NEWSLETTER

30th edition | Fall 2019

IST AUSTRIA
Institute of Science and Technology

10 YEARS

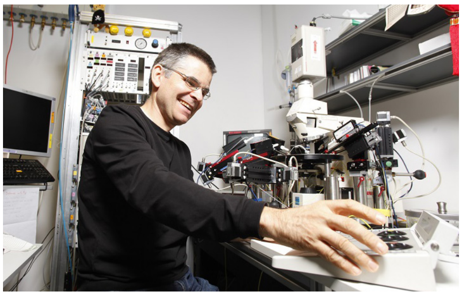
Foreword

From jellyfish to giraffes—when I watch a David Attenborough film I am struck by the intricacies of animal behavior. These clips are only a trailer of the behavioral panoply available to each species. Behavioral versatility is coordinated by dynamic coalitions of neurons, whose activities change over milliseconds and which can be sculpted by experience over seconds or years. I am interested in the molecular mechanisms that underpin circuit function, and make plasticity possible.

I studied molecular biology, and during my PhD at the Laboratory of Molecular Biology (LMB) in Cambridge learned the awesome power of genetics while investigating sex-determining mechanisms. It was there I became interested in the nervous system, and went to the University of California, San Francisco (UCSF) to establish a behavioral paradigm amenable to systematic genetic dissection in the worm *C. elegans*. In 1999, I returned to LMB, and embraced genomics, biochemistry, neural imaging and cell biology, in a quest to understand nanomachines that sustain and sculpt circuit function.

At LMB, I saw how strong core facilities, long-term support, free exchange of ideas, and constant challenge by colleagues can stimulate scientists to take long-term risks that led to revolutions, such as sequencing the human genome and developing cryo-electron microscopy. IST Austria combines these fundamentals with a disregard for interdisciplinary boundaries, and the freedom to pursue curiosity-driven research. I am excited to join, and eager to learn, by interacting with everyone on campus.

Mario de Bono | Professor, IST Austria



Professor Peter Jonas elected member of EMBO

The European Molecular Biology Organization (EMBO) is an organization of more than 1'700 leading researchers that promotes excellence in the life sciences. In June, it announced the election of 56 new members. One of them is IST Austria Professor Peter Jonas whose outstanding research achievements in neuroscience were honored by EMBO with life-long membership. The neuroscientist investigates the mechanisms of synaptic signals in the brain. For this purpose, he uses state-of-the-art methods, including recording methods for several cells, subcellular patch-clamp technique, imaging methods to determine intracellular calcium concentration and modelling.

With Peter Jonas being elected, IST Austria has now eight EMBO members among its professors. The other faculty members who are members of EMBO are: Nick Barton, Eva Benková, Mario de Bono, Jiří Friml, Michael Sixt, Carl-Philipp Heisenberg, and Leonid Sazanov.

IST Austria ranks 3rd among the world's best research institutions

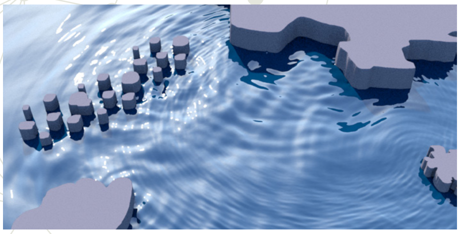
IST Austria takes the 3rd place in the "Nature Index 2019". Published annually by the scientific journal Nature, the index is a measure for the success of scientific institutions in the natural sciences. Based on a list of 82 quality journals of different subject areas, it sums up the contributions of authors to articles in these journals and analyzes their affiliations. For the first time in 2018, the size of the institutions in which the publishing researchers work was also taken into account. The statistics shows IST Austria 3rd worldwide in the ranking.

While IST Austria in 2017 was already listed as one of the top ten "rising star" institutes in the world, in 2018 it made the leap into the realm of the world's leading scientific institutions—whether young or time-honored. First place goes to Cold Spring Harbor Laboratories, USA, second place to the Weizmann Institute of Science in Israel. Among the Top 10 only one other European institution, the EPFL Lausanne, Switzerland, is represented.

President Thomas A. Henzinger receives EATCS Award

IST Austria President Thomas A. Henzinger received the 2019 European Association for Theoretical Computer Science (EATCS) Award for his "fundamental contributions to the theory and practice of formal verification and synthesis of reactive, real-time, and hybrid computer systems, and to the application of formal methods to biological systems." The EATCS Award recognizes significant contributions to the field of theoretical computer science over a life-long career.

The award was officially presented at the main conference of the EATCS, the 46th International Colloquium on Automata, Languages and Programming (ICALP 2019) in Patras, Greece. Tom Henzinger on receiving the EATCS Award: "It is a great honor to get selected by one's peers from the scientific community to receive a prestigious award. EATCS is the main European organization for advancing research in algorithms, computational complexity, and models of computation."

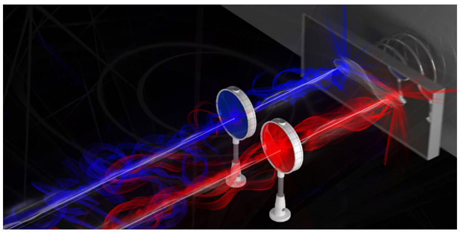


New method makes realistic water wave animations more efficient

Producing high-quality and realistic water wave animations that interact with complex objects is often computationally expensive, with designers frequently opting for methods that are fast to compute but of lower quality. IST Austria researchers developed a technique to produce more realistic water wave animations at a lower computational expense as compared to current approaches. Their results were published in the journal ACM – Transactions on Graphics.

In general, water wave simulations are based on one of two available methods. "Fourier-based" methods are efficient but cannot model complicated interactions, such as water hitting the shore of an island. More elaborate, "numerical" techniques, on the other hand, can simulate a wide range of such effects but are much more expensive computationally. As a result, detailed scenes such as ripples forming as a wave interacts with an island or even a boat passing by are practically impossible due to the sheer processing time and computational power needed. Computer scientists from Professor Chris Wojtan's research team developed a method that makes it possible to animate realistic waves and their interaction with solid objects, at a large scale and also in a computationally efficient manner.

Achieving this feat required innovation and a deep understanding of the physics involved by solving complex mathematical equations that model wave-surface interactions. At this year's SIGGRAPH conference—the annual event is the world's largest conference on visual computing, graphics and animation that brings together leading researchers and enterprises—the team showcased their methods and saw numerous applications to the movie and video game industry. Scenes such as boats moving past islands are demonstrated to be computationally efficient to do so.

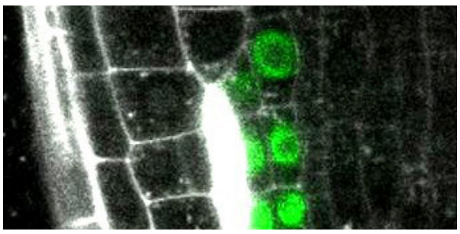


Building a bridge to the quantum world

Entanglement is one of the main principles of quantum mechanics. Physicists at IST Austria found a way to use a mechanical oscillator to produce entangled radiation. This method, which they published in a Nature study, might prove extremely useful when it comes to connecting quantum computers.

Entanglement is a phenomenon typical of the quantum world, which is not present in the so-called classical world—the world and laws of physics that govern our everyday lives. When two particles are entangled, the characteristics of one particle can be determined by looking at the other. This was discovered by Einstein, and the phenomenon is now actively used in quantum cryptography where it is said to lead to unbreakable codes. But it not only just affects particles, radiation can also be entangled: This is the phenomenon that Shabir Barzanjeh, a postdoc in the group of Professor Johannes Fink at IST Austria and first author of the study, is currently researching.

"Imagine a box with two exits. If the exits are entangled, one can characterize the radiation coming out of one exit by looking at the other," Shabir Barzanjeh explains. Entangled radiation has been created before, but in this study, a mechanical object was used for the first time. With a length of 30 micrometers and composed of about a trillion atoms, the silicon beam created by the group might still be small in our eyes but, for the quantum world it is large. "For me, this experiment was interesting on a fundamental level," he says. "The question was: can one use such a large system to produce non-classical radiation? Now we know that the answer is: Yes." But the device also has practical value. Mechanical oscillators could serve as a link between the sensitive quantum computers and optical fibers connecting them inside data centers and beyond. "What we have built is a prototype for a quantum link," says Barzanjeh.



Specialized plant cells regain stem-cell features to heal wounds

If plants are injured, cells adjacent to the wound fill the gaps with their daughter cells. However, which cells divide to do the healing and how they manage to produce cells that match the cell type of the missing tissue has been unclear. A Cell study by researchers from the group of Professor Jiří Friml, including former PhD student Petra Marhava, current PhD student Lukas Hörmayer, and former postdoc Saiko Yoshida, has shown that to correctly replace dead cells, neighbors to the inside of the wound re-activate their stem cell programs.

All plant organs endure injuries to their tissue. It has been known for almost a century that in plants, cells adjacent to the wound replace harmed tissue with new daughter cells. Yet, a completely new aspect of plant wound healing in the sensitive root tip has only been discovered now: the scientists have found out that injured or destroyed root cells are not simply replaced by a proliferation of healthy cells from the same cell type above and below to the wound. Instead, specifically the cells adjacent to the inner side of the injury reactivate their stem cell programs to produce de novo cells of the correct type to replace missing neighbors.

With a UV laser, the researchers removed individual cells in the root tip of *Arabidopsis thaliana*. Live imaging via the innovative vertical stage microscope allowed them to track the wound healing process in vivo. Restorative patterning could be observed in various specified tissue layers: epidermis, cortex, endodermis, and in innermost pericycle cells encircling the vascular tissue. In all tissue layers, the restorative patterning started with the division of the inner adjacent cells in response to a damaged or missing neighbor cell. However, the cell cycle of these "healing cells" happened significantly faster and included a shift of division planes by 90 degrees, allowing the cells to arrange perpendicular to the root axis.

Carl-Philipp Heisenberg, Cell and Developmental Biologist

What was your original field of study? I studied biology in Munich, and I initially focused on neuroscience. But during my PhD studies in Tübingen, I started to work on aspects of developmental biology and continued working on this field as a young group leader in Dresden. I started to combine developmental biology with cell biology and biophysics when moving to IST Austria ten years ago.

Why did you become a scientist? The reason for becoming a scientist was certainly the wish to follow my curiosity in all aspects of nature. It also was to a certain degree family-inspired. Being a scientist was certainly a realistic option and it was quite logical to choose this path of profession.

What do you like about basic research? The thing I like most about basic research is that you can freely decide what you want to do. The questions that you are addressing in your work are sort of naturally coming up. You cannot predict what they will be but you can focus on certain questions that appear particularly interesting and promising to you. In essence, you are free to choose what you want to do with your professional life. That is a big plus for doing basic research.

What is your main area of research? We are looking at the processes by which the embryo takes shape. We are looking at mechanical aspects of it, and what kind of mechanical forces are produced, generated, transfused, and received within the embryo. We are trying to combine these mechanical aspects with biochemical aspects of development. We are looking at mechanochemical feedback in development that lead to shape changes of the embryo during the development, using zebrafish as a vertebrate model organism.

Which scientific result are you particularly proud of? We have contributed to understanding how cell and tissue morphogenesis works in an intact organism. We have provided insights into how mechanical forces interact with biochemical processes in shaping the embryo. That is what we have done researchwise in these fields.

Why did you join IST Austria? I joined IST Austria ten years ago as the third professor who signed a contract. At that stage, IST Austria was not really present, it was more of an idea, the buildings were not yet finished. I chose it because it had an apparent enormous potential to develop into one of the few places where a lot of different disciplines are on campus together. The potential inter-disciplinary nature of IST Austria was the most attractive feature for which I have chosen IST Austria as my new home.

What is special about IST Austria? IST Austria is one of the few places in Europe, where you have different disciplines on campus. It is a campus university where you can do interdisciplinary research. That was the reason why I came here and that is what makes IST Austria special.

Watch the entire ProfTalk interview on our YouTube channel!

The Development of the Bioimaging Facility at IST Austria

Light microscopy is an instrumental tool for life sciences. The Bioimaging Facility at IST Austria provides state-of-the-art services in high-end light microscopy, flow cytometry, image analysis and optical development. Its services are designed to fulfill the requirements of the faculty. Both equipment and services are continuously updated to meet the requirements of the researchers, and novel advances in the field of light microscopy, flow cytometry, and image analysis are implemented.

The Bioimaging Facility was established in October 2010 with the arrival of the first experimentalist groups on campus. It started out with five advanced light microscopy setups including an atomic force microscope, two-photon, Total Internal Reflection Fluorescence (TIRF) and confocal setups; a Fluorescent Assisted Cell Sorting (FACS) analyzer and a FACS sorter were also purchased and made operational. Ever since then, the Bioimaging Facility has undergone continuous development. Today, it hosts three flow cytometry devices, 11 image analysis computers and 22 microscopes (24 by the end of 2019), that all require regular performance maintenance and service checks. The equipment park is currently used by 18 research groups from IST Austria, but also sees utilization by external academic and commercial customers, together servicing more than 200 researchers last year.

The equipment purchased at the initial start-up period has begun to show signs of aging thereby announcing a period of new challenges. In order to maintain the facility's high-end scientific capability, the Bioimaging Facility made extensive efforts in 2018 to upgrade five systems including one TIRF and four confocal microscopes, with further state-of-the-art upgrades planned for 2019 and 2020.

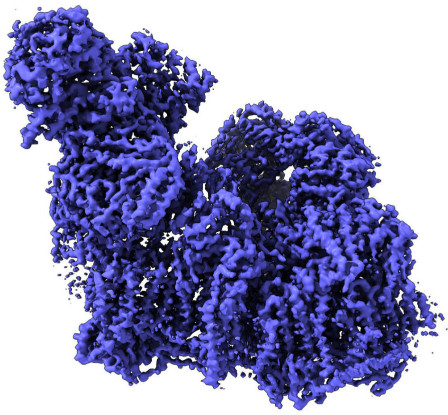
A new flow cytometer has been added recently, allowing researchers to make use of these services outside of core facility times. Additionally, a new microscope room is being constructed in the Bertalanffy Foundation Building that can host up to seven high-end imaging machines, and the image analysis services are being expanded to include machine learning technologies that will open new possibilities in both image acquisition and analysis.

The long-term strategy is for the Bioimaging Facility team to further develop into multiple specialization "focus points" that will ensure in-house expertise in current and upcoming technologies. In addition, the facility intensively collaborates with two affiliated staff scientists to develop and implement new optomechanical applications and image analysis routines. It also works closely with IT, the Miba Machine Shop, Electron Microscopy Facility, Life Science Facility, and continuously relies on the services from the construction and maintenance team.

The Bioimaging Facility is one of eight Scientific Service Units currently established at IST Austria. Its team provides expertise in state-of-the-art microscopy, flow cytometry, image analysis and optical development, by providing assistance, trainings and maintenance of equipment. For more information visit the website.

Library Services for Open Science meeting on August 21

On August 21, the IST Austria library will host "Library Services for Open Science", the satellite meeting to the 85th World Library Information Congress of the International Federation of Library Associations and Institutions (IFLA). Organized by the Evidence for Global and Disaster Health Special Interest Group of IFLA, supported by the Austrian Library Association and funded by International Standard Serial Number Agency, the one-day conference will explore what libraries can do to support open science. Besides an interactive workshop and four talks, invited speakers—i.e. Lambert Heller of the German National Library of Science and Technology in Hanover and Ina Smith of the Academy of Science of South Africa—will present innovative services for libraries to foster open science. For more information visit the website.



IST Austria cryo-EM inauguration symposium on October 18

On October 18, IST Austria will host a one-day symposium to inaugurate its recent investments in cryo-EM infrastructure. Equipped with state-of-the-art instrumentation such as a 300 kV Thermo Scientific Titan Krios TEM, a 200 kV Thermo Scientific Glacios TEM, a Thermo Scientific Aquilos cryo-FIBSEM, and a Leica cryo-CLEM setup, IST Austria has the largest cryo-EM facility in Austria. Currently, there are three research groups—the Bernecky, Sazanov and Schur Groups—working with cryo-EM on campus The aim of the symposium is to highlight exciting research involving cryo-EM, including the latest developments in the field as well as their application to biological questions. The program will be divided into three blocks covering new advances in cryo-EM methodology, SPA cryo-EM and cryo-electron tomography. For more information visit the website.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: Andrew Mackenzie, Max Planck Institute for Chemical Physics of Solids (Apr 8) | Roger Heath-Brown, Oxford University (Apr 29) | Magdalena Götz, Ludwig Maximilian University of Munich (May 20) | Josh Sanes, Harvard University (May 27) | Gordon Wetzstein, Stanford University (Jun 24)

FUTURE SPEAKERS: Richard Murray, CalTech (Sep 9) | Eve Marder, Brandeis University (Sep 16) | Zeev Rudnick, Tel Aviv University (Sep 23) | Taekjip Ha, Johns Hopkins University (Oct 7) | Jay T. Groves, UC Berkeley (Oct 21) | Ed Boyden, MIT (Nov 4) | Adrian Bird, University of Edinburgh (Nov 11) | Nir Shavit, MIT (Nov 18)

SELECTED RECENT PUBLICATIONS

Akopyan A, Fedorov R. 2019. Two circles and only a straightedge. Proceedings of the American Mathematical Society. 147, 91–102.

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Chatterjee K, Goharshady AK, Okati N, Pavlogiannis A. 2019. Efficient parameterized algorithms for data packing. Proceedings of the ACM on Programming Languages. 3 (POPL), 53.

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Fischer JL, Kneuss O. 2019. Bi-Sobolev solutions to the prescribed Jacobian inequality in the plane with L p data and applications to nonlinear elasticity. Journal of Differential Equations. 266 (1), 257–311.

Fu H, Chatterjee K. 2019. Termination of nondeterministic probabilistic programs (eds. C. Enea &; R. Piskac). 11388, 468–490.

Hausel T, Mereb M, Wong M. Arithmetic and representation theory of wild character varieties. Journal of the European Mathematical Society.

Käfer K, Malagon-Vina H, Dickerson D, O'Neill J, Trossbach SV, Korth C, Csicsvari JL. 2019. Disrupted-in-schizophrenia 1 overexpression disrupts hippocampal coding and oscillatory synchronization. Hippocampus.

Kavcic B, Sakashita A, Noguchi H, Ziherl P. 2019. Limiting shapes of confined lipid vesicles. Soft Matter. 15 (4), 602–614.

Kutzer M, Kurtz J, Armitage SAO. 2019. A multi-faceted approach testing the effects of previous bacterial exposure on resistance and tolerance. Journal of Animal Ecology.

Li X, Bighin G, Yakaboylu E, Lemeshko M. 2019. Variational approaches to quantum impurities: from the Fröhlich polaron to the angulon. Molecular Physics.

Pietrzak KZ. 2019. Simple verifiable delay functions. 10th Innovations in Theoretical Computer Science Conference. ITCS 2019: Innovations in Theoretical Computer Science, LIPIcs, vol. 124. 60.

A full list of publications from IST Austria can be found in the IST Austria Research Explorer.

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