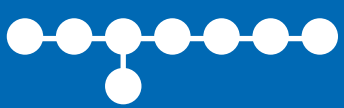
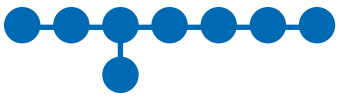
ETH zürich

Report 2016/2017

ETH Institute for Theoretical Studies

ETH-ITS





Contents

(Photo: Christina Buchmann)

The ITS building on Clausiusstrasse 47.

Foreword

The academic year 2016/17 the ETH Institute for Theoretical Studies was busy with activities and achievements of Senior and Junior Fellows, often in collaboration with ETH Zurich and the Swiss research community, as described in this report.

The Institute, founded in 2013, provides a interdisciplinary environment where Fellows, who are leading scientists and promising young researchers in theoretical sciences, can dedicate their time to the projects of their choice. It also promotes interactions of Fellows with ETH researchers as well as Swiss and international scientists through workshops, lectures, schools, seminars, the ITS Science Colloquium, and a visitor programme. A welcome effect is that the Institute acts as a catalyst for discussions across disciplines. For example, the workshop on Quantum Matter, co-organized by Senior Fellow Alexander Balatsky, brought together physicists and material scientists from ETH Zurich and the Paul-Scherrer Institute, as well as international scholars; the programme on Collective Dynamics, Control and Imaging, organized by Senior Fellows Jean-Michel Coron and Eitan Tadmor with Habib Ammari of ETH Zurich, was a successful cross-disciplinary activity in mathematics, computer science and engineering.

A highlight of last Spring was the Shaw prize attributed to Senior Fellow Claire Voisin. It is the second time, after Henrik Iwaniec in 2015, that a Senior Fellow at the ETH-ITS receives this high recognition.
I believe that I speak also on behalf of the involved wide research community, at ETH Zurich and elsewhere, when I express my immense gratitude to the donors for making this Institute possible.

Giovanni Felder, Institute's director

The ETH Institute for Theoretical Studies is supported by Dr. Max Rössler, the Walter Haefner Foundation and the ETH Foundation.

(Photo: Christina Buchmann)

The seminar room of the Institute.

The ETH Institute for Theoretical Studies

History and aims

The ETH Institute for Theoretical Studies (ETH-ITS) is an interdisciplinary research facility dedicated to inquiries into the fields of mathematics, theoretical computer science and theoretical natural sciences. In particular, it is aimed at promoting research efforts into emerging topics at the interlink of those three disciplines. It was founded on 1 June 2013 on the initiative of former ETH president Ralph Eichler, with a generous donation of Dr. Max Rössler and the Walter Haefner Foundation. The Institute's objective is to offer top theoretical scientists a stimulating work environment at ETH, fostering interactions with local researchers and establishing lasting scientific collaborations in an interdisciplinary context.

Fellows at the ITS

The Institute hosts up to six Senior Fellows and up to twelve Junior Fellows. Junior Fellows are talented young independent postdocs who will spend up to three years at ITS. In this time, they can work on research topics of their own choice with the support of a mentor, who is an ETH professor.

The Junior Fellows are selected by the director, with the assistance of the scientific Advisory Committee, from a group of candidates emerging from a nomination procedure: promising young researchers are first nominated by faculty members and senior researchers of universities and research institutions. These candidates are subsequently invited to apply at the ITS.

Schedule for the selection of Junior Fellows

Mid-September	Target date for nominations, eligible candidates are invited to apply
Mid-October	Deadline for application of nominated candidates
November	Interviews with ETH members of the Advisory Committee
December	Offers are made

Senior Fellows are leading international researchers in mathematics, theoretical computer science and theoretical natural sciences who will spend up to a year at the ITS on a sabbatical leave from their home institutions. They dedicate this time to research and participate in the activities of the ITS and of ETH Zurich, for example by giving a lecture course on research topics. Candidates are often suggested by members of the Advisory Committee or ETH faculty, but they may also apply directly. Select candidates are subsequently invited by the Vice-President for Research and Corporate Relations of ETH Zurich upon recommendation of the Advisory Committee.

www.ethz.ch/eth-its/fellows.html →

Collaborations
The ETH Institute for Theoretical Studies collaborates with the Departments of ETH and their visitor programmes, such as Forschungsinstitut für Mathematik (FIM) at the Department of mathematics and the Pauli Centre at the Department of physics. It also nurtures the relationships with other Swiss research institutions through its Fellows by promoting joint research projects as well as contributing to other scientific activities such as workshops and conferences.

Home institutions of current ITS Fellows and their collaborators on projects described in the Reports section below.

(Photo: Christina Buchmann)

Participants of the workshop «Quantum Matter: Functional, Topological and Dirac» that took place at the ETH main building in May 2017.

Activities

Courses, workshops

The ETH-ITS co-sponsored several activities such as a winter school in «Conservative Dynamics», which took place in the town of Engelberg in the Swiss Alps attracting the interest of 37 young researchers, and a workshop on «Quantum Matter», where physicists and material scientists met at ETH Zurich to exchange fascinating new approaches towards the creation of novel states in condensed matter. The ITS also hosted a series of lectures on «Collective Dynamics, Control and Imaging» under the umbrella of the KI-NET research network which is aimed at studying the kinetic description of multi-scale phenomena in physical, biological and social sciences.

In the autumn semester of 2016, Senior Fellow Vadim Kaloshin gave a course in the series ETH Lectures in Mathematics (Nachdiplomvorlesungen) entitled «Stochastic Arnold Diffusion of Deterministic Systems», which treated the subject of nearly integrable deterministic dynamical systems exhibiting instabilities – a phenomenon most famously describing the dynamics of asteroids inside the Kirkwood gaps of the asteroid belt.

In the spring semester of 2017, Senior Fellow Eitan Tadmor also contributed a lecture course to the same series on the subject of «Self-Organized Dynamics: From Emerging Consensus to Hydrodynamic Flocking». Here, participants learned about recent developments on the long-time behaviour and large-scale aggregate dynamics of systems of agents which are locally driven by ‹social engagement›.

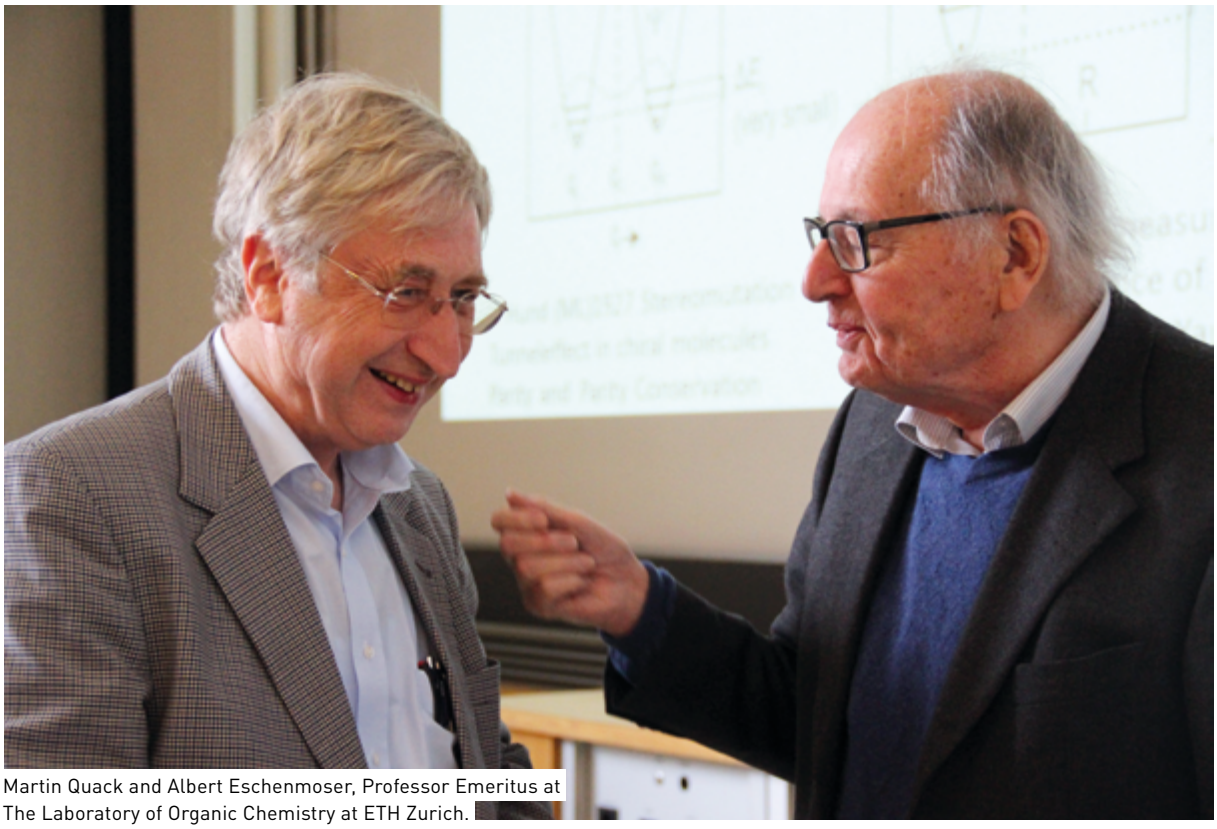
(Photo: Christina Buchmann)

Mauro Maggioni explaining his geometry-based framework for statistical learning in biomolecular simulations at the ITS Science Colloquium.

The ITS Science Colloquium

The ITS Science Colloquium is aimed at exposing students and researchers in mathematics, theoretical computer science and theoretical natural sciences to new questions and current interdisciplinary research topics. This year, several talks served to cast some light on the state-of-the-art in simulation and control of dynamical systems. Interesting challenges were examined, such as the automated detection of locally effective degrees of freedom in biomolecular simulations and the stabilization of physical dynamical systems by implementing suitable feedback controls.

(Photo: Christina Buchmann)



Martin Quack and Albert Eschenmoser, Professor Emeritus at The Laboratory of Organic Chemistry at ETH Zurich.

Programme 2016/2017

29.09.2016	Francis Brown, All Souls College, University of Oxford	Feynman amplitudes and number theory
06.10.2016	Martin Quack, ETH Zurich	Paritiy violation in chiral molecules: from theory towards spectroscopic experiment and the evolution of biomolecular homochirality
20.10.2016	Benoît Perthame, Université Pierre et Marie Curie	Models of tumor growth and therapy
17.11.2016	Mauro Maggioni, John Hopkins University	Geometric methods for the approximation of highdimensional dynamical systems
09.03.2017	Vadim Kaloshin, ETH-ITS and University of Maryland	On convex planar billards, Birkhoff Conjecture and whispering galleries
23.03.2017	Jean-Michel Coron, ETH-ITS and Université Pierre et Marie Curie	Stabilization of control systems: from the clepsydrae to the regulation of the rivers La Sambre and La Meuse
27.04.2017	Marco Hutter, ETH Zurich	Legged robots – the future of allterrain mobility

Videos of selected talks can be viewed on www.ethz.ch/eth-its/activities →

Dynamical Systems Seminar

This seminar was kindly organized by Senior Fellow Vadim Kaloshin who is an expert in the field. It has attracted a lot of attention, partly because it ties in conveniently with the curriculum at the Department of mathematics, providing interested students with up-to-date insights into current dynamical systems research.

Programme 2016/2017

29.09.2016	Dmitry Turaev, Imperial College London	Adiabatic quantum acceleration
	Marcel Guardia, UPC Barcelona	Oscillatory motions for the restricted three body problem
13.10.2016	Ian Melbourne, University of Warwick	Stochastic limits for deterministic multiscale systems
	Carlangelo Liverani, University Roma Tor Vergata	Strong statistical properties for some partially hyperbolic dynamical systems
27.10.2016	Jacques Féjoz, Université Paris-Dauphine	A review of some theorems of KAM theory, with a view to celestial mechanics
	Abed Bounemoura, Université Paris-Dauphine and CNRS	Some remarks on perturbations of linear integrable Hamiltonian systems
	Raphael Krikorian, ENSTA-Paris Tech	On almost-reducibility of pseudo-rotation in the disk
10.11.2016	Jean-Pierre Marco, Université Pierre et Marie Curie, Paris 6	Some geometrical aspects of zero entropy geodesic systems
	Ludovic Rifford, University of Nice Sophia Antipolis	The Sard conjecture on Martinet surfaces
01.12.2016	Carlos Matheus, CNRS, Parisi	On the geometry of dynamical Lagrange and Markov spectra
09.03.2017	Sylvain Crovisier, Université Paris-Sud	Spectral decomposition of surface diffeomorphisms
	Romain Dujardin, Université Pierre et Marie Curie, Membre junior de l'Institut Universitaire de France	Manin, Mumford and Hénon
23.03.2017	Péter Bálint, Budapest University of Technology and Economics	Mean field coupling of expanding circle maps
	Jianlu Zhang, University of Maryland	On Siegel's question and density of collisions in the Restricted Planar Circular Three Body Problem

(Photo: Christina Buchmann)

Gisbert Wüstholz discussing with Vadim Kaloshin after his talk at the ITS Science Colloquium.

06.04.2017	Pierre Berger, Université Paris 13	Emergence and paradynamics
	Alfonso Sorrentino, Università degli Studi di Roma Tor Vergata	Aubry-Mather theory for conformally symplectic systems
26.04.2017	Michela Procesi, Sapienza University of Rome	Long-time stability of small finite gap solutions of the cubic NLS on T^2
	Riccardo Montalto, University of Zurich	Quasi-periodic solutions of water waves
11.05.2017	Yulij Ilyashenko, Cornell University and Higher School of Economics Moscow	Global bifurcations on the two sphere
18.05.2017	Daniel Peralta-Salas, ICMAT	Vortex reconnection in the threedimensional Navier-Stokes equations
	Jacopo de Simoi, University of Toronto	Decay of correlations in fast-slow partially hyperbolic systems
01.06.2017	Kristian Bjerklöv, KTH Royal Institute of Technology, Stockholm	On some generalizations of skewshifts on T^2
	Maria Saprykina, KTH Royal Institute of Technology, Stockholm	Isolated elliptic fixed points for smooth Hamiltonians

(Photo: Christina Buchmann)

ITS Fellows meeting for tea time in the institute's garden.

Fellows' seminar

The objective of the Fellows' seminar, organized by Junior Fellow Lavinia Heisenberg, is to present the current research of the Fellows of ETH-ITS. It is open to everyone interested and as a general rule, talks should be accessible to other Fellows, that are typically from a different field.

This year a variety of different subjects in mathematics and physics were presented, reflecting the diversity of research subjects of the Fellows. Still some common themes, viewed from very different perspectives, were recognizable, such as the Einstein equations of general relativity, playing a role in Kähler geometry, in mean curvature flow and in the search of dark matter and energy, or the nonlinear methods in analysis, important in the Vlasov-Poisson equations of plasma physics but also in control theory and image recognition.

Programme 2016/2017

11.10.2016	Vadim Kaloshin	Can you hear the shape of a drum and deformational Spectral Rigidity for convex planar domains
25.10.2016	William Sawin	Cap Sets
01.11.2016	Maria Colombo	Flows of vector fields and the Vlasov-Poisson system
15.11.2016	Shoham Letzter	Minimising the number of triangular edges
29.11.2016	Eitan Tadmor	Images, PDEs and hierarchical constructions in critical regularity spaces
14.03.2017	Claire Voisin	Algebraic geometry and Kähler geometry
24.03.2017	Titus Lupu	Towards the decomposition of the Gaussian free field in excursions
25.04.2017	Jean-Michel Coron	Some methods to use the nonlinearities in order to control a system
02.05.2017	Gerhard Huisken	Mean curvature evolution and asymptotically flat 3-manifolds
23.05.2017	Lavinia Heisenberg	Our mysterious dark universe

(Photo: Christina Buchmann)

Claire Voisin observing a presentation at the ITS Science Colloquium.

Awards

ETH-ITS Senior Fellow Claire Voisin was awarded the Shaw Prize 2017 in mathematical sciences. She shares the $1.2 million prize with János Kollár from Princeton University for their «remarkable results in many central areas of algebraic geometry, which have transformed the field and led to the solution of longstanding problems that had appeared out of reach.»

The Shaw prize, established in 2002 in Hong Kong, is awarded every year since 2004 by the Shaw Prize Foundation for outstanding contributions in astronomy, life science and medicine, and mathematical sciences. It *«honours individuals, regardless of race, nationality, gender and religious belief, who have recently achieved significant breakthrough in academic and scientific research or applications and whose work has resulted in a positive and profound impact on mankind»*. The presentation ceremony for the 2017 Shaw prizes is scheduled for 26 September 2017.

(Photo: Christina Buchmann)

Senior Fellow Jean-Michel Coron giving a talk.

Fellows' report

Senior Fellows

Jean-Michel Coron joined the Institute for Theoretical Studies as a Senior Fellow in January 2017 for one year. At home, in France, he is professor at Université Pierre et Marie Curie, Laboratoire Jacques-Louis Lions. His interests are in nonlinear partial differential equations and control of systems modelled by means of ordinary or partial differential equations. His three current PhD students Amaury Hayat, Shengquan Xiang and Christophe Zhang joined ETH for 2017 thanks to support from the Institute for Mathematical Research (FIM). They worked together with Jean-Michel Coron on the control of various nonlinear partial differential equations (Korteweg-de Vries equations, 1-D hyperbolic systems, nonlinear coupled wave equations). Jean-Michel Coron and Christophe Zhang started a collaboration with Professor Habib Ammari (ETH) on electric fish. Professor Hoai-Minh Nguyen (EPFL), who was guest at ETH-ITS for one month, and Jean-Michel Coron worked together on the controllability and the stabilization in optimal time of 1D linear hyperbolic systems. Jean-Michel Coron, Professor Habib Ammari and Senior Fellow Eitan Tadmor (who joined the Institute for Theoretical Studies in August 2016 for one year) organized a regular activity on «Collective dynamics, control and imaging». The aim was bringing together researchers with interest in collective dynamics and related questions in control, in current challenges in control and image processing, and in related questions within the general framework of inverse problems. Twelve lectures were given in the framework of this activity. At ETH and ETH-ITS, Jean-Michel Coron gave three talks on his research.

(Photo: Christina Buchmann)

Gerhard Huisken.

Gerhard Huisken, Professor at Tübingen University and Director of the Mathematical Research Institute Oberwolfach, spent a 7 month sabbatical leave at the ITS from February 2017 till September 2017. He expressed his gratitude for the possibility to forge new contacts and to absorb new developments in geometric analysis, mathematical physics and control theory. He also wished to thank ITS and FIM for hosting his PhD students for extended periods, allowing their participation in important activities.

During his stay, he completed work on the evolution of hypersurfaces along their inverse mean curvature in a project with P. Daskalopoulos which, for the first time, proves a long-time existence result for complete noncompact solutions. Surprising analogies to fast diffusion equations were discovered – in particular it was shown that a certain class of convex solutions converges uniformly to a flat plane in finite time with speed uniformly tending to infinity. [P. Daskalopoulos and G. Huisken, Inverse mean curvature evolution of entire graphs, preprint, (2017) 44pp., submitted].

In another project with C. Sinestrari, 2-surfaces moving by mean curvature flow were studied in asymptotically flat 3-manifolds arising as space-like slices in models of isolated gravitating systems in General Relativity. Such sweep-outs help to construct coordinate independent structures describing mass and center of mass in such isolated systems.

This research benefited greatly from the interaction with former ITS Junior Fellow Alessandro Carlotto (now assistant professor at ETH) and researchers at the department of mathematics and FIM including M. Struwe, T. Riviere and R. Schoen. The results were presented in a number of lectures:

- ITS-Fellow Seminar, 2 May 2017, «Mean curvature evolution and asymptotically flat 3-manifolds».
- Zurich Colloquium in Mathematics, 25 April 2017, «Properties and applications of inverse mean curvature flow».
- Basel-Zürich Seminar in Analysis, 19 May 2017, «A fully non-linear flow with surgeries for 2-convex hypersurfaces».
- Conference in Honour of Demetrios Christodoulou, 11 July 2017, «Foliations in asymptotically flat 3-manifolds».

Gerhard Huisken was an organiser (jointly with M. Struwe, T. Riviere, R. Schoen) of the conference on «Advances in Geometric Analysis», 6-9 June 2017, at FIM. He plans to give a mini-course on geometric evolution equations in September 2017.

(Photo: Christina Buchmann)

Vadim Kaloshin.

Vadim Kaloshin spent the academic year 2016/2017 at the Institute for Theoretical Studies as a Senior Fellow. He holds a permanent position of the Michael Brin Chair at the University of Maryland at College Park. His research interests include Hamiltonian systems, celestial mechanics and spectral rigidity. During his stay in Zurich, jointly with A. Sorrentino and M. Guardia, Kaloshin organized a winter school in dynamical systems at Engelberg and will organize a conference in Ascona in October 2017. He also organized the institute's regular dynamical systems seminar. In the fall term of 2016, Vadim Kaloshin delivered a Nachdiplom lecture course on Stochastic Arnold diffusion based on his work on stochastic Arnold diffusion with O. Castejon, M. Guardia, J. Zhang and K. Zhang [Comm. Math. Phys., 2016, 348, Issue 1, 321–361, arXiv:1511.04835, arXiv:1705.09571]. During his stay at the ITS, Prof. Kaloshin worked on several projects: one concerns spectral rigidity of axis symmetric planar domains and the question of M. Kac ‹Can you hear the shape of a drum?› [Ann. Math. 186 (2017), 277-314], joint with J. De Simoi, Q. Wei, and A. Figalli. The second one is about the local Birkhoff Conjecture [Ann. Math. 184 (2016) 527–558, arXiv:1612.09194] and on further developing functional analytic techniques for classifying integrable billiards, jointly with G. Huang and A. Sorrentino. The third project, joint with M. Guardia and J. Zhang, is concerned with Alexeev's question about the density of collision conditions for a planar three body problem. A preprint is in preparation.

(Photo: Christina Buchmann)

Senior Fellow Eitan Tadmor.

Professor Eitan Tadmor is a Distinguished University Professor at the University of Maryland, College Park, who, prior to his arrival at ETH, served as the Director of the university Center for Scientific Computations and Mathematical Modeling (CSCAMM) during the 14 year period 2002–2016. Prof. Tadmor spent the period of August 2016–July 2017 as a Senior Fellow at ETH-ITS. His primary research interests include analysis of time-dependent problems, the development of high-resolution algorithms for the approximate solution of such problems and the interplay between analytical theories and computational aspects with applications to shock waves, kinetic transport, incompressible flows, image processing and selforganized dynamics.

While at ETH-ITS, Tadmor worked on a variety of topics related to collective dynamics, flocking hydrodynamics, chemotaxis and numerical entropy stability. In particular, he introduced a new class of Eulerian dynamics driven by a forcing with a commutator structure. The study of such systems is motivated by the hydrodynamic description of agent-based models for flocking driven by alignment. In the series of works *«Eulerian dynamics with a commutator forcing»* (I, II and III), jointly with Prof. Roman Shvydkoy who visited ETH-ITS on November 2016, these commutator-based systems were studied with singular kernels, corresponding to fractional powers of the Laplacian. Singular kernels were proved to behave better than bounded ones: global regularity persists and flocking follows for all initial data. Singularity helps! They also studied the setup of two-dimensional commutator-based models with bounded kernels together with graduate student Siming He from the University of Maryland, who visited the ITS for two-month periods in autumn of 2016 and spring of 2017. In their joint work *«Global regularity of two-dimensional flocking hydrodynamics»*, they emphasized the role of spectral gap, proving existence of strong solutions for subcritical initial data.

In yet another line of research with graduate student Siming He, they offer a new mechanism to suppress chemotactic blow-up through a fast splitting scenario on the plane, working in the context of a rather realistic scenario of the Keller-Segel model where they take into account an ambient environment due to the fluid transport by a vector field. Surprisingly, they find that already the simplest case of a linear stationary vector field prevents chemotactic blow-up for initial mass up to double the usual critical threshold.

In November 2016, Prof. Tadmor wrote a review on *«Entropy stable schemes»* for the *Handbook of Numerical Methods for Hyperbolic problems* (R. Abgrall and C.-W. Shu, eds.). The review covers a range of topics from classical first-order accurate scalar monotonicity to high-order entropy measure-valued solutions for systems developed together with Ulrik Fjordholm from Trondheim and Siddhartha Mishra from ETH.

(Photo: Christina Buchmann)

The Institute's neighbourhood on Clausius-Strasse as seen from the top floor.

During the fall semester of 2016, Prof. Tadmor gave a large number of invited talks at various forums, including *«Zurich Colloquium in Mathematics»* on (10/2016) and the ITS Fellows lecture on (11/2016).

In autumn 2016, Tadmor hosted Prof. Benoit Perthame from University of Pierre & Marie Curie and Prof. Mario Maggioni from Johns Hopkins University who delivered the ITS colloquia in October and, respectively, in November 2016.
On 1–4 November 2016, Tadmor, together with Prof. Gianluca Crippa from University of Basel and Prof. Siddhartha Mishra from ETH Seminar for Applied Mathematics, organized a joint FIM-Ki-Net meeting Senior Fellow Eitan Tadmor *«Transport phenomena in collective dynamics: from micro to social hydrodynamics»*. The 23 lectures covered a broad range of topics related to descriptions of transport phenomena and were very well attended with over 70 registered participants.
In the spring semester of 2017, Prof. Tadmor delivered a Nachdiplom course *«Self-organized dynamics. From emerging consensus to hydrodynamic flocking»* for a group of about 20 graduate students. The aim of this series of 13 lectures was to discuss systems driven by the ‹social engagement› of agents with their neighbours. Prototype models are found in opinion dynamics, flocking, self-organization of biological organisms and rendezvous of mobile systems. The lectures addressed two natural questions which arise in the context of such systems, namely (i) what is the long-time behavior of such self-organized systems --- consensus, flocking and swarming, synchronization etc., and (ii) the effective dynamics for large crowds of agents in terms of their kinetic and hydrodynamics descriptions.

Prof. Tadmor, together with Prof. Habib Ammari from ETH and ITS Senior Fellow Jean-Michel Coron, organized a series of ITS lectures on *«Collective dynamics, control and imaging»*, delivered during April–June 2017. A series of 12 speakers covered a diverse range of complementary topics on collective dynamics, on issues of control and controllability and on imaging.

In March 2017, Prof. Tadmor hosted Prof. Ron DeVore from Texas A&M University. Prof. DeVore spent the month of March 2017 at the invitation of FIM. During that month, Tadmor and DeVore continue their ongoing collaboration on extensions of Bourgain-Brezis' problem.

In spring Prof. Tadmor gave several invited talks including the *«Pearl Colloquium»* at the University of Basel (3/2017) and Applied and Computational Mathematics seminar (4/2017) and the PDE and Math-Physics seminar (5/2017) at the University of Zurich.

(Photo: Christina Buchmann)

View over Zurich from the top floor of the ITS building.

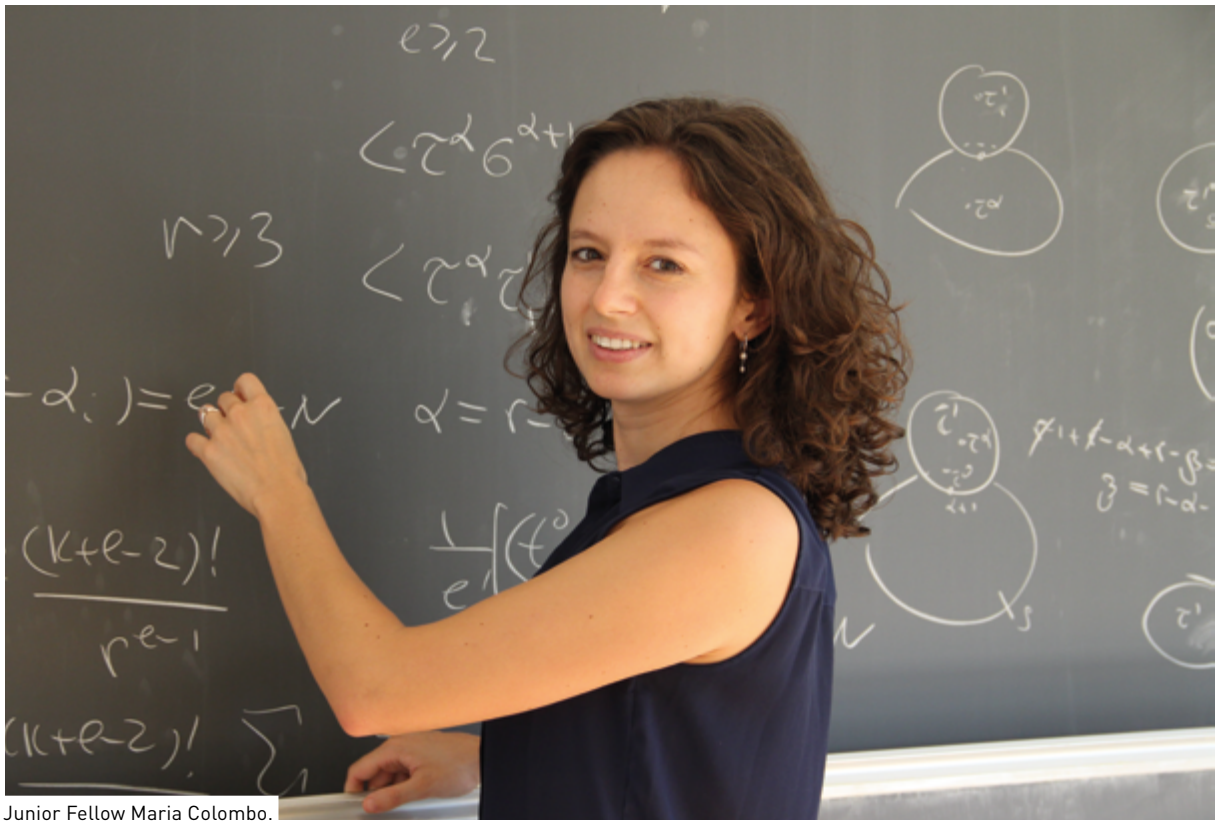
Claire Voisin, Professor at Collège de France, joined the ETH-ITS as a Senior Fellow in January 2017 and will stay there until December 2017. Her present research has two main directions:

1. ***Hyper-Kähler manifolds*** are complex projective manifolds of a very restricted type. Their abstract deformation theory is well understood but the construction problem for their topological types and also for explicit models and moduli spaces via algebraic geometry is still at an experimental stage. Together with Laza and Saccà, Prof. Voisin had previously constructed certain 10-dimensional Hyper-Kähler manifolds, starting from cubic hypersurfaces of dimension 4, and she proved recently with Kollár, Laza and Saccà that the manifolds thus constructed are deformation equivalent to the exotic O'Grady manifolds. More generally, they studied the deformation type of Hyper-Kähler manifolds via degenerations, giving an easy proof of many previously known results of this type.

2. She introduced the notion of universally defined cycle and proved that in the case of families of smooth surfaces, universally defined cycles are given by universal polynomials in the relative Chern classes and diagonals. This result allows her to recover previously known results on the Chern numbers of Hilbert schemes of surfaces, and combined with other arguments, this can also be applied to prove many results on the Chow ring of the Hilbert scheme of a K3 surface. Together with Rahul Pandharipande, Claire Voisin organized a conference on *‹Cycles and Moduli›* at ETH in March 2017. This subject is related to both items 1) and 2) above, as on one hand many talks were devoted to recent progresses on Hilbert schemes and moduli spaces of K3 surfaces, and on the other hand, K3 surfaces and their Hilbert schemes are examples of Hyper-Kähler manifolds.

Claire Voisin will teach in Fall 2017 a Nachdiplom course entitled *‹Hyper-Kähler manifolds›*.

(Photo: Christina Buchmann)



Junior Fellow Maria Colombo.

Junior Fellows

Since her PhD studies, **Maria Colombo** has been involved in the theory of optimal mass transport, where she has been studying the interplay between this theory, the regularity of elliptic equations and some applied models from density functional theory.
During her current year at ITS as a Junior Fellow, she focused on models exhibiting a branched structure, whose purpose is the mathematical description of supply-demand systems such as the structure of the nerves of a leaf, the system of roots of a tree and the nervous or cardiovascular systems. She focused on the study of the stability of optimal transport paths, in collaboration with Luigi De Rosa and Andrea Marchese from the University of Zurich. Together with them and Annalisa Massaccesi, she was awarded a grant for young researchers and she organized a workshop in Zurich on Problems in Optimal Transport with a particular focus on branched structures.

In a new collaboration with Gianluca Crippa from the University of Basel and Laura Spinolo from the University of Pavia, she proved new results and counterexamples to the convergence of a nonlocal approximation of the Burgers' equation.

Among several conferences where she was invited to contribute with a talk, Maria Colombo presented these results at the conference *‹Transport phenomena in collective dynamics: from micro to social hydrodynamics›*, a joint FIM-KiNet conference at ETH. She has also been one of the invited speakers at the prestigious 23rd Rolf Nevanlinna Colloquium, where she presented her recent results concerning the transport equation and their applications to partial differential equations.

(Photo: Christina Buchmann)

Junior Fellow Aline Ramires (at the top) and Lavinia Heisenberg (in the centre) watching intently at the Science Colloquium.

Lavinia Heisenberg spent her second year at the ITS, reinforcing the bridge between the theoretical physics and the observational astrophysics groups at ETH, that she had initiated in the previous academic year.
Together with Professor Alexandre Refregier at ETH, she has been working on the role of gauge freedom in General Relativity and its direct implementation into a relativistic Boltzmann code based on Python, which shall be extended to incorporate different modifications of gravity and confront the most promising models to CMB observations. A paper incorporating these first results is being prepared and will be published soon. She has been the main supervisor of the master student Anne-Mazarin Victoria Lyon from EPFL, with Professor Alexandre Refregier at ETH and Professor Mikhail Shaposhnikov at EPFL playing the role of cosupervisors. This has initiated a direct collaboration between EPFL and ETH and will also result in a joint publication. The master project dealt with the study of cosmological implications of a specific class of vector-tensor theories, which Lavinia Heisenberg had proposed a couple of years ago. These theories have received quite some attention in the literature and offer new and exciting avenues in theoretical cosmology. They constitute consistent generalizations of the Proca action based on derivative self-interactions of a massive vector field with non-minimal couplings to gravity. In the academic year 2017 her research activities within this topic alone resulted in four publications together with her collaborators.
Given the recent developments in gravitational wave physics, Lavinia Heisenberg has been very much interested in understanding the implications of modified gravity in the regime of strong gravity. Together with her collaborators she has presented a new family of exact hairy black-hole solutions on a static spherically-symmetric background in generalized Proca theories. In these models, the deviation from General Relativity is most significant around the horizon and hence there is a golden opportunity for probing the Proca hair by the measurements of gravitational waves in the nonlinear regime of gravity. The resulting paper has been submitted to Physics Review Letters.
She has also initiated a new collaboration in the Theoretical Physics group at ETH. Together with Charalampos Anastasiou she is supervising the master student Amit Bhoonah Pritish and the main goal is to study the role of vector fields in early universe, especially in the context of primordial magnetogenesis. This will allow to create synergies between particle physics and cosmology at the Institute for Theoretical Physics at ETH.
Along an independent research line, Lavinia Heisenberg played one of the leading roles in building consistent generalizations of Born-Infeld gravity theories. These are ultraviolet modifications of gravity and have important

direct applications to early universe cosmology and astrophysics. These theories have initiated a lot of activities and interest in the community with applications to stellar structure, compact objects, inflationary scenarios, cosmological singularities, and black hole and wormhole physics, among others. Lavinia Heisenberg and her collaborators have been invited to write an exhaustive review article for Physics Reports, where they summarised the motivations, various formulations, and main results achieved within these theories. This article is very useful for providing an overview of current open problems and future research opportunities and will facilitate the future works in this direction.

During the academic year 2016–2017 she has been giving plenary talks at conferences and workshops as invited speaker and also invited institute seminars. Just to mention a few, she was invited speaker at the «12th Iberian Cosmology Meeting» in Valencia/Spain, at the «52nd Rencontres de Moriond, Gravitation» La Thuile/Italy, at the «Quantum Vacuum and Gravitation: Testing GR in Cosmology» at the Johannes Gutenberg University, Mainz/Germany, at the workshop «Models of Gravity» Leipniz University Hannover/Germany, at the «1st CANTATA CA-15117 COST meeting» in Lisbon/Portugal and at the workshop «Unifying Tests of General Relativity» at the Keck Institute for Space Studies, Caltech, Pasadena/USA. She has been invited to give seminars at the University of Marseille, Heidelberg, Lisbon, Oslo and Helsinki apart from local invitations in Zurich. She was also invited to give block courses on Massive Gravity and Modified Gravity in Switzerland, Brasil and Japan. She has also given the Astrophysical Colloquium at ETH. Worth to mention is also that she was one of the main speakers of the Thanksgiving event organised by the ETH Foundation and a *portrait article* about her was released at ETH News.

Concerning her participations in big collaborations, she is a leading member of the management committee of the COST Action «Cosmology and astrophysics network for theoretical advances and training actions» and she also recently joined the COST Action «Gravitational waves, black holes and fundamental physics». Additionally, she is in the theory working group of the EUCLID collaboration. Furthermore, she has been the organiser of the Fellow seminar at Institute for Theoretical Studies this academic year. Lavinia Heisenberg is also very passionate about space and human space exploration. She has participated in many ESA events in this academic year and also participated in workshops with the aim to fascinate kids for space and physics in general.

(Photo: Christina Buchmann)

Junior Fellow Shoham Letzter.

Shoham Letzter spent in 2016/2017 her first year at the ITS as a Junior Fellow, throughout which her main focus has been the study of Ramsey theory. Very roughly speaking, Ramsey theory studies the preservation of structure in parts of a larger structure which is broken into pieces arbitrarily. One of the earliest and most basic examples of such a phenomenon is Ramsey's theorem, which states that for every integer k, there exists (large) n for which, whenever the edges of the complete graph on n vertices are coloured red and blue, there must exist a monochromatic clique on k vertices. In this example, n has to be quite a lot larger than k: at least exponential in k. Together with PhD student Matija Bucić and Prof. Benny Sudakov from ETH, the focus has been not on monochromatic cliques, which are very dense graphs, but rather on much sparser graphs such as paths and trees. The three studied several such problems in several different settings, including paths in complete bipartite graphs, directed paths in random tournaments and oriented trees in arbitrary tournaments and in the complete directed graph. For example, they showed that given any tree T on k vertices, whose edges may be oriented arbitrarily, and given any red and blue colouring of any tournament on roughly k^2 vertices, there exists a monochromatic copy of T; the latter expression is asymptotically best possible, e.g. for directed paths. Interestingly, when, instead of allowing arbitrary tournaments, one considers random tournaments (where edges are given a direction at random), much fewer vertices are needed in order to ensure the existence of a monochromatic T: for example, with high probability, any red and blue colouring of the edges of a random tournament on roughly $k \cdot log(k)^{1/2}$ vertices yields a monochromatic directed path on k vertices, which is again best possible (up to a constant factor).

Shoham Letzter has also been involved in other research projects. Together with António Girão from the University of Cambridge and Julian Saharasbudhe from the University of Memphis, she investigated another Ramsey type problem, about covers and partitions of the vertices of graphs with large minimum degree using monochromatic connected subgraphs. In collaboration with Richard Snyder, from Memphis, she studied the structure of graphs with large degree and given odd girth. In particular, they managed to characterise completely the structure of graphs which have no triangles or 5-cycles and have minimum degree larger than $n/5$ (where n is the number of vertices). This is a special case of a more general class of questions, and they hope to make more progress on the general case in the future. Vytautas Gruslys, from Cambridge, proved that any graph H, which is a subgraph of the hypercube of order which is a power of 2, can ‹tile› any sufficiently large hypercube (i.e., the vertices can be covered by disjoint copies of H). This statement clearly does not generalise to graphs H whose order is not a power of 2; however Gruslys and Letzter were able to show that, on the one hand, any such graph H can ‹almost tile› any large hypercube, while on the other hand they showed that the number of vertices that remain uncovered cannot be too small.

Shoham Letzter presented her research on several occasions, including a workshop at the Hebrew University, in seminar talks at the ITS, ETH and Cambridge, and in the Colloquia in Combinatorics at LSE.

(Photo: Titus Lupu)

Junior Fellow Titus Lupu mingling among the other participants of a conference at Columbia University, New York.

Titus Lupu has been a Junior Fellow at ITS since September 2015. His research deals with the connections between the Gaussian free field (GFF) and Markov trajectories (for instance Brownian motion), in particular in dimension 2, where one has conformal invariance. Since the works of Kurt Symanzik and Evgeniy Dynkin, it was known that the square of the GFF is related to occupation times of Markov trajectories.

During his doctorate, Titus Lupu gave more geometric versions of this relation, which take in account the sign of the GFF and clusters of Markov paths. This gave rise to the publications «From loop clusters and random interlacements to the free field» in *Annals of Probability* and «Convergence of the two-dimensional random walk loop soup clusters to CLE», accepted in *Journal of European Mathematical Society*.
During his second year at the ITS, Titus Lupu, in collaboration with Juhan Aru and Avelio Sepùlveda (both at ETH) continued to investigate the relation between the continuum Gaussian free field and clusters of Brownian loops in dimension 2. The main result is that the clusters of Brownian loops in a Brownian loopsoup can be seen as sign components of the GFF (which is a generalized function in this setting). This in turn facilitates new understanding of the structure of the GFF. It is explained in the preprint «First passage sets of the 2D continuum Gaussian free field» [arXiv:1706.07737]. A further goal in this direction would be to obtain a decomposition of Liouville Quantum Gravity measure (exponential of the GFF) using this sign components and clusters of Brownian loops.

Titus Lupu was invited to present these results at the conferences «SLE, GFF and LQG in NYC» in Columbia University, New York, «Statistical Mechanics, random planar geometry and interacting random walks» in Lyon and at the workshop «Stochastic Analysis: Geometry of Random Processes» in Oberwolfach.

He also worked on relations between discrete GFF and some models of reinforced random walks in collaboration with Christophe Sabot (Université Lyon 1) and Pierre Tarres (Université Paris Dauphine). This gave rise to the preprint «Inverting the coupling of the signed Gausssian free field with a loop soup» [arXiv:1701.01092].
During the Spring Semester 2017, Titus Lupu, jointly with Juhan Aru, gave a master course in mathematics on the topic «Concentration of Measure». Covered topics were Efron-Stein inequality, Gaussian Poincaré inequality, martingale method in concentration, Gaussian concentration, isoperimetry and concentration, logarithmic Sobolev inequality and concentration.

In May 2017, Titus Lupu obtained a position at CNRS, France.

(Photo: Christina Buchmann)

Junior Fellow Zur Luria.

Zur Luria's research interests include the study of random graphs and hypergraphs, Latin squares and hypercubes, designs, and the connections between these and other combinatorial objects.
Together with Ran Tessler, he worked on the threshold for Hamiltonian spheres in hypergraphs: A celebrated classical result in random graph theory states that the threshold for a random graph *G* of type *G(n,p)* to contain a Hamiltonian cycle is *p=log(n)/n*. The goal of the present project is to generalize this result to higher dimensions. A Hamiltonian *d*-sphere in a *d*-dimensional simplicial complex is a spanning subcomplex homeomorphic to the *d*-dimensional sphere. Thus, a Hamiltonian cycle is a Hamiltonian 1-sphere. What is the threshold for the appearance of a Hamiltonian *d*-sphere in a random simplicial complex?

Let *X* be a random 2-dimensional complex on *n* vertices, in which each triple belongs to *X* with probability *p*. Luria and Tessler find the threshold for the appearance of a Hamiltonian 2-sphere in *X* and prove that it is a sharp threshold.

Another research interest is finding new bounds for the *n*-queens problem, i.e. in how many ways can *n* queens be placed on an *n×n* chessboard so that no two queens attack each other? This famous problem was proposed by Max Bessel in 1848 and has an impressive pedigree, having been studied by Gauss and Pólya, among others. Pólya also proposed a variant of the problem in which the board is toroidal. In his paper «New bounds on the number of *n*-queens configurations», Luria provides new upper and lower bounds for both problems, substantially improving on previous results. In particular, he gives superexponential bounds for both problems, confirming a conjecture of Rivin, Vardi and Zimmerman [RVZ, The *n*-queens problem, The American Mathematical Monthly 101.7 (1994)]. On the way, Luria proves an upper bound on the number of perfect matchings in regular hypergraphs. This result has far-reaching applications, and may prove to be very useful in the future.

Another work in progress is on the threshold problem for Latin squares in collaboration with Michael Simkin: An *(n,q,r)*-Steiner system is a *q*-uniform hypergraph on *n* vertices in which each *r*-set is contained in exactly one hyperedge. These objects are a generalization of the concept of perfect matchings in a graph to higher dimensions. It is natural to ask: When does a random hypergraph contain a Steiner system? The solution of this problem for graphs proved to be extremely influential and important. Johannson, Kahn and Vu [JKV, Factors in random graphs, Random Structures and Algorithms 33.1 (2008)] found the threshold for the more general case *r=1*, but the problem remains completely open for higher values of *r*. A natural place to continue the search is Latin squares, which are equivalent to tripartite *(n,3,2)*-Steiner systems. Simkin and Luria proved several results about the threshold problem for Latin squares and related objects.
Yet another line of research is about high dimensional expanders of bounded vertex degree in collaboration with Ron Rosenthal and Alex Lubotzky. A recent paper of Lubotzky, Luria and Rosenthal [LLR, Random Steiner systems and bounded degree coboundary expanders of every dimension, arXiv:1512.08331 (2015)] showed that the union

(Photo: Christina Buchmann)

Junior Fellow Aline Ramires.

of a bounded number of random Steiner systems yields a high dimensional expander, proving the existence of *d*-dimensional coboundary expanders in which every set of *d* vertices is contained in a bounded number of *d*-dimensional cells. Some recent results seem to indicate that it may be possible to construct coboundary expanders of bounded vertex degree [KKL, Isoperimetric inequalities for Ramanujan complexes and topological expanders, arXiv:1409.1397 (2014); S. Evra and T. Kaufman, Bounded degree cosystolic expanders of every dimension, arXiv:1510.00839 (2015)]. The goal of this project is to construct such complexes via a probabilistic construction. However, it is clear that a naive construction will not work. This fascinating problem leads naturally to new models for random hypergraphs.

During her second year as a Junior Fellow, **Aline Ramires** explored the presence of enlarged symmetries in cold atomic systems. The motivation for this work originated from her background in large-*N* treatments for strongly correlated solid state systems. Large-*N* treatments are theoretical approaches which allow one to perform controlled calculations which are exact in the infinite-*N* limit. The model of interest is usually generalized to a model with an enlarged symmetry, characterized by the parameter *N*, usually taken to be *SU(N)*. For spin systems, the most appropriate generalization is actually to *SP(N)*-symmetry in order to preserve the inversion of the spin under time-reversal. Aline Ramires developed a Fermi Liquid theory characterizing the behaviour of fermions with interactions respecting *SP(N)*-symmetry and contrasted their behaviour with the case of *SU(N)*-symmetry. One interesting result concerns the enhancement of the tendency towards magnetic order in the *SP(N)* scenario. This work is currently under review in Physical Review A. Ramires also supervised the Master Thesis of Tudor Pahomi, now a PhD student in the group of Prof. Manfred Sigrist. The topic concerned the effects of Rashba spin-orbit coupling in Josephson junctions with unconventional superconductors. Josephson junctions formed by superconductors with different parities usually do not allow for first order couplings between the two superconducting states. Ramires and Pahomi reviewed the selection rules for couplings between two superconductors with different parities in presence of a non-trivial metal with spin-orbit coupling. Interesting results concerning the presence of charge and spin currents perpendicular to the direction of the junction were found. They are currently investigating other topics related to superconducting junctions and heterostructures, focusing on the induction of new phases by proximity effect of parity mismatched unconventional superconductors. Aline Ramires also participated in several meetings in Switzerland and abroad in the academic year of 2016–2017. In particular, she has been invited for seminars at the Max Planck Institute in Stuttgart, Germany, and at the Paul Scherrer Institute in Villigen, Switzerland to discuss her work on unconventional superconductivity and at Heidelberg University to talk about her most recent interests in systems with enlarged symmetries. Over the summer of 2017 she also participated at the 28th International Conference on Low Temperature Physics in Gothenburg, Sweden, and in the Swiss Physical Society Meeting held in Geneva.

Will Sawin arrived at ETH-ITS in Fall 2016. A few months prior to that, he had begun work on the slice rank method, emerging from the breakthrough work of Croot-Lev-Pach and Ellenberg-Gijswijt, where upper bounds for certain combinatorial structures are deduced from upper bounds on a new invariant, the «slice rank», of tensors.

With Blasiak-Church-Cohn-Grochow-Naslund-Umans, he used slice rank to bound the size of certain triples of subsets in finite abelian groups, generalizing upper bounds on progression-free sets. In addition, the authors showed that such a triple of subsets can be derived from a certain class of fast matrix multiplication axioms, and so this bound implies a nontrivial lower bound for the time complexity of these algorithms – although no nontrivial lower bound is known or expected for general matrix multiplication algorithms. This was published in Discrete Analysis. He spoke about this work at the EPFL combinatorics seminar and at the Geometric and Analytic Number Theory conference in ETH.

With Robert Kleinberg and David Speyer, Will Sawin developed an explicit construction showing that the bound of the previous paper is sharp to within a subexponential factor. This paper has been submitted for publication. The results were used by Fox and Lovasz to give a sharp bound for the arithmetic triangle removal lemma in vector spaces over finite fields. Before their work, the best bound for this important result in additive combinatorics was of tower-of-exponentials type, a far cry from the true polynomial bound.

Will posted a preprint that extends these methods to nonabelian groups, obtaining bounds giving exponential savings in any power of a finite group. It is not clear whether a sharp bound can be proven in this context.
He participated in an informal workshop at the Heilbronn institute in Bristol on these topics, and gave two talks.
Will Sawin has also been working on topics in number theory. He completed this year his joint work with Emmanuel Kowalski and Philippe Michel on new bounds

(Photo: Christina Buchmann)

Junior Fellow Will Sawin.

for Kloosterman sums with applications to analytic number theory. This was published as a paper in the Annals of Mathematics. He spoke about this work in the Recent Developments in Analytic Number Theory workshop at MSRI. He also gave a talk, in the Introductory Workshop on Analytic Number theory at MSRI, providing an introduction to l-adic sheaf theory via its relationship to the classical theory of ordinary differential equations.

He wrote a short paper applying étale cohomology, and the theory of congruences between modular forms, to the question of the unirationality of the moduli space of curves in characteristic *p*-specifically to show that the moduli space of genus one curves with sufficiently many marked points is not unirational in characteristic p for all primes p greater than 7. The method is to exhibit a cohomological obstruction to unirationality by comparing the étale cohomology with a space of modular forms and finding a suitable modular form (A stronger bound is known in characteristic zero using Hodge theory). He spoke about this in the EPFL algebraic geometry and number theory seminar and the University of Michigan algebraic geometry seminar. Recently, Sawin has been thinking about several questions involving analytic number theory over function fields of algebraic curves. In some work in progress with Nicolas Templier, he is applying constructions from the (normally quite abstract) geometric Langlands program to prove concrete quantitative estimates on automorphic forms over function fields, such as new cases of the Ramanujan conjecture and conjectures about the distribution of zeroes of L-functions that are far out of reach over number fields.

(Photo: Christina Buchmann)

Junior Fellow Ran Tessler (second from the right) at the Nairobi workshop on algebraic geometry.

Ran Tessler has been a Junior Fellow since September 2015. His research interests lay in the intersection of geometry, physics and probability. His main research is in open Gromov-Witten (GW) theory. Gromov-Witten theory is the theory of counting holomorphic curves inside manifolds. Open GW theory tries to extend such enumeration problems to the more complicated setting when the Riemann surfaces have boundaries. Ran Tessler and Sasha Buryak (ETH) published their proof of the open analog of the KdV conjecture [Communications in Mathematical Physics 353 (2017), no. 3, 1299–1328], and together with Alexander Alexandrov (CGP) they have extended their result (and added some conjectures) to the study of more refined open intersection numbers [Journal of High Energy Physics (2017) 2017: 123)].

In two joint works with Buryak and Emily Clader (a former ITS Junior fellow), an extension of the classical *r*-spin theory, defined originally by Witten, has been constructed. More interestingly, they have constructed the open genus 0 *r*-spin theory and related it to the Gelfand-Dickey integrable hierarchy. In a joint work with Mark Gross and Tyler Kelly (Cambridge) a generalization of the open *r*-spin theory is constructed to a larger family of Landau-Ginzburg models, and turns out to have very interesting properties.

In another work with Buryak, Rahul Pandharipande (ETH) and Amitai Zernik (IAS), the open GW theory of P^1 has been constructed, and the classical GW/Hurwitz correspondence of Okounkov-Pandharipande has been extended to the open theory. Together with Jake Solomon (HUJI), Ran defined the notion of graded spin structures and discovered an invariant which generalizes the classical Arf invariant of usual spin structures. This construction plays a key role in their solution of the orientability problem for moduli of high genus surfaces with boundary and related moduli of open stable maps. These works are expected to be online by autumn 2017.

This autumn, Buryak, Pandharipande and Tessler organize, with the support of FIM, a workshop on open Gromov Witten Theory and its relations to mirror symmetry and integrable hierarchies.

Tessler also works from time to time in more discrete areas of mathematics. Together with Noam Berger (HUJI), he proved [arXiv:1610.02647] that the most basic observable in the popular Edwards-Anderson model for spin glasses, the frustrated edges, does not percolate for low temperatures, and in particular for the most important case of temperature 0 (meaning that there are no infinite clusters of frustrated edges, under the Gibbs-Boltzmann measure, for low enough temperatures). This is one of the first rigorous results in this model, which stands in the border of mathematics and condensed matter physics.

Together with Zur Luria, another Junior Fellow, Ran Tessler has shown that in random 2-hypergraphs there is a sharp phase transition, at a prescribed point, after which a subhypergraph homeomorphic to a sphere which uses all vertices must appear [arXiv:1609:09836]. This generalizes Posa's famous result for the appearance o Hamiltonian cycles in random graphs. Very recently, Tessler has extended this result to the appearance of all genus spanning subhypergraphs, and gained a better understanding of the phase transition [to appear].

He talked about most of these works in several conferences and seminar talks in Europe, the US and Israel.

Recently he took part in the third Nairobi workshop for algebraic geometry, and gave a course about moduli spaces and intersection theories. This event is part of an exciting project whose goal is to help promoting the mathematics in Africa (and in particular eastern Africa). Tessler looks forward to attending other such events in the future as well.

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Outlook 2017/2018

Two new Senior Fellows are starting their activities at the Institute in spring respectively autumn of 2017.

1 Leonid I. Glazman, Donner Professor of Physics and Applied Physics at Yale University, is Senior Fellow since April 2017. He is a theoretical physicist in the area of condensed matter. He commands a wide spectrum of topics, ranging from materials and statistical physics to mesoscopic physics. Among his various achievements are his works on the conductance quantization in electronic mesoscopic systems, on the geometry of edge channels in quantum Hall systems, on the Coulomb blockade or on the Kondo effect in mesoscopic transport. Focusing on materials, Leonid Glazman has made major contributions to superconductivity, e.g., vortices in bulk type II superconductors but also extensive work on structured superconductors such as Josephson junctions or arrays thereof. Most recently, he has investigated the possibility to engineer Majorana states in condensed matter systems. (photo: Leonid Glazman).

2 Sandu Popescu, Professor of Physics at the University of Bristol, will be Senior Fellow at the ETH Institute for Theoretical Studies for a year from October 2017. He is known for his seminal contributions to quantum information theory, correlations in quantum systems and quantum measurement. His pioneering work with Rohrlich on quantum correlations is by now a cornerstone for the study of non-locality in quantum theory and plays a crucial role in modern quantum information theoretic applications such as device-independent cryptography. Over the past few years he has also been particularly active in quantum statistical mechanics and quantum thermodynamics. Among his results in this area are a novel relation between entanglement theory and thermalization and a proposal for thermal machines operating on single qbits. His research was honoured with a number of prizes, most recently with the Dirac medal in 2016. (photo: Gabriela Secara).

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Two new Junior Fellows will begin their stay at the ITS in September 2017:

3 Ulrike Rieß received her PhD in January 2017 from the University of Bonn under the supervision of Daniel Huybrechts. Her main area of expertise are irreducible symplectic varieties (or Hyper-Kähler manifolds).
This class of algebraic varieties with very interesting geometric properties has been actively studied throughout several decades. Her main contribution are works on their Chow rings and on the behaviour of base loci of big and nef line bundles. (photo: Michael Rieß).

4 Johannes Noller received his PhD in Theoretical Physics from Imperial College London in 2012 and was a Research Fellow of the Royal Commission for the Exhibition of 1851 and a Beecroft Fellow at the University of Oxford 2012–17. He is a theoretical cosmologist, working on understanding the fundamental degrees of freedom that drive the dynamics of the universe at large scales and is especially interested in cosmological structure formation and periods of accelerated expansion. More specifically, areas that Johannes Noller has worked on include effective field theories in cosmology, massive gravity and extensions thereof, inflation, primordial non-gaussianity and modified gravity theories. (photo: Johannes Noller).

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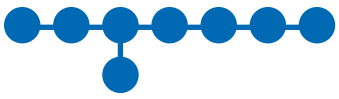
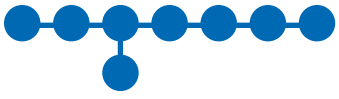


Senior Fellows

Riccardo Barbieri, SNS Pisa	11.2015 – 10.2016
Robert Brandenberger, McGill University	08.2015 – 07.2016
Gilles Brassard, Université de Montréal	06.2014 – 12.2014
Dmitry Chelkak, St. Petersburg	09.2014 – 08.2015
Eugene Demler, Harvard University	05.2015 – 06.2015 and 09.2015 – 12.2015
Henryk Iwaniec, Rutgers University	08.2014 – 05.2015 and 06.2016 – 07.2016
Terry Hwa, UC San Diego	01.2014 – 09.2014 and 04.2015 – 08.2015
Alex Lubotzky, Hebrew University	02.2015 – 08.2015 and 02.2016 – 08.2016
Vadim Kaloshin, University of Maryland	09.2016 – 08.2017
Walter Schachermayer, University of Vienna	09.2015 – 08.2016
Adi Shamir, Weizmann Institute	02.2015 – 07.2015 and 02.2016 – 07.2016
Alexander Balatsky, Nordita and LANL	02.2015 – 05.2015 and 07.2016 – 03.2017
Eitan Tadmor, University of Maryland	08.2016 – 07.2017
Jean-Michel Coron, Université Pierre et Marie Curie	01.2017 – 12.2017
Claire Voisin, Collège de France	01.2017 – 12.2017
Gerhard Huisken, MFO	02.2017 – 09.2017
Leonid Glazman, Yale University	05.2017 – 12.2017 and 05.2018 – 08.2018
Sandu Popescu, University of Bristol	10.2017 – 12.2017 and 03.2018 – 12.2018

Junior Fellows

Emily Clader	09.2014 – 07.2016
Zur Luria	09.2014 – 08.2017
Alessandro Carlotto	09.2015 – 08.2016
Maria Colombo (also at Zurich University)	09.2015 – 08.2019
Lavinia Heisenberg	09.2015 – 08.2018
Titus Lupu	09.2015 – 08.2018
Aline Ramires	09.2015 – 08.2018
Ran Tessler	09.2015 – 08.2018
Shoham Letzter	09.2016 – 08.2019
William Sawin	09.2016 – 08.2019
Ulrike Rieß	09.2017 – 08.2020
Johannes Noller	09.2017 – 08.2020



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