NEWSLETTER 26th edition | Fall 2018

IST AUSTRIA
Institute of Science and Technology

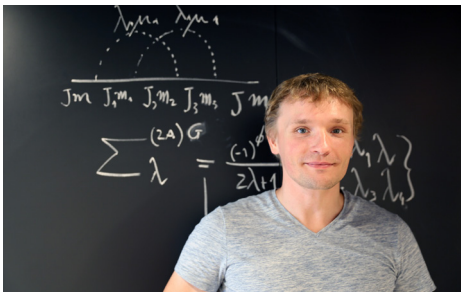
Foreword

More than half a century ago, the first quantum revolution gave us lasers and transistors. Today we are going through a second quantum revolution, creating new quantum-enhanced technologies for information processing, communications, and sensing. My interests fall in the sensing branch, where the concept of quantum entanglement is used to devise new sensing protocols and enhance existing sensors such as atomic clocks, magnetometers, and gravimeters.

I am an experimental atomic and optical physicist. I did my PhD at the University of Illinois at Urbana-Champaign in the fields of quantum optics and quantum information, developing advanced optical precision sensing techniques. From there, I went on to Stanford University and focused on atomic physics experiments interfacing trapped cold atoms with optical cavities. At IST Austria, I intend to develop new sensing techniques based on quantum entanglement. My goal is to study the underlying physics in these experiments as well as to utilize these sensors to do precision tests of fundamental physical laws.

I have officially been part of IST Austria for one month at the time of writing. I have just received my lab spaces without any delays following a relatively complicated eight-month planning and construction period—a token of the level of dedication displayed at the Institute. I am very excited about the enthusiasm and ambition among the faculty. With this magical feeling in the air, I am eager to do impactful work as a part of this unique institution.

Onur Hosten | Assistant Professor, IST Austria



ERC Starting Grant awarded to Mikhail Lemeshko

Theoretical physicist Mikhail Lemeshko was awarded a European Research Council (ERC) Starting Grant. In his project, which the ERC will support with about 1.5 million Euros, he will establish a general theory of a quasiparticle, the angulon, that he discovered during his time at IST Austria. The angulon quasiparticle is expected to help tackle previously unsolvable problems in various fields, ranging from physical chemistry to data storage technology.

Mikhail Lemeshko joined IST Austria four years ago following three years as an independent postdoctoral fellow at Harvard University. Last year, he was awarded the Ludwig Boltzmann Prize of the Austrian Physical Society. His research group focuses on the physics of quantum impurities possessing orbital angular momentum. Currently, the group includes two postdocs and three PhD students, and is expected to grow substantially with the newly available ERC funding.

IST Austria celebrates 18 new PhD graduates

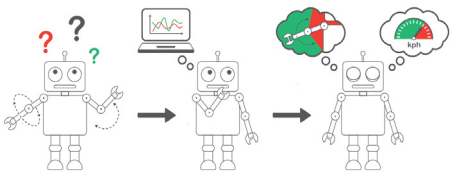
On June 29, IST Austria celebrated 18 new graduates of the Institute's PhD program. This is the largest class yet, and brings the total number of PhD alumni to 50. After years of dedication, learning, and independent research, these new alumni will go on to pursue careers in academia, industry, and education.

Educating PhD students is a core mission of IST Austria, and these new graduates represent future leaders not only in academia, but in any careers they choose to pursue. This year's class is diverse in background—comprising eleven different nationalities—and area of research. Many have already started in their first post-graduate jobs, which have taken them all over the world and include teaching, industry research, and postdoc positions at top universities. Wherever they go next, and whatever their focus, IST Austria looks forward to watching their progress and following their successes as they make their marks on the world.

Dan Alistarh receives ERC Starting Grant

Computer scientst Dan Alistarh received a European Research Council (ERC) Starting Grant. In his project, which the ERC will support with about 1.5 million Euros, he plans to use new approaches to dramatically decrease the time it takes to train large-scale machine learning models. Currently it can be hard to distribute machine learning computation efficiently among many computation nodes. This is what Dan Alistarh wants to change by leveraging the robustness of machine learning algorithms to noise in order to distribute efficiently.

Dan Alistarh obtained a double degree in mathematics and computer science before he did his PhD in distributed computing at the École Polytechnique Fédérale de Lausanne (EPFL). Afterwards, he worked as a researcher at the Massachusetts Institute of Technology, Microsoft Research Cambridge (UK), and ETH Zurich. In 2017, he joined IST Austria where he leads a research group "Distributed Algorithms and Systems".

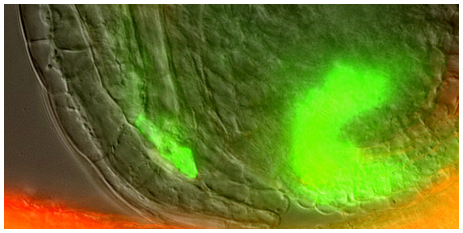


First machine learning method capable of accurate extrapolation

Understanding how a robot will react under different conditions is essential to guaranteeing its safe operation. But how do you know what will break a robot without actually damaging it? A new method developed by scientists at IST Austria and the Max Planck Institute for Intelligent Systems in Tübingen is the first machine learning method that can use observations made under safe conditions to make accurate predictions for all possible conditions governed by the same physical dynamics. Especially designed for real-life situations, their method provides simple, interpretable descriptions of the underlying physics. The researchers presented their findings at this year's prestigious International Conference for Machine Learning.

In the past, machine learning was only capable of interpolating data—making predictions about situations that are "between" other, known situations. It was incapable of extrapolating—making predictions about situations outside of the known—because it learns to fit the known data as closely as possible locally, regardless of how it performs outside of these situations. In addition, collecting sufficient data for effective interpolation is both time- and resource-intensive, and requires data from extreme or dangerous situations. But now, Georg Martius, former IST Austria postdoc and since 2017 group leader at MPI for Intelligent Systems, PhD student Subham S. Sahoo, and IST Austria professor Christoph Lampert developed a new machine learning method that addresses these problems. It is the first machine learning method to accurately extrapolate to unseen situations.

The key feature of the new method is that it strives to reveal the true dynamics of the situation: it takes in data and returns the equations that describe the underlying physics. That is what allows the method to extrapolate reliably, making it unique among machine learning methods.



Plant mothers talk to their embryos via the hormone auxin

While pregnancy in humans and seed development in plants look very different, parallels exist—not least that the embryo develops in close connection with the mother. In animals, a whole network of signals from the mother is known to influence embryo development. In plants, it has been clear for a while that maternal signals regulate embryo development. However, the signal itself was unknown – until now. Plant scientists at IST Austria, CEITEC, and the University of Freiburg have found that a plant hormone from the mother, called auxin, is one of the signals that pattern the plant embryo. Their Nature Plants study is a collaboration between Jiří Friml and his group, notably Helene S. Robert, a former post-doc of Friml and now group leader at CEITEC in Brno, and the group of Thomas Laux at the University of Freiburg.

"Plant scientists have been trying to figure out the nature of the signal between mother and embryo for decades", explains IST Austria Professor Jiří Friml. "We show that the mother is the source of auxin which regulates early embryo development." Auxin is a hormone that plays many roles in the development of plants, and has been known to regulate embryo development. By visualizing the biosynthesis of and the response to auxin, the researchers show that the maternal tissue that surrounds the embryo in the seed starts to produce more auxin after fertilization.

The authors show that this increased maternal auxin production is crucial for the embryo: when auxin production is interrupted, the embryo does not develop correctly. And it is maternal auxin in particular that plays this important role. When the researchers set up a cross between plants so that the mother does not produce auxin but the embryo does, the same defects in embryo development are observed—proving that auxin from the mother is the key developmental signal.

Engineering cooperation

When what we want as individuals clashes with what is best for the group, we have a social dilemma. How can we overcome these dilemmas, and encourage people to cooperate, even if they have reason not to? In a Nature paper, Christian Hilbe and Krishnendu Chatterjee of IST Austria, together with Martin Nowak of Harvard and Stepan Simsa of Charles University, have shown that if the social dilemma that individuals face is dependent on whether or not they work together, cooperation can triumph. This finding is the result of a new type of framework that they introduced—one that extends the entire theory of repeated games.

The tragedy of the commons: if we can (ab)use a public good without seeing negative consequences, we will—without consideration of others or the future. We see examples of this in our daily lives, from climate change and forest depletion down to the stack of dirty dishes in the office kitchen. In game theory, scientists have used repeated games to understand when individuals choose to cooperate, i.e. their strategies. However, these games have always kept the value of the public resource constant, no matter how players acted in the previous round. In their new framework, the scientists consider repeated games in which cooperation does not only affect the players' present payoffs, but also which game they face in the next round.

When they explored the new model, they found that this dependence on players' actions could greatly increase the chance that players cooperate. "Our framework shows which kinds of feedback are most likely to lead to cooperation," says first author Christian Hilbe. "Using this knowledge, you can design systems that maximize cooperation, or create an environment that encourages people to work together," he adds. For example, these ideas could even be implemented by a business or corporation, to create a community that encourages working together.

Science-Industry Day 2018

US and European universities have been actively engaged in technology transfer since the early 2000s. Licensing and liaison offices have been set up to match technologies with corporate partners. How do their efforts on a micro level, i.e. finding the best available partner worldwide, relate to the macro perspective of tech-based competition between countries and regions?

This year's Science Industry Day, "Micro. Macro. Global.", will take place on September 26th. Organized jointly by IST Austria and the Federation of Austrian Industries (IV), it will offer an afternoon program for young researchers and founders. The evening event will feature a panel discussion with experts and specialists in technology transfer. For information and registration visit the website.

The role of competitive research funding in science

IST Austria and the Federal Ministry of Education, Science and Research (BMBFW) have organized a high-profile event on the occasion of Austria's Presidency of the Council of the European Union. On October 22nd, the role of competitive research funding in science will be discussed from different angles: What are competitive research grants? What societal and institutional factors should be considered when implementing them? And what is the impact of competitive research grants on society? Top speakers from all across Europe will come together to share their views on project-related funding in an institutional framework. The goal will be to provide a platform for exchange and discussion in the area of public sector research with a special focus on curiosity-driven research. For information and registration see the website.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: 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) | Edvard Moser, Norwegian University of Science and Technology (May 7) | Alysson Muotri, University of California San Diego (June 18)

FUTURE SPEAKERS: Gil Kalai, The Hebrew University of Jerusalem (Sept 3) | Orna Kupferman, The Hebrew University of Jerusalem (Sept 10) | John O'Keefe, University College London (Sept 17) | Wolf Singer, Max Planck Institute for Brain Research (Sept 24) | Grant Jensen, Caltech (Oct 1) | Immanuel Bloch, Ludwig Maximilian University of Munich (Oct 29)

SELECTED RECENT PUBLICATIONS

Abbas, Mohamad, Hernández García J, Pollmann, Stephan, Samodelov Sophia L, Kolb Martina, Friml, Jiří, Hammes Ulrich Z, Zurbriggen Matias D, Blázquez, Miguel A, Alabadí, David: Auxin methylation is required for differential growth in Arabidopsis. In: PNAS. National Academy of Sciences, 26, 2018.

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Edelsbrunner, Herbert, Osang, Georg: The multi-cover persistence of Euclidean balls. In: SoCG: Symposium on Computational Geometry (Leibniz International Proceedings in Information, LIPIcs). Schloss Dagstuhl - Leibniz-Zentrum für Informatik, 2018, 341-3414.

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Fulek, Radoslav, Kynčl, Jan: The Z2-Genus of Kuratowski minors. In: SoCG: Symposium on Computational Geometry (Leibniz International Proceedings in Information, LIPIcs). Schloss Dagstuhl - Leibniz-Zentrum für Informatik, 2018, 401-414.

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Grones, Peter, Abas, Melinda, Hajny, Jakub, Jones Angharad, Waidmann Sascha,, Kleine-Vehn, Jürgen, Friml, Jiří: PID WAG mediated phosphorylation of the Arabidopsis PIN3 auxin transporter mediates polarity switches during gravitropism. In: Scientific Reports. Springer, 1, 2018, Article number: 10279.

Ratheesh, Aparna, Biebl, Julia, Vesela Jana,, Smutny, Michael, Papusheva, Ekaterina, Krens, Gabriel, Kaufmann, Walter, György, Attila, Casano, Alessandra M, Siekhaus, Daria E: Drosophila TNF modulates tissue tension in the embryo to facilitate macrophage invasive migration. In: Developmental Cell. Elsevier, 3, 2018, 331-346.

Yakaboylu, Enderalp, Lemeshko, Mikhail: Anyonic statistics of quantum impurities in two dimensions. In: Physical Review B - Condensed Matter and Materials Physics. American Physical Society, 4, 2018, Article number: 045402.

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

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