INSIGHTS

EINSTEIN FELLOWS AND PROFESSORS

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The Einstein Foundation Berlin provides support for exceptionally talented academics to work in Berlin – as international Visiting Fellows with a temporary research group or in the long term as Einstein Professors.
These scientists bring important characteristics to their work, including patience and perseverance, optimism and imagination, intuition, and – not least – unbridled curiosity. They are searching for light in the darkness, advancing the energy transition, or analysing topics such as new materials, our perception in space, and vision across different cultures. They are fighting to find a cure for yet incurable diseases, to preserve biodiversity, or to support alternative versions of society. Though their fields of research vary, these scientists all have one thing in common: they are at the forefront of their respective disciplines worldwide. For this brochure, they have shared insights into their daily research, their motivation, and their goals.

EINSTEIN FOUNDATION BERLIN


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“The important thing is not to stop questioning”

ALBERT EINSTEIN, 1955

"I sound out the depths"

BETTINA ALBERS EINSTEIN JUNIOR FELLOW

BETTINA ALBERS

EINSTEIN JUNIOR FELLOW

Geomechanical engineer **BETTINA ALBERS** studies acoustic wave propagation in soils and rocks. She is Adjunct Professor in the Department of Soil Mechanics and Geotechnical Engineering at the Technische Universität Berlin.

You use sound waves to study the ground?

Conventional methods rely on borings to obtain soil samples. But those techniques destroy the soil. In the theoretical part of my work, I develop a foundation for non-destructive test methods, which are also less expensive. My approach relies on the properties of acoustic waves. When you send a signal through the ground and measure the wave velocity, for example, it lets you draw conclusions about the soil composition and firmness. That is also the route specialists took to stabilize the Leaning Tower of Pisa, by the way. Other wave properties may even be useful in predicting landslides: once the soil reaches a certain saturation level, one of the sound waves almost doubles in speed. If this saturation is achieved after heavy, prolonged rains, for example, the increase in speed can be detected to activate a warning system.

So your research is theoretical with specific practical benefits?

My work is situated in the category of basic research. As an engineer, however, I am also always interested in practical applications. One of my concerns is how to combine engineering approaches with mathematics and utilize the complex modelling possibilities for practical applications. I find it fascinating to transfer the processes that occur in the depths of a medium to an abstract mathematical level. It is especially interesting with porous media, because you need to account for the interplay of solids and interstitial fluids. These small cavities contain immiscible fluids flowing through them; because the fluids cannot combine, a surface tension emerges. Even when the saturation remains the same, what we call "capillary pressure" varies, depending on whether water is entering or exiting the soil. In my project as an Einstein Junior Fellow, I develop a mathematical model that describes the impact of these factors on the propagation of sound waves in order to create even better non-destructive test methods.

What do you think about when you are studying sound waves?

Wave propagation is a bit like life, actually. When a wave is attenuated and its amplitude slowly decreases, we might compare it to our energy as we approach the end of our journey on this earth. The amplitude of a wave, with its ups and downs, also shows us parallels: setbacks often lead to something positive. For me, one of those positive events has been the opportunity to have so much freedom in my field thanks to support from the Einstein Foundation.

MILESTONES

SINCE 2012
Einstein Junior Fellow, Institute of Civil Engineering, Technische Universität Berlin

2010
Habilitation, Technische Universität Berlin

2005—2009
Principal investigator, DFG-funded research project, Technische Universität Berlin

1997—2005
PhD and postdoc, Weierstrass Institute for Applied Analysis and Stochastics, Berlin

“Art is philosophy with different tools”

ALEX ARTEAGA EINSTEIN JUNIOR FELLOW

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ALEX ARTEAGA

EINSTEIN JUNIOR FELLOW

ALEX ARTEAGA researches how meaning emerges through aesthetic experience. He is Director of the Auditory Architecture Research Unit in the Master's degree programme for Sound Studies at the Berlin University of the Arts.

I would describe what I do as aesthetic research. The research environment is a hybrid, somewhere between art, philosophy, and architecture. What interests me is how architecture shapes our everyday experience and helps us understand the world as a meaningful ensemble. My goal is to overcome the classic duality between the built environment and our subjective experience of space. My model proposes a dynamic system in which individual and collective meaning is predicated on how we experience built space. It might sound very abstract at first, but with my research I want to help change how we "do" architecture. Basic research has the potential literally to change the world.

Over time, I have come to experience built environments as increasingly detached and closed off. They do not enrich our experience or help us interact with space. I believe it has to do with how we train architects. Architecture is taught as a two-dimensional approach that is heavily influenced by engineering. Basically, architecture is conceived as drafting plans and building spaces. That approach to training has many gaps. I want to offset it with an architecture that is based on how we experience space – architecture as spatial artistry. It will require us to redefine and revalue subjective experience.

When I investigate architectural space, the approach I use is aesthetic fieldwork. I don't assume a given reality that I find in a data set and run through a program once I am back in my office. Instead, I try to gain access to a space from an aesthetic angle. That lets me see processual aspects. It also prevents the space from appearing timeless. One example is performative video recordings that I make for different places. I show these videos where they originated as on-site installations. This superposition and medial shift opens up a dynamic perspective – we perceive how we actually perceive space.

"Artistic work isn't just about creating beautiful objects"

My interest in perception stems from my artistic work. I always viewed perception as the substrate or basic material for my work. It is the fundamental moment of how we constitute the world by recreating it through our own experience. Artistic work isn't just about creating beautiful objects, but opening up new perspectives and new ways of experiencing the world. Art is more or less philosophy with different tools.

MILESTONES

SINCE 2013
Einstein Junior Fellow, Auditory Architecture Research Unit, University of the Arts (UdK), Berlin

2008—2012
Research Fellow, Collegium for the Advanced Studies of Picture Act and Embodiment, Humboldt-Universität zu Berlin

SINCE 2006
Co-founder and Director, Auditory Architecture Research Unit, UdK

2005—2008
PhD in philosophy, Humboldt-Universität zu Berlin, with funding from the Heinrich Böll Foundation

“Like watching a ballroom dance”

KAAN ATAK EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

KAAN ATAK uses X-ray spectroscopy to study the properties of metalloproteins in the human body. Trained as a physicist, he is postdoctoral fellow at the Freie Universität Berlin.

KAAN ATAK

EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

When we have a problem in our body, the doctor uses radiography to take a picture of what is happening inside. My approach is very similar. I use X-ray spectroscopy to look into the microcosm and observe the interactions of molecules and atoms. Our instruments are like special eyes; they let us see what would otherwise remain invisible. Seeing microcosmic processes helps us discover what is really causing a phenomenon – for example why viruses make us ill.

It's like watching a ballroom dance, in a way. On the dance floor, people interact, come together, interpret cues, and signal their affinities and dislikes. Atoms and molecules are also engaged in a type of dance, creating bonds and communicating through electrons. Their electronic structure determines how they interact. The X-rays we need for our experiments are produced in the synchrotron facility BESSY II in Adlershof near Berlin. We use X-rays to bombard the molecules we want to investigate. The molecules react and produce their own X-rays, which we record to obtain crucial information about their electronic configurations.

At the moment, I am investigating a family of biomolecules called porphyrins, more specifically hemin, a molecule which contains an iron atom. The iron atom bonds with smaller molecules like water, oxygen, and carbon dioxide. We are trying to understand this function because it will help us gain a better understanding of haemoglobin, a much larger molecule that carries oxygen to our cells and carbon dioxide back to our lungs.

"Physicists are modern-day oracles"

My research is both basic and applied. We study the properties of different materials and learn about their electronic structures. Our results can create opportunities for many other scientific fields. We can design more efficient molecules for drug delivery in medicine, for instance.

I have always been a curious person. As a child, I was constantly taking apart my toys to understand how they worked. Even then I already wanted to become a scientist to gain a better understanding of the world we live in. And I'm still insatiably curious. I want to be inspired by different visions and ideas every day. There are so many stimulating fields, especially psychology and history. But physics fascinates and challenges me the most. Physicists are like modern-day oracles. They search for the rules that govern the universe. Once we have found them it might even be possible to predict the future. That's magical, I think.

MILESTONES

SINCE 2012
Einstein International Postdoctoral Fellow, Freie Universität Berlin

SINCE 2012
Member of the Helmholtz Young Investigators Group "Structure and Dynamics of Functional Materials in Solution"

SINCE 2011
Postdoctoral researcher, Helmholtz Zentrum Berlin für Materialien und Energie

2000—2009
Graduate Research and Teaching Assistant, Bŏgaziçi University, Istanbul, PhD in physics


“Is vision a cultural sense?”
VERA BEYER EINSTEIN JUNIOR FELLOW

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VERA BEYER

EINSTEIN JUNIOR FELLOW

VERA BEYER analyses forms of perception in different cultures. The art historian is a research and teaching assistant at the Department for Art History at the Freie Universität Berlin.

My work engages with the most primeval instrument of art history: vision. How we see today is shaped by our current contemporary perspective. But I think that different pictures can convey an impression of how people used to see things in different times and in different contexts. They also help us trace the development of our current modes of sight.

I examine pictures that represent different visual moments. Scenes that involve watching and looking. There is a scene in the story of Joseph in the Old Testament, for example, in which Potiphar's wife – in the Persian context she is known as Zulaikha – glances toward Joseph. This scene is revisited not only in the Koran, but also in mystic Persian poetry and in Protestant catechisms. And each time, it was reconceived or redrawn. We can use these images to create an intercultural comparison of how differently this glance at Joseph is shown and valued.

For Rembrandt, the scene has a strong emphasis on the body. But physical beauty usually remains highly ambivalent in the European context: it is something to be shown, but not coveted. And the woman who awakens covetous thoughts is placed in a negative light. In the Persian context, on the other hand, these negative connotations are absent: Zulaikha realises that Joseph's physical beauty is a reflection of the Divine. Then the story takes what western observers would regard as an unexpected turn: Joseph agrees to marry Zulaikha after she understands that his beauty is not merely physical, but actually comes from within.

"Artefacts need to be seen in context"

Since I started researching the links between European and Middle Eastern visual cultures, I have been confronted with a number of clichés about fundamental differences. The claim that Middle Eastern cultures are less driven by images than their European counterparts is just one stereotype. My team and I try to focus on the close ties between those visual cultures – common references to Antiquity, for example, or other objects that circulated between Europe and the Middle East. There are rugs with Arabic lettering in Western European churches and German processional images in the albums of Muhgal rulers. This helps us better understand dividing lines in a shared history. Of course that doesn't mean that art should be seen as a universally intelligible language – instead, artefacts need to be seen in context to combat clichés.

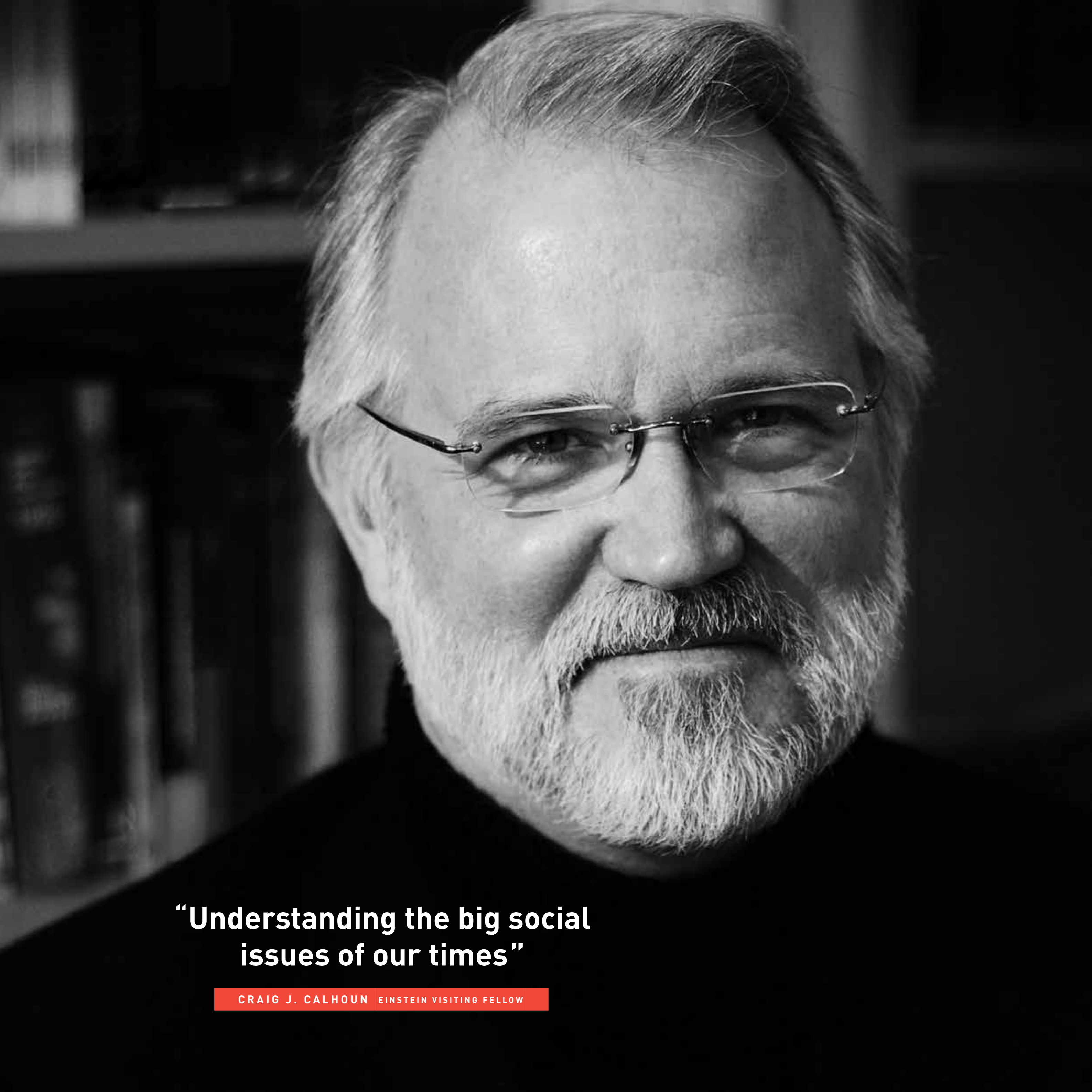
MILESTONES

SINCE 2012
Einstein Junior Fellow, Department for Art History, Freie Universität Berlin

SINCE 2008
Director, DFG Emmy Noether Programme: "Kosmos/Ornatus. Ornament as a Form of Cognition – A Comparison of Persia and France c. 1400"

2005—2008
Teaching and research in New York, Bochum, and Basel

2002—2005
Member of the research training group "Representation – Rhetoric – Knowledge", European University Viadrina; PhD with distinction, Universität Hamburg



“Understanding the big social issues of our times”

CRAIG J. CALHOUN | EINSTEIN VISITING FELLOW

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CRAIG J. CALHOUN

EINSTEIN VISITING FELLOW

CRAIG J. CALHOUN is Director of the London School of Economics and Political Science. As a sociologist, he is concerned with the link between individual expectations and large-scale social realities.

It's not just the intellectual pull. I have always had an emotional connection to my work that drives me. Emotionally, a pivotal project was my study of the Tiananmen Square protests in China in 1989. I was there; I was able to talk with students and interview them. I felt a kind of personal connection and a strong ethical obligation to give an accurate account of what was happening. I wanted the world to understand their movement. Ever since then, I have strived to make my work accessible to a wider public.

I learned an important lesson in this regard after the 9/11 attacks on the World Trade Center in 2001. I was involved in organising a group of the world's leading social scientists to write concise essays based on their individual expertise to help people understand the events and their implications. How did the clandestine Al-Qaeda movement operate? What were the risks of an invasion of Iraq? What about the nature of war today and the role of the media? More than 1.5 million people on average downloaded these essays.

That was the catalyst for our work on what we coined "real-time" social science. The goal is to understand public issues as they happen, for example the social circumstances of Hurricane Katrina. I want to motivate social scientists to contribute their knowledge to public debates as they unfold. Of course, that does not mean giving up on long-term research. Sometimes we need to get our knowledge where it's needed more quickly.

"We need the contributions of social scientists"

My passion in research is to understand the ways in which people try to translate their personal desires and values into collective action, and why that is so hard. For example, why is it so difficult to get our governments to eliminate poverty or respond to climate change? I have studied this topic in areas ranging from radical politics to the financial crisis. My current work is informed by my Einstein research group in Berlin. We focus on how strangers organise their interactions and how physical places play a role in shaping these social processes. We want to extend this topic to cover contemporary issues such as migration, both locally in Berlin and on a larger European scale.

I am convinced that we need the contributions of social scientists. However, social scientists could do a better job in improving the quality of public debate. They could also contribute to stronger, more empirically informed public understanding of the big issues in our time. It is our professional responsibility to reach a wider audience.

MILESTONES

2010—2014
Einstein Visiting Fellow, Berlin Graduate School of Social Sciences, Humboldt-Universität zu Berlin

SINCE 2012
Director, London School of Economics and Political Science

2001
Co-founder of the interdisciplinary working seminar NYLON, New York State University/London School of Economics and Political Science

1996—2012
Professor of Sociology, New York University and Columbia University, New York

“How do decisions happen in the brain?”

RAYMOND DOLAN EINSTEIN VISITING FELLOW

RAYMOND DOLAN studies decision-making processes in the human brain. The neuro-psychiatrist is Professor at the University College London and Director of the Wellcome Trust Centre for Neuroimaging.

RAYMOND DOLAN

EINSTEIN VISITING FELLOW

How much do we know about the brain today?

Neuroscience as a discipline has been around for maybe 150 years. A lot of it started here in Berlin with Herrmann von Helmholtz. Since then we've made tremendous progress. We now have a very good idea of the scale and complexity of the human brain – a colossal "machine" consisting of around a hundred billion neurons, each with 10,000 or so different connections. We know a lot about its energy consumption, and we can create highly sophisticated maps of functions such as vision, audition, and taste.

Despite all this progress, the unanswered questions still seem endless. It is very daunting. If you think of it as a journey to the top of the Himalayas, we are down in the foothills. Right now, our biggest challenge is finding the mathematical algorithm that neurons may be running to compute everything we experience. We often refer to this as the "neuronal code". If someone were to discover this algorithm, it would be as significant as cracking the DNA code.

Which functions of the brain are you studying?

My current research is concerned with the processes that underlie human decisions. We might think that there is a central decision-making executive sitting in our brains, something very much like the CEO of an organisation. But it turns out that decisions are multi-layered and involve different brain systems. Usually, they cooperate to find the best solution for a given situation. Yet sometimes there is a conflict. Excessive operation of the habitual system is one potential explanation for pathologies, such as obsessive-compulsive disorder, for instance.

We are particularly interested in what determines the precise balance between the different decision-making systems. Which brain functions and neurochemical processes are active in maintaining this equilibrium? The prime technology that we use is functional magnetic resonance imaging, which enables us to measure activity in the human brain, while it performs tasks like reading, thinking, memorizing, and emoting.

Does your research influence psychiatry?

Psychiatry has been rather divorced from neuroscience for over 100 years. But understanding the core problems in psychiatry today requires cutting-edge neuroscience. I started my research career as a psychiatrist. Then I pursued what was mainly a neuroscience agenda for 25 years. Now I want to come full circle, return to psychiatry, and apply the knowledge I have gained to understand psychiatric disorders, which are ultimately the source of so much human misery and unhappiness.

MILESTONES

2014
Director, Max Planck UCL Centre for Computational Psychiatry and Ageing Research, London and Berlin

2010—2014
Einstein Visiting Fellow, Berlin School of Mind and Brain, Humboldt-Universität zu Berlin

SINCE 1996
Professor of Neuropsychiatry, Institute of Neurology, University College London

1994
Founder, Wellcome Trust Centre for Neuroimaging, University College London

“Creating new materials on computers”

CLAUDIA DRAXL EINSTEIN PROFESSOR

CLAUDIA DRAXL

EINSTEIN PROFESSOR

CLAUDIA DRAXL simulates and analyses the atomic structure of materials. The native Austrian is Professor of Theoretical Solid State Physics at Humboldt-Universität zu Berlin.

Material design on the computer screen? Tell us more.

We apply computational methods to the physical properties of materials, which can include anything from simple metals to semi-conductors, or even plastics. We also analyse and try to improve on the methods we use to compute material properties. To do this, we develop and write computer programs, and apply them to a wide range of materials. Whether our goal is to mix different material components, or even just replace individual atoms, we always want to innovate. For us, that means producing a new material with properties that did not previously exist. Computers facilitate this process. They help us predict how different properties will change without the need to actually produce the materials.

Which materials have captured your interest?

Right now, I would definitely say the hybrid materials. This is a group of nanostructured materials with interfaces which bring together components with different properties. One example is the combination of carbon nanotubes and organic molecules – two very different materials. Carbon nanotubes are robust; they also have very good electrical properties. But they are useless for constructing optoelectronic elements, because they cannot emit or capture light in the visible range. However, there are many molecules among their organic counterparts that can do exactly that. When we introduce them into the nanotubes, we can create a new material that combines the mechanical and electrical properties of nanotubes with the light-absorbing properties of the organic molecule. The basic idea in this case is to produce a light-emitting nanoobject in the hopes of someday using it for optoelectronic materials. That includes elements we need for flat screens, for example.

Does creating a new material basically mean you have outsmarted nature?

We leave the actual work of "outsmarting" nature to the experimenters. They are the ones who produce what we decided was a good material on paper, or in our case on the screen. But it's a long process. The path to finding a new material until it can be applied usually takes about 20, and sometimes even 30, years.

My work is in the area of basic research. But that does not prevent me from thinking about what could be useful in the future. One case is thermoelectric materials, for example, which is a class of materials that could be very efficient in transforming exhaust heat into electrical energy. I believe that we need to stick with the basic questions so that we can keep moving forward.

MILESTONES

SINCE 2011
Einstein Professor of Theoretical Solid State Physics, Humboldt-Universität zu Berlin

2005—2011
Professor, Montanuniversität Leoben, Austria

2000—2001
Visiting Professor, Uppsala University, Sweden

1990—2005
University of Graz: Habilitation, Associate Professor, Director of the Institute of Theoretical Physics


“We want to find a cure
for childhood cancers”
ANGELIKA EGGERT EINSTEIN PROFESSOR

ANGELIKA EGGERT

EINSTEIN PROFESSOR

ANGELIKA EGGERT conducts research on neuroblastoma, a tumorous cancer that occurs in children. She directs the paediatric clinic for oncology and haematology at the Charité – Universitätsmedizin Berlin.

People are surprised to hear that I enjoy working with children who have cancer. There are very special, very positive sides to my work, like witnessing a recovery or certain moments and experiences with the kids. It is a joy to see them grow up and be able to lead normal lives. Today, there is an 80 per cent chance of curing childhood cancer; in the 1960s, that rate was only 20 per cent. We made advancements through a better combination of chemotherapy and radiation, but there is not much more that we can improve in that area. Now, we need to develop new, molecularly specific drugs that can detect certain structures on the surface of a tumour and attack it – enabling personalised therapies for our patents. That is what we are working to achieve for the future of cancer treatment. We need to get to a cure rate of 100 per cent.

In my research group, we study individualised therapies for neuroblastoma in children. This type of tumour interests me because we have observed that it has two completely different life cycles. In one group of patients, this malignant tumour just suddenly recedes. It is fascinating and very uncharacteristic – we have never seen this kind of behaviour with cancer before. You could say it's a miracle. But we want to understand this process in order to apply those findings to the second, incredibly devastating life cycle: advanced or metastatic neuroblastoma that has spread to the liver or the bone marrow. For these patients, there is often little hope. Our success rate is very low, even with highly aggressive chemotherapy, radiation, or bone marrow transplants. That is why we want to develop new drugs to push the tumour into a positive life cycle.

"When a child dies, I go to the lab and feel motivated to do even more"

When a therapy is unsuccessful, it stays with me. I go home and need to spend time processing the experience. When one of my patients relapses, it is usually a child that I have got to know well during treatment. In the worst case, the child dies. Unfortunately that is part of our work. When that happens, I often go to the lab and I feel motivated to do even more. Other times there are phases in my lab work when none of my hypotheses hold and none of my experiments provide any results. Then I look forward to going back to the paediatric clinic and spending time with my patients. Sometimes I spend an entire night fighting for the life of a child whose prognosis was poor, but then ended up making it through. In the morning everything looks different. Those are experiences that you will never have in the lab.

MILESTONES

SINCE 2013
Einstein Professor of Paediatric Oncology and Hematology, Charité – Universitätsmedizin Berlin

2008—2013
Director of the paediatric clinic "Kinderheilkunde III", Essen University Hospital

2007—2013
Director of the West German Cancer Centre, Essen

2004—2008
Professor of Paediatric Oncology Research and Paediatrics, Essen University Hospital

"Understanding the book of life"

ANN EHRENHOFER-MURRAY EINSTEIN PROFESSOR

ANN EHRENHOFER-MURRAY

EINSTEIN PROFESSOR

ANN EHRENHOFER-MURRAY analyses the molecular foundation for reading genetic information. She is Professor of Molecular Cell Biology at Humboldt-Universität zu Berlin.

Does the human DNA sequence give us the key to our biology?

No, it's about more than DNA. We have known the primary sequence for the human genome since 2001, but what we still do not fully comprehend – which is what I study – is how genetic information is actually expressed. How are individual genes activated or deactivated in order for certain functions to emerge from a genome? As epigeneticists, we investigate the molecular mechanisms that occur along the DNA sequence. We are interested in how the DNA is bundled and which changes in the packaging proteins lead to deviations in the expression of genetic information. Cancer cells, for example, are very different from normal cells, both genetically and epigenetically. Their genetic changes cannot be reversed, but that may not apply to epigenetic behaviour. This is the starting point for new cancer therapies. We want to understand epigenetic mechanisms such as enzymes that trigger undesirable reactions in order to develop effective inhibitors.

What motivates you in your daily research?

I love to immerse myself in molecular details. I want to keep exploring until I find the underlying mechanism for a given process. In my everyday work, I revel in small breakthroughs, for example when an experiment works or when we find another puzzle piece in the bigger picture. Ultimately, I would love to understand every process that is involved in the expression of genetic information and then compare these processes to what happens in diseased cells. Then we would know where to intervene. But we still have a long way to go before we understand everything.

What will epigenetics engage with in the future?

One new field is neurodegenerative diseases such as Alzheimer's or Parkinson's. Meanwhile, research has shown that epigenetic therapies could be helpful in treating these diseases. We have already isolated a molecule that inhibits a certain enzyme and its effects on neurogenerative defects are now being tested. Epigenetics is also playing an increasing role in gerontology. In model organisms, scientists have already found genetic mutations that result in a modified protein which decelerates ageing. This means that we should be able to find a chemical inhibitor that has the same effect. The question is whether it could also have negative consequences or side effects. Intervening in the ageing process is ultimately a matter of applying treatments on healthy adults. But it is a fascinating topic for research.

MILESTONES

SINCE 2013
Einstein Professor of Molecular Cell Biology, Humboldt-Universität zu Berlin

2008—2013
Professor of Genetics, Universities of Duisburg-Essen and Gießen

1997
Junior research group leader, Max Planck Institute of Molecular Genetics

1994—1997
Postdoctoral fellow, University of California, Berkeley

"Searching for the light"

HÉLÈNE ESNAULT EINSTEIN PROFESSOR

HÉLÈNE ESNAULT

EINSTEIN PROFESSOR

HÉLÈNE ESNAULT conducts research in the field of algebraic arithmetic geometry. She is Professor of Algebra and Number Theory at the Freie Universität Berlin and recipient of the Gottfried Wilhelm Leibniz Prize.

"It all happens in my mind"

I see the world in terms of fog and light. When we are in a fog, we cannot see forms and we are colour-blind. Once the fog starts to lift, we can discern certain objects, light, and colours. For me, mathematics is this light. When we do research, which involves a series of reflections to solve a problem, we need to see clearly. It's my job to create this light.

We have some major conjectures in mathematics, but nobody has a clue about how to prove them. Imagine standing in an incredibly dense forest, where the strongest beam of light can shine for just two metres, and you believe there is something worthwhile on the outskirts. To get there, you would develop a strategy: maybe it would be to turn right, knock down a few trees, and then zigzag to the left. Others would argue: just go left. Entire generations of mathematicians develop new theories for new paths, but many are dead ends. It is a rare thing to actually prove an initial hunch. Sometimes you think you are on the right path, but then you come up against an obstacle. Sometimes it even springs up in the night, in the middle of a dream. That's when you know that you are onto something.

My area of research, algebraic arithmetic geometry, is a very abstract field of mathematics. It is at the centre of various sub-disciplines such as arithmetics, differential geometry, or topology. I try to understand problems that span these boundaries. For example, there used to be a long-standing question in arithmetics, or in other words number theory. I had an image in my head that came from geometry; basically a "foreign" concept. As it turns out, I was able to translate it, once I understood the analogy between the image in geometry and the arithmetical problem I was trying to solve. The image simply provided a clear answer to my conjecture. Dovetailing these two ideas was a serendipitous moment for mathematics.

My work and my results belong to the category of basic research. Maybe someday, someone will apply them in fifty years or so, but that still has not happened. My motivation lies in the inherent dynamics of mathematics and in abstraction. Mathematics is the embodiment of abstraction. I just need a writing utensil for my work, sometimes not even that. Ultimately, it all happens in my mind. I could be at a concert and suddenly no longer able to concentrate on the music because I need to pursue an idea. You might liken it to a poet who suddenly finds a phrase so captivating that everything else becomes secondary.

MILESTONES

SINCE 2012
Einstein Professor of Algebra and Number Theory, Freie Universität Berlin

2003
Gottfried Wilhelm Leibniz Prize, German Research Foundation

2001
Paul Doistau-Émile Blutet Prize, French Academy of Sciences

1990—2012
Professor of Mathematics, University of Duisburg-Essen

"I am trying to give a diagnosis of our time"

NANCY FRASER | EINSTEIN VISITING FELLOW

NANCY FRASER

EINSTEIN VISITING FELLOW

NANCY FRASER is Professor of Political and Social Science at the New School for Social Research in New York. She leads the “Crisis of Democracy” research group at the John F. Kennedy Institute for North American Studies at the Freie Universität Berlin.

“Unintended consequences need to be made explicit”

I want to understand the forms of inequality that characterize our world today and analyse them from a critical perspective to find solutions. I have applied that angle to problems of the welfare state, to multiculturalism, gender relations, democracy, and the economy. You could say I am a philosopher; my degrees are all in philosophy. But I prefer to see myself as a critical theorist in the tradition of the Frankfurt School – I am trying to give a diagnosis of our time, combining insights from social research, history, and philosophy. My research is about giving conceptual expression to very recent phenomena, things that are going on that may still need a name.

A great deal of my work has focussed on gender. I was inspired by second-wave feminism, which developed out of the new left starting in the late 1960s. I was active in the US civil rights movement, the anti-Vietnam War movement, and eventually the feminist movement. That was a very heady, radical time with a strong utopian spirit. As time went on, that idealism faded and what I would call “liberal feminism” started to dominate. Feminist ideas today ultimately serve to legitimate neoliberalism. Feminist critiques of the “male breadwinner, female homemaker” family model, which were absolutely important at the time, have recently been taken up to defend a more neoliberal organisation of labour.

I am not simply an activist or partisan, nor a distant observer of feminism. I am somewhere in between, with an activist history and a background as a scholar. I think these different aspects create a very productive tension.

My Einstein research group at the Freie Universität Berlin addresses the theme of crisis. We are not only interested in economic and financial crisis, but also in ecological, political, and social crises, and what we might call the “crisis of emancipation”, that is, the difficulty social movements have in grasping the situation in which they find themselves and developing adequate strategies.

Many important emancipation movements have ended up dovetailing with neoliberalism, just like feminism. Dominant currents within the green movement, for example, are flirting with notions of green finance, environmental derivatives, and so on. The same is true of dominant currents of the gay and lesbian movement. In all these cases, we find a story of unintended consequences that need to be made explicit so we can look closer and ask: Is this what we really want? Or is there another, better path?

MILESTONES

2011—2014
Einstein Visiting Fellow, John F. Kennedy Institute for North American Studies, Freie Universität Berlin

2011
Humanitas Visiting Professorship in Women’s Rights, Cambridge University

1999—2011
Professor of Philosophy and Politics, New School for Social Research, New York

1984
Assistant Professor of Philosophy, Stanford University


"How do metaphors evoke emotions?"
ADELE E. GOLDBERG EINSTEIN VISITING FELLOW

ADELE E. GOLDBERG

EINSTEIN VISITING FELLOW

ADELE E. GOLDBERG studies our capacity to learn language. In the Cluster of Excellence "Languages of Emotion" at the Freie Universität Berlin, she looks at how taste metaphors evoke emotions. She is Professor of Linguistics at Princeton University.

Are our emotions related to our language?

Metaphors about taste perception are widespread in both literature and everyday speech. In a recent project with neuroscientist Francesca Citron, we had people in a scanner read simple metaphorical sentences like "she is a sweet person", or "he was bitter about the break-up". Then we asked them to read literal sentences like "she is a kind person", and "he was upset about the break-up". We found that when people read sentences with taste metaphors, it activated the same areas of the brain that respond to tasting actual food. We also registered more activity in the amygdala and surrounding areas associated with emotion than for literal sentences. If it's true that metaphorical language in general is more emotionally evocative, this may have important implications, not only for neuroscience but also for semiotics and rhetoric. We are currently applying various techniques to extend this line of research and examine metaphors beyond taste.

Which general questions are you trying to answer in your research about language?

What exactly is language and what do we know about it? Those are central questions. My research and that of others has pointed to the idea that language is a network of pairings of form with function. I call these pairings "constructions". Words clearly fit this concept: a word's function is its meaning. But phrasal patterns also fit it, such as relative clauses or passive constructions. Another big question: how do we know so much about language, given that we learn it relatively effortlessly and quickly? In our lab, we often look at how people learn what not to say. For example, in English you can say "high winds", but not "tall winds". We know what it means, but we just do not say it that way. Even if children are not corrected, they still learn which formulations to use and which not to use. Our choice and use of words can also be very innovative on certain occasions. I am interested in how we learn when novel formulations sound natural and when they do not.

What does language mean to you?

The reason that I am interested in language is that it offers a window into the ways in which humans are especially intelligent. We retain a huge amount of very specific information, we remember countless idioms and collocations, song lyrics, and particular phrases, and we also generalise about that knowledge creatively and say sentences we have never heard before. It is an area where we are amazingly skilled in a way that no other animal is. I find that fascinating.

MILESTONES

2010—2014
Einstein Visiting Fellow, Cluster of Excellence "Languages of Emotion", Freie Universität Berlin

SINCE 2004
Professor of Linguistics, Princeton University

1996—1997
Visiting Professor, Stanford University

1981—1992
Studies in mathematics and philosophy, University of Pennsylvania, and linguistics, University of California, Berkeley

“Our lab is a perpetual crime scene”

DETLEF GÜNTHER EINSTEIN VISITING FELLOW

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DETLEF GÜNTHER

EINSTEIN VISITING FELLOW

DETLEF GÜNTHER is Professor of Trace Elements and Microanalytics at the Swiss Federal Institute of Technology (ETH) in Zurich. As a chemist, he develops instruments and methods for elemental analysis, which help detect nanoparticles in the environment.

“Demonstrating harmful agents gives my work meaning”

Verifying the presence of elements is like criminalistics. In the lab, we deal with a crime scene every day. But instead of searching for criminals, our suspects are elements. We develop instruments and methods for trace element analysis. That means that we try to demonstrate the presence of elements in fluid, solid, and gaseous samples.

We use a laser to vaporise very small sample quantities. The result is an aerosol, which we inject into an 8,000 degrees Celsius plasma source to atomise and ionise the vaporised sample. We then apply mass spectrometry to identify the elements and their isotopic composition. Our devices and methods are currently in use in many geological institutes. And they offer high sensitivity levels: we were able to demonstrate the presence of a silver coin hidden in the steel of the Eiffel Tower in a sample of just one milligram.

As analysts, our work overlaps with many other scientific fields. The more basic research we do, the larger the common ground. That makes what we do very exciting. We have developed a portable laser unit, for example, to collect samples from large objects. You carry it around in a small case like James Bond. This laser has opened up completely new applications, for example for museums that cannot send us their exhibit pieces. It lets us study the origin of colour pigments in major exhibits like the Chinese Terracotta Army.

Our Einstein project involves the quantification of nanoparticles. The impact of these particles on humans and the environment is a huge topic worldwide. Today, nanoparticles are used virtually everywhere, for example in antibacterial socks, which release hundreds of thousands of silver nanoparticles into waste water with each wash cycle. The doctoral candidate I supervise in Berlin is currently working on a sampling method for fluids. We want to be able to determine both the number of nanoparticles and their size in waste water treatment plants. It is important to investigate trace particles in terms of how they circulate in the environment and the damage they create.

Few would believe the pollution I saw working as an intern at the Buna plants in Schkopau in East Germany in 1986. Back then, no one could swim in the Saale or Elbe rivers. Those conditions and experiences motivated me to go into analysis. I was certain that if I could learn about and improve different procedures that could be used to demonstrate harmful agents, I would be doing something meaningful.

MILESTONES

SINCE 2013
Einstein Visiting Fellow, School of Analytical Science Adlershof (SALSA), Humboldt-Universität zu Berlin

2010—2012
Head of the Department of Chemistry and Applied Biosciences, ETH Zurich

1999—2003
Executive Board, Competence Centre for Analytical Chemistry, ETH Zurich

SINCE 1998
Professor of Trace Elements and Microanalytics, ETH Zurich

EINSTEIN FOUNDATION BERLIN 2014, PHOTOS: PABLO CASTAGNOLA


“How can we design more efficient catalysts?”
JOHN F. HARTWIG
EINSTEIN VISITING FELLOW

JOHN F. HARTWIG

EINSTEIN VISITING FELLOW

JOHN F. HARTWIG conducts research on the basic functions of catalysis to develop more efficient catalysts. He is Professor of Chemistry at the University of California in Berkeley.

Almost all technological progress relies on catalysis. From petroleum or renewable resources to pharmaceuticals, agrochemicals, and even materials like next generation plastics made from seed oil – all of these products need molecules that are generated by catalytic reactions.

We invent chemical reactions with new catalysts to try to understand the fundamental rules governing catalysis. The catalysts we use in our work are based on transition metals like platinum, palladium, rhodium, or iron, and combined with an organic structure attached to the metal. These substances can be used to produce modern plastics or acetic acid, the basis for many chemical products from glue to aspirin. The application potential for these classes of homogeneous catalysts has grown enormously in recent years.

I have always been fascinated by the bridge between the tangible and the intangible. For the world around us, this bridge is a molecule's chemical structure, which gives rise to its colours and other properties. Designing experiments to understand reactions actually feels more like a game than work: it is fun, but we also learn a lot about the world, so we call it "science". It's intellectually challenging and satisfying, and the information it yields allows us to address important issues such as human health or energy consumption. We're thrilled to find reactions we have developed being regularly used in drug discovery, for example.

"We are still in the trial-and-error phase"

As part of our Einstein research project, we conducted reactions at carbon–hydrogen bonds, which are normally unreactive. Most organic reactions occur at other reactive parts of the molecule. We used silicon compounds as reagents with iridium catalysts to induce reactions at the carbon–hydrogen bonds. The reaction generated large molecules whose function could help treat diabetes or cure HIV, or stop pests from decimating crops.

One long-term goal of my research is to be able to accelerate and streamline chemical reactions that currently require many individual steps. Getting to a single step is a very long process. Besides what I would call "chemical intuition", it also involves a lot of trial and error. Can we get to a point where we can design a catalyst for a desired transformation through computational methods or on paper? We have a long road ahead of us. Right now we are still in the trial-and-error-phase, but we are slowly moving towards design.

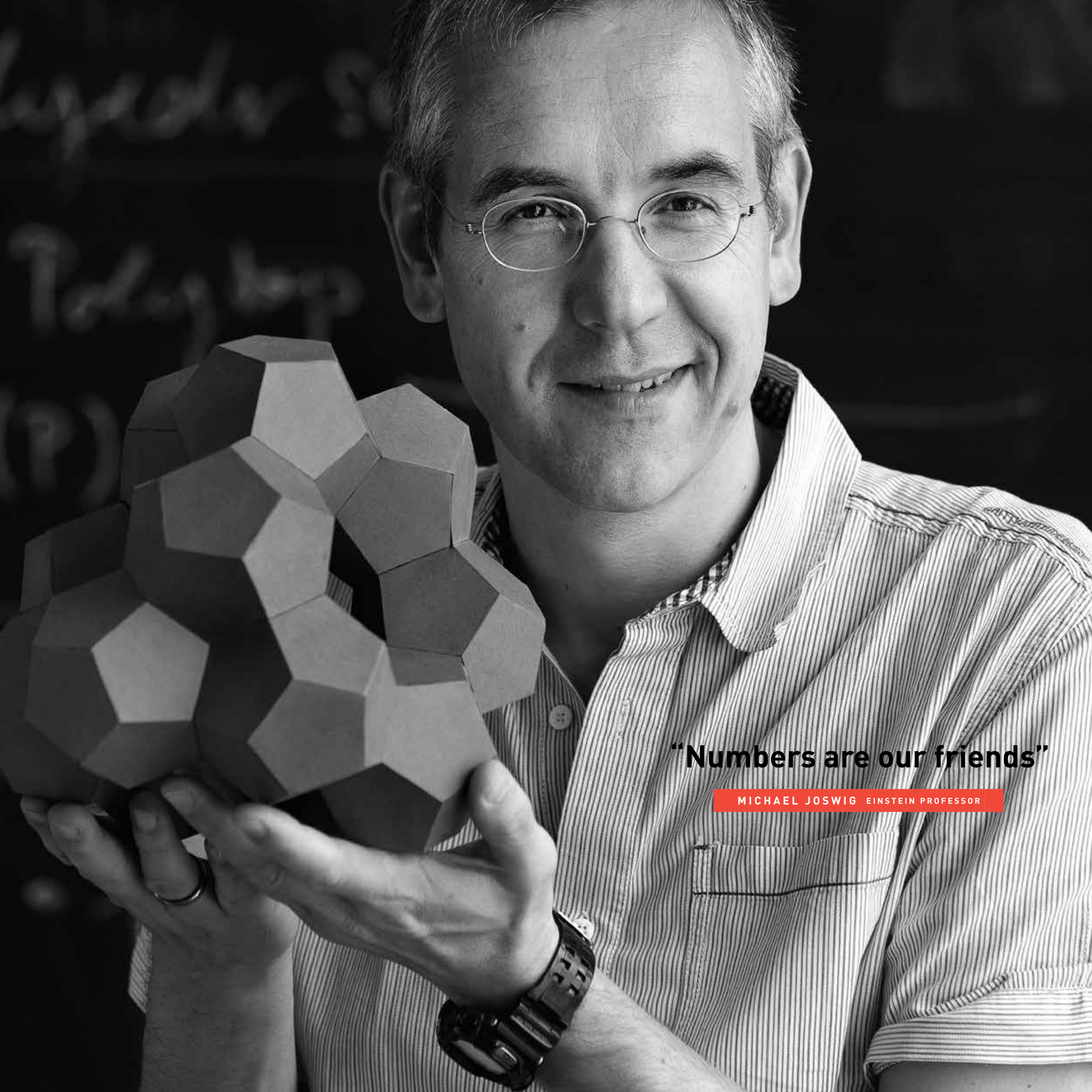
MILESTONES

2014
Einstein Visiting Fellow, "Unifying Concepts in Catalysis" Cluster of Excellence

SINCE 2011
Professor of Chemistry, University of California, Berkeley

1990—1992
Postdoctoral Associate, American Cancer Society, Massachusetts Institute of Technology, Cambridge

1986—1989
Graduate Student Instructor, University of California, Berkeley



"Numbers are our friends"

MICHAEL JOSWIG EINSTEIN PROFESSOR

MICHAEL JOSWIG

EINSTEIN PROFESSOR

MICHAEL JOSWIG researches in the area of polyhedral and geometric combinatorics, and develops mathematical software. He is Professor of Discrete Mathematics and Geometry at the Technische Universität Berlin.

I became interested in programming at an early age. As a teenager, I programmed physical formulas and games on pocket calculators. One of my creations was called "Lunar Lander"; the player's task was to land a space capsule safely on the moon. There were two parameters: height and the landing engines. The number in the display stood for the height above the moon's surface. I ended up programming that game in several different versions. Today, computers play an important role in my research. I am involved in basic research in geometry that I combine with linear optimisation problems in both engineering and biological applications.

Together with colleagues, I programmed the software "polymake". The program provides a flexible research platform for geometric combinatorics that is used around the world. In a nutshell, polymake gives you geometric information for optimisation tasks. We used it to analyse an engine control problem, for instance, which was dependent on six parameters. Standard methods proved useless in that case, but with polymake, we were able to find other methods that could be employed for modelling.

Precisely because I use computers often, I am always pondering how we can harness their computational power to create valid mathematical proofs. These questions currently make up a highly specialised niche, but I think that we will devote more attention to them in the future, because computers are being used more and more for mathematical problems.

There are quite a few mathematical problems that have hounded me for days, weeks, or even years. They remain in my thoughts when I go home in the evening and well into the night. Then I wake up in the morning and there is a glimmer of a light that can develop into a real idea while I'm in the shower. Puzzling over a problem like that helps me find answers.

"Geometric forms are a big part of how I think"

Numbers are foreign to so many people. They are not part of their everyday lives and they don't have a very easy relationship with them. As a mathematician, I have absolutely no qualms about approaching numbers; I think we see them differently: numbers are our friends.

Geometric forms are a big part of how I think. I am an avid photographer and when I am taking pictures, I look for geometric forms in my environment. But even when I'm just walking through the city and I see a certain shape or form, it can have an impact on my thought process. It's a form of visual inspiration that takes my thoughts in a new, unexpected direction.

MILESTONES

SINCE 2013
Einstein Professor of Discrete Mathematics and Geometry, Technische Universität Berlin

2004—2012
Professor of Algorithmic Discrete Mathematics, Technische Universität Darmstadt

2006
Research Professor, Mathematical Sciences Research Institute, University of California, Berkeley

1995—1996
Lise-Meitner scholarship for study at the Research Institute for Symbolic Computation, Linz

“Series demand commitment”

FRANK KELLETER EINSTEIN PROFESSOR

FRANK KELLETER

EINSTEIN PROFESSOR

FRANK KELLETER studies the cultural significance of serial narration as well as 17th and 18th-century American cultural history. He is Head of the Department of Culture at the John F. Kennedy Institute, Freie Universität Berlin.

Are series a contemporary phenomenon?

When we hear the word "series" today, we immediately think of TV series. Television has become the defining medium of the serial form. But ever since people have told stories, they have done it in episodes. With the dawn of industrial manufacturing in the early 19th century, serial storytelling emerged as a dominant narrative format for entire societies. In our research unit "Popular Seriality – Aesthetics and Practice", in addition to television series and 19th-century feuilleton novels, we also study films and computer games. Our work in the past years has been instrumental in re-evaluating our understanding of seriality as a category of observation.

What draws you to serial forms of narration?

Series are confronted with one of the most difficult tasks of storytelling: they need to walk the line between innovation and familiarity. We all know that a "happy ending" generates a certain amount of satisfaction – when our protagonists end up tying the knot or the murderer gets caught. What we rarely recognise is the satisfaction that comes with repetition. My hypothesis is that series make an important contribution to our identity as modern societies. They generate trust, because although there is a steady stream of new episodes and events, the underlying communicative structures remain the same. They generate excitement again and again, but do it reliably. Especially a country like the United States, with its immense diversity and geographical size, is faced with the question of how its many different inhabitants can view themselves as members of the same society. Modern media and serial narratives play an enormous role in providing answers.

Do you also enjoy watching series in your free time?

It is difficult to make the distinction between what I watch for work and what I watch for pleasure. Even when I'm sitting in front of the television in the evening with my wife, I am often taking notes. It's hard to switch off those thoughts. The decision to watch a series in a family has implications. Series demand a certain amount of commitment. As in life, you don't just suddenly switch the family dentist you have been going to for years. We can also be very forgiving with our series in the hopes that they will soon get better. We often incorporate them as rituals in our daily lives. The best example would have to be the crime series Tatort, which is a recognised institution. Sunday evenings in Germany wouldn't be the same without it.

MILESTONES

SINCE 2013
Einstein Professor of North American Culture and Cultural History; Head of the Department of Culture, John F. Kennedy Institute, Freie Universität Berlin

SINCE 2010
Spokesperson of the DFG-sponsored research unit "Popular Seriality – Aesthetics and Practice"

2002—2012
Professor of English Philology and Chair of the Department of North American Studies, University of Göttingen

2000, 2005, 2009
Visiting Scholar, New York University, University of California, Berkeley, and Nanjing University

"Cancer cells are like very complex machines"

FREDERICK KLAUSCHEN | EINSTEIN JUNIOR FELLOW

FREDERICK KLAUSCHEN

EINSTEIN JUNIOR FELLOW

FREDERICK KLAUSCHEN analyses and simulates processes in tumour cells in order to develop new therapies for treating cancer. He is Head of the Systems Pathology research group at the Institute for Pathology, Charité – Universitätsmedizin Berlin.

Will we someday have a cure for cancer?

A number of renowned cancer researchers predicted that we would be able to cure cancer in five or ten years. Unfortunately, those predictions have not materialised. Cancer medicine has continued to focus on anatomical changes that researchers like Rudolf Virchow were already studying over 100 years ago. In recent years, however, new molecular methods have been developed which let us register the genetic changes in tumours in great detail. This has helped researchers determine that tumours with a similar anatomy can be vastly different at the genetic level. The new methods also allow us to develop therapies which can precisely target these genetic changes.

Is that one of your research goals as an Einstein Junior Fellow?

My Einstein project looks at why some lung cancer patients respond much better to a targeted therapy than others. We are trying to figure out why this happens, because the cancer appears to produce the same genetic changes. We study cell lines and tissue samples from patients in the lab in order to establish the function of tumour cells at the molecular level. Once we have our experimental lab results, we model them on computers in order to simulate cell processes. We can simulate a genetic mutation, for example, then add a drug treatment and observe how it reacts on the computer. After that, we need to go back and verify the simulation results in experiments.

Cancer cells are like highly complex machines with built-in errors. These errors result in an enormous advantage in terms of survival for cancer cells, but their uncontrolled growth has devastating effects on the body. I want to understand how these errors intervene in the mechanics of cell growth and which are especially important in order to help develop new drugs for cancer treatment.

Does your work also involve contact with patients?

At the Charité university hospital, we have many cancer patients and where I work at the Institute for Pathology, we need to diagnose patients who may have cancer and prepare the lab results. It's difficult for me to know that someone's future depends on each tissue sample. But it also motivates me to keep improving our understanding of cancer through diagnostics and research. My dream is someday to be able to understand the cancer that is attacking each individual patient, so that we can develop customised therapies and help find a cure in the long term.

MILESTONES

SINCE 2014
Einstein Junior Fellow, Charité – Universitätsmedizin Berlin

SINCE 2011
Young Investigator, Human Frontier Science Program

SINCE 2009
Head of Systems Pathology, Charité – Universitätsmedizin Berlin

2004—2009
Postdoctoral Fellow, Laboratory of Immunology and Laboratory of Systems Biology, National Institutes of Health, Bethesda, USA

“We build efficient detours”

RALPH KRÄHNERT EINSTEIN JUNIOR FELLOW

RALPH KRÄHNERT

EINSTEIN JUNIOR FELLOW

RALPH KRÄHNERT conducts research on new catalyser materials for energy storage. He is Junior Research Group Leader at the Department of Chemistry, Technische Universität Berlin, and in the Cluster of Excellence "UniCat" of the German Research Foundation.

The future of the energy transition is an important driver for my research. I want to be a part of Germany's commitment to making renewable energies its main energy source in the foreseeable future. This will obviously also help us to reduce our dependence on fossil fuels and electricity imports. One basic problem with renewables is that we rarely need the power that is produced at the precise moment when the sun is shining or the wind is blowing. Energy from solar cells or wind therefore requires a storage structure. One solution is to convert this power into chemical energy, which can then be converted back on demand. In our research group, we develop the catalyst materials that are needed for these conversions.

Hiking gives us a good analogy when we want to understand the effects of a catalyst. In the mountains, hikers often need to choose between a direct path with a few strenuous peaks and an alternate route around the mountain that consumes less energy – a smart "detour" if you will. Building these efficient detours is basically how you could describe our work. We try to develop catalyst materials that are more economical, durable, and efficient than the materials we currently have. Once I have found an efficient catalyst, I can minimise the energy required for chemical reactions.

In the coming years, we will be able to employ our catalysts in electrolysers for use in conjunction with wind parks. They will ensure maximal efficiency when converting the electricity generated through wind power into hydrogen for storage. Hydrogen is a clean fuel, but it is hazardous to store and transport. To make it more amenable to handling, we can temporarily bind the hydrogen to fluid hydrocarbons. One of the projects sponsored by the Einstein Foundation within our research group looks at finding a suitable catalyst to convert the chemically bound hydrogen back to pure hydrogen when needed – for use in fuel cells, for example.

I am a strong advocate of the energy transition, because every single person on the planet will benefit from this change. In the past 100 years, we have consumed most of the available fluid hydrocarbons and emitted carbon dioxide as a result into the atmosphere. If we want to stop the Earth from heating up any further, we need sustainable alternatives to this process. As a scientist, it is extraordinarily exciting to be working on technologies that will have a positive impact on our society.

> "The energy transition makes sense for every single person on the planet"

MILESTONES

SINCE 2012
Einstein Junior Fellow, Technische Universität Berlin

SINCE 2011
Junior research group leader, Cluster of Excellence "UniCat", German Research Foundation

2007—2012
Junior research group leader, "NanoFutur" Group, sponsored by the German Federal Ministry of Education and Research

2006
"NanoFutur" award, German Federal Ministry of Education and Research


“I want to find pathways to a more sustainable future”
TOBIAS KÜMMERLE EINSTEIN JUNIOR FELLOW

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TOBIAS KÜMMERLE

EINSTEIN JUNIOR FELLOW

TOBIAS KÜMMERLE researches human–environment relationships, especially the impact of changing landscapes on biodiversity. He leads the Biogeography and Conservation Biology Lab in the Department of Geography at Humboldt-Universität zu Berlin.

"I refuse to be pessimistic"

My current research revolves around topics that I have been passionate about for many years. Growing up in a small town, I roamed the woods, caught frogs, and watched Heinz Sielmann's "Expeditionen ins Tierreich" (Expeditions into the Animal Kingdom) for as long as I can remember. Although my involvement in nature conservation started at a young age, today I try to maintain a more neutral perspective. Global biodiversity is a huge concern for me. I think it is difficult, however, to judge the processes – like certain agricultural methods – that contribute to this problem, since they also produce goods that are essential to people's lives. It is important to strike a good balance. As a scientist, I want to produce knowledge that helps decision makers and other key members of society make informed decisions.

I am astonished at how little we know about the critical relationship between humans and nature. In Europe, when we decide to cut subsidies for intensive farming, but the consumption of agricultural products either remains the same or increases, then this means that deforestation rates will increase in countries like Brazil, Argentina, or Paraguay, because we need to import more soybeans for animal feed. Thus, in my Einstein project, we examine agricultural expansion and intensification processes at the global level and investigate their impact on biodiversity loss in different international regions. It is critical to have knowledge about these types of feedback processes, in order to align our resource consumption with goals for ecosystem protection.

If you talk to people who have been working in the field of conservation biology for some time, you will not meet many optimists. For decades, ecosystems have faced mounting pressure, which has already led to the loss of different species and incredibly unique landscapes. At the same time, we have learned that there are a wide range of options to get our consumption to line up with conservation targets. Especially now that I am the father of two children, I refuse to be pessimistic, even though our society needs a much more fundamental transformation than anything that currently seems possible. With my research, I want to contribute to a better understanding of the impact of our activities on biodiversity and therefore find pathways to a more sustainable future. I am convinced that we will be able to achieve this transformation.

MILESTONES

SINCE 2012
Einstein Junior Fellow and Visiting Professor of Biogeography and Conservation Biology, Humboldt-Universität zu Berlin

2010—2011
Research Group Leader, Geography Department, Humboldt-Universität zu Berlin

2010
Researcher, Potsdam Institute for Climate Impact Research

2008—2010
Researcher, University of Wisconsin-Madison, sponsored by the Alexander von Humboldt-Foundation

“Big data is full of existential questions for humanity”

GITTA KUTYNIOK | EINSTEIN PROFESSOR

GITTA KUTYNIOK conducts research on mathematical methods for data analysis. She is Professor of Applied Functional Analysis in the Department of Mathematics at the Technische Universität Berlin.

GITTA KUTYNIOK

EINSTEIN PROFESSOR

We live in an age of data. We are confronted with massive amounts of it every day. In astronomy, for example, new telescope generations are recording huge data volumes in order to detect remote galaxies. The phenomenon we have come to call "big data" confronts us with the existential issue of how we can pick out relevant information from an enormous ocean of data. In my research, I develop efficient mathematical models to address this challenge. To give you a picture, I apply a mathematical lens to data that lets me see certain structures and patterns. I immerse myself in mathematics to create models and develop methods. In the process I apply various theories – applied harmonic analysis, frame theory, approximation theory, and compressed sensing, to name a few.

I am working to expand the new research field "compressed sensing" in Berlin, and we are currently in a very exciting phase. The potential applications seem to be endless at this point. For example in medicine, our findings could help reduce the time that patients need to spend lying in an MRI scanner. In this context, our approach is to reduce the number of sample values, while retaining the same image quality. And only collect data that matters. After sampling, to retrieve the image as a whole, we need to develop an algorithm that uses a modular system and then fills in the gaps with as few elements as possible. With sets of wavelets, we have already been able to achieve a time that is one sixth of the original time patients spent in the scanner, in other words just ten minutes, instead of an hour lying in an MRI. And we are now applying a further development called shearlets to reduce these ten minutes even further.

"The world of mathematics is a completely structured environment"

I can focus on mathematical problems for hours or even days on end when I want to prove a statement. It was like that at school and it's still the same today. Once I find a solution, I am always quite excited to be the very first person to lay eyes on it. But it doesn't take long until I am itching to pursue new questions or improve on what I have already developed. My perfectionism drives me to keep pushing ahead and make things even better.

The precision of mathematics is fascinating. It is the only scholarly field that can support its statements one hundred per cent. Mathematics is unique in that it gives us actual guarantees. The world of mathematics is a completely structured environment. And its methods work astonishingly well in reality. The natural world becomes much more understandable, once you have a reliable foundation.

MILESTONES

SINCE 2011
Einstein Professor of Applied Functional Analysis, Technische Universität Berlin

2008—2011
Professor of Applied Analysis, Osnabrück University

2007—2008
Heisenberg scholarship, study at Princeton, Stanford, and Yale Universities

2004—2005
Visiting Scholar, Georgia Institute of Technology and Washington University in St. Louis

"I am constructing a media archaeology of voice mail"

THOMAS Y. LEVIN EINSTEIN VISITING FELLOW

THOMAS Y. LEVIN is chronicling the history of gramophonic audio letters and building a vast digital archive of this forgotten chapter of media history. He is Professor in the German Department at Princeton University.

THOMAS Y. LEVIN

EINSTEIN VISITING FELLOW

Were records also used to make voice recordings?

Yes, though it's all but forgotten. There used to be a widespread culture of gramophonic recording from the early 1930s until the late 1950s in Europe, in North and South America, and elsewhere. Public recording booths were virtually ubiquitous: in post offices, train stations, amusement parks – even on the 86th floor of the Empire State Building! Bourgeois households often had a device to make gramophonic recordings at home.

Many of these unique records were sent by post as audio letters. My Einstein project is a reconstruction of this important cultural history of literal "voice mail" captured on small metal or cardboard gramophonic discs. It all started a few years ago at a flea market, when I stumbled across a curious aluminium record in an envelope that had been sent by post. When I went to research it and found almost nothing, I realised that this curious, but widespread, type of recordable record had been completely ignored by media history. The first years of my Einstein project were thus largely occupied with hunting down examples of such "phono-post" and then cataloguing, scanning, and digitising them. This archive is now the basis for the monograph I am writing.

What makes the phono-post archive unique?

Historically, these recordings represent something deeply important: the moment when, for the first time, people could hear themselves as others did. For the first time, the voice could exist outside the body. Not surprisingly, people often started talking about death, because their recorded words would ultimately outlive them. This is an archive of largely anonymous voices from the past. It is also a vernacular archive: everyday people making everyday comments about everyday things. As such, it documents a nascent media literacy: we can follow the process of learning to use a new technology.

How does this project fit into your general research and personal interests?

The phono-post project is marked by a media theoretical materialism that characterises much of my research. I am deeply interested in how these seemingly mundane artefacts can shed new light on a wide range of cultural practices.

One of the most satisfying aspects of this project is the opportunity to combine my passion for "hoarding" with my research. I am a collector. I love finding objects, tracking them down, and figuring out what they mean. There is no greater feeling for a collector than making a great find. The same goes for researchers and their own different discoveries. It's the perfect example of a happy coincidence.

MILESTONES

2010—2014
Einstein Visiting Fellow, Friedrich Schlegel Graduate School of Literary Studies, Freie Universität Berlin

2004
Senior Scholar, Getty Research Institute, Los Angeles

2001
Curator, "CTRL [Space]: Rhetorics of Surveillance from Bentham to Big Brother", Centre for Art and Media Karlsruhe

SINCE 1990
Associate Professor of German, Princeton University

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“Can biomaterials replace medical implants?”

DAVID J. MOONEY EINSTEIN VISITING FELLOW

EINSTEIN Foundation.de

DAVID J. MOONEY

EINSTEIN VISITING FELLOW

DAVID J. MOONEY experiments with new biomaterials that can be used to regenerate injured body tissue or activate the immune system more efficiently. Mooney is Professor of Bioengineering at Harvard University.

Historically, we have tended to intervene in the human body in a very gross way. We typically treat the whole body, even though the problem may only exist in one particular tissue. With bioengineering, we are able to target flawed tissue or organs much more precisely. Right now we are developing procedures that use biomaterials, basically plastics, to transport stem cells to where they are needed to repair defective tissue. In the area of bone regeneration, we are exploring the capacity of biomaterials to "recruit" existing stem cells or, in other words, adhere to the cells and draw them to the regeneration site. We can decide when, where, and for how long we want these interventions to happen. Bioengineering will ultimately give us far better control in terms of time and space.

Our material is designed to be biodegradable; it should only be in the body as long as necessary for regeneration. Because the material orchestrates the behaviour of cells in this process, it has to communicate. This can be achieved chemically with biomaterials that release drugs or molecules which adhere to cells and change their function. Or we can change physical properties – such as stiffness – that affect cell responses in the body.

I absolutely believe that medicine will move away from treating symptoms and using materials as crude replacements. Instead, our approach will be to regenerate tissue in the body. It is going to be a tremendous revolution, but it will take some time.

"Disappointments led me down important paths"

When I first got involved in this area of research, I was very excited about the possibility of using cells to regenerate and grow tissue and organs. Then, in one of my first animal studies, I discovered that the vast majority of the cells that I had transplanted were dying. This experience eventually led to the idea that instead of pursuing transplants, we might be better off "training" cells that were already in the body. Although it was a disappointment, it actually led me down a very important path. Another disappointment came during our initial trials for therapeutic cancer vaccines when we discovered that we were actually making the tumours grow faster. What we learned, however, was that we could have an impact. In other words, if we can make something worse, we can probably also make it better. The worst outcome is zero change. Over time I have realized that having some effect, any effect, is good. It means we can start to take control.

MILESTONES

SINCE 2011
Einstein Visiting Fellow, Berlin-Brandenburg School for Regenerative Therapies

SINCE 2009
Founding Core Faculty Member, Wyss Institute for Biologically Inspired Engineering, Harvard University

SINCE 2004
Professor of Bioengineering, Harvard University

1992
PhD, Massachusetts Institute of Technology

"I want to help make cars safer"

STEFFEN MÜLLER EINSTEIN PROFESSOR

STEFFEN MÜLLER

EINSTEIN PROFESSOR

STEFFEN MÜLLER conducts research on electromobility, self-driving cars, vehicle dynamics, and driver assistance systems. He heads the Department of Motor Vehicles at the Technische Universität Berlin.

Do you enjoy driving in your free time?

Yes, but not all the time. The technology fascinates me and mobility is an important asset. But I use public transport for the commute to work, because I can then use the time to do other things. That's one of the major drawbacks of driving, the fact that I have to drive the vehicle constantly, even if the actual road situation is monotonous.

I am passionate about cars, but I didn't grow up thinking that I would build them someday. After studying aerospace engineering, I did some work with railed vehicles which finally brought me to automotive engineering. My passion for motor vehicles really started during my research at BMW. Ever since then I have wanted to help make cars safer and more attractive. It's a very exciting challenge, but I don't see cars as the ultimate form of transport.

What are you working on currently?

One of my current projects looks at how different assistance systems interact. For example, how does a distance control system interact with a lane-keeping system with a side assist function? We want to find out how these systems impact on the driver's control in road situations. Imagine you are driving and another driver suddenly cuts in front of you. Your distance control system wants to hand over the reins since it detects a dangerous situation with very little distance to the next vehicle. At the same time, you see blinking in the instrument panel showing that someone is overtaking you on your left. Then, to top it all, there's a bend in the road and the lane assist cuts in. All of these events can place excessive demands on the driver. Those are the scenarios we look at.

When will our cars be able to drive without us?

In the press you often read that we will be there by 2020. I tend to be more cautious, even though Google is already testing self-driving cars and Daimler held a 100-kilometre demo run. The car drove by itself, but there was a driver at the wheel who could have intervened. The move toward self-driving cars will happen gradually. Assistance systems already control the proximity to other objects and make sure that we stay in our lane. They also guide us safely through traffic jams with "stop-and-go" functions. But if you read the instructions for all these systems, you will find that they still require constant monitoring and drivers still need to keep their hands on the steering wheel. We will probably get to the point of parallel activity during driving in the next few years. Maybe we will be able to read or write text messages – but fully self-driving cars are still in the distant future.

MILESTONES

SINCE 2013
Einstein Professor of Motor Vehicles, Technische Universität Berlin

2008—2013
Department Chair, Mechatronics in Mechanical and Automotive Engineering, Technische Universität Kaiserslautern

2001—2008
Various executive positions, BMW Group Research and Innovation Center, Munich

2000—2001
Postdoc, University of California, Berkeley

“Like a game of Lego”

MARTIN OESTREICH EINSTEIN PROFESSOR

MARTIN OESTREICH

EINSTEIN PROFESSOR

MARTIN OESTREICH studies fundamental questions of synthesis and catalysis. He is Professor of Chemistry at the Technische Universität Berlin.

Engineering molecules with my own hands in the lab reminds me in some ways of playing with Lego bricks as a child. Getting to tinker with molecules was one of the reasons I decided to study chemistry. Meanwhile, my workplace is no longer in the lab. That's just part of a career in science: at some point, you go from being an experimenter to a manager. Today, I gain satisfaction from the fact that I can tackle larger and more challenging projects, because with 20 people working for me, I have a steady stream of results to compile and evaluate. And training young researchers is very motivating. It's always a proud day when I can see them go off into the world as independent scientists after their PhD.

My research group looks at fundamental issues in catalysis. I work with two rather unconventional elements in organic chemistry: boron and silicon. I try to introduce them into organic molecules and then develop catalysts based on these composites. The long-term objective is for these catalysts to replace expensive precious metals and accelerate or even enable the formation of chemical bonds.

My work is clearly basic research. Of course, I could claim that our results will be important for everyday items in 20 years. But in reality, we are at the very bottom of the food chain. It is a real problem that science today is so focussed on fast results and quick wins. Financing institutions often demand a description of potential applications or use scenarios to justify funding. We currently do not allocate enough risk capital so that scientists can have more freedom in their work. If we only did minutely planned research with clear, direct ties to applications, we would have no novel findings. Basic research harbours the seeds of innovation.

> **"Minutely planned research would yield no new findings"**

The system is not designed to tolerate long stretches without new discoveries. Back when I was a postdoc, I decided to work in a field of research that was not part of the mainstream at the time, and I needed to get through a long phase without any breakthroughs. I put in some 80-hour weeks in the lab, but it paid off. At some point, I was getting excellent results and suddenly people were noticing my work. To do successful research, you not only need a good deal of stamina, but also mentors and financers that don't get nervous if everything does not immediately go as planned. Creating new knowledge takes work, and not just a simple trip to the drawing board.

MILESTONES

SINCE 2011
Einstein Professor of Organic Chemistry, Technische Universität Berlin

2006—2011
Professor of Organic Chemistry, University of Münster

2001—2005
Habilitation, University of Freiburg

1999—2001
Postdoc, University of California, Irvine

“Simulations enhance our insight into molecular processes”

NURIA PLATTNER EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

NURIA PLATTNER

EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

NURIA PLATTNER searches for optimal simulation methods to study the organisation of biomolecules. She is postdoctoral fellow in the Department of Mathematics and Computer Science at the Freie Universität Berlin.

My research centres on biomolecular simulations. These simulations rely on atoms as their smallest basic unit, so they differ somewhat from simulations in quantum mechanics, which look at electrons as an even smaller common denominator. With our simulations, the objective is to study how different molecules, for example proteins, organise their behaviour. There are already established methods and computer programs that help researchers study the dynamics of individual proteins. We take these tools and use them as a basis to observe what happens when many different proteins come together and interact. The question then becomes: how do these various molecules behave as a whole?

As a computational chemist, I work very closely with experimental researchers. We need their data as input for our simulations. That might include, for example, data on the crystalline structures of proteins or on the development of force fields, that is, the reciprocal effects occurring between atoms. Based on simulations, I can either predict the outcome of an experiment that still has not happened, or I can reproduce a procedure demonstrated in an experiment to verify the results.

Experiments often result in a string of numbers. Mapping this string onto my simulation gives me detailed information about which values correspond with different processes in the protein. On the screen, for example, I can say: "Look, this is how the protein component is moving; here, one molecule is detaching itself, and here, another is being added".

"I want to contribute to our knowledge of biological processes"

The visualisation helps us develop a better understanding of molecular processes, which is what I view as one of the most important contributions of simulations.

As a society, it would be incredibly difficult for us to abandon our current path of technological development – although the technological progress we are making is fraught with a host of difficulties. When I say that, I'm thinking about the nuclear threat or climate change, for instance. But nevertheless, I do believe that it makes sense to continue with our research. For me, that means being able to respond to current developments and point to new possibilities for action. In terms of my own work, I want to contribute to our knowledge of biological processes. This will give us the opportunity to enhance our understanding of various different illnesses, for example, which would give us better prospects of finding cures.

MILESTONES

SINCE 2013
Einstein International Postdoctoral Fellow, interdisciplinary working group "Computational Molecular Biology", Freie Universität Berlin

2010—2011
Postdoctoral researcher, Brown University, Providence, Rhode Island

2006—2009
PhD, University of Basel

2002—2005
Studies in chemistry, University of Basel

“Proteins are my passion”

JURI RAPPSILBER EINSTEIN PROFESSOR

JURI RAPPSILBER studies protein interactions and folding using mass spectrometry; his results could be applied in the development of new drugs. He is Professor of Bioanalytics at the Technische Universität Berlin.

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JURI RAPPSILBER

EINSTEIN PROFESSOR

> "Life's complexity does not phase me"

Using mass spectrometry to analyse proteins is my biggest passion as a researcher. Just like artists with their brushes and palettes, scientists are enamoured of their tools. It's exciting for me to work with mass spectrometers and the data they produce, and discover different aspects of life at the molecular level.

Proteins are highly sophisticated and multi-faceted molecules. That should come as no surprise – they're the building blocks of life. We investigate proteins by breaking them down into their component parts and weighing these fragments in a mass spectrometer.

To understand the functions of different proteins, we also need to study how they interact. Unfortunately, current technologies make this task very time-consuming. Our new technology is designed to simplify this process with the objective of describing entire protein networks in great detail and tracking their changes. There's a small trick that we use to join proteins: we chemically bond neighbouring points in the same protein or in two interacting proteins. Traces of the three-dimensional structure and interactions are then retained in the fragments we measure and analyse using the mass spectrometer. This helps us determine whether two proteins shake hands as "lefties" or "righties", for example.

Someday I would like to be able to watch the interactions of all proteins in a cell like I would watch a film. That would give us a comprehensive insight into how life works and how illnesses arise, since many diseases can be identified based on faulty protein structures and interactions. Pinpointing and understanding these defects will help us find the right approach for developing new medications. Our technology will be an important part of the discovery process.

It's going to be a long road until we finally reach our goal. But our technology is already being used to address a whole series of important questions in collaboration with different colleagues. This lets us test our tools in everyday research settings and it also means we can keep expanding the limits of biological and medical science.

Life's complexity does not phase me. At some point, I realised that it would simply be impossible to comprehend the vastness of the universe. We inhabit a limited part of space and that's all we can ultimately explore. This exploration process is something that I truly enjoy. I know I will never be able to understand life in its full molecular complexity. It's the same infinite conundrum, simply on a microcosmic scale.

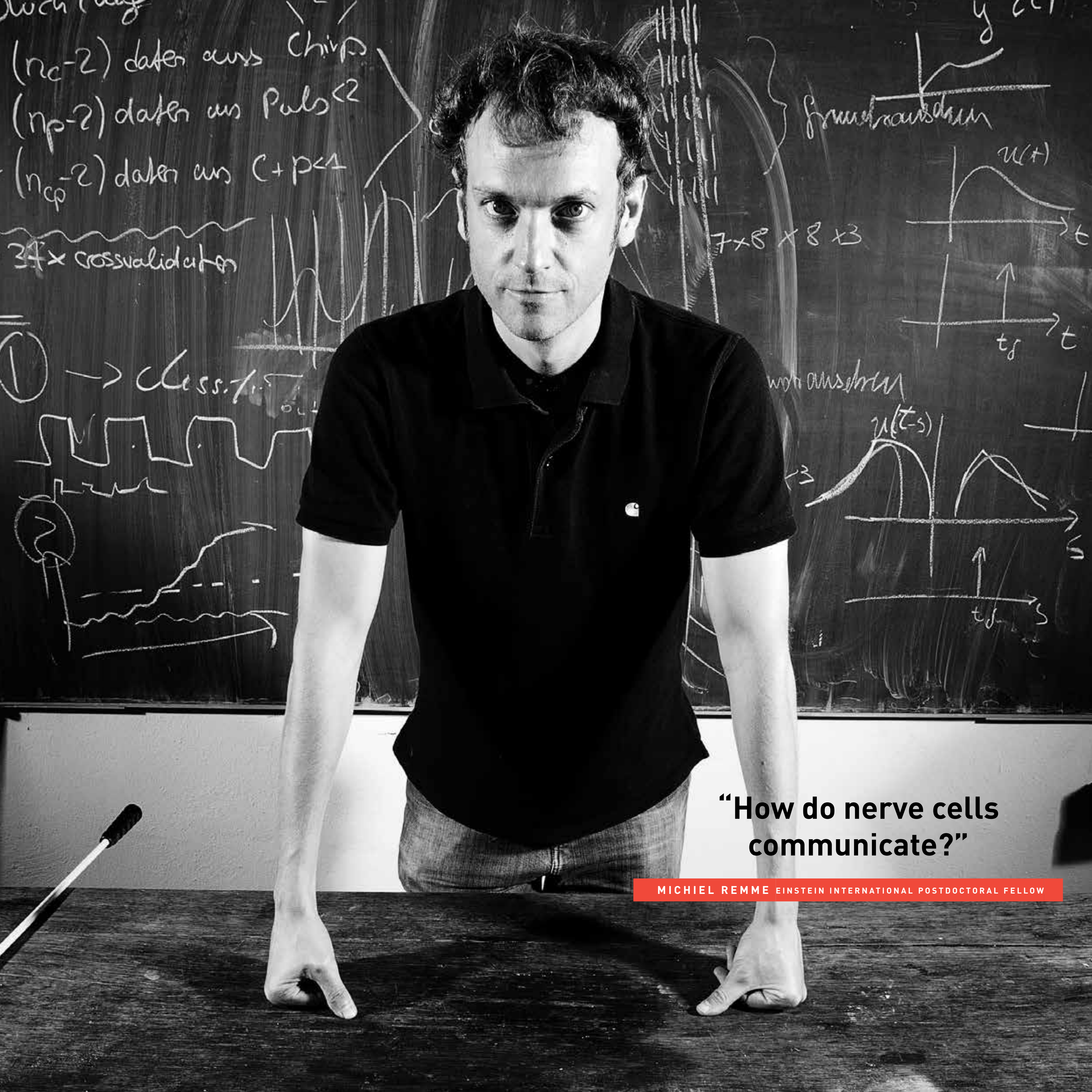
MILESTONES

SINCE 2011
Einstein Professor of Bioanalytics, Technische Universität Berlin

SINCE 2006
Research Fellow, Wellcome Trust Centre for Cell Biology, University of Edinburgh

2003—2006
Team Leader, FIRC Institute of Molecular Oncology, Milan

1995—2003
Harvard Medical School, FMP Berlin, EMBL Heidelberg, IMP Vienna, University of Dundee, University of Southern Denmark



“How do nerve cells communicate?”

MICHIEL REMME EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

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MICHIEL REMME

EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

MICHIEL REMME simulates the transfer of signals between nerve cells. The Dutch neurobiologist is postdoctoral fellow at the Institute for Theoretical Biology, Humboldt-Universität zu Berlin.

The neurosciences include a wide range of topics, from research at the molecular level to psychology and psychophysics. My branch of research is neuropsychology, which looks at measuring the activities of individual neurons, or in other words nerve cells. There are many different types of nerve cells. My work concentrates on the pyramidal neurons, which are located in the cerebral cortex, the outer layer of the brain.

What is the function of a nerve cell? It receives electrical signals from between 10,000 and 20,000 other nerve cells and transforms them into electrical signals that it then transmits. The cell is covered by numerous small projections called dendrites. These structures are my area of expertise. You can picture them like the top of a tree, full of very fine, extensively branched structures. They are in fact very beautiful. In terms of their size, dendrites are hundreds of micrometres in length and less than one micrometre wide. Each branch obtains input signals from hundreds of other cells. I investigate how the spatial configuration of the dendrites impacts on the further transmission of signals.

We have made a great deal of progress in the past 15 years. Unfortunately, animal experiments are still required in our work. When a mouse completes a certain task, for example stepping on a lever to get a drop of water, we can now measure the activity of single neurons using electrodes. At the same time – and this is a new possibility – we can use fluorescent substances to demonstrate how the concentration of calcium changes in a cell. Calcium is an important indicator in determining whether a cell is receiving an input or generating an output.

“Formulas showcase the beauty of mathematics”

I do not conduct any experiments. My task is a mathematical one. I interpret data that other specialists have collected in experiments. Complex mathematical formulas can be used to map and understand many neuronal processes. While I do not work on the visualisation of dendrites, I do feel that these formulas contain an inherent beauty, the beauty of mathematics.

Apart from research, my biggest passion is music. I start every day by sitting down at my piano and playing music, Bach for example. In the past I studied musicology, but I do not see any direct link to my current work. We are very, very far away from understanding why people enjoy and appreciate music at a neural level. I am also quite sceptical as to whether we will ever get there.

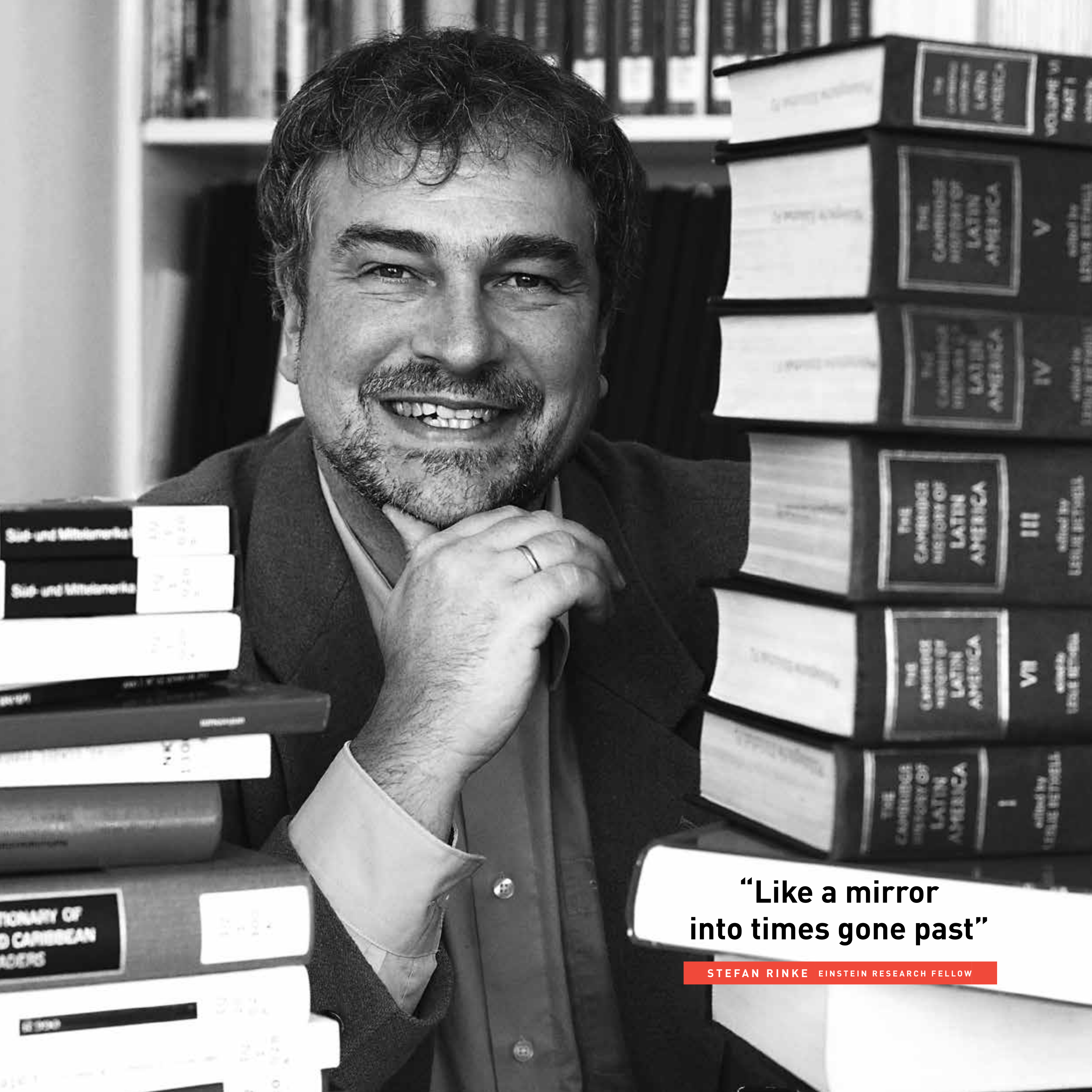
MILESTONES

SINCE 2011
Einstein International Postdoctoral Fellow, Institute for Theoretical Biology, Humboldt-Universität zu Berlin

2008—2011
Postdoctoral research fellow, Center for Neural Science, New York University

2006—2008
Postdoctoral research fellow, Group for Neural Theory, École normale supérieure and Collège de France, Paris

2001—2006
PhD, SILS-Center for NeuroScience, University of Amsterdam



“Like a mirror into times gone past”

STEFAN RINKE EINSTEIN RESEARCH FELLOW

STEFAN RINKE

EINSTEIN RESEARCH FELLOW

STEFAN RINKE investigates the significance of World War I for Latin America. During his research as an Einstein Research Fellow, the Einstein Foundation finances the position of Nikolaus Böttcher, who substitutes him as Professor of Latin American History at the Institute for Latin American Studies, Freie Universität Berlin.

I grew up with people who had very eventful lives. There were constant reminders of their stories of loss: the teacher with one hand, for example. What happened to the other? As a child, I often asked those types of questions and the adults in my life either would not or could not give me answers. So later on, I set out to find them myself.

There are two main subjects that drive me. One is history, because it hands us a mirror into past times, which we can use to scrutinise various problems of human coexistence and then draw conclusions. The other is Latin America, which served as a laboratory for political and social problems throughout the 20th century. The conflicts on that continent have moved me ever since my last years of school. Later, I joined Amnesty International in the fight against human rights abuses in Chile and Argentina. During my time as a student, I found a way to combine these two passions.

My research examines the significance of World War I for Latin America. The discussions that it unleashed there were much more far-reaching than we previously knew. I want to find out how the war changed Latin American collective consciousness. At the time, Latin American elites were debating how they could position themselves in a world that had been set ablaze. After a colonial period of over 300 years, and 100 years of independence spent in the shadow of the Old Word, the continent started to turn its back on Europe, a longtime role model which was now in a shambles, and seek out its own new identity. The hope was that various Latin American countries would gain equal footing on the world stage.

"Historians are becoming more interested in non-European topics"

In order to gain access to different sources from this time, I visit several Latin American archives, which can be a very adventurous undertaking. Sometimes, I will be sent down into a basement, where old documents are just lying around in piles. While it can be a drawn-out process to peruse these documents, it is also very exciting, because it can lead to some very surprising discoveries.

History has long perceived Europe as separate from the rest of the world. In recent years, this perspective has changed and historians are becoming more interested in non-European topics. The discipline is opening itself to transnational and global questions. As a regional specialist, I want to do my part to ensure that the Latin America's history is no longer regarded as peripheral. The old model of centre and periphery is something we need to discard.

MILESTONES

SINCE 2012
Einstein Research Fellow, Ibero-Amerikanisches Institut, Berlin

SINCE 2009
Spokesperson, International Research Training Group "Between Spaces/Entre Espacios"

SINCE 2005
University Professor for the History of Latin America, Freie Universität Berlin

2003
Habilitation award, Association of the Catholic University of Eichstätt-Ingolstadt

“Like cerebral detective work”

DIETMAR SCHMITZ | EINSTEIN PROFESSOR

DIETMAR SCHMITZ researches the function of synapses and neuronal networks as well as their role in neuropsychiatric disorders. He is Professor of Cellular and Molecular Neurosciences at Charité – Universitätsmedizin Berlin.

DIETMAR SCHMITZ

EINSTEIN PROFESSOR

The further I delve into brain research, the more I am struck by a certain sense of awe. When I am sitting in an experiment, watching brain cells generate their rhythms, I often wonder: How is that possible? What is making that happen? Sometimes I think I will never be able to understand it. But most days are not like that. It's clear that we will not be able to figure out every last detail, but small breakthroughs are very motivating in my daily work. The sum of many small observations from numerous laboratories will ultimately help brain research advance in its major lines of questioning.

I am fascinated by the enormous complexity and plasticity of the brain. Far from being static, synapses undergo continuous changes, enabling us to store the new information that we receive. On the one hand, minor changes can lead to serious disorders; on the other hand, the brain is very adept at compensating major injuries. We are still not completely clear about the details of how that is possible. That's one of the many questions raised by the human brain.

Our research group investigates how brain cells communicate with each other and how learning and memory work. When neurological and psychiatric disorders are present, these processes are often impaired – for example with epilepsy, Alzheimer's, autism, or schizophrenia. We try to understand the underlying cellular and molecular mechanisms to develop better diagnostics and therapies. A few years ago, we were able to discover how epilepsy damages nerve cells. Since then, we have developed concepts to try to reverse this disorder.

"The brain is mostly too complex for our hypotheses"

For a long time, I concentrated on basic research, mainly because I found it frustrating that we were making such little progress in clinical applications in neuropsychiatry. Now, I think that we can achieve a great deal. The technology has undergone significant changes in recent years and large research associations like our Cluster of Excellence "Neuro-Cure" or the German Center for Neurodegenerative Diseases enable in-depth basic research with close ties to clinical applications.

Our research often reminds me of detective work. We read a lot and create hypotheses which we test and analyse in experiments. But the brain is mostly too complex for our hypotheses. Therefore, it is extremely important to follow experiments closely and be precise about our observations. Then we can be open to unexpected results. That's how I ended up discovering interesting phenomena that gave me completely new insights into brain functions.

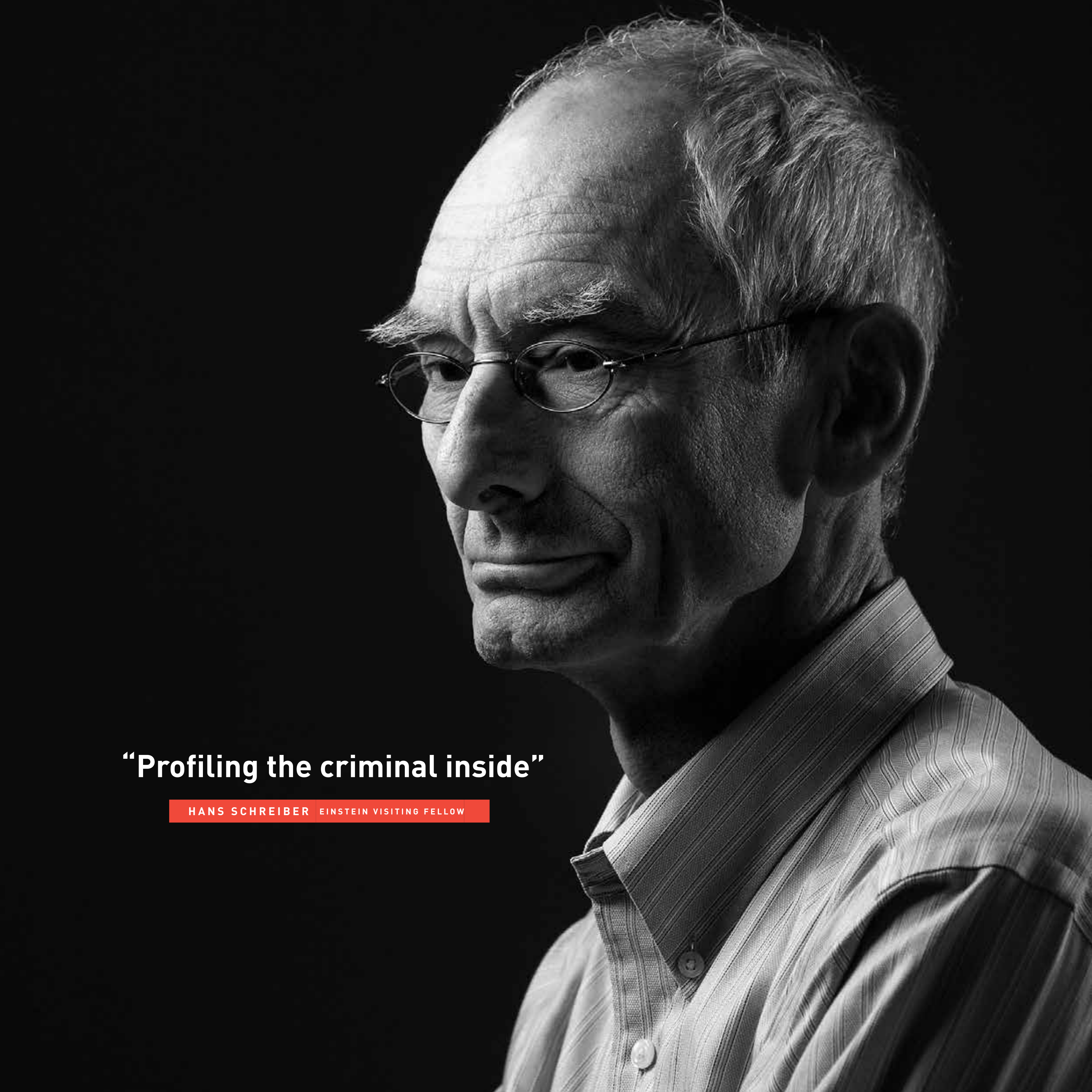
MILESTONES

SINCE 2011
Einstein Professor of Cellular and Molecular Neurosciences, Charité – Universitätsmedizin Berlin

SINCE 2011
Spokesperson, German Center for Neurodegenerative Diseases, Berlin

2005—2014
Spokesperson and Co-spokesperson for a research training group and the Cluster of Excellence "NeuroCure"

SINCE 2005
Director, Neuroscience Research Center (NWFZ), Charité – Universitätsmedizin Berlin



“Profiling the criminal inside”

HANS SCHREIBER EINSTEIN VISITING FELLOW

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HANS SCHREIBER

EINSTEIN VISITING FELLOW

HANS SCHREIBER develops novel cancer therapies by enabling the body's immune system to eradicate cancer cells. He is Professor at the Department of Pathology at The University of Chicago.

Cancer is like a criminal that steals into our body and destroys us from within. The disease is extraordinarily complex; it contains an enormous number of gene mutations. We are trying to approach it as profilers to decipher its "personality", so to speak, and use its genetic fingerprint as a target. It really is similar to a criminal investigation.

We want to use the body's own immune system to combat cancer. Many people think that once cancer is there, the body has no resources to stop it. But even if a relatively strong immune system has failed to prevent cancer, it can still help to destroy it. Our hypothesis is that cancer can be eradicated by a patient's own T cells, which are the immune cells in our body. The approach is extremely logical and elegant in its simplicity. Immune cells that fail to stop the cancer keep failing over the course of its growth, because they are programmed to believe that the mutation is part of the body. The consequences for the patient are catastrophic.

We remove the T cell receptors from failed immune cells, clone them, and put them on fully functioning immune cells that can "see" the cancer and attack it. You can compare this to a drill that has the right bit, but a dead battery: the bit fits the cancer, but the machine is out of power. We remove the bit and put it on a charged machine, something that is in plentiful supply in the patient's body. We use tools that the patient already has.

This approach has already been successful in animal experiments. The effect is dramatic: the cancer virtually disintegrates. I am very optimistic that it will become effective for humans as well. We have good evidence that all human cancers have mutations that can be targeted by the immune system. Currently we are trying to define various sets of patient-specific and cancer-specific mutations. This will enable a highly personalised therapy.

"Research is my life's work; the mysteries it holds are endless"

My own mother and some of my closest friends died of cancer. Like them, most people are healthy when cancer breaks in and robs them of their best years. That perspective and my own experiences have driven me to find a cure.

Many people retire at my age, but for me that's out of the question. I love going to my office every day. Research is my life's work; the mysteries it holds are endless. I collaborate with my wife now; she has a talent for experiments and our work together is very innovative. I think it is important to stay close to discovery, even as you get older.

MILESTONES

SINCE 2014
Einstein Visiting Fellow, Berlin School of Integrative Oncology, Charité – Universitätsmedizin Berlin

2003
Alexander von Humboldt Award

SINCE 1986
Professor of Pathology, The University of Chicago

1983—1984
Visiting Professor, Department of Genetics, University of California, Berkeley

“If nature could be written in equations, there would be no more surprises”

ADRIEN SEMIN EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

ADRIEN SEMIN develops mathematical models to describe the propagation of sound waves. He is postdoctoral fellow in the Department of Mathematics, Technische Universität Berlin.

ADRIEN SEMIN

EINSTEIN INTERNATIONAL POSTDOCTORAL FELLOW

Why do we need mathematical models to study natural phenomena?

Modelling and simulations are often less time-consuming and expensive than real experiments. And in some cases, it would simply not be feasible to conduct a real experiment and make observations. For example, if we wanted to understand the aerodynamics of an aeroplane in flight, it would be very difficult to see or measure air behaviour in a real experiment. The same applies to sound waves, which is what I am trying to model. I am working on a Navier–Stokes equation that describes acoustic waves in the presence of fluids. My goal is to understand how waves are propagated at different length scales. I'll give you an example: if we have a turbine chamber which is one metre long with small holes of one millimetre in diameter, there will be perturbations near these small holes. But they will not happen in the same way on a larger scale, if the holes are ten times that size, for example. The patterns will be different. Our idea is to derive a mathematical model that fits both scales.

What about wave type? Does it make a difference in simulations?

When mathematicians think about wave propagation, it makes no difference whether we are talking about water waves, sound waves, or light waves. The theoretical models, the geometry, and even our observations can vary, but the mathematics behind them always stays the same. So the techniques we use to develop the model also remain relatively constant.

How close do models come to real phenomena?

Not especially close, I would have to say. To describe a complex physical phenomenon like the flow of water in a turbine chamber, we have to break it up into a series of different mathematical problems. We start with simplified equations that only include a limited number of parameters, for example the size of the turbine chamber. We cannot create a complete model that accounts for all possible parameters of the phenomenon we are studying. That would be mathematically impossible. Our models can offer little more than approximations. This is fine, as long as we apply a given model within our explicit range of parameters. However, we will start to have problems when we try to transfer a model to a new set of parameters.

Reality is far too complex to be described in mathematical terms. On the other hand, if nature could be written in equations, there would be no more surprises. That would make my job as a scientist far less exciting.

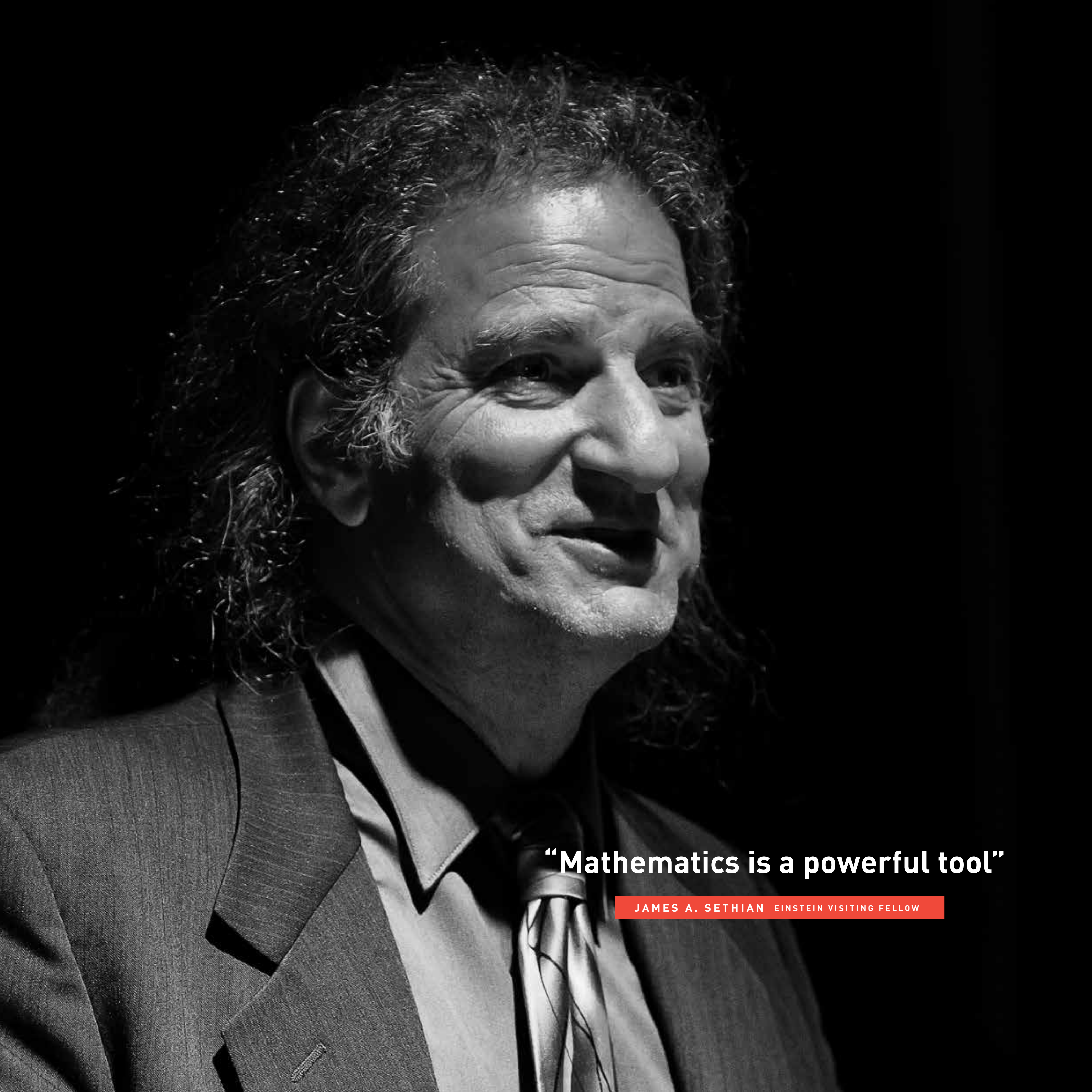
MILESTONES

SINCE 2012
Einstein International Postdoctoral Fellow, Department of Mathematics, Technische Universität Berlin

2010—2012
Postdoc in applied mathematics, Foundation for Research and Technology – Hellas, Heraklion, Greece

2007—2010
PhD in mathematics, Paris-Sud University and INRIA Rocquencourt

2007
Degree in applied mathematics, Paris-Sud University



“Mathematics is a powerful tool”

JAMES A. SETHIAN EINSTEIN VISITING FELLOW

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JAMES A. SETHIAN

EINSTEIN VISITING FELLOW

JAMES A. SETHIAN develops mathematical approaches to model physical phenomena on computers. The mathematician teaches and pursues his research at the University of California, Berkeley.

What do interfaces have to do with computational physics?

When mathematicians talk about a boundary or "interface", they are not only referring to simple stationary objects, but to any sort of free-flowing surface that separates two or more regions. These moving interfaces are relevant to a wide range of engineering problems. We also see them in nature. For example, the surface of an ocean is a water–air boundary; a polluted river can contain a boundary between clean water and contaminants. Tracking these moving interfaces is very important, yet also very challenging, because they are driven by complex and dynamic phenomena. One simple example is a collection of buoys on a lake connected by a string: as the water flows, the buoys move, and the rope between them represents the moving boundary.

Are your methods a universal tool to model interfaces?

Most of my work has to do with developing mathematical models and numerical methods to trace these phenomena. The goal is to build accurate and efficient algorithms that we can also apply to highly complex interface motion. The simple buoy model is just the beginning: in the real world we can find interfaces that fracture into multiple segments and merge with other interfaces. And three dimensions add even more complexity. To model these more difficult problems, we have adopted a different view, which relies on the mathematics of "implicit functions" to represent the moving interface.

Our methods have been used in many applications, for example with internal combustion processes in engines, in semiconductor manufacturing, the development of new materials with industrial foams, and medical imaging for the early detection of illnesses.

What is new about these mathematics models?

The methods we have developed are particularly powerful when you have complicated problems in three-dimensional space. What we have done is bring together several different fields of mathematics – analysis, partial differential equations, and differential geometry – and combine them with modern aspects of computer science. This is one of the virtues of applied mathematics: it has many different fields at its disposal, which can be combined into tools to solve practical problems. At the same time, sometimes you need to invent completely new mathematics and computer algorithms in order to design the best tools. The blend of old and new is what makes applied computational mathematics so challenging, powerful, and fun.

MILESTONES

SINCE 2013
Member of the US National Academy of Sciences; since 2008 of the US National Academy of Engineering

2011—2014
Einstein Visiting Fellow, Berlin Mathematical School

2011
SIAM Pioneer Prize, Society for Industrial and Applied Mathematics; 2004 Norbert Wiener Prize in Applied Mathematics

SINCE 1996
Professor of Mathematics, head of the Mathematics Group, University of California, Berkeley

"How did ancient scientists think?"

LIBA TAUB | EINSTEIN VISITING FELLOW

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LIBA TAUB

EINSTEIN VISITING FELLOW

LIBA TAUB researches scientific discourses and instruments from the ancient world. She is Professor in the Department of History and Philosophy of Science at University of Cambridge, and Director of the Whipple Museum of the History of Science.

Can we learn from scientists of the past?

We live in an age in which science has incredible power. Even shampoo manufacturers cite scientific evidence to sell their products. From our current perspective, it is compelling to wonder: did science always dominate over other forms of knowledge? My answer is no, it didn't. Some of the greatest scientists to have ever lived, like Isaac Newton, Claudius Ptolemy, or Aristotle, knew that there are other ways of knowing and that different kinds of knowledge are interconnected.

Looking at the history of science gives us a way of better understanding our own culture and society. It makes us stop and think when people say, "science says this", because science changes. Ptolemy used to believe that the Earth was the centre of the universe. Today, the idea of a universe with a "centre" would strike us as odd. The history of science reminds us that knowledge is transitory, not permanent.

What specific topics are you working on right now?

In recent years, I have mainly focussed on different genres of communicating scientific ideas. Some of these genres are literary forms such as poetry, or subliterary formats like lists, for instance. If you pick up a copy of the Greek Anthology, you will find over 40 short poems about mathematical problems that were most likely recited during "symposia", or lively intellectual debates among male banquet-goers in ancient Greece. I also study scientific objects from antiquity, although very few remain. One example is a fragment of a celestial globe in the Neues Museum in Berlin. Ancient scientists may have used it to read an astronomical poem written by Aratus. We know that people used to read these poems with a globe so that they could trace the location and patterns of the stars. Actually, the sheer existence of globes at that time is interesting: it proves that people knew the Earth was round much earlier than we usually think.

Do you try to get into the minds of ancient scientists?

That's just not possible, unfortunately! But it is very fulfilling to feel that I have understood an idea that was near and dear to an author. In my work on Ptolemy, for instance, I focussed on the beginning of the "Almagest", which many people skip. I think it is a section that Ptolemy took very seriously, and I devoted a good deal of time and effort to understanding it. That gave me a strong sense of connection. Though I know that if Ptolemy were to walk in the room, he could just say "wait a minute, you got that totally wrong!" – I always try to remind myself of that.

MILESTONES

2010—2014
Einstein Visiting Fellow, Freie Universität Berlin, Cluster of Excellence "Topoi – The Formation and Transformation of Space and Knowledge in Ancient Civilisations"

2007
Visiting Scholar, Oregon State University

2006
Visiting Scholar, Kármán Centre for Advanced Studies in the Humanities, University of Bern

SINCE 1995
Professor of History and Philosophy of Science, Curator/Director at the Whipple Museum of the History of Science, University of Cambridge

“Why does our environment look the way it does?”

ANDREAS THIEL | EINSTEIN JUNIOR FELLOW

ANDREAS THIEL looks at different mechanisms societies use to govern natural resource use, with his current focus being on EU legislation. He is Visiting Professor of Environmental Governance at the Department for Agricultural Economics, Humboldt-Universität zu Berlin.

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ANDREAS THIEL

EINSTEIN JUNIOR FELLOW

Are EU environmental laws really the bureaucratic monstrosity that so many claim?

From my perspective, they are actually drivers of innovation. They modify administrative practices and often improve environmental management. Local administrative officials are careful in considering how they can use European regulations to promote good administration. Many things begin to change and we often witness an intense exchange of ideas – it's the start of a journey in search for better environmental management. A good metaphor would be the shadows that are cast in the evening sunlight: at the EU level, the directives are lean objects. But when they fall on the member countries, they cast incredibly long shadows. They have a huge impact at the local level, but they also come with a heavy administrative burden.

What is it that interests you about EU laws and their implementation?

My project as an Einstein Junior Fellow looks at new taxation procedures for fresh water and sea use based on EU regulations in the member states. I want to understand how the EU member countries implement these rules and which factors lead to variations in their results – for example administrative practices, political and cultural contexts, varying use behaviour, or the characteristics of specific natural habitats. My approach is innovative in that it combines explanations from a variety of disciplines, including new institutional economics, political science and geography, as well as the use of methods that are new to this context such as social network analysis for the investigation of actor constellations. Of course, I also rely on in-depth talks, for example to discover how a local administrator in Brandenburg interprets a European law and applies it to the Havel region.

Does your research aim to improve our current use of natural resources?

My goal is to find the best coordination mechanisms to promote an optimal use of natural resources and environmental protection. We still fully lack suitable instruments to govern how we use and protect the environment to help it remain habitable for the years to come. We need new interdisciplinary approaches to generate more specific knowledge and test new concepts. The mid-term goal of my research is to enable administrative officials to develop more individualised regulations for different natural habitats. I also want to contribute to a greater diversity in the instruments we use for environmental management. This is not the case of finding a "one size fits all" solution.

MILESTONES

SINCE 2012
Einstein Junior Fellow, Department of Agricultural Economics, Humboldt-Universität zu Berlin

SINCE 2012
Visiting Professor of Environmental Governance, Humboldt-Universität zu Berlin

2007
Post-doctoral researcher, Institute for Prospective Technological Studies (Joint Research Centre of the European Commission), Sevilla

1999—2005
Master's degree and PhD at the Technische Universität Berlin and Oxford Brookes University

“I question certainties”

ANITA TRANINGER EINSTEIN JUNIOR FELLOW

ANITA TRANINGER studies the pre-history of impartiality and other certainties. Trained as a literary scholar, she teaches in the Institute of Romance Languages and Literatures at the Freie Universität Berlin.

ANITA TRANINGER

EINSTEIN JUNIOR FELLOW

"The freedom of research is a great privilege"

My research requires me to rely on original sources that are not available in modern formats. That's something that I truly enjoy. Of course many old publications are now available digitally, which does facilitate my work. But there are certain discoveries that you only make by picking up a book: sometimes prints are bound together, and it is only by accident that you stumble across something that suddenly sheds new light on your work. Those are serendipitous moments in historical research. I am also very moved when I find handwritten notes in a margin – readers who held the same volume in their hands centuries ago echo through those words.

In my current project, I examine the pre-history of impartiality as a concept. I find this topic especially interesting, because today the term functions as a given. It is also absolutely central to our identity and self-image as scholars and scientists. My research, however, shows that impartiality only started to gain momentum as a scientific ideal in the 17th century. Prior to that, science had managed to exist without much of a problem since Antiquity. And I can also show that impartiality did not emerge solely in conjunction with empirical research, as we are accustomed to believe. Instead, it started to appear in many areas simultaneously and establish itself as an independent ideal – for example in theological controversies, review systems, or in aesthetics.

With my research, I want to increase awareness of the fact that many of our supposedly universal values are still relatively new. I question these certainties by studying their history. It can be very illuminating. One basic assumption that remains widely accepted in European cultural history is that the Renaissance was the dawn of a new age of humanity that put an end to the "darkness" of the Middle Ages. Nonetheless, by looking more closely at a variety of sources, we can clearly see that many scientific methods and techniques from universities in the Middle Ages continued to be practised during the Renaissance. They can even be found in humanist works prized as the antithesis of scholasticism and its pedantry. The break was ultimately much less radical than it is made out to be.

It is an enormous privilege to be able to do research on such fascinating topics. There are a number of other obligations at the university, but I am able to define the main part of my work. The freedom that comes with academic research is a great privilege.

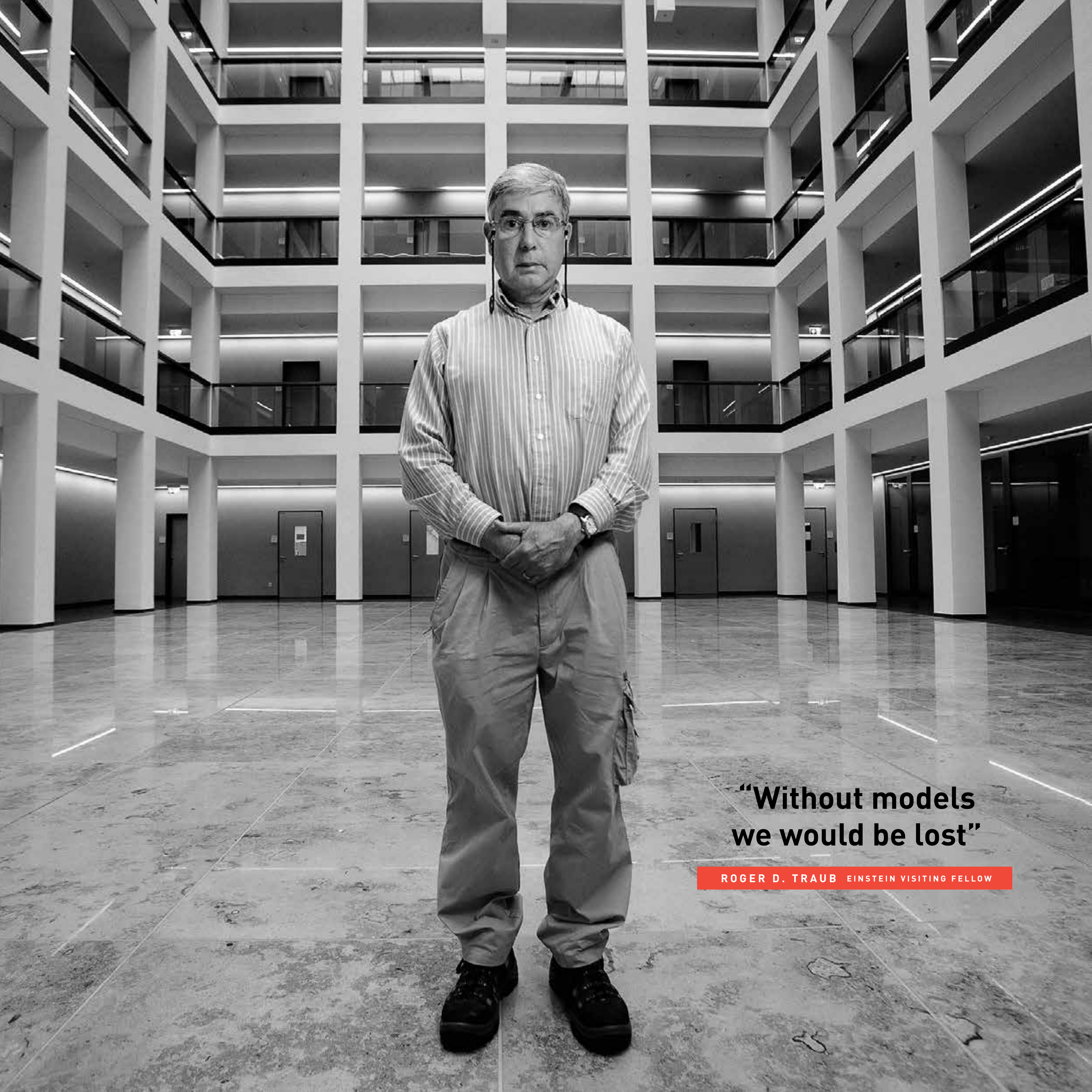
MILESTONES

SINCE 2012
Einstein Junior Fellow, Institute of Romance Languages and Literature, Freie Universität Berlin

2009—2012
Research Coordinator during the preparatory phase of the Collaborative Research Centre "Episteme in Motion"

2010
Habilitation, Freie Universität Berlin

2001—2004
Managing Director, Institute for Human Sciences, Vienna



"Without models we would be lost"

ROGER D. TRAUB EINSTEIN VISITING FELLOW

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ROGER D. TRAUB

EINSTEIN VISITING FELLOW

ROGER D. TRAUB creates computer simulations of neuronal circuits to help understand diseases like epilepsy. He is a researcher in the Physical Sciences Department at the IBM T.J. Watson Research Center in Yorktown Heights, New York.

"Mathematical models are essential for brain research"

The brain is both a thinking organ and a collection of cells. Its overall function still eludes us. That is beyond our capacity at the moment. What we can begin to understand is how brain cells work and interact, and try to relate those findings to thought processes.

I design detailed models of individual neurons and neuronal circuits to find out how cells communicate via synapses or in other, more unconventional ways. Then I connect these models to experiments that observe in-vitro brain slices or also take measurements on human subjects.

To make a model of a cell, you have to experimentally specify the properties of the membrane, a layer that in some ways resembles an undersea communication cable. In fact, it can be described by the same partial differential equation. You also need to define the properties of the proteins that live in the membrane and change their behaviour depending on the local electric field. Electrical signals propagate and influence chemical signals and vice versa. Then you put all that information together. My work requires enormous data processing and storage capacities and years of research. Longevity is the key. The model I use the most took me five years to develop; it contains some 35,000 lines of code and thousands of cells.

At the moment, the most important application area for my models is in epilepsy research. We found that the electrical activity patterns occurring in the brain during a seizure can be replicated in an in-vitro system and understood in relatively great detail. This is an active research area here at the Charité in Berlin. Years ago, my colleagues and I came up with a model that describes how the sharp waves that occur during a seizure are generated. We suggested that they were closely linked to "gap junctions" between the principal neurons. Many experiments conducted in Berlin support this model. If it is correct, the results would be quite revolutionary: we would be able to demonstrate that synapses are not the only pathway through which brain activities occur. It might even be possible to suppress an epileptic seizure by regulating gap junctions.

Mathematical models are essential for brain research because the brain – with its myriad systems of cells and circuits – is incredibly complex. We need a theory, not like relativity theory, but a model that enables a host of equations and simulations. Without models, we would be lost. It would be like trying to run a meteorology station without numbers or equations, only words.

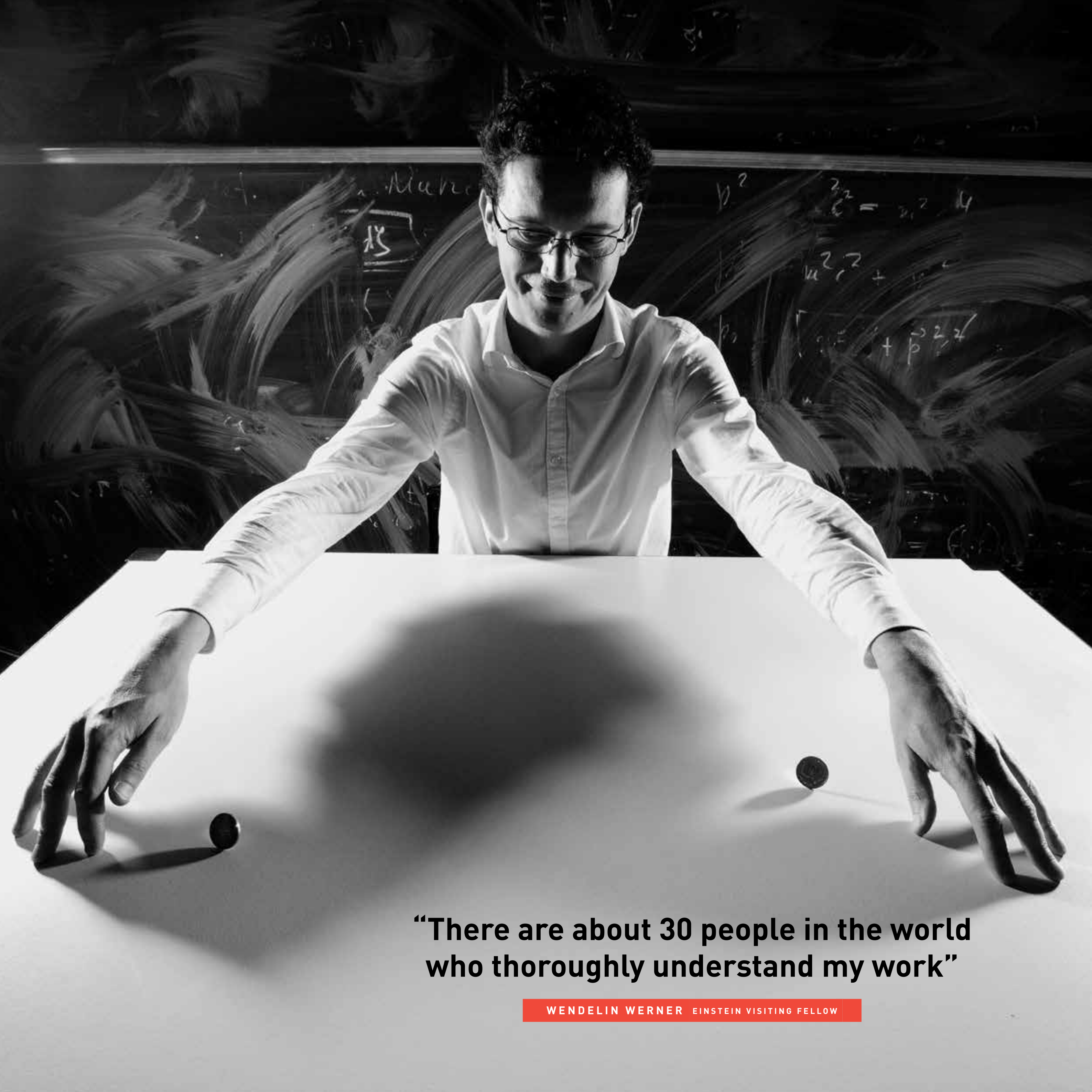
MILESTONES

2010—2014
Einstein Visiting Fellow, Cluster of Excellence "NeuroCure" Charité – Universitätsmedizin Berlin

2007
Humboldt Research Award

2001—2008
Professor of Physiology, Pharmacology, and Neurology, State University of New York

1967—1972
Studied mathematics and medicine, Massachusetts Institute of Technology, University of Pennsylvania, and Princeton University



“There are about 30 people in the world who thoroughly understand my work”

WENDELIN WERNER EINSTEIN VISITING FELLOW

WENDELIN WERNER

EINSTEIN VISITING FELLOW

WENDELIN WERNER does research in the area of probability theory, with a special focus on self-avoiding random walks and Brownian motion. He is Professor of Mathematics at the Swiss Federal Institute of Technology in Zurich (ETHZ).

Mathematicians often want to revisit an emotional world from their childhood through their work. For me, it's what I felt sitting with my brother and father in the garden at night watching the stars. It fascinated me that their size was a matter of perspective and that everything we were seeing had happened a very, very long time ago. That knowledge felt intoxicating and it drove me to investigate and master similar questions. I think it still remains one of the biggest motivators for my work.

One thing that interests me is the relationship between randomness and continuity. On an intuitive level, we know that time and space build a continuum. In very broad terms, my work looks at how randomness can be scattered and retrieved along a continuum of randomness. This question is relevant, for example, for phase transitions in physics. If a water glass has a temperature of zero degrees Celsius, it can contain water or ice. But how exactly are the states of water or ice determined at the various points in the medium? Which microscopic features trigger macroscopic features?

I could describe the specific topics I work on with similar brushstrokes, but it would be nothing more than propaganda. There are about 30 people worldwide who thoroughly understand my work. It's a pleasant situation, actually, because many of those colleagues are wonderful people. Mathematics draws a host of great people. At the same time, it is a very abstract world into which we can retreat and feel very secure and at ease.

"Mathematics draws a host of great people"

As a probability theorist, I often hear a number of pseudo-philosophical questions: Is there such a thing as coincidence? What is the meaning of randomness? Does our world have deterministic traits? But one of the beautiful things about mathematics is that we do not have to answer those types of questions. It's not in our job description. Our work takes place within the abstract world of maths. The same applies to certain geometries: you can work with them without knowing whether they even exist in the real world. In our abstract world, it is possible to prove the properties of seven-dimensional spaces, even though we will never be able to see those spaces with our own eyes.

I do not believe that my research will be useful for everyday applications in 20 or 50 years. Nor is that my goal. Like most pure mathematicians, my motivation comes from being able to create an elegant mathematical structure with elegant proofs.

MILESTONES

2011—2014
Einstein Visiting Fellow, Berlin Mathematical School

1997—2013
Professor, University of Paris-Sud; since 2013 Professor of Mathematics, Swiss Federal Institute of Technology, Zurich

2008
Admission into the French Academy of Sciences, Paris

2006
Fields Medal

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