NEWSLETTER 16th edition | February 2016

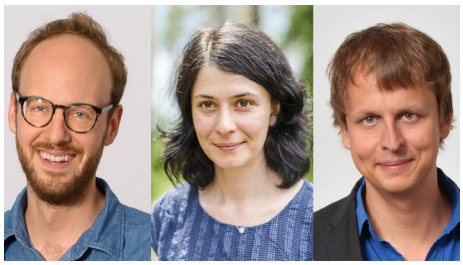
IST AUSTRIA
Institute of Science and Technology

Foreword

Almost one year ago IST Austria contacted me for an interview and offered me the position of the Manager of the Nanofabrication Facility. As a trained physicist with a strong background in solid state physics and nanofabrication, I was very happy about the job offer and accepted the challenge. Over the last eight years, during my PhD studies in material science and my postdoc position in ultrafast science in THz regime, I was working in several cleanrooms throughout Europe and was visiting a few in the US. Having gained a lot of expertise in nanofabrication processing, I really enjoy developing and fabricating new fancy devices today.

Now, after spending more than eight months on campus, I feel like time at IST Austria is flowing with a different velocity. The newly established nanofabrication facility is one of seven scientific service units that support scientists with high-performance research infrastructure. Located in the ground floor and basement of Lab Building West, it is scheduled to open at the end of this year. It will provide laboratories and two cleanrooms with state-of-the-art equipment for micro- and nanofabrication processing to push the institute as an excellent international research center even further. Curious and enthusiastic as I am, I cannot wait to see "my" nanofabrication facility in operation and support the frontier research conducted by excellent scientists at IST Austria.

Salvatore Bagiante | Manager of Nanofabrication Facility, IST Austria



Three ERC Grants for IST Austria

Martin Loose, Assistant Professor since January 2015, and Anna Kicheva, who joined IST Austria as Assistant Professor in November 2015, were endowed with an ERC Starting Grant each. Krzysztof Pietrzak, Assistant Professor since 2011, secured an ERC Consolidator Grant.

IST Austria President Thomas Henzinger expressed his appreciation: "ERC grants are highly competitive and have become a benchmark for excellence in research. I congratulate Krzysztof Pietrzak, Anna Kicheva, and Martin Loose on their success. Having now 20 out of 40 professors funded by ERC is a testimonial for the growing success and international recognition of IST Austria."

Biochemist Loose investigates the mechanisms of the self-organizing properties of bacterial cells. Developmental biologist Kicheva studies the coordination of tissue patterning and growth during vertebrate development. Pietrzak is a computer scientist working in the field of cryptography.

Lab Building West opened

Lab Building West was officially opened on December 1, 2015, after just 30 months of construction. Located on the western part of the campus, it expands the ring of buildings surrounding the pond and green areas in the campus center. Lab Building West has 10'000 sqm floor area spread over six floors, providing space for up to 300 scientists in 20 theoretical and 10 experimental research groups.

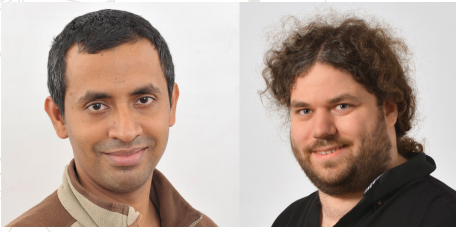
Lab Building West widens the scope of research carried out at IST Austria. A newly established Scientific Service Unit, a nano science facility located on two floors of Lab Building West, planned to be in operation in late 2016, will make this scientific expansion possible. In this cleanroom, novel materials and devices can be fabricated and studied free from contaminants. Using such materials and devices, researchers will be able, for example, to investigate completely new ways of information processing in computers. For the first time, solid state physicists and material researchers will be able to carry out experiments at IST Austria.

Hausel appointed, Wojtan promoted

President Thomas Henzinger announced the appointment of IST Austria's 40th member of its faculty and a promotion to Professor. The Hungarian mathematician Tamás Hausel will join IST Austria as Professor from the École Polytechnique Fédérale de Lausanne (EPFL) in 2016, and computer scientist Chris Wojtan has been promoted to Professor after his successful tenure evaluation.

Henzinger stated: "Tamás Hausel is a major gain for IST Austria and his appointment demonstrates the Institute's attractiveness for excellence. And I congratulate Chris Wojtan on his promotion. IST Austria offers a tenure-track model for scientists with an obligatory evaluation by an international peer review panel."

Hausel's research interests include combinatorial, differential, and algebraic geometry and topology. Wojtan's research focuses on the realistic simulation of complex phenomena in the physical world such as fluids or deformable bodies.



What computers won't tell you about ecological and evolutionary dynamics

In a paper published in PNAS, Postdoc Rasmus Ibsen-Jensen, together with IST Austria Professor Krishnendu Chatterjee and Harvard Professor Martin A. Nowak discovered surprising connections between computer science and biology, two disciplines that study how information proliferates in time and space.

The authors specifically took a look at complexity theory which is part of theoretical computer science as well as mathematics. It classifies algorithms that can solve certain categories of computational problems according to their inherent difficulty. They applied these well-defined classes of complexity to some fundamental questions in biology, namely to the ecological and evolutionary dynamics within structured populations. These research questions investigate how population structures affect the outcome of the evolutionary process.

The researchers found the rather unexpected proof that these fundamental questions in ecology and evolution can be precisely characterized by specific classes of complexity theory, as though these evolutionary processes would mimic aspects of computation. By defining the exact complexity class, they formally proved that these questions cannot be solved with a simple formula.

However, the scientists also demonstrated that two classic problems are indeed efficiently solvable: One is the molecular clock, and the other is the exact fixation probability for a genetic variation to take over in the case of a well-mixed population structure. They used the established methods of computational complexity theory and applied them to the defined evolutionary scenarios in evolutionary game theory and evolutionary graph theory. As a result, they were able to derive the exact complexity class for each of these research questions. The specific complexity class in turn can tell us if an efficient algorithm exists.

Error correction strategies of cells

Cells dynamically respond to environmental signals by turning appropriate sets of genes on or off. The control system depends primarily on the interactions between transcription factor proteins (TFs) and the regulatory DNA sequence. Surprisingly, while multicellular organisms need to regulate more genes compared to bacterial cells, their TFs are less specific and bind promiscuously on many genomic locations, including unsuitable ones.

Models of gene regulation rest on the assumption of a thermodynamic equilibrium. These models seem to concur with the results of experiments with bacterial cells. However, they do not consider the fact that the seemingly low specificity of TFs for their regulatory sites in multicellular organisms could induce erroneous expression of genetic information. This would lead to crosstalk, with disastrous consequences for the cell.

Assistant Professor Gasper Tkačik, together with graduate students Sarah Cepeda-Humerez and Georg Rieckh, examine this scenario in their Physical Review Letters paper. They investigate the importance of crosstalk and its effects, and propose an alternative model. Their work extends the concept of kinetic proofreading. This mechanism has also been crucial in understanding the fantastic ability of the cells to replicate their DNA prior to cell division with extremely high fidelity.

While proofreading reactions provide increased specificity, these reactions take place amongst only a few molecules, and thus lead to increased noise in gene expression. It is therefore unclear whether decreases in crosstalk due to proofreading would not be swamped by an increased noise in gene expression. The authors computed the optimal strategy for the cells to find that proofreading in gene regulation could provide a vast improvement over regulation at thermodynamic equilibrium for multicellular organisms.

Where wood is chopped, splinters must fall

Bacteria and other prokaryotes have been around for billions of years. They possess defense mechanisms that allow them to discriminate between self and non-self DNA in the event of a virus infection. These defense mechanisms are called restriction-modification systems and are based on the balance between the M (methyltransferase) and R (restriction endonuclease) enzymes.

In their Current Biology paper, PhD Student Maros Pleska, Professor Calin Guet, and Postdoc Tobias Bergmiller, with Edo Kussell of New York University and Yuichi Wakamoto of Tokyo University, studied two different restriction-modification systems originating from the bacterium Escherichia coli, named EcoRI and EcoRV. They analyzed populations and single cells carrying these restriction-modification systems and found that EcoRI is indeed prone to erroneously cleave self DNA while EcoRV is not. These autoimmune events are very rare and easily masked by the majority of unaffected cells.

The researchers spotted the rare events of bacterial autoimmunity and showed that when they occur, the SOS response is triggered and specific proteins disengage to repair the damaged DNA. By comparing and counting nearly one hundred thousand bacterial colonies, they found out that under standard conditions, everything works just fine, but the ability to fix the damage is decreased in conditions where resources are scarce.

In addition, the scientists found that the probability of cleaving self DNA is higher for more efficient restriction-modification systems—in this case EcoRI. It almost seems as if these systems are overeager at times in their attempt to protect the cell from harm. The result suggests the existence of an evolutionary tradeoff between enhanced protection against exogenous DNA and increased autoimmunity.

IST Lecture: Thomas C. Südhof

On March 16, 2016, Thomas C. Südhof will give an IST Lecture titled "Towards a molecular logic of neural circuits". He will discuss how neural circuits process information by transmitting and computing signals at synapses. He will hypothesize that interactions between trans-synaptic cell-surface molecules, such as neurexins, determine the molecular logic of neural circuits, and that some autism and schizophrenia syndromes are produced by impairments in this molecular logic, thereby providing a conceptual framework for understanding neural circuits in health and disease.

He has received numerous awards and honors including the Nobel Prize in Physiology and the Kavli Prize in Neuroscience. He has been elected to the National Academy of Sciences of the USA as well as the American Academy of Arts and Sciences. Most recently he was elected as Knight Commander of the Order of Merit of the Federal Republic of Germany in 2015. For information and registration view our website.

Long Night of Research at IST Austria

IST Austria will also be participating in this year's "Long Night of Research". On Friday, April 22, 2016, numerous national research institutions will be opening their doors to the public. The "Long Night of Research" is the biggest research-related event across Austria. Seven research institutions from Lower Austria and research groups at IST Austria will be presenting their current projects in science. Visitors will be able to listen to scientific talks, take part in guided tours, and discuss the latest findings with researchers.

The "Long Night of Research" is a nation-wide event which is funded by the Federal Ministry of Science, Research and Economy and the Ministry for Transport, Innovation and Technology, and supported by the Federal Ministry of Education and Women's Affairs.

Further information can be found on the IST Austria website or on the "Long Night of Research" website.

COLLOQUIUM SPEAKERS

PAST SPEAKERS (November - January): Harry Swinne, University of Texas at Austin (Nov 2) | Andrew V. Goldberg, Amazon.com Inc. (Nov 9) | Erik van Nimwegen, University of Basel (Nov 23) | Daniel Choquet, University of Bordeaux (Dec 14) | Renato Renner, ETH Zurich (Jan 18) | Eske Willerslev, University of Copenhagen (Jan 25)

FUTURE SPEAKERS (March - April): David Forsyth, University of Illinois (March 7) | Naama Barkai, Weizmann Institute of Science (March 14) | Ana Maria Rey, University of Colorado (March 21) | David DiVincenzo, Aachen University (April 4) | Richard Tsien, New York University (April 11) | Marcel Salathé, École polytechnique fédérale de Lausanne (April 18) | Gloria Corruzi, New York University (April 25)

SELECTED RECENT PUBLICATIONS

Barton, Nicholas H: Spread of pedigree versus genetic ancestry in spatially distributed populations. In: Theoretical Population Biology. Academic Press, 1, 2016,1-12.

Edelsbrunner, Herbert, Pausinger, Florian: Approximation and convergence of the intrinsic volume. In: Advances in Mathematics. Academic Press Inc., 2016,674-703.

Fulek, Radoslav, Kynčl, Jan, Malinovič, Igor, Pálvölgyi, Dömötör: Clustered planarity testing revisited. In: Electronic Journal of Combinatorics. Electronic Journal of Combinatorics, 4, 2015, Article number: P4.24

Kolmogorov, Vladimir, Rolinek, Michal, Takhanov, Rustem: Effectiveness of structural restrictions for hybrid CSPs. In: ISAAC: International Symposium on Algorithms and Computation. Unknown, 2015,preprint.

Kovács, Krisztián A, Steinmann, Myriam, Halfon, Olivier, Magistretti, Pierre J, Cardinaux, Jean-René: Complex regulation of CREB-binding protein by homeodomain-interacting protein kinase 2. In: Cellular Signalling. Elsevier, 11, 2015,2252-2260.

Maas, Jan, Rumpf, Martin, Schönlieb, Carola B, Simon, Stefan: A generalized model for optimal transport of images including dissipation and density modulation. In: ESAIM: Mathematical Modelling and Numerical Analysis. EDP Sciences, 6, 2015,1745-1769.

Pavlogiannis, Andreas, Chatterjee, Krishnendu, Adlam, Ben, Nowak, Martin A: Cellular cooperation with shift updating and repulsion. In: Scientific Reports. Nature Publishing Group, 17147, 2015, Article number: 17147.

Pentina, Anastasia, Lampert, Christoph H: Lifelong learning with non-i.i.d. tasks. In: NIPS: Neural Information Processing Systems. Neural Information Processing Systems, 2015, Epub ahead of print.

Sadel, Christian: Anderson transition at 2 dimensional growth rate on antitrees and spectral theory for operators with one propagating channel. In: Annales Henri Poincare. Birkhäuser, 2015, Epub ahead of print.

Tuğrul, Murat, Paixao, Tiago, Barton, Nicholas H, Tkačik, Gašper: Dynamics of transcription factor binding site evolution. In: PLoS Genetics. Public Library of Science, 11, 2015, Article number: e1005639.

A full list of publications from IST Austria can be found at publist.ist.ac.at.

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