NEWSLETTER 25th edition | Summer 2018

IST AUSTRIA
Institute of Science and Technology

## Foreword

Gene expression starts with the transcription of DNA into RNA. The RNA commonly serves as a template for the production of proteins. However, RNA is more than just a messenger; RNA is a focal point for gene regulation and has many functions beyond its role in protein production. During my PhD at the University of Colorado and postdoctoral research at LMU Munich and MPI for Biophysical Chemistry, I studied several aspects of how RNA is transcribed from the genome. In the future, I plan to study the detailed mechanisms of gene regulation mediated by the product RNA.

Many RNA-containing complexes are flexible, modular, and lowly abundant in the cell, making them challenging targets for structural studies. To obtain these insights, I use single-particle cryo-electron microscopy, collecting many 2D images of macromolecular complexes frozen in vitrified ice and then combining them computationally into a 3D reconstruction of the original structure. Images of single particles can be clustered into distinct subsets, thereby visualizing many states of a flexible complex and providing insight into how the molecule moves as it fulfills its biological function.

As I make use of the latest generation of microscopes and detectors, I have been impressed by IST Austria's commitment to providing an outstanding scientific infrastructure, in particular by the large investment into state-of-the-art microscopy equipment. Since joining the campus this January, I have enjoyed getting to know my colleagues and look forward to new interactions and potential collaborations.

Carrie Bernecky | Assistant Professor, IST Austria

## Professor Herbert Edelsbrunner awarded ERC Advanced Grant

In the latest round of funding awards, IST Austria Professor Herbert Edelsbrunner received an ERC Advanced Grant. Mathematician and computer scientist Edelsbrunner uses topology, algorithms, and computer software to answer questions related to the recognition, matching, and classification of shape that arise in a variety of applications. In his ERC project "Alpha Shape Theory Extended", he will work to fully develop a larger theory that unites several of the topics that he has worked on before: alpha shapes, wrap complexes, and persistent homology.

Thomas Henzinger, President of IST Austria, congratulates the awardee: "Herbert Edelsbrunner's work exemplifies both the high quality and the interdisciplinary nature of the research performed on campus, and I look forward to seeing further connections between the mathematical and experimental sciences—one of the Institute's characteristic strengths."

## 90 new apartments on IST Austria campus

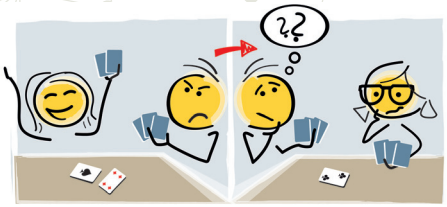
In mid-April IST Austria celebrated the opening of 90 new apartments on campus. Funded by the Lower Austrian government, designed by architect Ernst Maurer and constructed by the Krems-based company GEDESAG, the apartments are a mix of one-bedroom and two-bedroom units, furnished in a contemporary style with wood-laminate flooring in the kitchens and living areas. Clustered in a wonderful green area, the apartments in the nine residential buildings will contribute to turning the research campus into a place for living.

The festive opening ceremony was held in the Raiffeisen Lecture Hall. In their speeches, Governor Johanna Mikl-Leitner, Mayor Stefan Schmuckenschlager and President Thomas Henzinger emphasized the importance of the new IST Austria apartments, making the campus in Klosterneuburg even more attractive for first-class researchers. The symbolic handing over of the keys to the first renters concluded the celebration.

## HFSP Research Grant and Fellowships for scientists for IST Austria scientists

IST Austria Professor Gašper Tkačik is part of a transatlantic collaboration funded by the Human Frontiers Science Program (HFSP). In the funded project, Christian Landry at Université Laval, Quebec, Judit Villen at University of Washington, Seattle, and Gašper Tkačik at IST Austria will combine their expertise in theoretical biophysics, proteomics, and experimental evolution to investigate how cells face the problem of crosstalk.

Three postdocs also received Postdoctoral Fellowships by the HFSP: Anton Sumser will investigate neuronal networks of salience and spatial detection in the superior colliculus of mice. Diana Pinheiro will study the coordination of mesendoderm fate specification and internalization during zebrafish gastrulation. Wiebke Jahr will use high-speed 3D-nanoscopy to study the role of adhesion during 3D cell migration. Postdoctoral fellowships allow talented early career scientists to obtain training in a new research area in an outstanding laboratory.

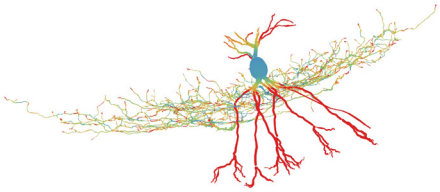


## Researchers develop first model to capture crosstalk in social dilemmas

In their Nature Communications paper, researchers developed a new framework for the quantitative evaluation of the effects of crosstalk on cooperation dynamics in a population. The team includes co-first authors Johannes Reiter, IST Austria alumnus and current Stanford Instructor, and Christian Hilbe, a postdoc at IST Austria, as well as Professors David Rand, Krishnendu Chatterjee, and Martin Nowak, of Yale, IST Austria, and Harvard, respectively. Their various expertises and perspectives, including evolutionary dynamics, game theory, psychology, and economics, all played a role in helping to create their new model.

In a given simulation, each virtual player has a memory of the games played with each of the other players. In previous models, a player would review their past with their current opponent, and decide on a course of action based on this past and their game strategy. In the new model, there is some chance that these memories will be replaced with the memories corresponding to a third player. This method of encoding crosstalk accounts for all the many varieties of crosstalk—from a group where everyone knows everyone else to a circle to a random mess of connections.

This results in cooperative and defective behavior spreading much more easily—even a single defective player can cause the complete breakdown of cooperation in a society, if the other players are not sufficiently forgiving. But crosstalk also necessitates strategies with the "correct" level of forgiveness: too harsh, and you end up with a society where no one cooperates, too generous, and defection can also spread as players learn to take advantage of other players. Crosstalk moreover hinders the evolution of cooperation: the authors implemented an evolutionary model, and found that crosstalk decreases the number of different starting societies that end up in stable cooperative states.

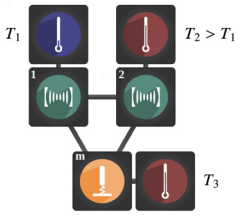


## Certain type of neurons is more energy efficient than previously assumed

Theory and reality don't always match completely. One contradiction about how a type of neurons generates signals was now resolved by researchers at IST Austria. In their Neuron study, Professor Peter Jonas and first author Hua Hu reconcile the observation that fast-spiking, parvalbumin-expressing GABAergic interneurons ($PV^+$-BCs) send trains of rapid signals, thought to be energy expensive, with the limited energy supply reaching the brain. They show that ion channels in the neuron are tuned so that rapid signals are energy efficient. $PV^+$-BCs are important in higher microcircuit functions, such as pattern separation, i.e. making similar patterns of neural activity more distinct, so we can distinguish between similar experiences.

Jonas and Hu investigated how the signaling properties of $PV^+$-BCs neurons can be reconciled with the limited energy supply to the brain. Surprisingly, this theoretical contradiction does not translate to reality. Studying functioning neurons is the only way to obtain the desired information, and the researchers therefore used brain slices to examine the axon of firing $PV^+$-BCs, where action potentials (APs) are initiated and propagate. To obtain direct information from the axon, they used a technique called subcellular patch-clamp recording, or "nanophysiology". They found that the energy required to generate the characteristic APs is only 1.6 times the theoretical minimum. Thus, APs in $PV^+$-BCs are surprisingly energy efficient.

Hu and Jonas found that the specialized ion channels in $PV^+$-BCs neurons are gated to optimize both fast signalling and energy efficiency. $Na^+$ channels in $PV^+$-BCs axons are inactivated very rapidly, while the Kv3-type $K^+$ channels are activated with a delay. This complementary tuning minimizes the overlap between $Na^+$ and $K^+$ currents during brief APs and optimizes signalling, so that it is both fast and energy efficient.




## Interference as a new method for cooling quantum devices

Quantum computer parts are sensitive and need to be cooled to very low temperatures. Their tiny size makes them particularly susceptible to a temperature increase due to the thermal noise that is produced by the environment and other components nearby. Shabir Barzanjeh, a postdoc in the research group of Professor Johannes Fink at IST Austria, together with André Xuereb from the University of Malta and Matteo Aquilina from the National Aerospace Centre in Malta has now proposed a novel method to keep quantum devices cool. Their approach, which they have proven to work theoretically, relies on quantum interference.

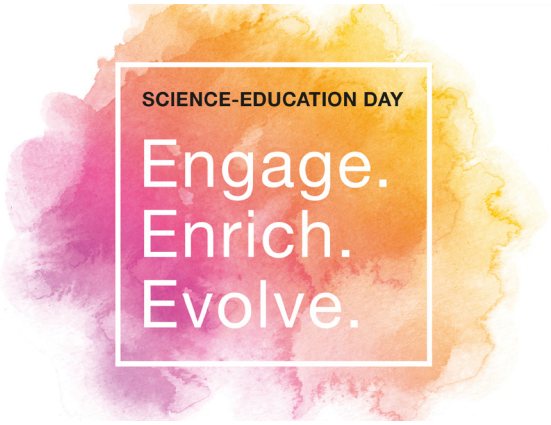
If a hotter object is placed next to a cooler one, the heat normally has only one option: it can only flow from the hotter object to the cooler one. Therefore, if one wants to cool an object that is already cooler than its surroundings, like it is done in a household fridge, an effort has to be made to achieve this. A new method for cooling down the elements of quantum devices such as qubits, the tiny building blocks of quantum computers, was now theoretically proven to work by a group of physicists.

"Essentially the device we are proposing is working like a fridge. But here we are using a quantum mechanical principle to realize it," explains Shabir Barzanjeh, the lead author of the study. In their Physical Review Letters paper, they studied how thermal noise flows through quantum devices and devised a method that can prevent the heat flow from warming up the sensitive quantum device. The secret lies in an additional heat bath, in other words: besides the object that needs to be cooled and the object that produces heat, there is a third object that can store heat, a so-called "heat bath". This heat bath is connected to both other devices, and the researchers showed that it is possible to control its heat flow such that it cancels the heat coming from the warm object directly to the cool one via special quantum interference.

## Open Campus on May 27

IST Austria will open its doors on Sunday, May 27, from 12:00-18:00. The Open Campus is the Institute's annual science festival with an interactive research exhibition. Everyone is invited to visit and perform hands-on experiments, explore the labs and other facilities during a campus tour, and attend the family lecture to learn more about basic research topics. Another highlight is the award ceremony for the winners of this year's school competition. Visitors will also find a variety of food, drink, and music, as well as a children's program that provides entertainment and information for children from 3 to 12 years old. Free shuttle buses from Vienna and Tulln will travel to and from campus on an hourly basis.


For information and registration visit our website.




## Science-Education Day on May 24

IST Austria cordially invites you to its first Science-Education Day on May 24 in the Raiffeisen Lecture Hall. Sharing the wonder and excitement of science and the methods of scientific research as well as communicating the resulting discoveries have become increasingly important missions for scientific institutions as they seek to reach out to local and global communities. IST Austria's first Science-Education Day will be about "Engage. Enrich. Evolve." and will provide a forum for international perspectives and exchange on a variety of topics in science education, with a focus on designing activities for children and teenagers and working effectively with teachers.

For further information view our website.

## COLLOQUIUM SPEAKERS

**PAST SPEAKERS:** Elaine Fuchs, The Rockefeller University (Mar 5) | Olga Sorkine-Hornung, ETH Zurich (Mar 12) | Lieven Vandersypen, TU Delft (Mar 19) | Luca Cardelli, Microsoft Research (Apr 9) | Yukiko Goda, RIKEN Brain Science Institute (Apr 16) | Jürg Fröhlich, ETH Zurich (Apr 23) | Walter Fontana, Harvard University (Apr 30)

**FUTURE SPEAKERS:** Edvard Moser, Norwegian University of Science and Technology (May 7) | Gil Kalai, The Hebrew University of Jerusalem (June 11) | Alysson Muotri, University of California San Diego (June 18)

## SELECTED RECENT PUBLICATIONS

Akopyan, Arseniy V, Bobenko, Alexander I: Incircular nets and confocal conics. In: Transactions of the American Mathematical Society. American Mathematical Society, 4, 2018, 2825-2854.

Hilbe, Christian, Chatterjee, Krishnendu, Nowak, Martin A: Partners and rivals in direct reciprocity. In: Nature Human Behaviour. Nature Publishing Group, 2018, 1-9.

Bodová, Katarína, Mitchell, Gabriel J, Harpaz, Roy, Schneidman, Elad, Tkačik, Gašper: Probabilistic models of individual and collective animal behavior. In: PLoS One. Public Library of Science, 3, 2018, Article number: e0193049.

Fischer, Julian, Grün, Günther: Existence of positive solutions to stochastic thin-film equations. In: SIAM Journal on Mathematical Analysis. Society for Industrial and Applied Mathematics , 1, 2018, 411-455.

Pleska, Maros, Lang, Moritz, Refardt, Dominik, Levin, Bruce R, Guet, Calin C: Phage-host population dynamics promotes prophage acquisition in bacteria with innate immunity. In: Nature Ecology and Evolution. Springer Nature, 2, 2018, 359-366.

Sacco, Roberto, Cacci, Emanuele, Novarino, Gaia: Neural stem cells in neuropsychiatric disorders. In: Current Opinion in Neurobiology. Elsevier, 2018, 131-138.

Tomasek, Kathrin, Bergmiller, Tobias, Guet, Calin C: Lack of cations in flow cytometry buffers affect fluorescence signals by reducing membrane stability and viability of Escherichia coli strains. In: Journal of Biotechnology. Elsevier, 2018, 40-52.

Kühnen, Jakob, Song, Baofang, Scarselli, Davide, Budanur, Nazmi B, Riedl, Michael, Willis, Ashley P, Avila, Marc, Hof, Björn: Destabilizing turbulence in pipe flow. In: Nature Physics. Nature Publishing Group, 2018.

Novarino, Gaia: Zika-associated microcephaly: Reduce the stress and race for the treatment. In: Science Translational Medicine. American Association for the Advancement of Science, 423, 2018, Article number: eaar7514.

Prat, Tomas, Hajny, Jakub, Grunewald, Wim, Vasileva, Mina, Molnar, Gergely, Tejos, Ricardo, Schmid, Markus, Sauer, Michael, Friml, Jiří: WRKY23 is a component of the transcriptional network mediating auxin feedback on PIN polarity. In: PLoS Genetics. Public Library of Science, 1, 2018, Article number: e1007177.

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

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