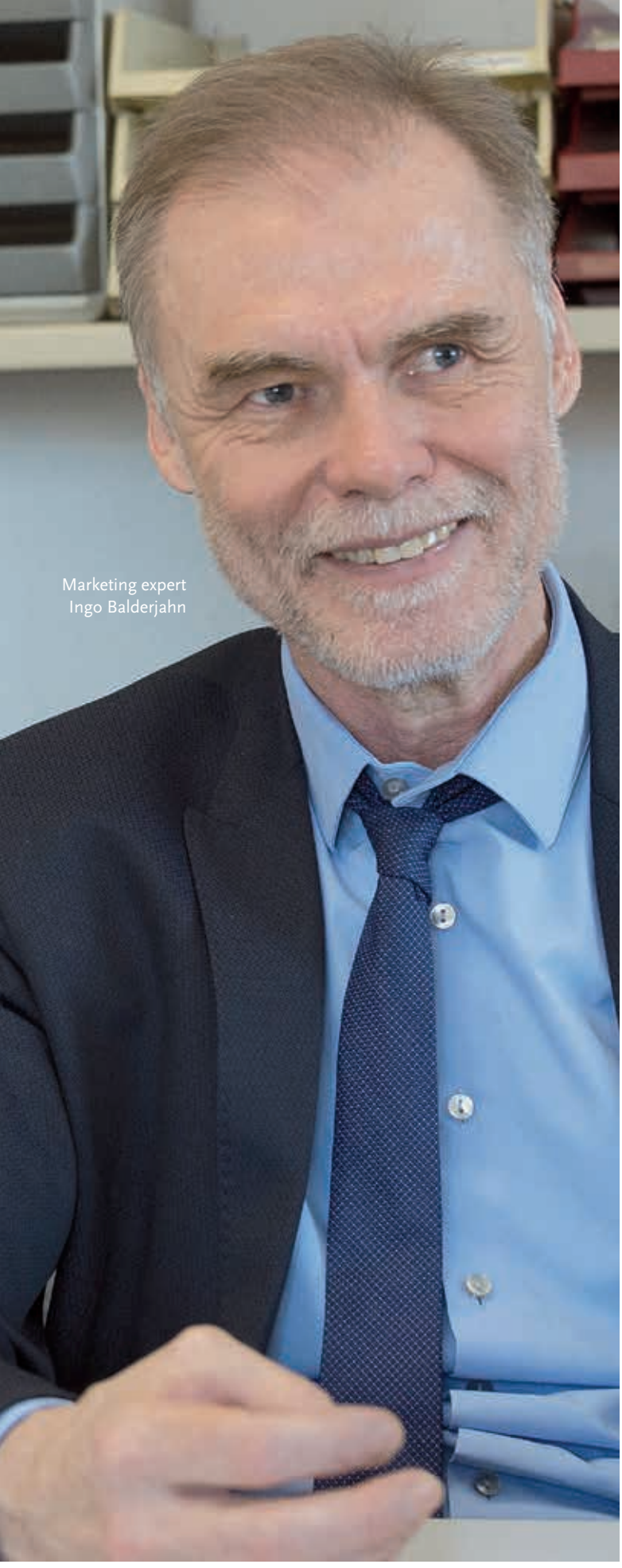
Illustration: Töpfer, Andreas (left); Photos: Fritze, Karla (right top, right middle, right bottom)



Marketing expert
Ingo Balderjahn

The teaching material is available at
www.tipp.fm/nachhaltiger-konsum

term, more sustainable buying behavior, you have to start very early: at home and at school," Balderjahn emphasizes. In collaboration with the Berlin-based agency Helliwood media & education, the researchers transformed their research results into a teaching unit for the 8th, 9th, and 10th graders, which was then tested at six schools in Brandenburg and scientifically evaluated – and successfully, Balderjahn proudly emphasizes: "We were able to significantly improve the students' awareness of sustainable consumption – especially with regard to ecological and social aspects. The young people enjoyed the lessons." The teachers were just as satisfied with the material and the outcome in the classroom. Most of them wanted to continue using this lesson.

Florence Ziesemer has identified a key reason for this success. "Our teaching material addresses the students' lives. That is how we got them interested in the topic." Where does this new smartphone come from? Under what working conditions were these jeans sewn? How environmentally friendly is this microfiber sweater actually? You need the right concept to gain access to the world of the students. Only in this way can they be persuaded to think outside the box of consumer promises.

So was the education project successful? Yes, but changes in sustainability consciousness were found primarily in female students. This is a motivation for further research. "This actually shows that the girls already have a better approach to this topic and are more mindful. The boys may need another year or two. We have to follow up and develop material for use in higher grades." The researchers will continue to tailor the teaching material to the school type. While these lessons already work well in high schools, the practical and technical aspects of other types of schools need to be better integrated.

Concepts, strategies and sometimes the political will are missing to bring this teaching concept to foster sustainability consumption consciousness to schools nationwide. Here, educational policymakers are needed, says Balderjahn. "We are doing everything we can to get the message across." The economist is sure that it is worth it. After all, it is about the greater good. "Of course, we also want to save the world with our project; we would not have initiated it otherwise. We know that every consumer choice can be a contribution."

MATTHIAS ZIMMERMANN
TRANSLATION: SUSANNE VOIGT

Photo: Fritze, Karla

For our SKETCHED page, we asked graphic designer and illustrator Andreas Töpfer to interpret one of the research topics graphically. In this issue, it is the research of economists Ingo Balderjahn, Alexandra Hüttel, and Florence Ziesemer on sustainable consumption.

Illustration: Töpfer, Andreas

SO CLOSE TO A ROBOT

RESEARCHERS STUDY THE INTERACTION BETWEEN HUMAN AND MACHINE

Photo: Fotolia/hagozr

Henry is tall, dark-haired, and has a gentle expression. He knows our favorite songs and tells jokes that make us laugh. Henry is not a man; he is a robot designed by the U.S. firm Realbotix to be an intimate partner for humans. Psychologist Yuefang Zhou and cognitive scientist Martin Fischer visited the company in San Diego, California. Together they are examining how intimate partnerships with robots could determine our future.

Realbotix is a subsidiary of Abyss Creations, a company that has manufactured realistic dolls since 2000. Hair color, body shape, and body size are all tailored to each customer's preferences. Prices start at $11,000. Most buyers are from Canada and Germany. But while these dolls can neither move nor talk autonomously, the newly developed robots are equipped with artificial intelligence (AI).

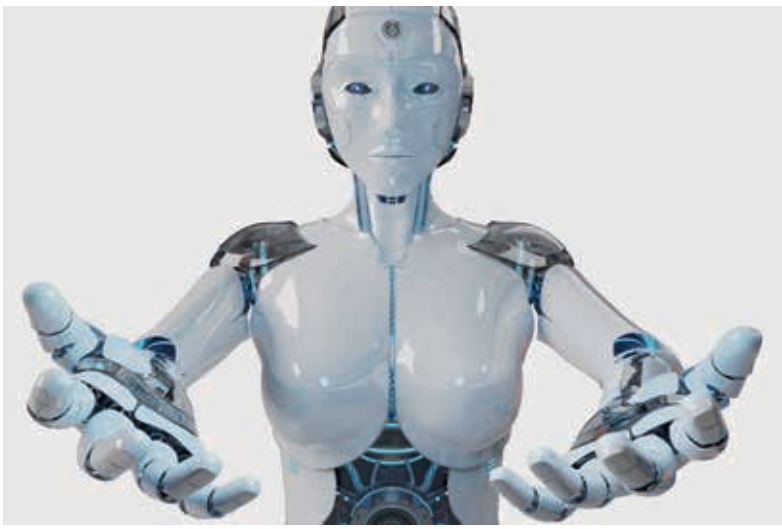
In research, AI is the ability of machines to solve problems. So far, Henry can only move his head and speak short sentences; his AI is limited, but this will change soon. "The company's objective is to create artificial bodies for intimate relationships," Zhou tells about her talk with company founder Matt McMullen. "In the future, there could be love robots around the world for lonely people with social hindrances."

Yuefang Zhou with robot Henry

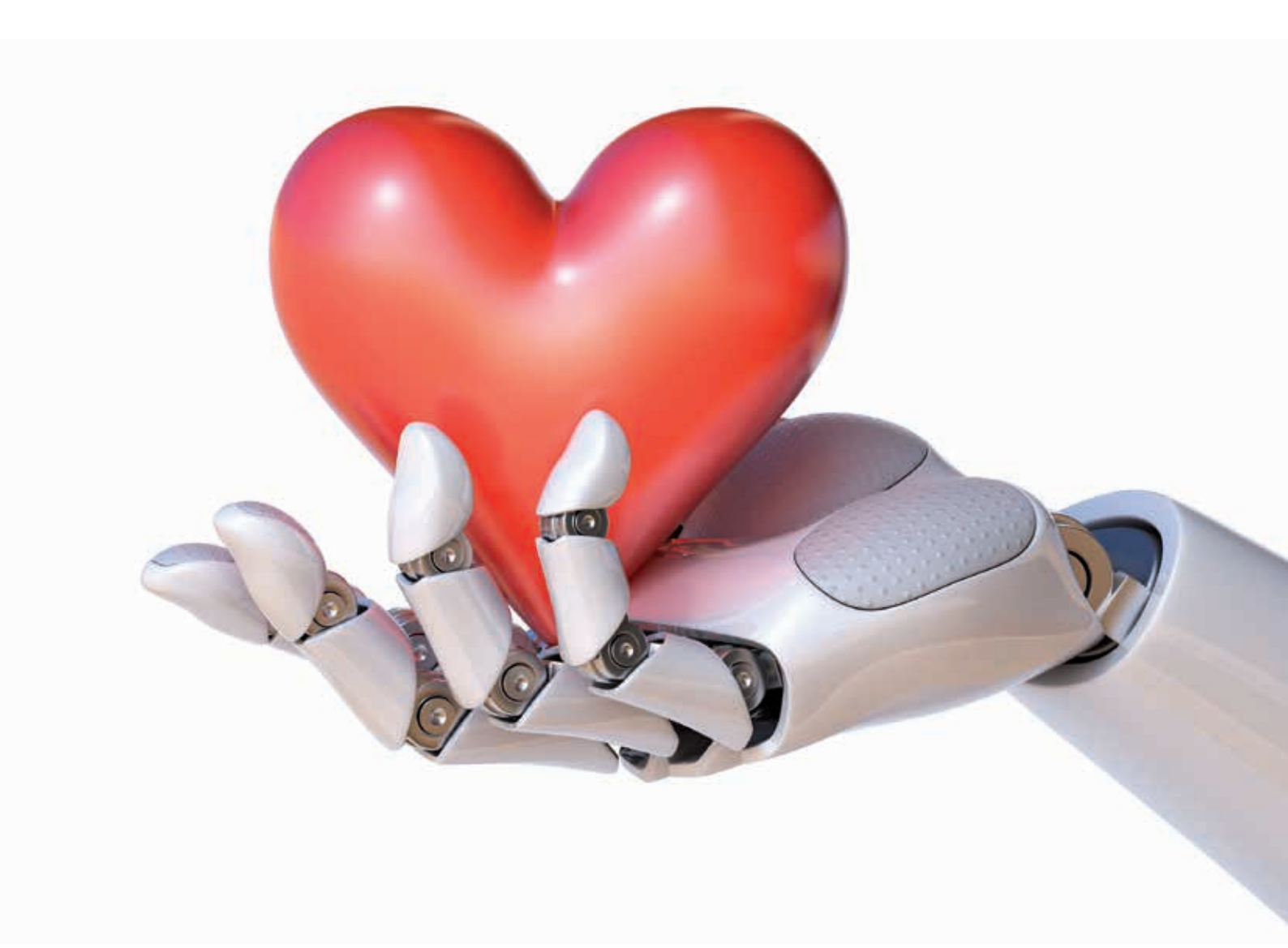
The social interest in interactions with robots is huge

Studies carried out at Stanford University revealed that we react emotionally when touching a humanoid robot: our hearts beat faster, and we start sweating and even blush. These are the reactions that Zhou and Fischer want to capture experimentally. Imaging techniques such as magnetic resonance imaging (MRI) could also give us some clues about what is going on in our brains when we interact with a robot. "In fact, there is tremendous interest in interactions with robots in society," Zhou explains. "But so far there is hardly any empirical data on this topic. They are urgently needed." Over the past two years, Zhou, who is a researcher from the University of St Andrews, has been a visiting scholar in Martin Fischer's group. In late 2017, Zhou and Fischer held an international workshop on intimate relationships with robots at the University of Potsdam. A book on the workshop proceedings will be published. The workshop also helped the initial research questions to be formulated for the planned study, for which the researchers are currently seeking funding.

Zhou has also very recently been involved in a sexual medicine project at Charité – University Hospital Berlin. Together with sexologists, the psychologist is looking into whether robots might be able to help to prevent crime. The idea is to see whether potential sex offenders can be treated by getting access to child-sized robots. "It might be possible that learning experiences with humanoid machines reduce inappro-



Photos: Fischer, Martin (left); Fotolia/sdecoret (right)



priate sexual behavior," Zhou states. "However, the opposite might happen as well, and the interaction with a childlike robot could intensify pedophilic desires." To find out more, researchers will first conduct interviews with test subjects, experts, and affected people at the University of Potsdam. They will then also conduct experiments to find out how humans physiologically react to human-robot touch interactions.

Zhou and Fischer are interested not only in sexual interactions with robots, but in particular in the emotional attachment to humanoid machines – which may, in fact, be even positively received and fueled by care and affection. So it comes as no surprise that robotic pets are being increasingly used in the care sector, from plush seals to purring cats. Today, robotic pets are equipped with sensors to register touch and voice; they move autonomously and make some noises. They are said to have a soothing effect on people with dementia, for instance. This said, robots as autonomous companions are probably still far away. Especially in the interaction with vulnerable people, they may become a hazard, since they are not yet flexible enough to meaningfully adapt to unforeseen situations.

The abilities of a robot are crucial to human perception

For many years, cognitive scientist Martin Fischer has been exploring the cognitive bases of interactions between humans and robots. From 2008 to 2011, he researched cognition- and perception-related patterns in the human brain at the University of Dundee for use in programming the iCub robot. Since 2004, researchers from all over Europe have been contributing to the open-source project to develop a humanoid machine able to learn about human cognition, optimizing the abilities of robots. iCub has the dimensions of a 5-year-old child; it has 53 joints, speaks, sees, and hears. Soon it will be equipped with the sense of touch as well. What Fischer was particularly interested in at the time was the interplay between perception and movement: When do we grasp a cup with the right hand and when with the left, for instance. How do robots learn that boxes can be stacked but not balls? How is a shovel used? How about a rake? Answering such questions is essential if robots are to be integrated into our daily lives as seamlessly as possible.

Photo: Fotolia/koya979

Martin Fischer and Yuefang Zhou

Uncannily real: Sophia

Fischer thinks that the abilities of robots are now more important than their external appearance in interactions with humans. "Our nervous system is highly sensitive to social signals," Fischer explains. "We are able to discern human faces even in abstract representations of them. So, robots do not need to look particularly humanlike to trigger interaction: Often, two dots resembling eyes will do. And a robot which is clearly identifiable as a machine has another advantage – a less humanoid robot is hardly perceived as uncanny. One explanation for it is the "uncanny valley" effect formulated by Masahiro Mori some 50 years ago: The more similar robots are to humans, the more we accept them – but only to an extent. Too much similarity makes them seem eerie.

Robots present challenges for a society

Sophia is a particularly uncanny robot. The humanoid machine might be confused for a flesh-and-blood woman were it not for her transparent skullcap with all the cables, printed circuit boards, and blinking lights. Sophia has the highest artificial intelligence of any robot at the moment. She is able to adapt to specific situations – she learns. "Sophia is at the cutting edge of technical developments," Fischer explains. "She can recognize problems, analyze them, and react accordingly. Since 2017, the humanoid machine has held Saudi Arabian citizenship. What sounds like a joke foreshadows the difficulties we might one day face in living with humanoid machines.

These days, there are highly technical companions for children, too

"When it comes to robots, social, ethic, and legal issues need to be addressed as well," Zhou states. What will happen if we perceive robots more and more as human, given that their reactions surprise us and give us food for thought, that we learn from them, or that we enjoy their company – because we love them? What will happen if artificial intelligence is such that we treat robots no longer as objects but as people? Would it mean that we created slaves without rights? The world of science fiction has long explored such dystopias and imagined the uprising of these slaves, who turn against humans and stand up for their freedom. If you take these gloomy visions seriously, the legal fundamentals need to proceed technological developments.

In that sense, humanoid machines pose challenges to experts in many fields. This is what fascinates Fischer and Zhou the most about interrelations between robots and humans. The topic attracts not only cognitive scientists and psychologists but also lawyers, philosophers, computer scientists and linguists. "Research on the interactions between human and machine is a multidisciplinary task," Zhou concludes. Only together can researchers get closer to finding an answer to one fundamental question: "Research on robots can help us understand what makes a human being a human being."

JANA SCHOLZ
TRANSLATION: MONIKA WILKE

THE RESEARCHERS

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Yuefang Zhou, Ph.D., studied psychology at the University of Dundee in Scotland. From 2016 to 2018, she has also been a visiting scholar in Cognitive Sciences at the University of Potsdam. Since 2017, she has also been affiliated with the Institute of Sexual Science and Sexual Medicine at Charité – University Hospital Berlin.

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Remembering through Literature and the Arts

A German-Polish project explores cultural memory

Magdalena Marszałek has a soft spot for the presence of the past in the present. In a German-Polish research project, the Potsdam Slavist examines how our culture reflects on the past. The project "Performances of Memory" analyzes three strategies for coming to terms with history: testimonial, reconstructive, and counterfactual practices in literature and performative arts. Prof. Marszałek – together with Prof. Małgorzata Sugiera from Krakow and Prof. Dorota Sajewska from Warsaw, who is now at the University of Zurich – secured funding in the first edition of the joint "Beethoven" call for proposals of German Research Foundation (DFG) and its Polish counterpart, the National Science Centre (NCN).

THE PROJECT

Performances of Memory: Testimonial, Reconstructive and Counterfactual Strategies in Literature and Performative Arts of the 20th and 21st Centuries

Head: Prof. Dr. Magdalena Marszałek (University of Potsdam), Prof. Dr. Małgorzata Sugiera (Jagiellonian University Krakow)
Project team: Dr. Mateusz Borowski (Jagiellonian University of Krakow), Dominika Herbst, M.A. (University of Potsdam), Prof. Dr. Dorota Sajewska (University of Warsaw/University of Zurich), Dr. Dorota Sosnowska (University of Warsaw)
Funding: German Research Foundation (DFG) and National Science Centre (NCN, Poland)
Duration: 2016–2019

Photo: pixabay/Dkrue

The three scholars have a lot in common: They all live and breathe the German-Polish scholarly exchange, work in the field of memory studies, research cultural memory, and are interested in performative aspects of literature and the arts. "For us, the current project on performances of memory has been the high point of our cooperation so far," Marszałek says. She first studied Polish philology and theater studies in Krakow. "This is also when I met my colleague Sugiera," she explains. She then studied Slavistics, art history, and theater and film theory in Bochum. Her academic exchange with Sajewska, who is from Warsaw, has been ongoing for years. "This is the first time we have had funding for joint research, and that inspires our cooperation in a very special way." Marszałek has been researching and teaching at the University of Potsdam for seven years. Her courses focus on Polish literature and modern and late-modern culture, cultural transformation processes in eastern Central Europe after 1989, and Polish-Jewish cultural history. Her main theoretical interests center around issues of literary and artistic documentary – such as autobiographical writing and literary evidence – as well as post-memorial aesthetics in literature, visual arts, and theater.

Abandoned places as memory spaces

"Testimonies are incredibly important for our culture of remembrance"

For the three scholars in the German-Polish project, memory studies is a broad research field, which uses a variety of methodical approaches to grasp the phenomenon of "memory", both today and historically. "We keep the past present in a very special way," Marszałek explains. The DFG project will be exploring exactly how this works through summer 2019. The scholars in Potsdam, Krakow, and Warsaw/Zurich see their research topic as a combination of three strategies of memory culture: practices of bearing witness, reconstructive practices (including the now-popular practice of reenactment), and counterfactual strategies (including para- and mock documentaries). Marszałek is focusing on the testimonial strategy, which includes various forms of bearing witness in literature and the arts. "Testimonies are incredibly important for our cultural memory. They convey emotions and authenticity, and lay claim to truth." But above all, she is interested in how literature and the arts deal with the role of witness and define their own testimonial tasks. For instance, University of Potsdam PhD student Dominika Herbst's dissertation, which is part of the research project, explores the testimonial consciousness of social reportage – a new literary genre – in Poland between the two world wars. In times of historical catastrophe and the ensuing profound cultural crises, the concept of the testimony is tremendously important for literature and the arts. That is why a demand for testimonial documentary arose right after World War I, a demand which continues to this day.

Contemporary witnesses bring the past to life

Photos: pixabay/Free-Photos (bottom left); pixabay/Tama66 (bottom right)

The second strategy, the reconstructive approach, is being researched by Dorota Sajewska, who explores the idea of the body as an archive. It is based on the observation that in popular reenactments and artistic performances, the presentation of the past originates from experiences stored in the body. The third scholar in the joint project, Małgorzata Sugiera, analyzes the counterfactual: 'Alternative histories' und 'Mockumentaries' challenge – or even satirize – our understanding of documentary conventions. "Prevailing memory cultural practices can be opened up and reflected on in their context," Marszałek summarizes. When we ask "What if?", thought experiments in history become possible as well that, if nothing else, help us to better understand how important the past is for the present.

Performance as memory art

All three cultural studies scholars also explore performative moments of memory. In May, a symposium on "Performing Memory" was held in Berlin's Sophiensäle. Three moderated evening lectures with high-profile representatives – among them Prof. Rebecca Schneider from Brown University in the US – discussed performance as memory art: What kind of memory work is done in this art form? What is the difference between performative and narrative forms of memory? Do artistic activities provide alternative access to history?

In Poland today, reflecting on the past is more topical than ever. "We did not expect the current rollback in memory politics to be that strong, but of course the context of such history politics needs to be taken into account." The findings of the German-Polish research project will ultimately be summarized in a joint monograph. "We still have to decide which language we want to use – German or Polish," Marszałek remarks. You can tell how much she identifies with the topic. So she will certainly be publishing more after the completion of this project.

SILKE ENGEL

TRANSLATION: MONIKA WILKE

THE RESEARCHER

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Photos: pixabay/herbertz312 (top); private (middle)

THE MYSTERY OF THE RAINFOREST

Geoscientists show that humans were already shaping the central African landscape 2,600 years ago

Photo: Garcin, Yannick

Fields, roads, and towns but also forests planted in neat rows, and dead-straight rivers: people shape nature to better suit their purposes. The fact that humans dramatically changed the ecosystems of Central Africa 2,600 years ago has now been discovered by a team led by Potsdam geophysicist Yannick Garcin. The researchers have taken a significant step towards solving the riddle of the so-called rainforest crisis. They examined lake sediments in southern Cameroon and found that it was not climatic changes such as extreme drought or large fluctuations in precipitation that were responsible for the drastic change in the local ecosystem but rather humans.

People need space – for settling, livestock, and agriculture. Population growth requires more space. Forests are cleared and crops sown in order to have more arable land. This is how humans change the ecosystems in which they live – a simple connection repeated throughout human history. A similar relationship exists between climate and ecosystems. When the climate changes, the amount and rhythm of precipitation changes as well. Less rainfall then leads to vegetation changes, i.e. changes in the variety and quantity of plants in an area. Both effects have the same result: a change in the diversity and composition of a region's flora.

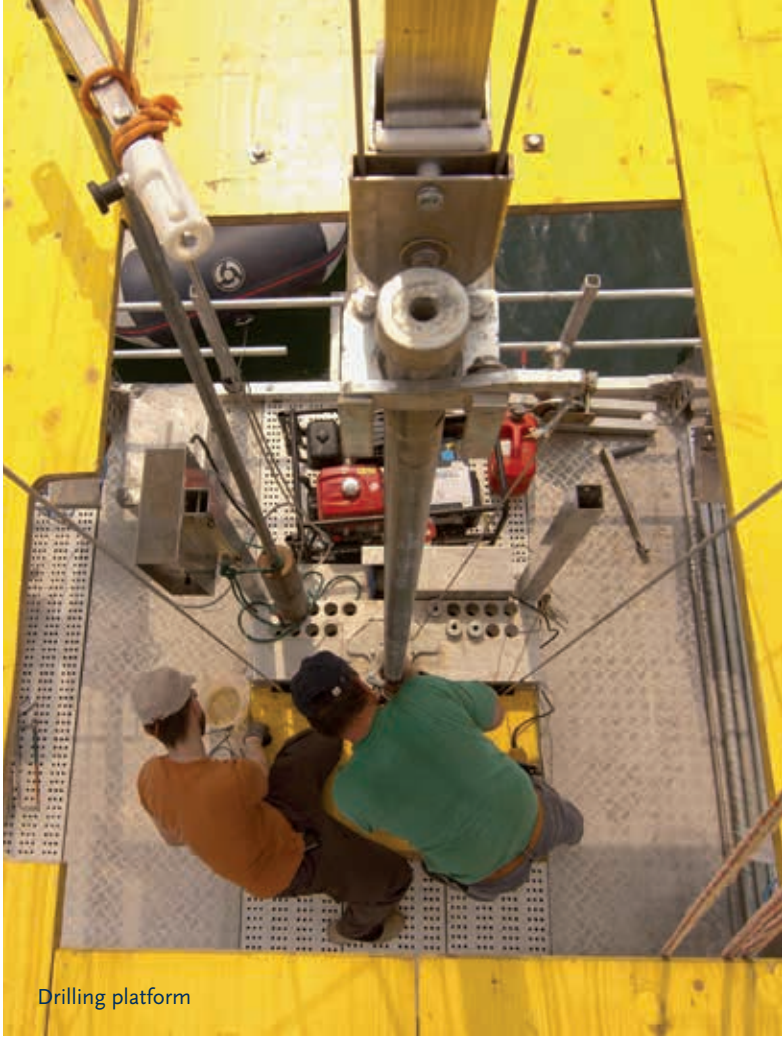
Lake Barombi in Cameroon

Millennia-old plant pollen provides information about the vegetation of that time

Environmental scientists are able to clearly identify and date such historical changes in regional vegetation by using various observation methods. They were able to prove that a dramatic change in the rainforest ecosystem in Central Africa must have happened 3,000–2,000 years ago. About 2,600 years ago, the dense rainforests were quickly replaced by a patchwork of forest and savannah followed by an equally abrupt recovery of the forest about 600 years later. But what triggered this sudden change that geologists call the rainforest crisis? The discussion has centered around these two processes, and most researchers have thought that a regional climatic change was more likely. So-called pollen analyses were considered as

Photos: Garcin, Yannick (2)

Sediment samples from Lake Barombi



Drilling platform

evidence of this thesis. Biologists and environmental scientists examined plant residues and seeds that can be found in lake sediments.

Garcin used this method as well. The geophysicist, who works at the Institute of Earth and Environmental Science at the University of Potsdam, is committed to answering how ecosystems and habitats develop. Where does his interest in landscapes that are thousands or even millions of years old come from? "For me, Africa is part of my homeland. I grew up in Cameroon and Senegal. I love its nature and people, and I see the great potential of the region. It is, therefore, almost self-evident that I'm interested in doing something for Africa as a researcher as well." He was particularly impressed by the complex rainforest ecosystem. "The processes that take place there impact many different parts of the Earth system."

Garcin and his team examined sediments from Lake Barombi in southern Cameroon, because sediments formed at the bottom of lakes, due in part to plant pollen being carried by the wind into the lake from the surrounding regions. Due to the low flow velocity of lakes, these deposits are hardly swirled and disturbed. Even seasonal changes can be detected. As a result, the age of the sediments can be very accurately determined.

Already in the 1980s, pollen analyses in sediments of Lake Barombi were showing that the ecosystem in Central Africa changed drastically about 2,600 years ago. Sediments before then had contained very little pollen from savannah plants but suddenly started becoming prevalent in sediments at this time. Since these plants can manage even with very little precipitation, the course of events in the rainforest crisis seemed to be resolved: Climatic changes must have caused the decline in rainforest. But Garcin and his colleagues were of a different opinion. They wanted to find out if the change in the ecosystem could have had other causes, so they decided to focus on analyzing plant waxes. Their studies confirmed that there must have been a sudden change in the ecosystem around Lake Barombi.

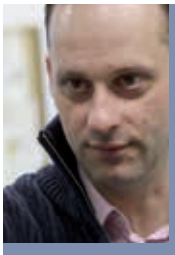
The researchers studied the bottom of Lake Barombi in Cameroon

Barombi Mbo, as it is known in Cameroon, is not a "blank spot" on the scientific map. By the end of the 19th century, German researchers had already visited the region around Lake Barombi and called it "Elephant Lake". At that time, scientific interest focused on the flora and fauna, and geographers only measured the lake and mapped its depth. Since then, the self-image of geo-research has changed a lot. "Today, we want to analyze the entire Earth system to get a better understanding of interactions, cascading effects, geosphere-biosphere relationships, the climate, and humans," says Garcin. He and his colleagues from research institutions in Germany, France, and Cameroon therefore also contacted archaeologists and anthropologists to get closer to solving the mystery of the rainforest crisis.

And indeed, the latest data measured by the international research team showed no change in to the amount or rhythms of precipitation. Fluctuations

Photos: Garcin, Yannick (2)

Yannick Garcin



THE RESEARCHERS

Dr. Yannick Garcin studied geology and has been a research assistant at the Institute of Earth and Environmental Science of the University of Potsdam since 2006.

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Dr. Simon Schneider studied geophysics and communication studies. He has been working at the Institute of Earth and Environmental Science of the University of Potsdam since 2015.

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in the intensity of rainfall in a region cause changes in the chemical composition of the rainwater. Such fluctuations are detectable in vegetable waxes and, in the long term, in the river and lake sediments. Researchers use the measurand δD to determine this. If climatic changes were the reason for the rainforest crisis, there would be also changes in δD observations. Supported by the Institut de Recherches pour le Développement (IRD) and others, Garcin accomplished a logistical masterstroke to get more accurate data. "Tons of material, a floating platform, analysis tools, power generators, tools, and computers – we shipped almost an entire laboratory to Lake Barombi, rebuilt, and reassembled everything there," says Garcin. A task for which he saw himself well prepared given that he had studied earth and environmental sciences. "As geoscientists, we work in the most remote areas. Good logistical preparation is almost as important as the scientific work itself."

The floating platform enabled them to retrieve sediment samples from different areas of the lake. "Obtaining samples from a depth of over 100 meters

requires special technology," Garcin explains. This would not have been possible without the local population consenting to having it brought to the lake, assembled, and used there. "So we spoke with the village elders and hired locals as drivers, helpers, and facilitators." Ultimately, the researchers were able to recover and analyze sediments of the highest quality. The measured δD data indeed failed to confirm the fluctuating precipitation theory. Changes in the regional climate were, therefore, not the cause of the rainforest crisis – another explanation had to be found.

Humans cleared the rainforest of Central Africa 2,600 years ago

"It is a basic principle of science: as researchers, we have to constantly review theories," emphasizes Garcin. "If a theory turns out to be unsustainable because of such tests, researchers need to develop a new one. We have now initiated this step for the rainforest crisis." For this new theory, he and his team resorted to the expertise of completely different areas of research. In collaboration with archaeologists and anthropologists, they found evidence for a new thesis in more than 460 archaeological finds from the region. Artifacts of indigenous people were rare until about 3,000 years ago. Starting around 2,600 years ago, on the other hand, many more were suddenly able to be found. This indicates an increase in human activity and the number of settlements in the area. More people, however, means more food is needed. Lake sediment contains, for example, a large amount of plant parts that originated from crops such as pearl millet and oil palm. The people with agricultural experience cleared the rainforest in order to gain acreage. Then, at the end of the rainforest crisis, the seeds and pollen of crops disappear again from the archaeological finds. The pressure exerted by human settlement had apparently subsided.

Garcin assumes, therefore, that it were not climatic changes that triggered the rainforest crisis but rather the people living in the region who needed arable land. A similar process can be observed in large parts of Africa, South America, and Asia today. The pressure of settlement, i.e. population growth, forces people to cultivate more land for agriculture. "We also see our study as a proof that nature has the ability to regenerate," says Garcin. If the pressure of settlement weakens, the original ecosystems might be able to re-emerge. "This does not mean we should continue to be irresponsible with our resources and ecosystems," says Garcin. "At some point, the great regenerative power of nature will be exhausted."

SIMON SCHNEIDER
TRANSLATION: SUSANNE VOIGT

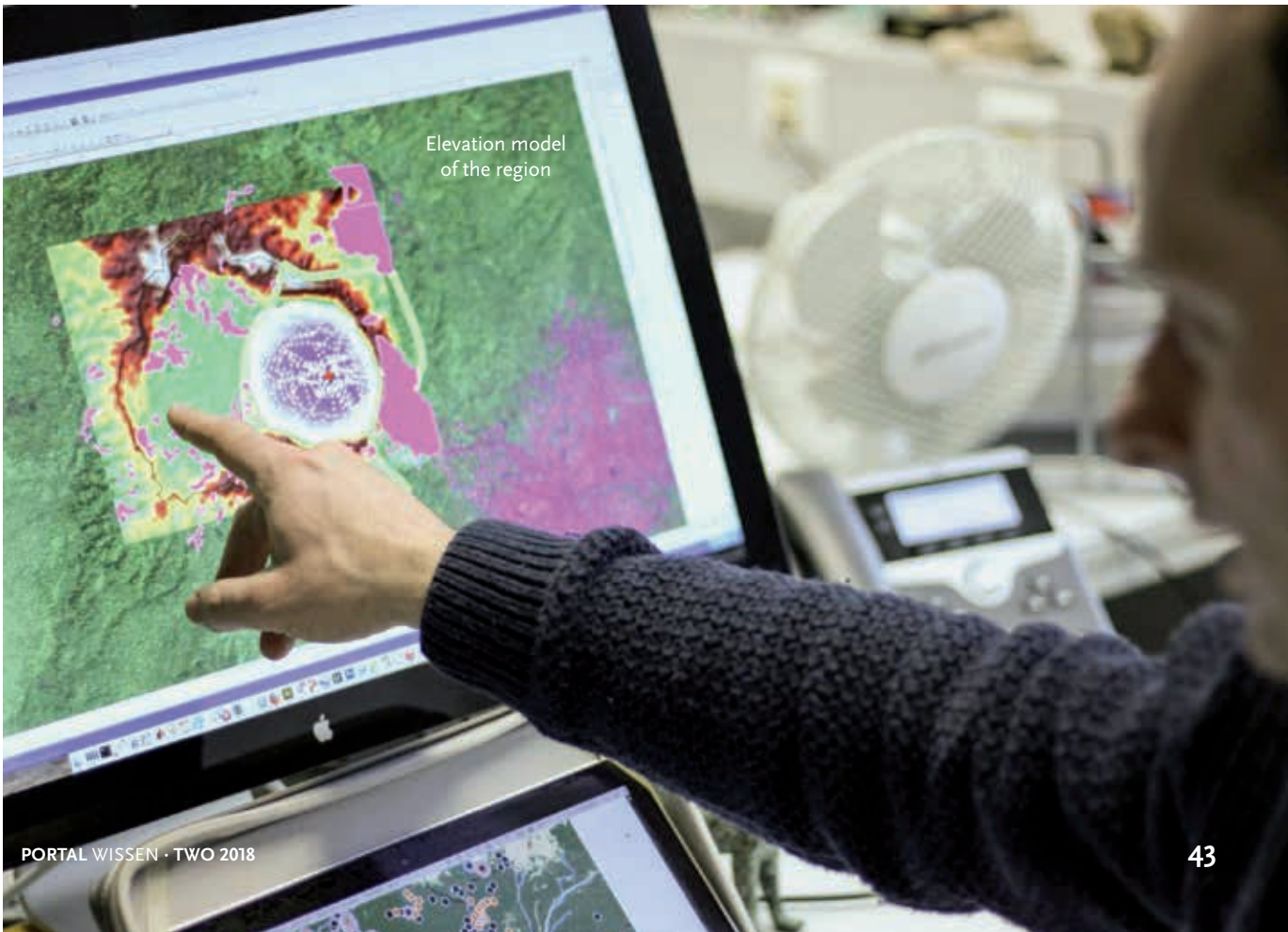


Photo: Kallich, Corinna

THE PROJECT

The learning experiment "Manuthetic" is part of the Priority Program "Intentional Forgetting in Organisations – mechanisms of forgetting as ways of organisations adapting to an environment in which the amount of information is constantly increasing". The project in which the University of Potsdam and Ruhr-Universität Bochum have been studying the mechanisms of forgetting and how they can be utilized in high-tech work processes since 2017 is funded by the German Research Foundation (DFG).

https://manuthetic.lswi.de

Research on the Production Line

Researchers at the Industry 4.0 Application Center Study Learning and Forgetting in Production

As work environments become increasingly complex and digital, the resulting changes also pose major challenges for the daily work of staff members. In a learning experiment, researchers explore how employees learn production processes and what factors influence their learning success. Heike Kampe participated in the experiment to find out more.

I feel warm in my white lab coat, and the goggles pinch my nose as I stand somewhat clueless in front of the monitor of a milling and grinding machine. I'm new here and have to get acquainted with the job. In a video I was shown beforehand, the production manager explained to me how important it is to work accurately and to strictly follow instructions. After all, we are manufacturing a medical product. When it comes to a knee prosthesis, every millimeter matters. At the same time, I have to work quickly to handle my workload.

I check the instruction sheet to find out how to set the correct program to mill and grind the blank on the conveyor belt in front of me. I press a bar on the display, and the blank moves into the milling machine. I fix it, choose the short milling program for the front end, and press "start". With a screech, the machine starts working. I'm able to monitor the process through a window at the front end. After 10 seconds, the blank has been milled; it now needs to be ground and then removed from the machine.

Almost like a real factory

I still feel somewhat uncertain, so I strictly follow the instruction sheet and have to keep referring back to it to see which step comes next. Which program do I set? Are the consumables in the machine sufficient? Which box do I tick on the form? Where do I find the correct size? I have to hurry, because my colleague is waiting for the blank to continue working on it.

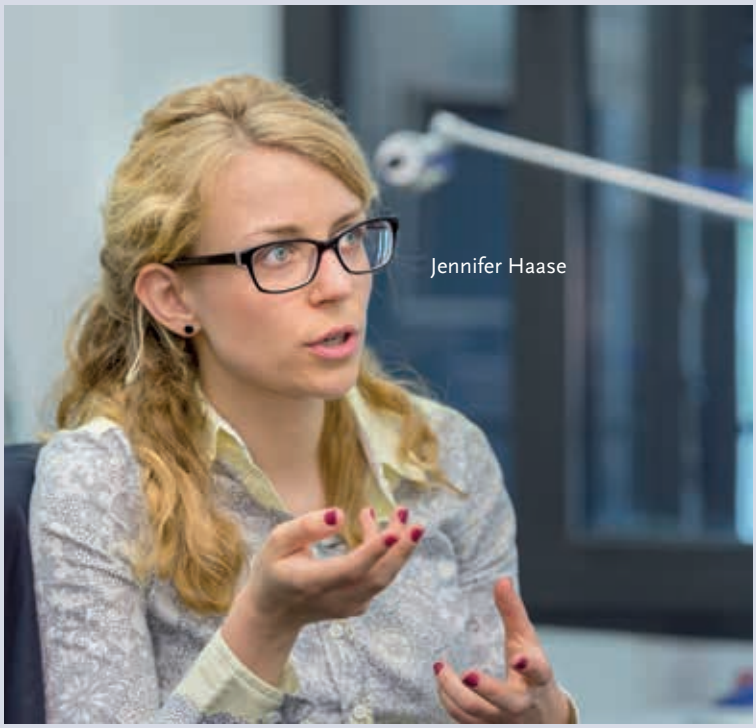
Gradually, I get better and better. The team manager takes the instruction sheet away from me – now I have to do without it and perform the tasks from memory.

It works! I collect the sheet with the right order number from the terminal, grab a blank with the right color and shape from the materials store, fill out the form, and grind the prostheses in the machine. I measure the blank with a caliper to make sure the size is correct. Then I mark it with a green sticker and place it on the conveyor belt. At the press of a button, the blank is transported to the next workstation, where my team colleague waits to polish it.

I really feel like I'm on a factory production line. But this is not a production hall; it is the Industry 4.0 Research and Application Center on the Griebnitzsee Campus. The production line – the conveyor belt, machines, robots – here simulates the work processes of a real factory.

Photo: Fotolia/Gorodenkoff

Next to me, two other women simulate production processes at their respective machines. We are participating in a research experiment on learning and forgetting. The machines are not real. Everything is digitally simulated yet feels authentic. Each step of our work is being analyzed. Our goggles record our eye movements and every sound. The vast datasets we are generating will later be thoroughly evaluated by researchers from Potsdam and Bochum. They are interested in the way we master the production process, the mistakes we make, and what makes us particularly effective and fast.


Jennifer Haase

Work routines are changing

The study is supervised by Christof Thim from the Chair of Business Information Systems, in collaboration with psychologist Jennifer Haase. By October 2019, hundreds of test subjects will have participated in it. Haase knows that digitization will be changing work routines at virtually every level.

"In the future, factory workers will also have to deal with new technologies, robots, tablets, and other digital tools more often," Haase explains. Entire processes are digitized and recorded in the background in order to make planning and work more efficient and to optimize resource use. This will also impact factory work routines.

How do people cope with these changes? And how can they be supported? These are the key issues addressed by the researchers in this learning experiment. For Haase, the experiment is unique: "Very rarely does one get to research under such realistic yet controlled conditions." The simulated production line allows the researchers to look at many variables, she explains.

The learning experiment "Manuthetic" is still looking for participants. Find out more at
https://manuthetic.lswi.de


Inside the Industry 4.0 Application Center

Photos: Roese, Thomas (2)

Respondents fill out a questionnaire ...

... and read the instruction sheet

THE RESEARCHERS

Jennifer Haase studied psychology with a focus on research at the universities of Halle-Wittenberg and Lund (Sweden). She has been a research assistant at the Chair of Business Information Systems and in charge of the Manuthetic experiment since January 2018.

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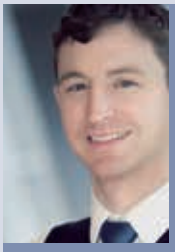

Dr. Christof Thim studied sociology, politics, and economics at the University of Potsdam. At the Chair of Business Information Systems he researches the adaptability of organizations to changing environments.

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Effective Learning

How do we learn production processes and change work routines? Are there any tools that facilitate learning? Under what conditions do we forget what we have learned? In various experiments at the Application Center, the researchers are also testing the role of reward, punishment, and time pressure in learning processes and how to formulate learning material in order to facilitate learning.

Meanwhile, everything is running like clockwork on the production line. I've gotten faster, so my team colleague no longer has to wait for me. We are very busy at our machines completing different tasks. We have worked through the instruction sheets and are now fully committed to what we are doing. There's not much talking.

In this respect, however, people differ, Haase explains: "In some groups, there is a lot of talking, people exchanging their views." These social interactions are also being studied in the experiment. The researchers want to find out whether communication between team members impacts productivity. Either way, initial results indicate that all groups ultimately end up working at roughly the same rate. While a complete run takes 20 minutes at first, only six are needed after the learning phase.

We are done for today. My head's spinning, and I'm tired, even though the job was neither physically demanding nor intellectually challenging. "The process as such is not difficult to learn," Haase confirms, "but the amount of detail makes it strenuous." I remove the goggles that have been tracking my eye movements for the past two hours. Before we leave, the researchers ask us to consolidate and internalize the steps we have learned today with the help of an app in the coming days. I take off my white lab coat and wonder what will happen in three weeks' time, when I return for the second part of the experiment. And whether the results will really enable the researcher – in a year from now – to tell how and when people learn production processes particularly effectively and quickly.

HEIKE KAMPE

TRANSLATION: MONIKA WILKE

Kettle hole near Damerow

The Mathematics of Nature

Gunnar Lischeid researches the environment with modern methods of data mining

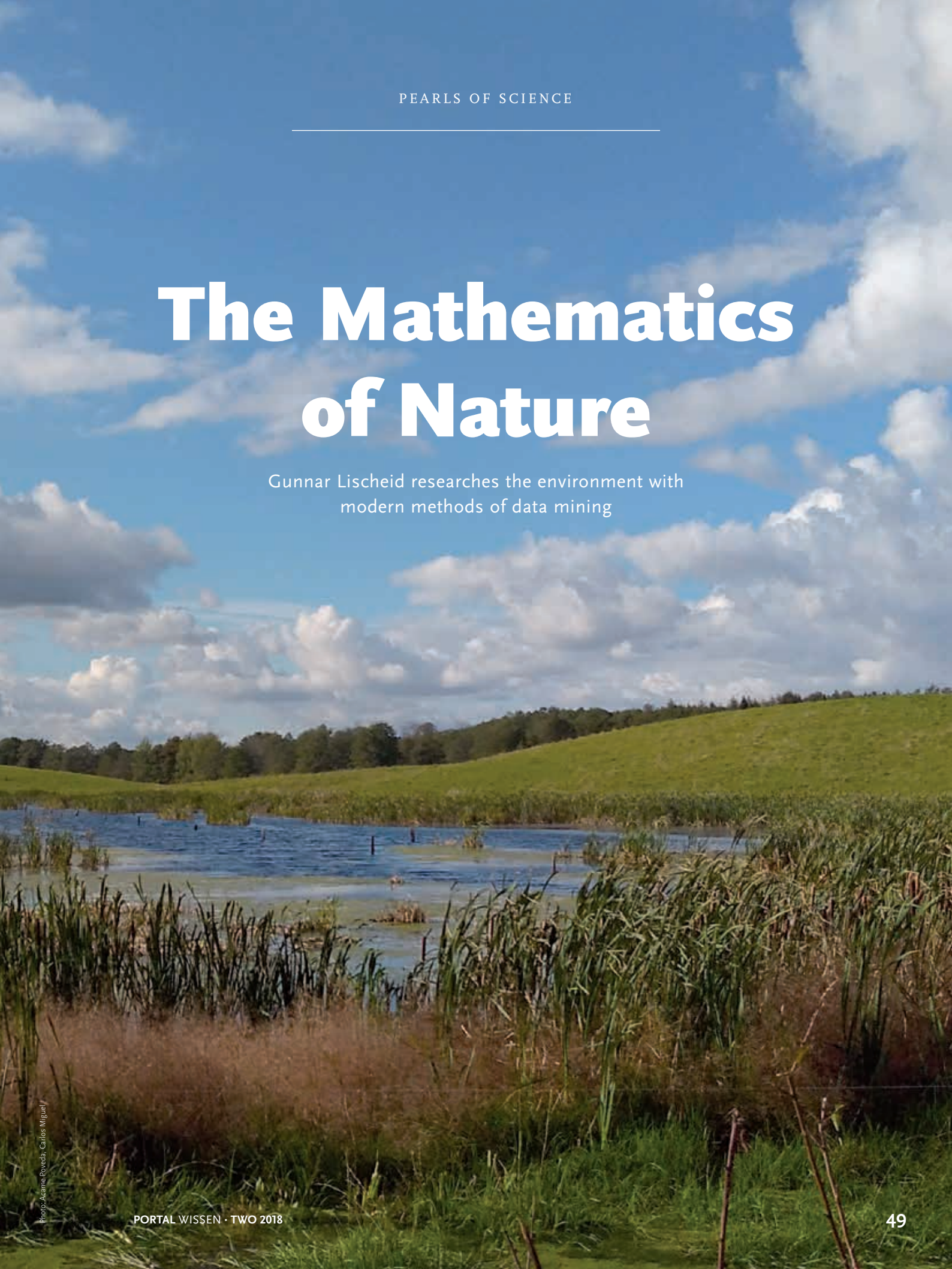


Photo: Acarne Poveda, Carlos Miguel

In our series "Pearls of Science" we regularly introduce researchers from institutions connected with the University of Potsdam in the "pearls – Potsdam Research Network".

Gunnar Lischeid is a researcher who likes to keep track of things. He sorts huge amounts of data, reveals patterns that open up new knowledge, and detects interrelations between processes in a landscape. At the Leibniz Centre for Agricultural Landscape Research (ZALF) in Müncheberg he heads the "Data" research platform in addition to being Professor of Landscape Hydrology at the University of Potsdam.

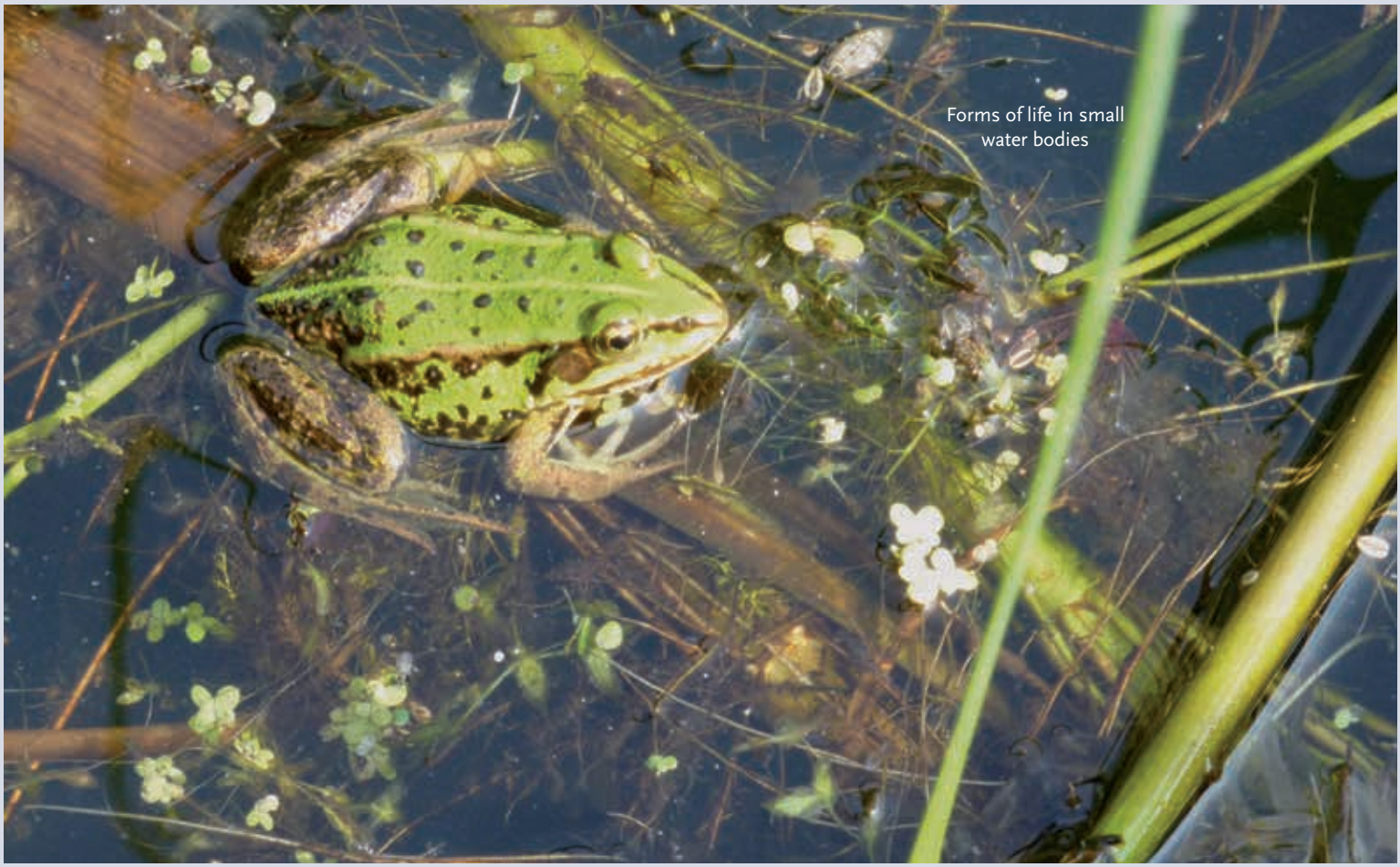
The rare moor frog and the common spadefoot live there as well as the marsh harrier and the water rail: Water-filled depressions in fields, often surrounded by thick belts of plants, are tiny biotopes – and valuable ecosystems in the agricultural landscape. But Professor Gunnar Lischeid is interested not only in the species of animals, plants, or microorganisms living there. First and foremost, he would like to find out more about nutrients and contaminants in small bodies of water known as kettle holes.

These processes are surprisingly intensive and complex, despite the fact that most kettle holes cover much less than one hectare. And what is more, their characteristics vary from hole to hole. Some emit trace gases such as methane that contribute to climate change – methane is a 25 times more potent greenhouse gas than carbon dioxide – whereas others don't. Researchers have yet to find an explanation for this. What is known about nutrient decomposition and material cycles in these kettle holes explains only a fraction of the measured data. So researchers are scratching their heads as to why the data do not fall in line with their expectations. "So far, 95% is yet to be understood," Lischeid states.

Researchers are analyzing water samples and sediment cores, studying pH levels and chemical compositions, and testing various hypotheses in laboratory experiments. But Lischeid wants to understand the remaining 95% as well, and by other means than measuring or counting. He and his team are less interested in individual processes: "We want to study the in-

Agricultural researcher and data expert Gunnar Lischeid

Photo: Roese, Thomas



Forms of life in small water bodies

THE RESEARCHER

Gunnar Lischeid studied agriculture and geology, holds a PhD in forestry, and habilitated in hydrology. At the ZALF, he heads the research platform "Data" set up in 2018, and he is Professor of Landscape Hydrology at the University of Potsdam.

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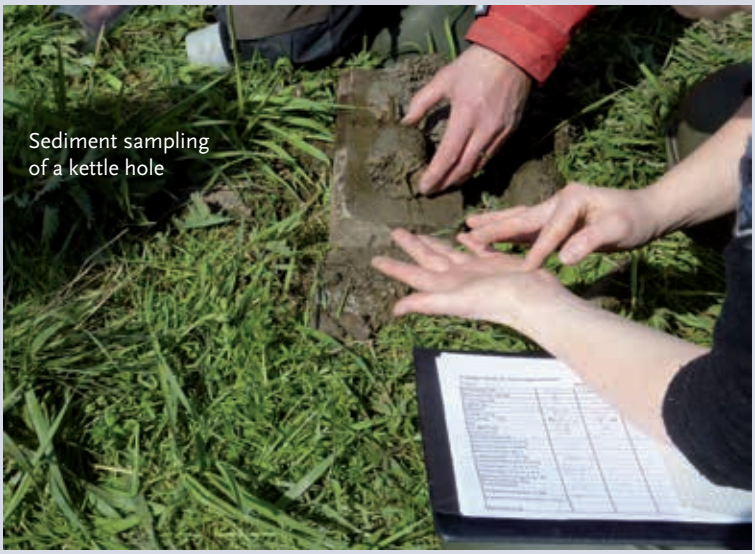

Sediment sampling of a kettle hole

teraction of many processes and understand them on a larger scale, in the landscape."

Long-term data collected over decades and stored in large databases, then, are his greatest treasure and mathematics and computer science his most powerful tools. With modern data mining methods, Lischeid, who is also an agricultural engineer, searches for previously unknown patterns and interrelations. Large data pools are analyzed with complex statistical methods to find new knowledge and results.

"These methods are not as common yet in environmental sciences, so it is high time to do something about it," Lischeid explains and gives an example of what knowledge can be gained when traditional methods are combined with data mining. In a forest in eastern Bavaria, Lischeid analyzed the turnover of nitrogen entering via the air and being discharged via the groundwater. Measurements in brooks of the drainage area revealed: "A major percentage of the nitrogen just disappeared." The researchers assumed that the wetlands were responsible for the depletion. However, measurements indicated that the wetlands removed only a fraction of the nitrogen.

Statistical methods brought Lischeid closer to an explanation: It turned out that the by far largest amount of nitrogen was being depleted in the forest soil and in deeper layers of the soil

Photos: Pätzig, Marlene (top); Roese, Thomas (middle left); Kaletka, Thomas (middle right)

Collecting research information outside, with tide gauge and measuring raft

The **Leibniz Centre for Agricultural Landscape Research (ZALF)** studies the sustainable utilization of agricultural landscapes. Its research focuses on social challenges such as climate change, food security, and the protection of biodiversity. Set up in the 1920s in Müncheberg, the Institute initially specialized in plant breeding. Today, it explores the natural- and social-scientific fundamentals of processes in agricultural landscapes, the effects of various uses, and resulting conflicts.

above groundwater level. It had previously been assumed that this process would take place only under oxygen deficiency. But there was sufficient oxygen in the forest soil! "My colleagues couldn't believe it at first," Lischeid remembers. Additional measurements confirmed the result. It was found that the nitrogen was being depleted by microorganisms in tiny, anaerobic soil aggregates – a process completely underrated at the time. "In retrospect, everything is conclusive and logical, but someone needs to spell it out for you."

Today, such thought-provoking impetuses often come from statistical data analyses. At the ZALF, the management of large research data sets, their analyses and documentation is being further intensified. The "Data" research platform headed by Lischeid is one of six new structural units set up here earlier this year. The combination of huge data volumes by statistical methods offers great potential for identifying complex interrelations, Lischeid is sure. Data mining could help environmental authorities, for instance, who have to decide on the basis of data which developments are harmful and which are not in order to arrive at new, more reliable estimates. Researchers can come to better understand why some of their models often go wrong. And in very special biotopes like kettle holes, many secrets could be revealed if the right data strings are pulled.

Critical thresholds, non-linear processes, or complex interactions in environ-

Photos: Kalettka, Thomas (top); Roese, Thomas (bottom)

ments are some of the phenomena Lischeid is fascinated by. As a researcher, he wants to get to the bottom of them. "There is no way to find out more using classical methods in this case," he explains. In the end, it was a theoretical physicist who inspired him to think out of the box.

He is now dealing with apparently strange methods like artificial neuronal networks, self-organizing maps, dimensionality reduction, and Sammon's Mapping – all enormously effective analytical tools for precisely and quickly processing high volumes of measurements. He enjoys twisting and turning data in all directions to find patterns which may become visible with one of the methods, he references various charts and, much like a detective, looks for clues to solve problems. As the head of a team of 22 researchers, there is little time to do this during the day, Lischeid admits. But when the Institute goes quiet in the evening, he broods over diagrams, scatterplots, and curves, or drills himself in new methods.

Often, what Lischeid finds when "playing around" with data is not surprising at all, and the interrelations opening up before him are logical and simple. In this case, the initial reflex is "We could have worked this out for ourselves". Nevertheless, the existing knowledge can be revalued and reclassified based on his findings.

Data science is a booming research field, yet it has not been able to attract enough young talent. "Of course, businesses can pay young researchers much higher salaries." After all, data mining techniques are also profitable in business consulting, marketing, and industrial enterprises.

Incidentally, Lischeid gets his best ideas while travelling on a train, as he tells us. "I love business trips by train." There he finds time to sort ideas and develop them further. So it is no big deal for him to take the train to Müncheberg every day. As the train passes by kettle holes in the fields, it is the most fertile working atmosphere for the agronomist.

HEIKE KAMPE
TRANSLATION:
MONIKA WILKE

The **pearls – Potsdam Research Network** connects the University of Potsdam and 21 non-university research institutions in the science region of Potsdam/Berlin. The network focuses on joint research projects, developing young researchers, and joint research marketing of the science region Potsdam.

pearls
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Photo: Fotolia/James Thew

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FOREIGN EMPLOYEES

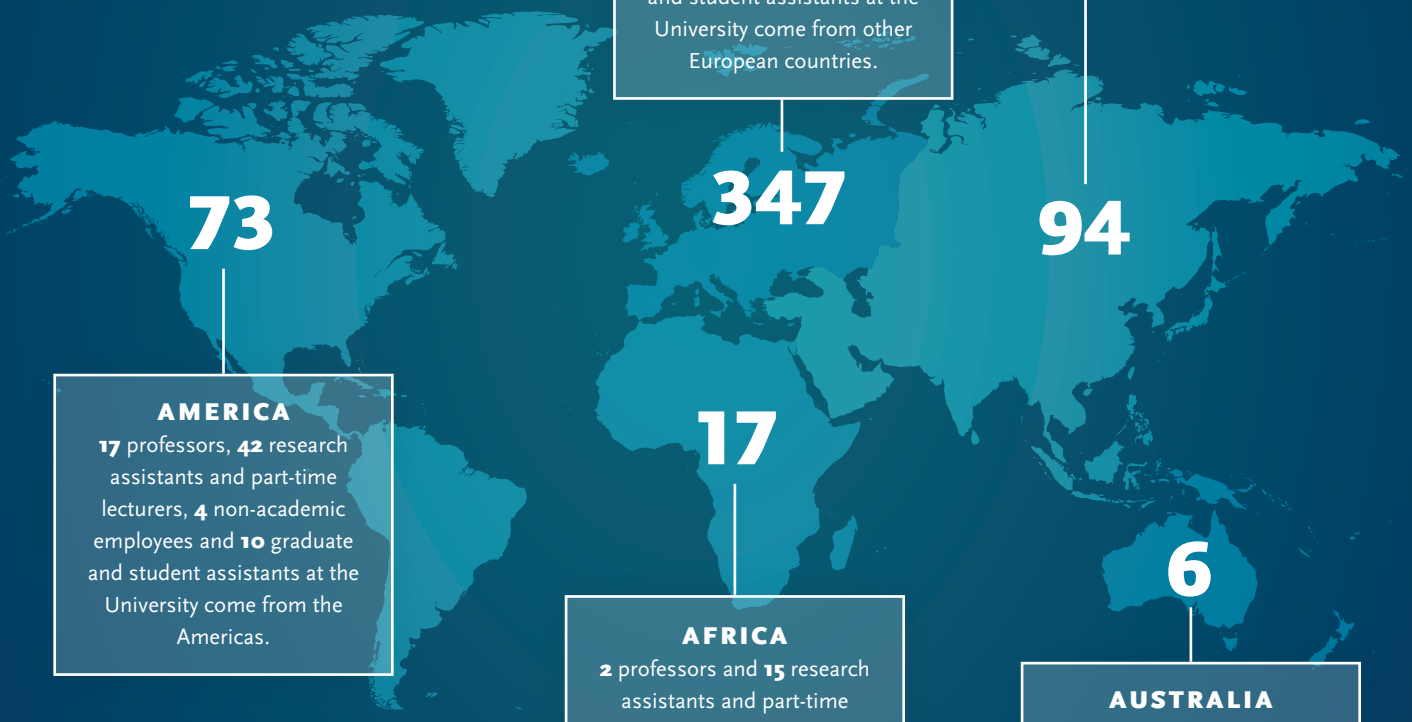
from 5 continents are currently working at the University of Potsdam.

ASIA

22 professors, **48** research assistants and part-time lecturers and **24** graduate and student assistants at the University come from Asia.

EUROPE

46 professors, **222** research assistants and part-time lecturers, **18** non-academic employees and **61** graduate and student assistants at the University come from other European countries.



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94

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17

6

AMERICA

17 professors, **42** research assistants and part-time lecturers, **4** non-academic employees and **10** graduate and student assistants at the University come from the Americas.

AFRICA

2 professors and **15** research assistants and part-time lecturers at the University come from Africa.

AUSTRALIA

4 professors and **2** research assistants and part-time lecturers at the University come from Australia.

FIGURES presents one of the many figures that describe the research work at the University of Potsdam, offering a glimpse of the hustle and bustle behind the scenes.

Research and teaching at the University of Potsdam is very international – as illustrated by these figures. They refer to the employees' nationality and include both the full-time and the part-time staff. The data were collected by the Department of Planning, Statistics, and Research Affairs of the University of Potsdam, reporting date December 01, 2017.

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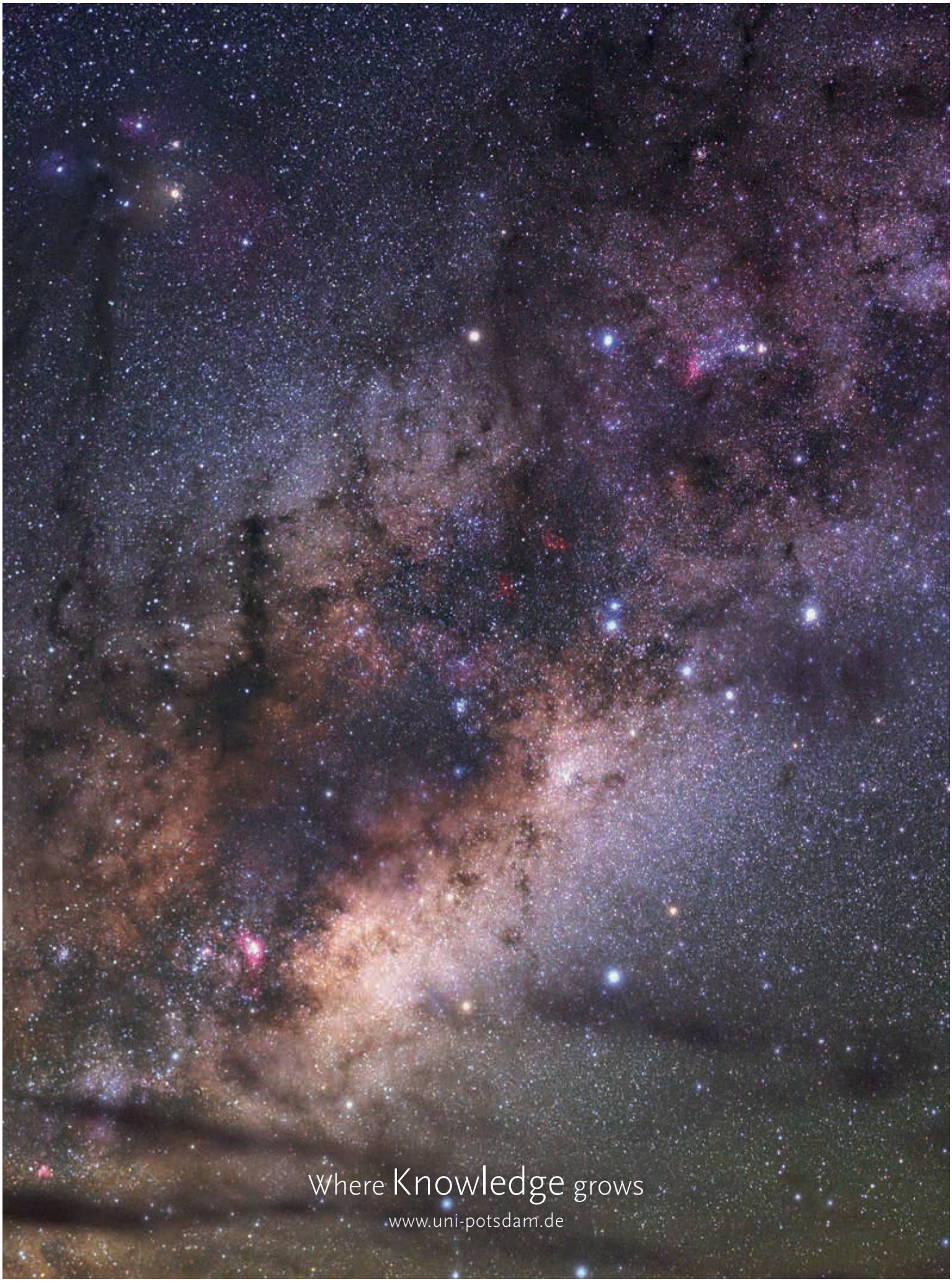
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