

Foreword



When I studied medicine in Innsbruck, I truly enjoyed looking at human biology from a diverse set of perspectives—from health to disease, from individual molecules to complex systems, from straightforward causation to the emergence of consciousness. While delving deeper into the biology, I wondered about the fundamental principles that determine how matter behaves. Thereby lured to physics, I got captivated.

After graduating in medicine and physics, I could not resist the temptation to explore the oddities of quantum physics. During my PhD in the field of ultra-cold quantum gases we used light to achieve perfect control over molecules at nano-Kelvin temperatures. For my postdoctoral research, I set out to reconcile the two fields by putting (optical) physics to good use in a biological context at the Max Planck Institute for Biophysical Chemistry in Göttingen, where I worked on high-resolution optical imaging.

What struck me first about IST Austria was the exceptionally high quality of the discussions on how the advanced light microscopy tools in my group and the biology and physics efforts at IST Austria could synergize. I am excited to set up my lab in this truly interdisciplinary and inspiring setting, look forward to using our optical methods to “look at” biology and see how we can contribute to the understanding of molecules, cells, tissues, and how they act together in the organism.

Johann Georg Danzl | Assistant Professor, IST Austria



ERC Advanced Grant for IST Austria Professor Carl-Philipp Heisenberg

Biologist Carl-Philipp Heisenberg has received an ERC Advanced Grant. In his project “Interaction and Feedback between Cell Mechanics and Fate Specification in Vertebrate Gastrulation”, he will study the interplay between the different mechanisms that determine the shape of an embryo.

To accomplish this, Heisenberg will focus on a specific phase of embryonic development called gastrulation. During this phase, an initially unstructured cluster of cells is transformed into an embryo consisting of three germ layers: the ectoderm, endoderm and mesoderm.

Heisenberg will combine an experimental approach involving genetic, cell biological, and biophysical experiments with mathematical modelling—an innovative approach that might provide answers to an as-of-yet unresolved question in developmental biology: how cell mechanics, dynamics, and genetics work together to give an embryo its shape.



IST Austria strengthens Austria's position as science base

In 2007, the European Research Council (ERC) was established by the EU as an initiative to fund excellent science in Europe. On average, the chances of obtaining one of its highly sought-after grants—worth 1.5 to 2.5 million Euros—is 10-13%. IST Austria can be proud of a success rate of almost 50%. More than 60% of IST Austria's professors under contract have obtained one or more ERC grants and have brought ERC funding worth a total of 48.9 million Euros to Austria. Together with 13.4 million Euros in funding from other European programs, this brings the total EU funding brought to Austria by the Institute to more than 62 million Euros. This money not only provides the resources necessary to conduct excellent research, it allows professors to hire additional students and postdocs, thus creating employment opportunities in Austria. The ERC has contributed 58% of IST Austria's third-party funding. 23% comes from other international sources, and 19% from national funding sources, primarily the Austrian Science Fund (FWF), at 17%.

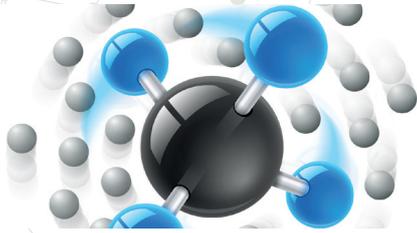


ERC Advanced Grant for IST Austria Professor Jiří Friml

Plant biologist Jiří Friml has been awarded an ERC Advanced Grant. In his project “Tracing Evolution of Auxin Transport and Polarity in Plants” he will study the transport of the plant hormone auxin from a novel perspective.

The patterning of tissues by the hormone auxin is a crucial developmental mechanism in plants. Auxin gradients are formed by polarized transport of the hormone within plant tissues, which depends on transport proteins called PIN auxin transporters. The methods currently used to study these transport proteins have so far been unable to solve long-standing questions regarding their structure and regulation.

In his project, Friml will use an innovative, evolution-based approach to understand PIN-dependent auxin transport. This will provide insights not only into the evolution of PIN transporters, but also into their structure, functional domains, and regulation.



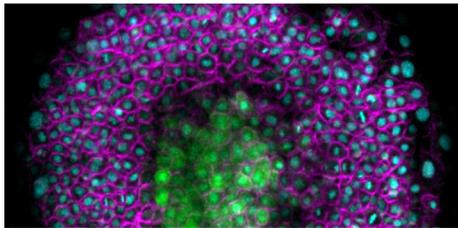
Existence of a new quasiparticle demonstrated

How do molecules rotate in a solvent? Answering this question is a complicated task as the molecular rotation is perturbed by the surrounding atoms. Large-scale computer simulations have long been the main approach to model molecule-solvent interactions. However, they are extremely time consuming and sometimes completely infeasible. IST

Austria Professor Mikhail Lemeshko has now proven that angulon quasiparticles do in fact form when a molecule is immersed in superfluid helium.

In physics, the concept of quasiparticles is used to simplify the description of many-particle systems. Instead of modeling interactions between trillions of individual particles, one identifies building blocks that interact with one another only weakly. These building blocks are called quasiparticles. For example, consider a running horse in a cloud of dust. One can think of it as a quasiparticle consisting of the horse and the dust cloud moving along with it. Understanding what is going on in terms of such a “quasi-horse” is significantly easier than treating every dust grain—not to mention the horse—separately in a complicated simulation.

The example is similar to what Lemeshko did in his *Physical Review Letters* study. Instead of treating the rotating molecule and all the atoms of the surrounding material separately, he used angulons quasiparticles to look at the problem from a different perspective. Angulons were predicted theoretically two years ago. Until now, however, they had never been observed. Lemeshko’s study is based on experimental data collected over the last two decades. All the experiments had one thing in common: molecules of different types were observed to rotate inside tiny droplets of superfluid helium. Independent of the molecule being studied, the experimental measurements were always in good agreement with the outcomes predicted by angulon theory, indicating that angulon quasiparticles do in fact form inside helium droplets.



Friction shapes zebrafish embryos

A simple ball of cells is the starting point for both humans and zebrafish, but at the end of embryonic development, a fish and a human look very different. The biochemical signals affecting this process have been studied extensively, but the effects of mechanical forces on the shaping of the embryo were previously relatively unknown. IST Austria Professor Carl-Philipp Heisenberg and his research

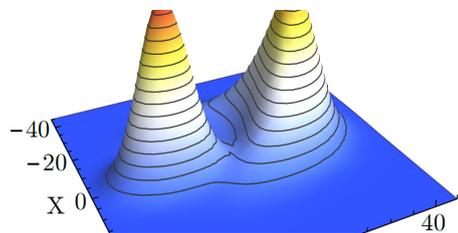
group address this gap in their study recently published in *Nature Cell Biology*. In this work, they show that friction between moving tissues generates a force that shapes the nervous system in the case of a zebrafish embryo, a popular animal model of embryonic development.

In order to establish the underlying mechanisms, the Heisenberg Group developed a theoretical model based on their observations. Through their model, they found that the movement of one of the three germ layers (the neurectoderm) against the other two (the mesoderm and the endoderm—collectively, the mesendoderm) causes friction between the layers.

The team moreover built a physical version of their

model in the lab. This consisted of culturing a layer of ectoderm cells in a dish, then moving it in one direction while pushing a bead coated in E-cadherin (a cell-cell adhesion molecule*) in the opposite direction. They observed that the ectoderm cells reoriented in the same manner as in the embryo. This finding shows that mesendoderm cells directly affect the movement of the neurectoderm cells through friction, and thus that friction is a key regulator of tissue morphogenesis in the embryo.

Neurectoderm morphogenesis defects are one of the most common birth defects in humans. The Heisenberg Group’s findings indicate that a previously unrecognized mechanism might underlie these birth defects: the friction that arises between developing germ layers.



Quantum phase transition observed for the first time

A group of scientists led by IST Austria Professor Johannes Fink reported the first experimental observation of a first-order phase transition in a dissipative quantum system. We encounter phase transitions in everyday life when we watch the change of the state of matter, for example the freezing of water at the critical temperature of 0 degrees

Celsius. However, phase transitions also occur at the quantum mechanical level, where they are relatively unexplored.

One example of a phase transition at the quantum level is photon-blockade breakdown, which was discovered only two years ago. During photon blockade, a photon fills a cavity in an optical system and prevents other photons from entering the same cavity until it leaves, hence blocking the flow of photons. If the photon flux increases to a critical level, a quantum phase transition was predicted to occur: the photon blockade breaks down, and the state of the system changes from opaque to transparent. Fink and his collaborators managed to create the very specific conditions necessary to study this effect in full, and have experimentally observed

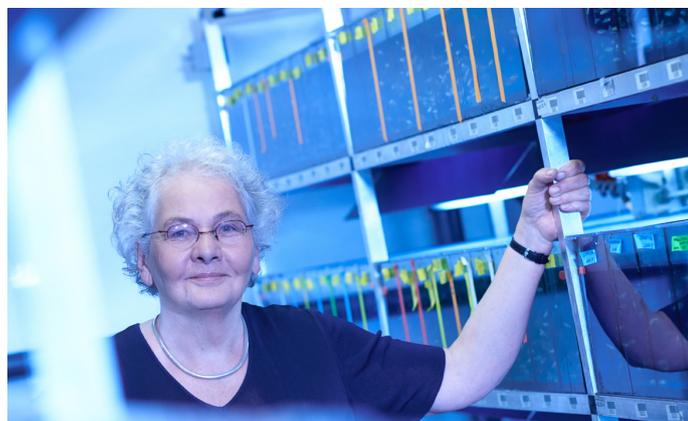
this phase transition.

During a phase transition, the continuous adjustment of an external parameter, for example temperature, leads to a transition between two robust steady states with different attributes. First-order phase transitions are characterized by a coexistence of the two stable phases when the control parameter is within a certain range close to the critical value. The two phases form a mixed-phase in which some parts have completed the transition and others have not, like in a glass in which ice and water are present at the same time. The experimental results published by Fink and his collaborators in *Physical Review X* give an insight into the quantum mechanical basis of this effect in a microscopic, zero-dimensional system.

Open Campus 2017

IST Austria will open its doors on Sunday, May 21, from 12-6pm. 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 further information please visit the [website](http://www.open-campus.at).



2nd ÖAW-IST Austria Lecture

The ÖAW-IST Austria Lecture series brings to Austria speakers of the highest international standing active in fields that are of interest to both institutions and to the wider public. The lecture series will be continued by Christiane Nüsslein-Volhard on May 30 at 6:30pm in the Festive Hall of the Austria Academy of Sciences. She is Honorary Professor at the University of Tübingen and former Director of the Max Planck Institute for Developmental Biology. In 1995, Nüsslein-Volhard was awarded the Nobel Prize for Medicine or Physiology. In "The Development of Colour Patterns in Fishes: Towards an Understanding of the Evolution of Beauty" she will explain how collective migration of pigment cells, cell interaction and the influence of the tissue environment cause the different color patterns observed in fish.

For information and registration, please visit the [website](http://www.open-campus.at).

COLLOQUIUM SPEAKERS

PAST SPEAKERS (March - April): Elaine Ostrander, National Institutes of Health (Mar 6) | Frank Jülicher, Max Planck Society (Mar 13) | Fiona Doetsch, University of Basel (Mar 20) | Erik Sahai, The Francis Crick Institute (Mar 27) | Daniel A. Fletcher, University of California, Berkeley (Apr 3) | Claudia Bagni, Katholieke Universiteit Leuven (Apr 10) | Ottoline Leyser, University of Cambridge (Apr 24)

FUTURE SPEAKERS (May - June): L Mahadevan, Harvard University (May 8) | Konrad Lehnert, University of Colorado Boulder (May 15) | Dianne Newman, California Institute of Technology (May 22) | Irit Dinur, Weizmann Institute of Technology (June 19)

SELECTED RECENT PUBLICATIONS

Alt, Johannes, Erdős, László, Krüger, Torben: Local law for random Gram matrices. In: *Electronic Journal of Probability*. The Institute of Mathematical Statistics and the Bernoulli Society, 2017, Article Number: 25.

Chatterjee, Krishnendu, Osang, Georg: Pushdown reachability with constant treewidth. In: *Information Processing Letters*. Elsevier, 2017, 25-29.

Fink, Johannes: Viewpoint: microwave quantum states beat the heat. In: *Physics*. American Physical Society, 32, 2017.

Fischer, Julian, Raithe, Claudia: Liouville principles and a large-scale regularity theory for random elliptic operators on the half-space. In: *SIAM Journal on Mathematical Analysis*. Society for Industrial and Applied Mathematics 1, 2017, 82-114.

Heisenberg, Carl-Philipp: Cell biology: Stretched divisions. In: *Nature*. Nature Publishing Group, 7643, 2017, 43-44.

Hurny, Andrej, Benková, Eva: Methodological advances in auxin and cytokinin biology. In: *Auxins and Cytokinins in Plant Biology*, 1569:1-29. Springer, 2017, 1-29.

Kainrath, Stephanie, Stadler, Manuela, Reichhart, Eva, Distel, Martin, Janovjak, Harald: Green-light-induced inactivation of receptor signaling using Cobalamin-binding domains. In: *Angewandte Chemie International Edition*. Wiley-Blackwell, 2017.

Moser, Thomas, Seiringer, Robert: Triviality of a model of particles with point interactions in the thermodynamic limit. In: *Letters in Mathematical Physics*. Springer, 3, 2017, 533-552.

Ringbauer, Harald, Coop, Graham, Barton, Nicholas H: Inferring recent demography from isolation by

distance of long shared sequence blocks. In: *Genetics*. Genetics Society of America, 3, 2017, Epub ahead of print.

O'Neill, Joseph, Boccara, Charlotte N, Stella, Federico, Schönenberger, Philipp, Csicsvári, József: Superficial layers of the medial entorhinal cortex replay independently of the hippocampus. In: *Science*. American Association for the Advancement of Science, 6321, 2017, 184-188.

von Wangenheim, Daniel, Hauschild, Robert, Friml, Jiří: Light sheet fluorescence microscopy of plant roots growing on the surface of a gel. In: *Journal of Visualized Experiments*, 119, 2017, Article number: e55044.

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