ETH zürich

Institute for Theoretical Studies

Report
2020/2021

ETH-ITS

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Dominik Schröder

Rahul Pandharipande enjoying the view over lake Obersee in spring 2021.

Foreword

The academic year 2020 – 2021 was unusual in many ways. While there were hopes in September 2020 for the end of the Covid-19 pandemic, the situation in fact worsened. Unfortunately, in-person events at the ITS were not possible. All Senior Fellows delayed their visits, and we had the first year at the institute without any Senior Fellows. Fortunately, we had a full house of Junior Fellows, seven in total, with two new arrivals – Christoph Kehle from Cambridge and Alexandru Gheorghiu from Caltech. Our first new Senior Fellows after the start of the pandemic, Albrecht Klemm from Bonn and Mikhail Lyubich from Stony Brook, arrived in August of 2021.

The institute activities for 2020 – 2021 were mainly online: virtual teas, virtual seminars for the Junior Fellows, and a regular virtual ITS colloquium covering topics ranging from mathematics, machine learning, and the spread of Covid-19. When the weather permitted, we had outdoor events (including group hikes as in the cover photo). But overall, it was a difficult year for everyone.

Our first Advanced Fellow, Marvin Künnemann in computer science from Saarbrücken, arrived in the Spring of 2021 – a new 5 year fellowship for successful young researchers with some experience after their PhD. Three more new Advanced Fellows will arrive in the upcoming year (along with three new Junior Fellows). The institute will again be full in the Fall of 2021, and we are very much hoping for a more normal 2021 – 2022.

Rahul Pandharipande, Director

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

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.

Fellows at the ITS

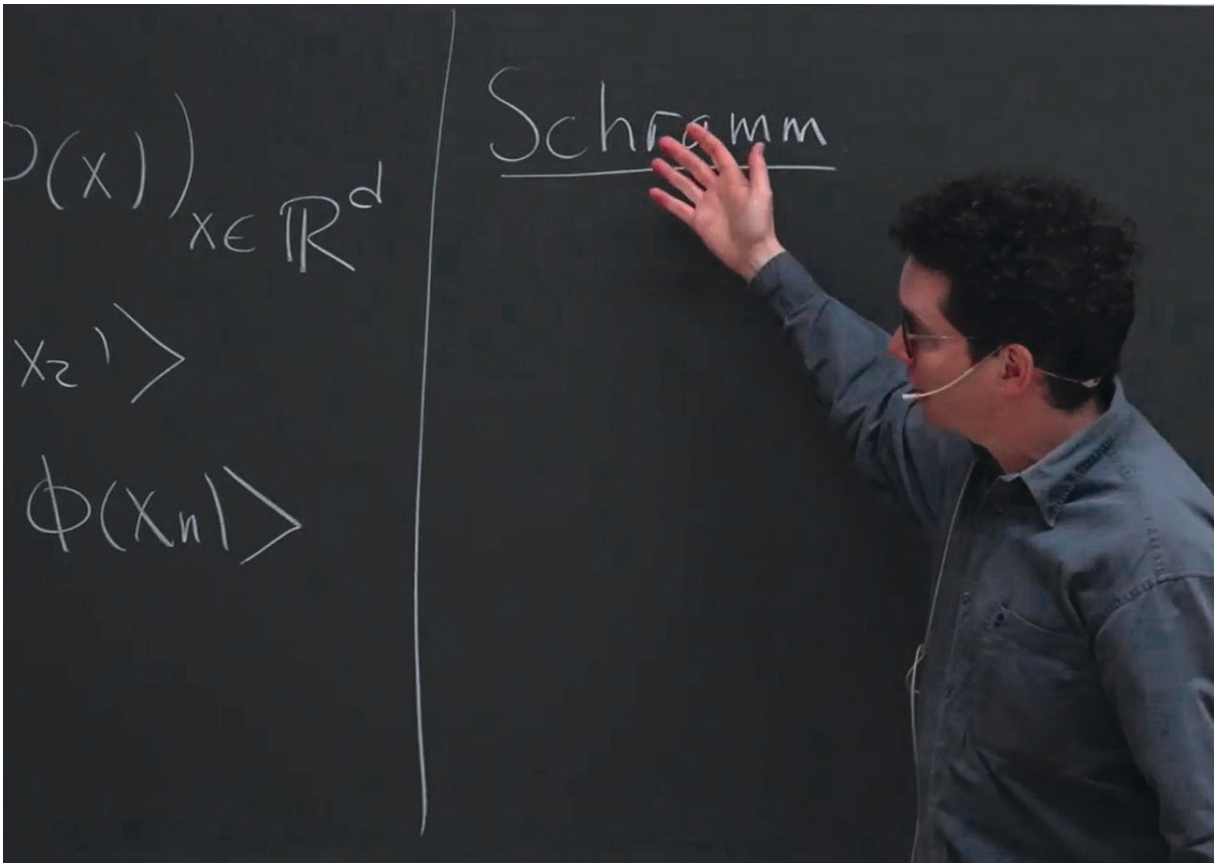
The Institute hosts up to six Senior Fellows and up to twelve Junior and Advanced Fellows. Junior Fellows are talented young independent postdocs spending up to three years at ETH Zurich to work on research subjects of their choice. They are supported by a mentor, who is an ETH professor. Advanced Fellows are young researchers with some experience after their PhD, who have established themselves as leaders in their disciplines. The Junior and Advanced Fellows are selected by the director, with the assistance of 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.

Schedule for the selection of Junior and Advanced 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, 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



ETH-ITS

Wendelin Werner during his talk at the ITS Science Colloquium in September 2020.

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.

There were four online ITS colloquia in the academic year 2020 – 2021. Wendelin Werner (ETHZ) started the colloquium series with a lecture on the Gaussian Free Field and its generalization to random geometries in spatial dimension greater than 2.

Announcement of Alessio Figalli's talk in November 2020.

Alessio Figalli (ETHZ and ITS Advisory Board member) spoke about his fundamental work on optimal transport. The third colloquium was by Fan Yang (ETHZ and a former ITS Junior Fellow) who spoke about the bias variance trade-off in high dimensions in the theory of machine learning.

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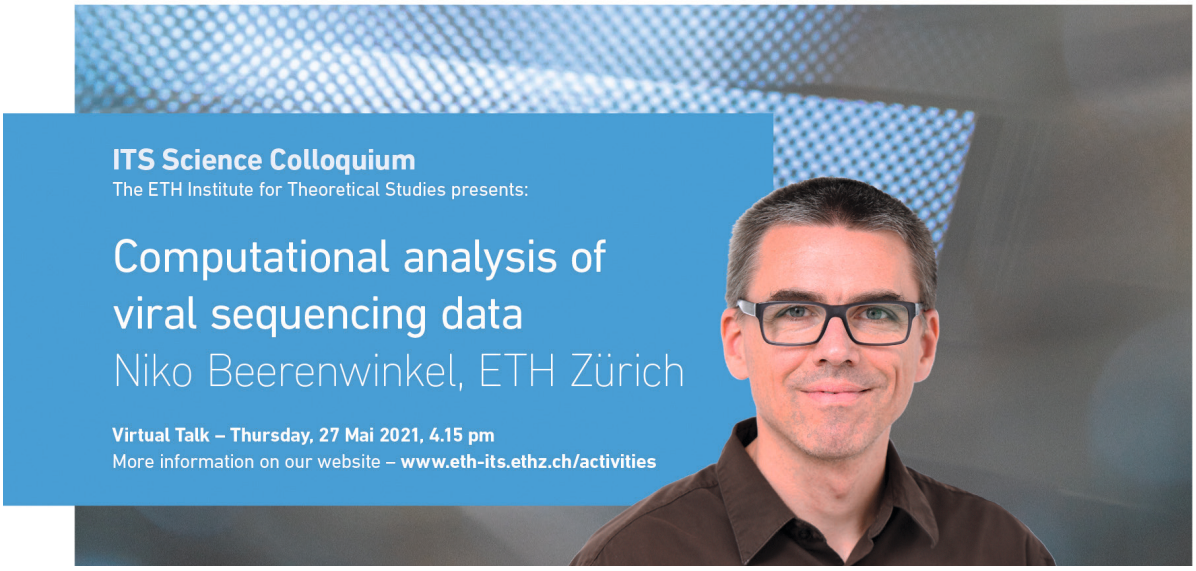
Announcement of Fan Yang's talk in spring 2021.



Announcement of Niko Beerenwinkel's colloquium in May 2021.

The last colloquium was by Niko Beerenwinkel (ETHZ) on the spread of Covid-19 variants via genetic analysis of wastewater in Switzerland. For the upcoming Fall, we are hoping to return to our usual in-person colloquia.

Programme 2020 – 2021

24.09.2020	Wendelin Werner, ETH Zurich	Basic geometric structures hidden in the free boson
26.11.2020	Alessio Figalli, ETH Zurich	Optimal transport: from nature to machine learning
29.03.2021	Fan Yang, ETH Zurich	A modern look at the bias variance trade-off in high dimensions
27.05.2021	Niko Beerenwinkel, ETH Zurich	Computational analysis of viral sequencing data

Videos of selected talks can be viewed on https://eth-its.ethz.ch/activities/videos.html

Fellows' seminar

The aim of the Fellows' seminar, organized by Junior Fellows Yi-Jun Chang and Dominik Schröder, is to present the research of the Fellows of the ETH-ITS. It is open to all interested and the rule is that talks should be accessible to other Fellows, which are typically from a different field.

Programme 2020–2021

03.12.2020	Christoph Kehle	The fate of Baire, Diophantus and Lebesgue traveling inside an AdS black hole
08.12.2020	Alexandru Gheorghiu	Quantum computation: hardness, verification and protocols for near-term devices

Awards

Nina Holden was awarded the 2021 Maryam Mirzakhani New Frontiers in Mathematics prize for her work in random geometry, particularly on Liouville Quantum Gravity as a scaling limit of random triangulations.

Yi-Jun Chang

Junior Fellow Yi-Jun Chang enjoying a stroll.

Fellows' report

Junior Fellows

During his second year at ITS, **Yi-Jun Chang** continued his research on distributed computing. Chang and his collaborators Keren Censor-Hillel, François Le Gall, and Dean Leitersdorf designed near-optimal distributed algorithms for clique listing, significantly extending his previous work which gave a near-optimal algorithm for distributed triangle listing. This work was accepted to the ACM-SIAM Symposium on Discrete Algorithms (SODA 2021).

In the area of energy-aware distributed computing, a central research goal is to design efficient distributed algorithms that work under a stringent energy usage constraint. Much progress has been made in understanding the energy complexity of leader election in radio networks, but very little is known about the trade-off between time and energy. With Ran Duan and Shunhua Jiang, Chang revisited the leader election problem in the deterministic setting. Chang and his collaborators proved several new upper and lower bounds that give near-optimal trade-offs between time and energy for deterministic leader elections. This work was accepted to the ACM Symposium on Parallelism in Algorithms and Architectures (SPAA 2021).

The design of many distributed graph algorithms involves partitioning the network into clusters of small diameter. A recent breakthrough of Rozhoň and Ghaffari presented the first polylogarithmic-round deterministic algorithm for constructing such a clustering with polylogarithmic weak diameter. Their algorithm uses small logarithmic-size messages. One can transform their algorithm to a strong-diameter decomposition algorithm with similar parameters. However, that comes at the expense of requiring unbounded-size messages. The key remaining qualitative question in this area was whether one can achieve a similar result for strong-diameter clustering using small messages. With his mentor Mohsen Ghaffari, Chang resolved this question by presenting a novel and simple algorithm that can transform any weak-diameter clustering algorithm to a strong-diameter one in a black-box manner, using small messages and with only moderate loss in the parameters. This work was accepted to the ACM Symposium on Principles of Distributed Computing (PODC 2021).

Dominik Schröder

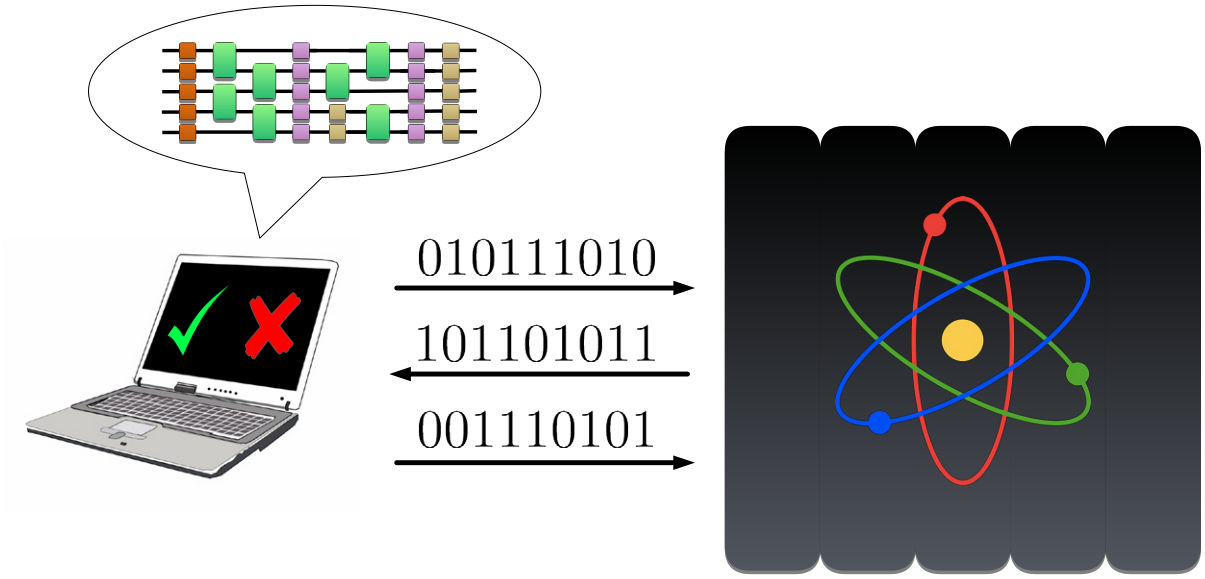
Alexandru Gheorghiu spending a beautiful day hiking in spring 2021.

In a collaboration between computer scientists and mathematicians, Chang and his collaborators Sebastian Brandt, Jan Grebík, Christoph Grunau, Václav Rozhoň, and Zoltán Vidnyánszky explored connections between distributed local algorithms, finitary factors of iid processes, and descriptive combinatorics. They are interested in the following two general questions. Can tools from one of the areas be used to obtain interesting results in another? Can we show that problem classes arising from different areas are identical? Chang and his collaborators answered both questions in the context of locally checkable labeling problems on regular trees. In particular, via connections to descriptive combinatorics, they showed new lower bounds in distributed computing and gave a simple characterization of local problems that can be solved in logarithmic rounds on regular trees. The preprint of this work is on arXiv (2106.02066).

Alexandru Gheorghiu started at the ITS as a Junior Fellow in September 2020. His work is mainly focused on verification of quantum computation and quantum complexity theory. Throughout his first year, he continued to work on these topics.

A major challenge in quantum computing research is coming up with protocols that allow non-quantum (classical) computers to efficiently verify the results of quantum computers (quantum verification protocols). This is motivated by the fact that quantum computers are expected to solve certain problems exponentially faster than the fastest classical algorithms. A number of verification protocols have been considered for checking the results of quantum computations, but they mostly remain impractical for use on existing or near-term quantum devices.

One of Gheorghiu's first projects was to improve upon existing protocols in order to make them more suitable for use on near-term devices. The goal was to optimize these protocols by reducing the required resources for implementation on existing quantum computers. In joint work with collaborators from Caltech, UC Berkeley and the University of Maryland, they developed and ran these optimized protocols on a 20-qubit ion quantum computer.



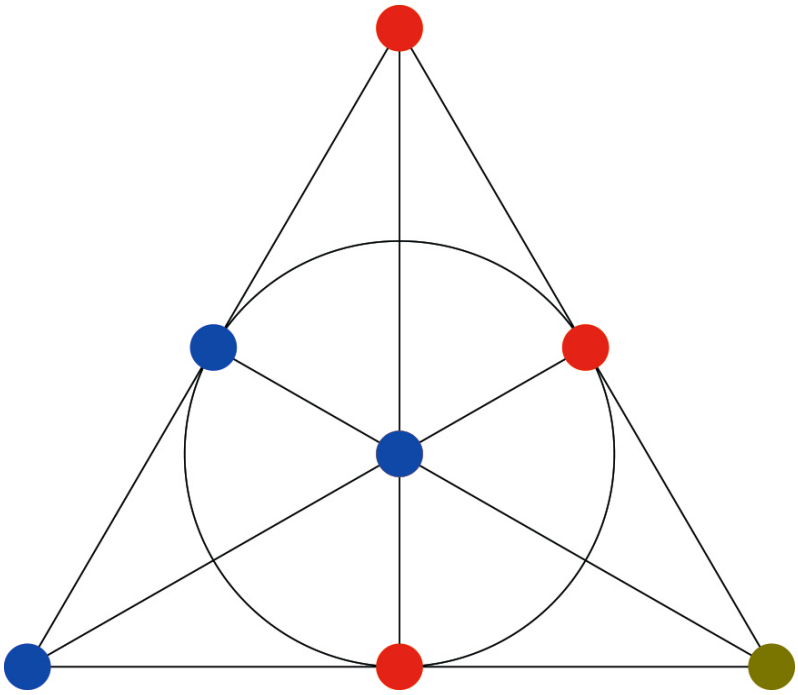
A high-level illustration of a quantum verification protocol. A classical computer wishes to delegate a computation to a quantum computer. They will exchange messages and at the end the classical computer decides whether to accept the results of the computation or not.

This was the first demonstration of an interactive verification protocol between a classical and a quantum computer. It serves as a stepping stone towards being able to reliably and efficiently verify the results obtained by quantum computers in the near future. The work was presented at the 52nd meeting of the American Physical Society.

Along the same line of work, Gheorghiu supervized ETH student Zhenning Liu for his masters project that also revolved around optimization of quantum verification protocols. While the previous work was concerned with optimizing protocols for use on existing devices, the work with Liu concerned the scalability of these protocols. They gave constructions for so-called depth-efficient protocols. These protocols would allow for the efficient classical verification of certain quantum computations which require very short quantum circuits to perform. The approach is useful for quantum devices that are constrained in the sizes of the quantum circuits that they can perform. It also serves as a theoretical demonstration that even short-depth quantum circuits can produce results which are intractable to reproduce with classical computers.

Finally, in the area of quantum complexity theory, Gheorghiu and co-author Matty Hoban improved upon a previous result concerning the hardness of estimating the entropy of short-depth circuit outputs. While their original result suggested that entropy estimation for shallow circuits is equally intractable for both quantum and classical algorithms, their updated results show that there is in fact a separation between the quantum and classical cases. Specifically, for certain families of circuits the estimation of classical entropy is easy, whereas the estimation of quantum entropy is hard. This work directly inspired Gheorghiu's result with Liu and hints at potential applications in quantum gravity research.

Gheorghiu presented his results at several venues, including seminars at MIT, Berkeley, UT Austin and ETH. He was also an invited speaker at the YITP workshop on «Progress in theoretical physics based on quantum information theory» and served on the programme committee for the conference Quantum Physics and Logic (QPL) 2021.



The Fano plane is one of the smallest examples of an intersecting hypergraph that is not 2-colorable.

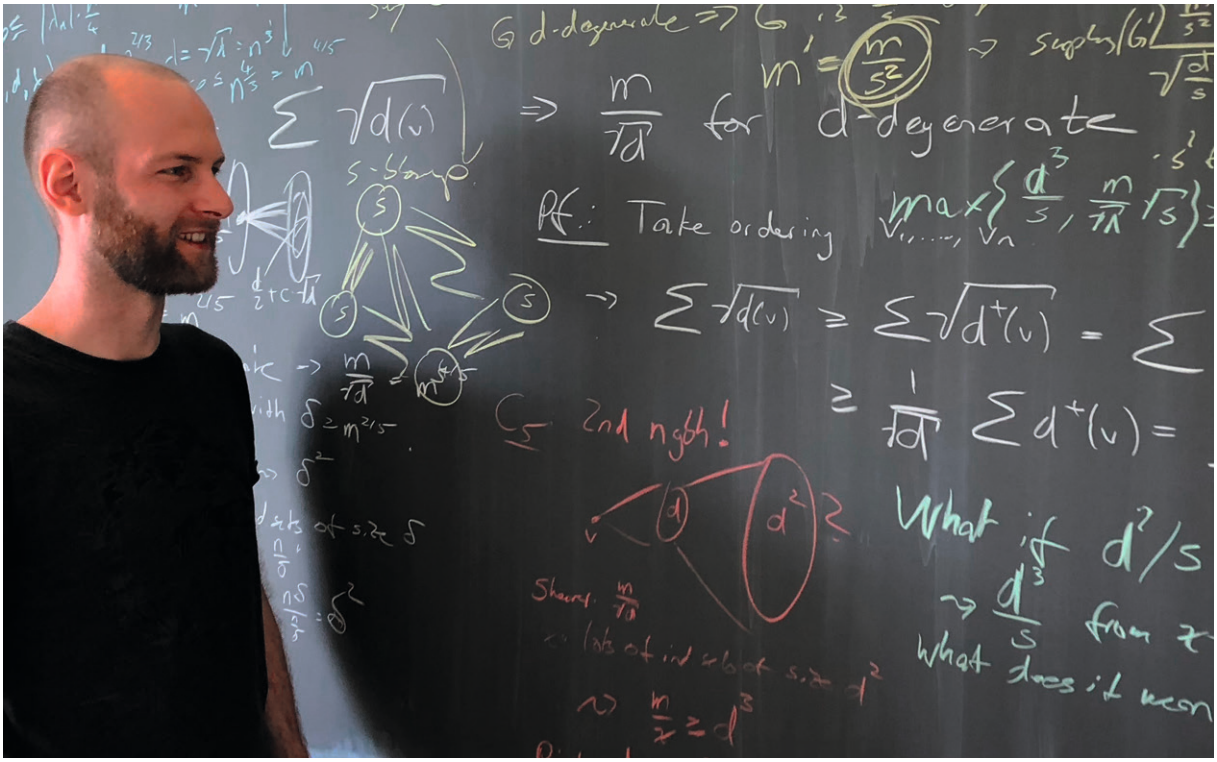
In his second year as a Junior Fellow at ITS, **Stefan Glock** continued his research in Combinatorics, focusing on three well known problems in the area.

In one project, together with Matija Bucić and Benny Sudakov, he investigated the so-called intersection spectrum of 3-chromatic intersecting hypergraphs. Roughly speaking, an intersecting hypergraph is a family of finite sets, all of the same size, such that any two of them have a non-empty intersection. One distinguishes «simple» (2-colorable) instances from more «complex» (non-2-colorable) examples. In the 70s, Erdős and Lovász initiated the study in the complex case, and made various conjectures about them. Together with his co-authors, Glock was able to prove one of these conjectures, postulating that the number of different pairwise intersection sizes in such a hypergraph tends to infinity with the size of the sets.

In another work, jointly with Oliver Janzer and Benny Sudakov, Glock considered the well-known MaxCut problem, which is of fundamental importance in Combinatorics and Computer Science and has many real-world applications. Following a line of earlier work by various researchers, they approached this problem from an extremal perspective, where one aims to prove efficient bounds on the guaranteed size of a maximum cut in graphs with certain properties. In particular, they could determine the correct behaviour for graphs not containing a cycle of a fixed odd length.

Finally, with Nemanja Draganić and Michael Krivelevich, Glock was able to settle a long-standing open problem in random graph theory, concerning the size of a largest induced path in a random graph. Previously, there was a factor 2 discrepancy between the best known upper and lower bounds. While the upper bound was widely believed to be asymptotically sharp, showing the existence of an induced path of the desired length has turned out to be very difficult, due to an «algorithmic barrier». By combining constructive methods with non-constructive methods, the researchers could bypass this algorithmic barrier and establish the existence of the desired object. Glock presented his research on several occasions, including the annual meeting of the German Mathematical Society and the European Congress of Mathematics.

In addition to his research, Glock supported the teaching activities of the mathematics department of ETH, as a teaching assistant for the course «Graph Theory», and by supervising two semester projects.



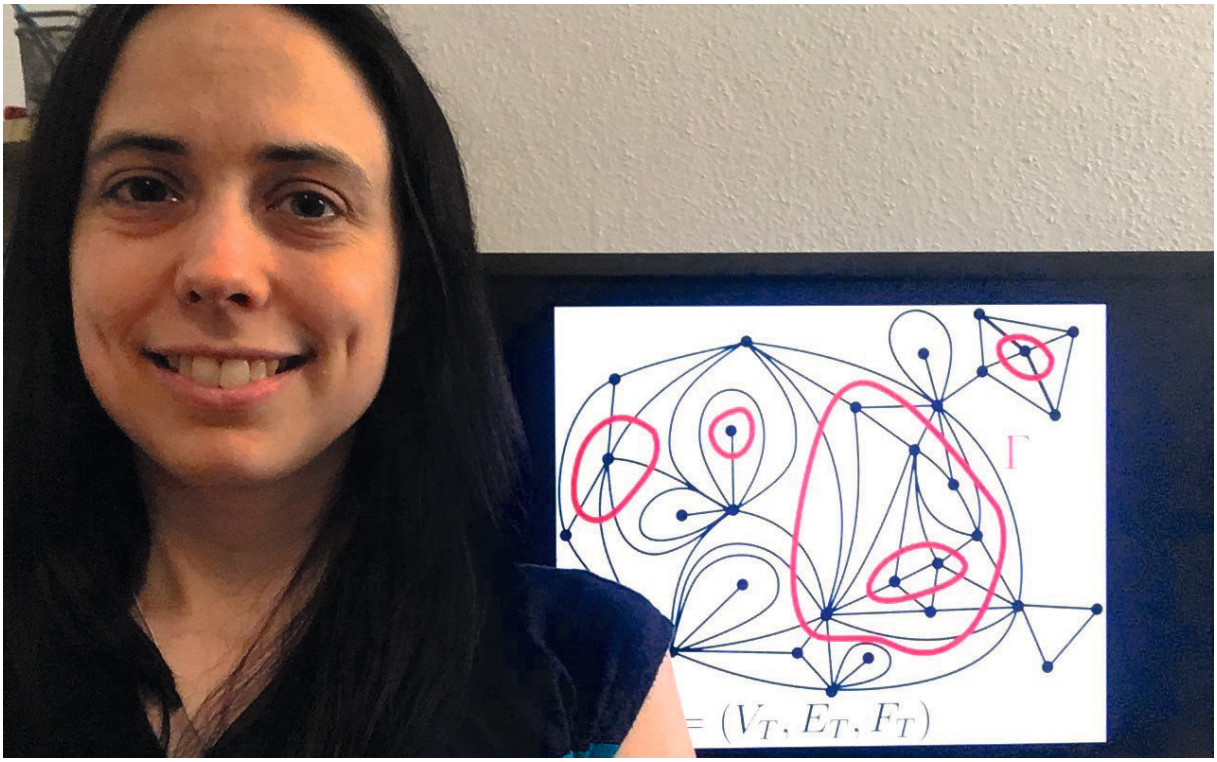
Stefan Glock

Stefan Glock sketches some aspects of the max cut problem.

Nina Holden spent her last semester at the ITS in fall 2020, after having spent 2.5 years at the ITS as a junior fellow. She works in probability theory, more specifically conformally invariant probability theory. Liouville quantum gravity (LQG) is a central object of study in her research. This is a natural model for a random surface with origin in conformal field theory and string theory in the 80s. It can be thought of as the canonical model for a random 2d Riemannian manifold, similarly as Brownian motion is the canonical model of a random path. LQG surfaces describe the scaling limit of natural discrete surfaces known as random planar maps.

Together with Matthis Lehmkuehler, who is a PhD student at ETH, she studied LQG surfaces decorated by conformal loop ensembles (CLE), which are collections of random non-crossing loops in the plane. In particular, they were interested in the case when the law of the surface has been reweighted according to nesting statistics for the CLE loops. They describe explicitly the law of a particular exploration process of the CLE-decorated LQG surface, they prove various results about its partition function, and they use the coupling with LQG to find a new proof for the law of the conformal radius of a CLE loop.

Nina Holden



The screen behind Nina Holden shows a random planar map, which is an object of study in her research.

Conformal welding of LQG surfaces means, roughly speaking, that one glues together multiple LQG surfaces to form a new LQG surface decorated by loops or curves defining the interfaces between the original surfaces. Together with Morris Ang and Xin Sun, Holden proved conformal welding results for LQG surfaces known as LQG disks. The interfaces arising in these welding results are variants of the random fractal curve known as a Schramm-Loewner evolution (SLE). They use the conformal welding result to find the law of the derivative of a particular uniformizing conformal map associated with SLE.

During the fall semester Holden organized a working group on LQG together with her mentor Wendelin Werner. The participants were members of the probability groups at ETH, the University of Zurich, and EPFL. The group met weekly, partly via Zoom and partly in person, and the participants rotated on giving talks.

Holden presented her work at several occasions, including seminars (mostly online) organized by the University of Oxford, the University of Chicago, the Perimeter Institute, and Max Planck Leipzig. She also gave online colloquiums for the University of British Columbia and the Perimeter Institute, gave an online talk at an AMS sectional meeting, and gave a mini-course at the Open Online Probability School.

Christoph Kehle started as a Junior Fellow in September 2020 after he obtained his PhD from the Department of Pure Mathematics and Mathematical Statistics at the University of Cambridge. His research interests lie at the interface of analysis, geometry and partial differential equations.

Since his start as a Junior Fellow, Christoph Kehle focused on projects within three different areas. His first project originates from fundamental puzzles about general relativity, the mathematical theory formulated by Albert Einstein upon which our contemporary understanding of gravitational physics rests. The mathematical formulation of general relativity considers time and space as part of a four-dimensional metric entity – spacetime. Its evolution is governed by the Einstein equations, which determine how spacetime is curved. The foundational question of where and how this determinism breaks down was first formulated by Roger Penrose as the Strong Cosmic Censorship conjecture. In collaboration with Van de Moortel (Princeton University), Kehle first addressed this question in the context

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Christoph Kehle enjoying the ITS group hike to Rigi in 2020.

of gravitation coupled to a charged and massive matter field. They proved that whether or not the strongest form of determinism holds true in the presence of matter, depends crucially on a novel oscillation condition of late time perturbations. Kehle's second project is motivated by extending the general idea of the celebrated Heisenberg uncertainty principle. In collaboration with Joao P. G. Ramos (ETH Zurich), Kehle considers under what conditions knowledge of zero sets of solutions to nonlinear equations are sufficient to uniquely determine that the solution is identically zero. Together with Ramos, Kehle proved that solutions to the cubic nonlinear Schrödinger equation whose zeros accumulate sufficiently fast at infinity for times t=0 and t=1 have to vanish identically. A future direction would be to extend their methods to higher dimensions and to other nonlinear dispersive PDEs. Kehle's third project is in collaboration with his mentor Alessio Figalli, in which they study global solutions to the fully nonlinear hyperbolic Monge-Ampère equation in higher dimensions. This is motivated by understanding higher-dimensional embedded surfaces with negative Gauss curvature.

Christoph Kehle was invited to present his research at various occasions, including seminars at MIT, the Perimeter Institute, Imperial College, UCL, the virtual Mathematical GR and Hyperbolic PDE Seminar as well as conferences including the 75 anniversary meeting of the Canadian Mathematical Society, the International Congress on Mathematical Physics (upcoming) and the Oberwolfach meeting on Mathematical Aspects of Relativity (upcoming). Kehle was also one of the organizers of the monthly GAuS seminar on Analysis and PDE.

Apart from his research activity, Kehle actively engaged in teaching at ETH. He led a student seminar on «Wave Equations on Black Hole Spacetimes», and supervised a semester paper, a Bachelor thesis as well as a Master thesis. Christoph Kehle will join the IAS in Princeton for the academic year 2021/22 before returning to the ITS in 2022.

Dominik Schröder

Ulrike Rieß (2nd left) at an ITS group hike to Rigi in 2020.

Ulrike Rieß has passed an exceptional past year due to the pandemic situation. As for almost everyone else, all travel plans have been canceled. She has passed almost all year in home office complemented with occasional meetings with other people from ETH which took place mostly outdoors. However, working in the remote setting got a habit which worked very well. Research seminars, conferences, as well as cooperation and discussions with other researchers were moved to an online setting. In the course of the year, Rieß gave online talks in research seminars around the world.

Rieß has pursued research projects in algebraic geometry with a focus on irreducible symplectic varieties. This is a class of varieties with trivial canonical bundle which naturally occurs in a classification theorem by Beauville and Bogomolov. Irreducible symplectic varieties can be considered as higher dimensional analogues of the famous K3 surfaces. They have a very rich geometry and they have been subject to intense research for almost four decades. While classically, research had focused on smooth irreducible symplectic varieties, there has been an increasing interest in generalizations with mild singularities in recent years. One of Rieß's research projects in the past year was a cooperation with Grégoire Menet (Grenoble) where they contributed to the theory of (mildly singular) irreducible symplectic orbifolds. The heart of this project was to establish a description of the Kähler cone of irreducible symplectic orbifolds – both in generality and for concrete examples.

In addition to her research, Rieß is an organizer of the Japanese European Symposium on Symplectic Varieties and Moduli Spaces (JES). This yearly series of conferences brings together researchers from around the world working on symplectic varieties and moduli spaces. Historically, there are strong communities of researchers in these areas both in Europe and in Japan, whose exchange has been significantly increased in recent years due to the JES. In September 2020 the first online edition of JES took place successfully with online talks and avatar based virtual coffee breaks.

In March, Rieß went to her maternity break. She will be restarting research soon. In the future, she will certainly still profit from the habits developed in this exceptional year. In particular for long distance cooperation, virtual discussions will be a useful and family friendly complement to classical travel.

Dominik Schröder

Dominik Schröder on top of the Speer mountain in November 2020.

Dominik Schröder spent his second year at the ITS. In past year he worked on projects on the mathematical aspects of random matrix theory, and applications to numerical analysis and machine learning.

Within pure random matrix theory one of the key results of the past year›s work is a series of works on the «eigenstate thermalisation hypothesis (ETH)» and the «quantum unique ergodicity (QUE)» of Wigner random matrices. A fundemantal conjectured property of disordered or chaotic quantum systems is that eigenstates tend to be uniformly distributed in the phase space. While a proof of this phenomenon for general physical systems remains elusive, Schröder and his collaborators solved the analogous problem for Wigner matrices and general observables, obtaining both the optimal speed of convergence and identifying the asymptotic distribution. Another important result of the last year on the probabilistic aspects of random matrices is the quenched form of universality. One of the landmark results in the field of the past decade is the annealed eigenvalue universality, in the sense that for large Hermitian random matrices the distribution of a single eigenvalue gap converges to a universal probability distribution irrespective of the precise choice of matrix model. In contrast, in the recent work on quenched universality Schröder and his collaborators proved that any generic fixed realisation of a random matrix gives rise to the same universal distribution simply by sampling consecutive gaps.

With regard to applications, Schröder worked on smoothed analysis and tail estimates of condition numbers, resolving a recent conjecture on the the regularising effect of random real perturbations of complex shifts. In another line of work Schröder, together with a master student, applied random matrix techniques to neural works and proved that, contrary to a recent result on the bias-free case, it is impossible to choose an activation function in such a way that the singular value distribution remains invariant throughout multiple layers of a network in the case of a non-zero additive bias.

After presenting his work at various online seminars, Schröder is looking forward to being able to give the first in-person talk of the current academic year at the upcoming international congress on mathematical physics in Geneva.

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Outlook

The ETH-ITS is delighted to welcome three new Junior Fellows in September 2021.

1 **Rhea Palak Bakshi** received her PhD in Mathematics from the George Washington University in May 2021 under the supervision of Józef H. Przytycki. Her research interests are in knot theory, low-dimensional topology, and algebraic and quantum invariants of manifolds. Her work focuses primarily on the study of skein modules and skein algebras of 3-manifolds and the Topological Quantum Field Theoretic description of the Witten-Reshetikhin-Turaev 3-manifold invariant. She is the coauthor of a scholarly book on knot theory where her chapters are devoted to the study of 3-manifold topology and skein modules. She is also a coauthor of two chapters in the Encyclopedia of Knot Theory.

2 **François Bienvenu** received his PhD in mathematics from Sorbonne Université in 2019 under the supervision of Amaury Lambert. His research interests are centered on applications of discrete probability (in particular, random trees and random graphs) to ecology and evolution. He has worked on developing methods to study the genealogical structure of populations and theoretical models to describe the structure and dynamics of the tree of life.

3 **Sándor Kisfaludi-Bak** received his PhD in Computer Science from TU Eindhoven in 2019. His main field of interest is computational geometry: more specifically, he is interested in understanding how geometric constraints impact the computational hardness of problems, both in exact and approximation algorithms. His dissertation focused on finding faster algorithms and proving matching complexity-theoretic lower bounds for fundamental problems, including geometric variants of the traveling salesman problem.

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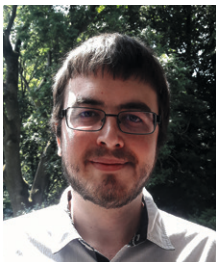

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For the first time in the history of the ETH-ITS, there will be four Advanced Fellow starting in 2021/22.

4 Michael Borinsky's research is centered around quantum field theory, which is the mathematical language in which the laws of nature at the smallest scales are formulated. He uses modern mathematical tools to enhance the physical understanding and expressiveness of this theory, but also applies it to answer questions in purely mathematical contexts as for instance in topology or combinatorics. He received his PhD from Humboldt University Berlin in 2018 under the supervision of Dirk Kreimer and continued his research as a postdoc at Nikhef in Amsterdam until 2021.

5 Marvin Künnemann obtained his PhD in Computer Science at Saarland University and the Max Planck Institute for Informatics in 2016. He is broadly interested in theoretical computer science, with a particular focus on fine-grained complexity theory and algorithm design. In his core research, he explores the complexity landscape of polynomial-time problems by establishing connections to central hardness hypotheses. This exposes algorithmic barriers for processing large data sets, such as quadratic-time hardness of computing popular sequence similarity measures.

6 Sylvain Lacroix received his PhD in theoretical physics from the École Normale Supérieure de Lyon in July 2018, under the supervision of Marc Magro and Benoît Vicedo, and later held a postdoctoral position at the University of Hamburg, in the research group of Gleb Arutyunov. His main domain of research is the theory of integrable systems, which are physical models with a high number of symmetries, and their applications to the development of exact methods in the study of classical and quantum field theories. In particular, he has worked on a class of integrable systems called Gaudin models and their relations with integrable sigma-models and conformal field theories.

7 Yunan Yang received her PhD in Mathematics under the supervision of Prof. Bjorn Engquist from the University of Texas at Austin. Before joining ITS as an Advanced Fellow, Yunan spent three years at Courant Institute of Mathematical Science at New York University as a Courant Instructor. Her current research focuses on computational mathematics, especially developing numerical methods for computational inverse problems, PDE-constrained optimization, and computational optimal transport with data science applications.

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Two new Senior Fellows are joining the ETH-ITS in the fall semester of 2021.

8 Albrecht Klemm, Professor of Physics at the University of Bonn, received his PhD in 1990 from the University of Heidelberg. He is a leader in many directions related to string theory, mirror symmetry, enumerative geometry, and modular forms. A long-standing interest of his has been the higher genus structure of topological string theory for Calabi-Yau manifolds where Klemm's contributions include the topological vertex, modular forms related to K3 geometries, and the study of the holomorphic anomaly equation. Klemm arrived in Zurich in August.

9 Mikhail Lyubich, Professor of Mathematics and Director of the Institute for Mathematical Sciences at Stony Brook University, received his PhD in 1984 from Tashkent State University. He is a leader in the field of low-dimensional dynamics (real and complex) and has proven fundamental results on the dynamics of quadratic maps, Feigenbaum-Coullet-Tresser universality, and, more recently, on the Mandelbrot locally connected conjecture. Lyubich was an invited speaker at the ICM 1994 and a plenary speaker at the ICM 2014. He arrived in Zurich in August.

People at the ETH-ITS

Director
Rahul Pandharipande

Administration
Livia Kürsteiner
Barbara Frey

Board of Patrons
Martin Haefner, Walter Haefner Foundation
Dr. Max Rössler
Prof. Dr. Ralph Eichler

Advisory Committee

2013 – 2017
ETH members
Gianni Blatter, Matthias Gaberdiel, Rahul Pandharipande, Tristan Rivière, Angelika Steger, Nicola Spalding*
External members
Noga Alon (Tel Aviv and Princeton), Luis Alvarez-Gaumé (CERN), Artur Ekert (Oxford), Shafira Goldwasser (MIT and Weizmann Institute), Gerhard Huisken (MFO), Elon Lindenstrauss (Hebrew University), Martin Hairer (Warwick)
*replaced by Ueli Maurer in 2015

2017 – 2019
ETH members
Alessio Figalli, Matthias Gaberdiel, Ueli Maurer, Rahul Pandharipande, Manfred Sigrist, Angelika Steger
External members
Noga Alon (Tel Aviv and Princeton), Robert Brandenberger (McGill), Artur Ekert (Oxford), Gerhard Huisken (MFO), Elon Lindenstrauss (Hebrew University), Martin Hairer (Imperial College), Claire Voisin (Collège de France)

2019 – 2021
ETH members
Alessio Figalli, Renato Renner, Manfred Sigrist, Olga Sorkine-Hornung, David Steurer, Tanja Stadler
External members
Robert Brandenberger (McGill), Ben Green (Oxford University), Albrecht Klemm (University of Bonn), Nathan Linial (Hebrew University of Jerusalem), Madhu Sudan (Harvard University), Corinna Ulcigrai (University of Zurich), Claire Voisin (Collège de France)

Fellows 2014–2021

Senior Fellows

Terry Hwa, UC San Diego	02.2014 – 09.2014 and 04.2015 – 08.2015
Gilles Brassard, Université de Montréal	06.2014 – 12.2014 and 04.2019 – 06.2019
Henryk Iwaniec, Rutgers University	08.2014 – 05.2015 and 06.2016 – 07.2016
Dmitry Chelkak, St. Petersburg	09.2014 – 08.2015
Alex Lubotzky, Hebrew University	02.2015 – 07.2015 and 02.2016 – 08.2016
Adi Shamir, Weizmann Institute	02.2015 – 07.2015 and 02.2016 – 07.2016
Eugene Demler, Harvard University	05.2015 – 06.2015 and 09.2015 – 12.2015
Robert Brandenberger, McGill University	08.2015 – 07.2016
Walter Schachermayer, University of Vienna	08.2015 – 08.2016
Riccardo Barbieri, SNS Pisa	11.2015 – 10.2016
Alexander Balatsky, Nordita and LANL	02.2016 – 04.2016 and 07.2016 – 03.2017
Eitan Tadmor, University of Maryland	08.2016 – 07.2017
Vadim Kaloshin, University of Maryland	09.2016 – 08.2017
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
Yakov Eliashberg, Stanford University	06.2019 – 09.2019
Ivan Cherednik, University of North Carolina at Chapel Hill	07.2019 – 06.2020
Nicolai Reshetikhin, UC Berkeley	07.2019 – 07.2020
Kannan Soundararajan, Stanford University	09.2019 – 03.2020
Albrecht Klemm, University of Bonn	08.2021 – 03.2022
Mikhail Lyubich, Stony Brook University	08.2021 – 01.2022

Junior Fellows (with current affiliation of former Junior Fellows)

Emily Clader, University of San Francisco	09.2014 – 07.2016
Zur Luria, Azrieli College of Engineering	09.2014 – 09.2017
Alessandro Carlotto, ETH Zurich	09.2015 – 08.2016
Maria Colombo, EPF Lausanne	09.2015 – 08.2018
Lavinia Heisenberg, ETH Zurich	09.2015 – 09.2018
Titus Lupu, CNRS, U. Paris 11, Orsay	09.2015 – 12.2017
Aline Ramires, ICTP-SAIFR, Sao Paulo	09.2015 – 08.2018
Ran Tessler, Weizmann Institute	09.2015 – 10.2018
Shoham Letzter, University of Cambridge	09.2016 – 12.2019
William Sawin, Columbia University	09.2016 – 07.2018
Ulrike Rieß	09.2017 – 09.2021
Johannes Noller, University of Cambridge	09.2017 – 03.2020
Pierrick Bousseau, CNRS, Université Paris-Saclay	09.2018 – 09.2020
Nina Holden, New York University	09.2018 – 12.2020
Fanny Yang, ETH Zurich	09.2018 – 09.2019
Yi-Jun Chang, University of Singapore	07.2019 – 08.2021
Stefan Glock	09.2019 – 08.2022
Dominik Schröder	09.2019 – 08.2022
Christoph Kehle	09.2020 – 08.2021 and 07.2022 – 06.2024
Alexandru Gheorghiu	09.2020 – 08.2023
Rhea Palak Bakshi	09.2021 – 08.2024
François Bienvenu	09.2021 – 08.2024
Sándor Kisfaludi-Bak	09.2021 – 12.2021

Advanced Fellows

Marvin Künnemann	04.2021 – 03.2026
Michael Borinsky	09.2021 – 08.2026
Sylvain Lacroix	09.2021 – 08.2026
Yunan Yang	01.2022 – 06.2023

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