ETH zürich

Report 2014 / 2015

ETH Institute for Theoretical Studies

ETH-ITS

(Photo: ETH Zurich, Tom Kawara)

Foreword

The ETH Institute for Theoretical Studies enters its third year of activity. Founded on 1 June 2013 with the aim of promoting theoretical science by inviting international top researchers to spend time at ETH, it is already having a significant impact on several groups of researchers at ETH. In the past academic year six Senior Fellows were present at different times and the first two Junior Fellows joined the Institute in the autumn of 2014. Several activities resulted, including the lively workshop on «Foundations of quantum mechanics», designed by Senior Fellow Gilles Brassard with Renato Renner of the Physics Department of ETH, the successful «Informal number theory seminar», organized by Senior Fellow Henryk Iwaniec with Emmanuel Kowalski of the ETH Department of mathematics, that attracted several young researchers in the area, and the «Open to all seminar», organized by Senior Fellows Alex Lubotzky and Adi Shamir, exploring open questions from different fields at the fertile crossroads of number theory, computer science and combinatorics. Two Senior Fellows were awarded prestigious prizes in the academic year: Dmitry Chelkak received the Salem Prize, which is awarded every year to a young mathematician for outstanding work in mathematical analysis, and Henryk Iwaniec, together with Gerhard Faltings of the Max-Planck-Institut für Mathematik in Bonn, received the Shaw Prize in Mathematical Sciences 2015. The coming academic year is marked by a substantial growth, with six new Junior Fellows who start this year and work in several different fields of theoretical science. Physics, with three new Senior Fellows to join the Institute this year, will be strongly represented in the coming academic year and will complement the activities in mathematics and computer science.

I invite you to join the activities of the Institute. In particular, you might be interested to attend the ITS Science Colloquium, aiming at presenting themes of common interest across disciplines.

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: ETH Zurich, Giuseppe Micciché)

The building in the Clausiusstrasse.

The ETH Institute for Theoretical Studies

History and aims

The ETH Institute for Theoretical Studies (ETH-ITS) is an interdisciplinary institute dedicated to research in mathematics, theoretical computer science and theoretical natural sciences. 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 aim of the institute is to enable top theoretical scientists to be active for an extended period of time at ETH, interact with local researchers, and establish lasting scientific collaborations in an interdisciplinary context.

Collaborations

The ETH Institute for Theoretical Studies collaborates with the Departments of ETH and their visitor programmes, such as the Forschungsinstitut für Mathematik (FIM) at the Department of mathematics and the Pauli Centre at the Department of physics. It also nurtures the relationship with other Swiss research institutions through its Fellows and by contributing to scientific activities. For example, last year a conference on «Foundations of quantum mechanics» was organized by Senior Fellow Gilles Brassard with ETH Professor Renato Renner at the ETH-ITS in collaboration with the Pauli Centre. The Institute also cosponsored with the Conférence Universitaire de Suisse Occidentale a meeting on «High-dimensional expanders» in the Swiss Alps, organized by Senior Fellow Alex Lubotzky with Geneva Professor Tatiana Nagnibeda. Senior Fellow Henryk Iwaniec gave a lecture course in the ETH lectures series of the Department of mathematics and co-organized a conference at FIM. The ETH-ITS also hosts part of the activities of the new National Centre of Competence in Research «SwissMAP – The Mathematics of Physics» of the Swiss National Science Foundation, based on a collaboration between the University of Geneva and ETH Zurich involving researchers in Switzerland working at the interface between mathematics and physics.

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

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 spending up to three years at ETH Zurich to work on research subjects of their choice. They are supported by a mentor, who is an ETH professor. The Junior Fellows are selected by the director, who is assisted by the scientific Advisory Committee, by a nomination procedure: candidates are selected from a group of young researchers that are nominated by faculty members and senior researchers of universities and research institutions and are invited to apply.

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

www.ethz.ch/eth-its/fellows.html →

(Photo: Christina Buchmann)

Participants of the Workshop on Foundations of quantum mechanics.

Fellows' report

Professor **Gilles Brassard** FRS, O.C., joined the Institute for Theoretical Studies as a Senior Fellow in June 2014. Back home, he is Canada Research Chair in quantum information science and computer science professor at the Université de Montréal, from where he took a six-month sabbatical. Educated as a theoretical computer scientist at Cornell University in the late 1970s, his main current interests are the use of quantum mechanics to enhance our information-processing capabilities and, conversely, the use of a fresh information-theoretic perspective to shed new light on the foundations of quantum mechanics. He is best known for his invention of quantum cryptography and quantum teleportation, jointly with Charles Bennett.

Gilles Brassard has been using his sabbatical leave at the ETH-ITS to interact with physics professor Renato Renner (who was at the time head of the Institute for Theoretical Physics) and computer science professor Ueli Maurer, as well as with their very bright students. He gave four talks at the ETH, including an ITS Science Colloquium on «Cryptography in a quantum world» and the 2014 Quantum Science and Technology Annual Special Lecture for Students on «A personal perspective on quantum cryptography». He also made the best of his presence in Europe to attend scientific events in Vienna and London and to give invited lectures in Geneva, Lugano and Paris, in addition to a tutorial at the 14th Asian Quantum Information Science Conference in Kyoto and a round table participation in the 4th International Conference on Quantum Cryptography in Paris. But the best part of Gilles Brassard's stay at the ITS was an intimate workshop on the Foundations of Quantum Mechanics that he organized in collaboration with Professor Renato Renner, which took place in October 2014 in the cozy ITS seminar room. For this one-week event, Gilles and Renato hand-picked a baker's dozen of the world authorities in the field, with the purpose of allowing them to debate their sometimes widely contrasting views through ample interaction in a very loose schedule of at most three talks in any given day. Local students were encouraged to attend and not only witness the memorable discussions, but also participate fully. Charles Bennett gave the ITS Science Colloquium as highlight of the workshop.

Gilles Brassard's original invitation was for a one-year period and he is looking forward to coming back to the ITS for another six months.

(Photo: Christina Buchmann)

Dmitry Chelkak.

Dmitry Chelkak spent the academic year 2014/15 at the Institute for Theoretical Studies as a Senior Fellow. He holds a permanent position at the St. Petersburg Department of the Steklov Institute, RAS. His research interests include complex analysis, probability theory and statistical mechanics. During his stay in Zurich, Chelkak mainly collaborated with the group of Wendelin Werner at the ETH Zurich and the group of Stanislav Smirnov at the University of Geneva. He is also involved in the special master class program in planar statistical physics which is organized by the Swiss National Centre of Competence in Research SwissMAP in the academic year 2015/16.

In the fall term, Dmitry Chelkak led a graduate seminar at the ETH on his recent joint paper with Hongler and Izyurov *Conformal invariance of spin correlation functions in the planar Ising model* (Ann. Math. 181 (2015), 1087–1138). He also participated in organizing the Geneva-Zurich working group on rigorous approaches to the renormalization of 2-dimensional lattice models and gave a mini-course on the link between the full-plane correlation functions and orthogonal polynomials in the spring term.

During his stay at the ITS, Chelkak worked on further developments of discrete complex analysis techniques related to the planar Ising model, as well as on mathematically rigorous understanding of Conformal Field Theory predictions for the scaling limits of other critical lattice models in 2 dimensions. The results obtained in collaboration with Alexander Glazman and Stanislav Smirnov, of the University of Geneva, are discussed in the preprint *Discrete stress-energy tensor in the loop O(n) model* (in preparation). Another preprint *Revisiting the combinatorics of the Ising model* (arXiv:1507.08242) joint with Adrien Kassel (ETH Zurich) and David Cimasoni (University of Geneva) contains a presentation of several formalisms developed by physicists to study the Ising model (on a general planar weighted graph), which is particularly intended for the probabilistic community. It also includes a discussion of recent conjectures on the scaling limits of interfaces in the double-Ising model at criticality, from the viewpoint of boundary value problems for discrete holomorphic observables. These developments are also important for the ongoing project with Clement Hongler (EPFL) and Konstanin Izyurov (Helsinki) on the convergence of general spindisorder correlations in multiply-connected domains and the identification of their limits, a setup which is not covered by the standard tools of conformal field theory.

(Photo: Christina Buchmann)

Tea in the garden of the Institute.

In her first year as a Junior Fellow at the Institute for Theoretical Studies, **Emily Clader** launched several research collaborations. With ETH graduate student Felix Janda, she proved a conjecture of Aaron Pixton concerning the double ramification cycle, a cohomology class on the moduli space of curves that has generated much recent interest. In joint work with visiting ETH scholar Dustin Ross, she proved a correspondence between Gromov-Witten theory and the gauged linear sigma model for a wide class of targets, building both computationally and theoretically on the results of her PhD dissertation. She also began collaborations with Ran Tessler (who will join the ITS in Fall 2015 as a Junior Fellow) on the foundations of open r-spin theory, as well as with Felix Janda and Yongbin Ruan on the higher-genus Landau-Ginzburg model. Both of these projects present exciting avenues for ongoing research.

Emily also delivered a number of talks in the academic year 2014–2015, both at ETH and abroad. These included a three-lecture series at ETH in Fall 2014 on orbifolds and the Landau-Ginzburg model, a talk on the double ramification cycle in the ETH Algebraic Geometry and Moduli Seminar, and visiting lectures at Columbia University, University of Michigan, Hebrew University, Peking University, and the Association for Women in Mathematics Research Symposium.

Alongside her research program, Emily also devoted time to pedagogical pursuits. She mentored Master's student Nikolas Kuhn in a reading course, where he learned the basics of Gromov-Witten theory. She also participated in a reading seminar on motivic Donaldson-Thomas theory, in which she gave an introductory lecture for her peers. And, in collaboration with Yongbin Ruan, she produced an expository text on mirror symmetry (E. Clader and Y. Ruan. *Mirror Symmetry Constructions.* arXiv:1412.1268, 2014), which will serve as a reference for Professor Ruan's future students as they master this subject. Through these projects, Emily served the mathematical community and established important connections with a younger cohort of upcoming Gromov-Witten theorists.

(Photo: Christina Buchmann)

«Overall, I have definitely benefited enormously as a Senior Fellow at ITS. I hope that my visit has also left a positive effect, stimulating quantitative, theoretical thinking in systems biology at ETH.» **Terry Hwa.**

Terry Hwa returned to ITS during the spring-summer of 2015 for the second leg of his 12-month sabbatical visit, to develop new concepts and approaches in theoretical biology. During this time, he completed several manuscripts and initiated multiple projects with ETH collaborators as described below.

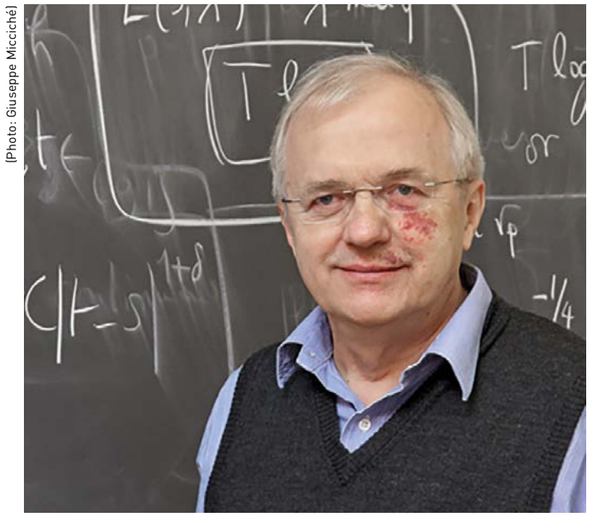
One manuscript is on the optimal strategy cells use to generate energy from carbon substrates. This work, to appear shortly as an article in the journal *Nature*, addresses a 90-year puzzle regarding why fast growing cells ranging from bacteria to cancer prefer to generate energy using the wasteful process of fermentation (with massive excretion of fermentation by-products such as lactate and ethanol), instead of the much more efficient process of respiration, which «burns» the above byproducts into CO_2. Hwa and collaborators proposed that the use of respiratory process imposes as an additional cost, the cost of building the respiratory machinery that cells could otherwise use for proliferation under good growth condition. They built a simple resource allocation model that quantitatively predicted how bacterial cells would shift its use of fermentation vs respiration under different perturbations. The results suggest similar studies for higher cells to see if they are governed by the same principle of resource allocation.

Another manuscript, under review at *Molecular Systems Biology*, addresses an experimental discovery that one can inflate a cell to many times its normal size by making it synthesize a generic protein it does not need. The work introduces a new effector, protein allocation, to cell size control which is one of the long-standing mystery of cell biology.

In addition, the main collaborative projects with researchers at the Institute for Molecular Systems Biology (the labs of Uwe Sauer and Ruedi Aebersold) are coming to fruition. A long series of «omics experiments», each involves the measurements of thousands of proteins and small molecules in cells, have been completed and they have started to analyze the data. Together, these datasets represent perhaps the most complete coverage of the molecules inside living cells across carefully controlled physiological conditions. With the analysis of these data, Hwa hopes to construct bridges relating quantitative phenomenological rules (such as those described in the two manuscripts above) and molecular interaction, analogous to how statistical mechanics bridges thermodynamics to molecular interactions.

The original of plan of Hwa was to facilitate the data generation process during his first visit last year, and spend his visit this year building the new theory. As it turned out, the data generation process was much more involved than he had anticipated. Also it involved multiple biologists each of whom needs to be motivated and educated of the quantitative, theoretical aspect of the work. Now that the data have been generated, they are working together long-distance to extract information. Hwa expects to continue to visit ETH in the future, to complete these projects and possibly launching new ones.

(Photo: Giuseppe Micciché)



«The 10 months spent in ETH-ITS was a great experience in my mathematical life. Never before I had better working conditions, free unlimited time to indulge myself into beloved mathematical problems, and relaxed atmosphere to interact with many distinguished visitors. I hope I shall visit ITS again and enjoy its very attractive surroundings.» **Henryk Iwaniec.**

Henryk Iwaniec, New Jersey State Professor in Mathematics at Rutgers University, spent the period from August 2014 to May 2015 at the ETH Institute for Theoretical Studies as a Senior Fellow, on a leave of absence without pay from Rutgers.

His main occupation at the Institute was to conduct research in his own field of interest, which is analytic number theory. He was working on several projects which were initiated in unfinished works and on new problems in collaboration with Professor Emmanuel Kowalski. They have made considerable progress in several areas.

For example, Iwaniec expanded the construction and enhanced the treatment of long mollifiers which are parts of his work in progress with B. Conrey on the zeros of the Riemann zeta function on the critical line. In the same direction, but by a different argument, Conrey and Iwaniec succeeded to show that 100% of the zeros are on the critical line, subject to the condition that the «exceptional characters» do exist. Most of this work was accomplished in the Institute and the results were written in the paper *Critical Zeros of Lacunary L-functions* (49 typed pages, not yet submitted for publication).

During his stay Iwaniec had numerous conversations on mathematics with Manfred Einsiedler, Javier Fresán, Özlem Imamoglu, Paul Nelson, Gisbert Wüstholz, other members of the ETH faculty as well as with participants of seminars and lectures. In particular, their frequent discussions about the spectral theory of automorphic forms with Paul Nelson let Paul develop the classical Kuznetsov trace formula in a more appealing new setting.

Course description

ANALYTIC THEORY OF L-FUNCTIONS – a course in the series ETH Lectures in Mathematics

L-functions encapsulate information about important arithmetical sequences through their coefficients in Dirichlet series and Euler products representations. Analytic properties, such as the distribution of complex zeros (among many other things), reveal intrinsic features beyond superficial formulas. The course covers a wide panorama of the most current investigations.

(Photo: Christina Buchmann)

Alex Lubotzky in the garden of the ETH-ITS.

(Photo: Christina Buchmann)

Adi Shamir at the ITS Science Colloquium.

During both semesters Kowalski and Iwaniec ran the «Informal Number Theory Seminar» at ITS. This was primarily designed for graduate students and young researchers to give them an opportunity for talking about their work in progress and to discuss with the audience their ideas. Occasionally senior mathematicians presented their own results in a broad context. Moreover Iwaniec participated in the Number Theory Seminar at ETH which distinguishes itself by covering very advanced topics.
In November 2014 Iwaniec gave a talk «Counting in Number Theory» in Zurich Colloquium in Mathematics. In December 2014 he presented his results on the zeros of the zeta function (joint work with B. Conrey) at the conference in Princeton, USA. In the spring semester he gave a Nachdiplomvorlesung on various topics in «Analytic Theory of L-functions» at the Department of Mathematics of ETH. In April he gave a colloquium talk at EPF Lausanne and in May a talk in the Number Theory Days-EPFL. In May 18–22, 2015 he organized (jointly with Emmanuel Kowalski and Philippe Michel) an international conference on «Analytic Aspects in Number Theory» sponsored by FIM at ETH Zurich.

Professor **Alex Lubotzky** spent six months from February to July 2015 at the ETH-ITS with a leave of absence from the Hebrew University, Jerusalem, were he holds the Maurice and Clara Weil chair in mathematics. He has concentrated in his stay at the ITS on two directions of research:

1 High dimensional expanders: expander graphs have been a focus of interest in computer science in the last four decades and in the last decade found applications also in pure mathematics. Lubotzky has been a central figure in these directions in the last 30 years. In recent years he is leading an effort to establish a high dimensional theory of expanders. Namely, simplicial complexes (or hypergraphs) which resemble in the high dimensional case the properties of expander graphs in dimension one. This direction suggests many problems and several possible applications in topology, geometry, computer science and more. Lubotzky co-organized in June 2015 (with Prof. Tatiana Nagnibeda from Geneva) a Borel conference on this subject. This was an educational event (partially supported also by the ITS) which attracted almost 80 participants who got within a week a quick path to the cutting edge material of this area. A second conference – this time for experts and also supported by the ITS – is planned for June 2016. It is also planned that Lubotzky will give a lecture course on this subject at the ETH in the spring semester 2016. Lubotzky also cooperated on a project within this area with the ITS Junior Fellow Zur Luria and with a post-doc at the math department Ron Rosental.

2 Testability in group theory: this is a new direction of research within group theory proposed by Lubotzky. To illustrate the concept, let's look at two permutations on n elements A and B and assume A and B «almost» commute (i.e. for almost all i between 1 and n, AB(i)=BA(i)). Is it true that A and B are «close» to two permutations which really commute? The answer in this case is positive, but for various other sets of equations the answer to a similar question is negative. It turns out that the answer depends on some deep properties of the group defined by the equations. This suggests a new direction of study of understanding which groups are «testable». Lubotzky has decided to take the opportunity of the extra free time and scholar environment at the ITS to dedicate his time to start to work in this new direction. Few initial results have already been established and the topic looks very promising: it combines methods and connections from group theory, combinatorics, model theory, measure theory and more.
Lubotzky has also used his visit to Zurich to give a good number of lectures in Switzerland, France, Germany and England.

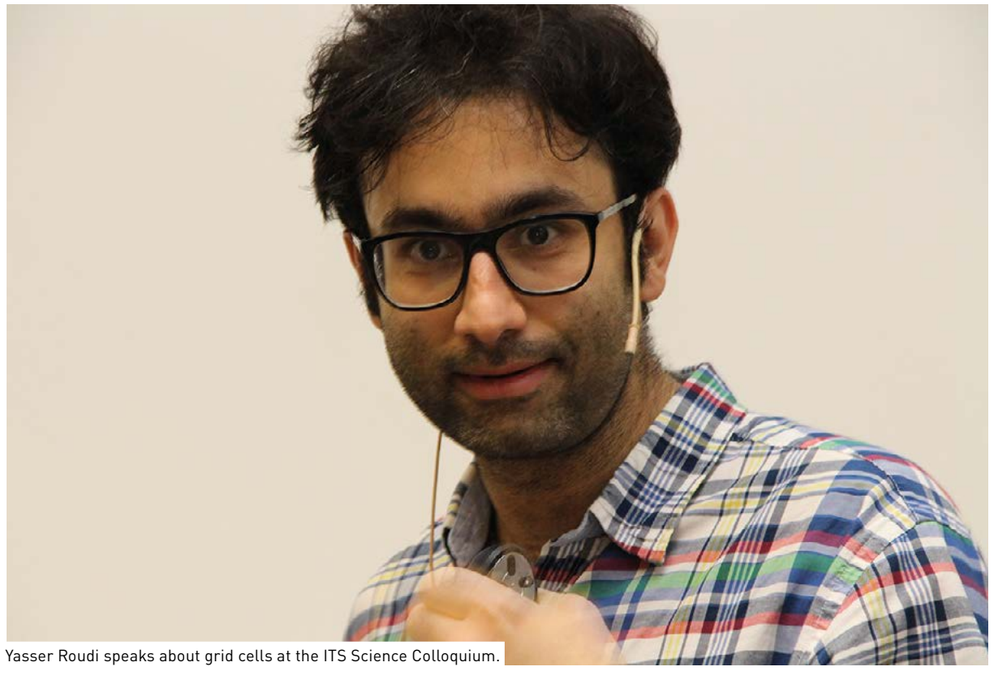
Zur Luria is a Junior Fellow since September 2014. His research interests include the study of hypergraphs and simplicial complexes, Latin squares and hypercubes, designs, and the connections between these and other combinatorial objects.
In joint work with Roman Glebov, Zur Luria studied the maximal number of Latin transversals. An order-n Latin square is an $n \times n$ matrix over the symbols $\{1, \dots, n\}$ such that each symbol appears exactly once in each row and each column. A transversal of a given order-n Latin square is a collection of n elements, one from each row and column and one of each symbol.
The most famous open problem in the study of Latin transversals is Ryser's conjecture, which states that every Latin square of odd order contains a transversal. It is known that there are Latin squares of even order that do not contain a transversal. Ryser's conjecture contains the minimum number of transversals in a Latin square. Luria and Glebov asked the complementary question: What is the maximal number of transversals in an order-n Latin square? They found a new proof of a known upper bound and showed that it is tight by proving a new lower bound. They also proved high dimensional versions of these bounds for transversals in Latin hypercubes. They have submitted their paper, *On the maximal number of Latin transversals*, to the Journal of Combinatorial Theory A.
Work in progress by Luria includes the study of high dimensional expanders of bounded degree in collaboration with Ron Rosenthal, a research project on a lower bound on the number of 1-factorizations with Benny Sudakov and research on perfect matchings on random hypergraphs.

Professor **Adi Shamir** of the Weizmann Institute, a leading researcher in cryptography and computer science, spent six months as a Senior Fellow at the ETH Institute for Theoretical Studies. He interacted with various groups at ETH and co-organized with Alex Lubotzky the «Open to all seminar». He gave several talks, including an ITS Science Colloquium and a memorable talk on «Post-Snowden cryptography» in the ETH Global lecture series.

(Photo: Christina Buchmann)

Audience at the ITS Science Colloquium.

(Photo: Christina Buchmann)



Yasser Roudi speaks about grid cells at the ITS Science Colloquium.

The ITS Science Colloquium

The ITS Science Colloquium aims at exposing students and researchers in mathematics, theoretical computer science and theoretical natural sciences to new questions and research subjects of common interest to different disciplines. The circle of ideas around classical and quantum cryptography, quantum information theory and foundations of quantum mechanics is a stimulating field at the crossroad of disciplines. Different viewpoints on this were offered in the talks of Gilles Brassard, Charles Bennet, Adi Shamir and Wojciech Zurek. Thomas Holenstein gave a well attended talk on the history and challenges of the electronic currency Bitcoin. The recent spectacular results on the Ising model of magnetisation in statistical mechanics were presented by Dmitry Chelkak. In a talk involving biology, physics and mathematics, Yasser Roudi, a collaborators of last year's Nobel laureates in medicine or physiology Moser, explained recent results on grid cells, brain cells storing a triangulation of space in the brain of mammals. Alex Lubotzky showed how p-adic numbers, a notion arising in pure mathematics, found important applications in computer science.

Programme 2014/2015

02.10.2014	Gilles Brassard, ETH-ITS and Université de Montréal	Cryptography in a Quantum World
16.10.2014	Charles H. Bennett, IBM Research, Yorktown Heights	Boltzmann's brain and Wigner's friend
06.11.2014	Thomas Holenstein, ETH Zurich	Is there a theory behind Bitcoin?
11.12.2014	Dmitry Chelkak, ETH-ITS and Steklov Institute, St. Petersburg	2D Ising model at and near criticality: what we can prove and what we still would like to understand
05.03.2015	Adi Shamir, ETH-ITS and Weizmann Institute	Random graphs in cryptography
26.03.2015	Yasser Roudi, NTNU Trondheim	Network Inference and its application to mammalian spatial navigation system
30.04.2015	Alex Lubotzky, ETH-ITS and Hebrew University	Real applications of non real numbers
21.05.2015	Wojciech Zurek, LANL Los Alamos	Quantum theory of the classical

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

(Photo: Christina Buchmann)

Senior Fellows Terry Hwa, Henryk Iwaniec and Dmitry Chelkak.

Awards

The Salem Prize 2014 was awarded to ETH-ITS Senior Fellow Dmitry Chelkak «for his contributions to establishing scaling limits and proving their conformal invariance and universality for interfaces and lattice fields in the two-dimensional critical Ising model, which confirmed predictions, originating in theoretical physics, and also led to new precise results.» The prize, in memory of Raphael Salem, is awarded yearly to young researchers for outstanding contributions to the field of analysis.

The Shaw prize in Mathematical Sciences 2015 was awarded in equal shares to Gerd Faltings and ETH-ITS Senior Fellow Henryk Iwaniec «for their introduction and development of fundamental tools in number theory, allowing them as well as others to resolve some long-standing classical problems.»

The Shaw Prize is an international award to honour individuals who are currently active in their respective fields and who have recently achieved distinguished and significant advances, who have made outstanding contributions in academic and scientific research or applications, or who in other domains have achieved excellence. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity's spiritual civilization.

Organization of the ETH Institute for Theoretical Studies

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Giovanni Felder

Coordinator
Christina Buchmann

Advisory Committee
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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
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
Walter Schachermayer, University of Vienna	09.2015 – 08.2016
Adi Shamir, Weizmann Institute	02.2015 – 07.2015 and 02.2016 – 07.2016

Junior Fellows

Emily Clader	09.2014 – 08.2017
Zur Luria	09.2014 – 08.2017
Alessandro Carlotto	09.2015 – 08.2018
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

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Outlook 2015/2016

In September 2015 three Senior and eight Junior Fellows will be at the Institute. Physicist Eugene Demler will spend the rest of his stay at the ETH-ITS after his first visit at the beginning of summer. Cosmologist Robert Brandenberger and mathematician Walter Schachermayer will spend a year the ETH Institute for Theoretical Studies as Senior Fellows from August 2015. They are joined in September 2015 by six starting Junior Fellows: Alessandro Carlotto, Maria Colombo, Lavinia Heisenberg, Titus Lupu, Aline Ramires and Ran Tessler. In November another Senior Fellow, particle physicist Riccardo Barbieri, of the Scuola Normale Superiore, Pisa, will also join. In the spring, Alex Lubotzky and Adi Shamir will return to the institute for their second period of six months.

1 Robert Brandenberger is a theoretical cosmologist who has made numerous important contributions to the subject. Among other things he has developed, together with Cumrun Vafa, the *string gas cosmology model* that gives an intriguing explanation for why only 3 spatial dimensions are large (and hence we seem to live in a (3+1)-dimensional universe). He has also studied the dependence of inflationary models on the assumptions about the nature of trans-Planckian physics. Professor Brandenberger, an ETH Zurich alumnus, obtained his PhD from Harvard University in 1983. He holds a Tier 1 Canada Research Chair at McGill University and he is also affiliated with the Perimeter Institute. He is the recipient of several awards, including the Alfred P. Sloan Fellowship in 1988 and the CAP-CRM Prize In Theoretical And Mathematical Physics in 2011.

2 Eugene Demler is a leading theoretical condensed matter physicists working on quantum gases. He has pioneered efforts aimed at realizing synthetic gauge fields for ultracold atoms or photons, proposed new methods such as noise spectroscopy to study many-body states and investigated novel quantum phases in spinor and dipolar gases. He obtained his PhD from Stanford University in 1998 and is currently professor of physics at Harvard University. He was Sloan Fellow and received the Gutenberg Lecture Award in 2006.

3 Walter Schachermayer is one of the leading researchers in mathematical finance: many major developments in this field, such as the fundamental theorem of asset pricing and the dual formulation of utility optimization, are inextricably connected with his name. His research interests range from functional analysis to stochastic analysis and control theory. He also stretches out beyond the mathematical community: his articles on the impact of finance on society reach a wider audience. He received his doctorate from the University of Vienna in 1976 and is now professor at the University of Vienna. He received numerous awards, including the 1998 Wittgenstein prize for his work in mathematical finance.

4 Alessandro Carlotto received his PhD from Stanford University in May 2014 under the supervision of Richard Schoen. His main research interests are in Differential Geometry and Geometric Analysis, with special emphasis on the large-scale structure of asymptotically flat spaces, on the Einstein constraint equations and on various global aspects of the theory of minimal subvarieties. He will join the Institute in September 2015 after being a member of the Geometry group at Imperial College of Science and Technology, London.

5 Lavinia Heisenberg received her PhD at the University of Geneva in February 2014 under the supervision of Claudia de Rham. After a research visit at Perimeter Institute, she started her first postdoc in Stockholm as Nordita Follow in September 2014. Her main area of expertise is gravity and cosmology. Her research so far has been mainly devoted to the study of field theories, specially within the context of Massive Gravity, higher dimensional scenarios, Galileon fields and vector fields, comprising the fundamental properties of field theories, their cosmological consequences and observational signatures.

6 Aline Ramires received her PhD in Physics from Rutgers University under the supervision of Piers Coleman. Her work addresses several aspects of heavy fermion systems, ranging from phenomenological models to new theoretical approaches based on supersymmetric spin representations. She is interested in developing new theoretical tools in order to understand the unusual phases of matter observed in strongly correlated systems.

7 Maria Colombo is interested in partial differential equations, calculus of variations, optimal transport, and geometric analysis. In her PhD thesis, under the supervision of Luigi Ambrosio and Alessio Figalli, she studied some general tools concerning the connection between the Lagrangian and the Eulerian structure of transport equations with non-smooth vector fields; in turn, these tools apply to show that weak solutions of the Vlasov-Poisson system are Lagrangian and to obtain global existence of weak solutions under minimal assumptions on the initial data.

8 Titus Lupu received his PhD mathematics in May 2015 at the University Paris-Sud Orsay with a thesis on loop soups of Markov processes under the supervision of Yves Le Jan. He worked on the relation of these loop soups to the Gaussian Free Field and showed that the scaling limits of random walk loop soup clusters on a two-dimensional lattice are the Conformal Loop Ensembles.

9 Ran Tessler received his PhD from Hebrew University, Jerusalem, under the supervision of Jake Solomon. He works in open Gromov-Witten theory. With his collaborators he has constructed analysed the intersection theory on the moduli spaces of open Riemann surfaces. He is also interested in probability theory.

Contact

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