Erwin Schrödinger International Institute
for Mathematics and Physics

ESI

ANNUAL REPORT 2017

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Annual Report 2017

ESI

THE INSTITUTE PURSUES ITS MISSION THROUGH A VARIETY OF PROGRAMMES

THE ERWIN SCHRÖDINGER INTERNATIONAL INSTITUTE FOR MATHEMATICS AND PHYSICS (ESI), founded in 1993 and part of the University of Vienna since 2011, is dedicated to the advancement of scholarly research in all areas of mathematics and physics and, in particular, to the promotion of exchange between these disciplines.

WORKSHOPS with a duration of up to two weeks focus on a specific scientific topic in mathematics or physics with an emphasis on communication and seminar style presentations.

THE JUNIOR RESEARCH FELLOWSHIP PROGRAMME supports external or local graduate students and recent postdocs to work on a project of their own.

THE ESI FREQUENTLY HOSTS GRADUATE SCHOOLS organized by research groups at the University of Vienna on topics in mathematics or physics aimed at local as well as external PhD students.

THEMATIC PROGRAMMES offer the opportunity for a large number of scientists at all career stages to come together for discussions, brainstorming, seminars and collaboration. They typically last between 4 and 12 weeks, and are structured to cover several topical focus areas connected by a main theme. A programme may also include shorter workshop-like periods.

THE SENIOR RESEARCH FELLOWSHIP PROGRAMME aims at attracting internationally renowned scientists to Vienna for visits to the ESI for up to several months. Senior Research Fellows contribute to the scientific training of graduate students and postdocs of Vienna's research institutions by teaching a course and by giving scientific seminars.

THE RESEARCH IN TEAMS PROGRAMME offers support for research teams to carry out collaborative work on specific projects at the ESI in Vienna for periods of one to four months.

DETAILED INFORMATION about all ESI programmes and the respective application procedures and deadlines are available on the ESI website **www.esi.ac.at**

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Preface

The Institute and its Mission

The Erwin Schrödinger International Institute for Mathematics and Physics (ESI), founded in 1993 and part of the University of Vienna since 2011, is committed to the promotion of scholarly research in mathematics and physics, with an emphasis on the interface between them. While in the beginning the scientific focus of the ESI was on mathematical physics and mathematics, over the years the thematic spectrum of its scientific activities has been carefully extended, while maintaining high scientific standards. Today, the scientific profile of the ESI includes all theoretical, computational and experimental aspects of mathematics and physics. Since January 1, 2016, reflecting this steady extension of scope, the Institute carries the name *Erwin Schrödinger International Institute for Mathematics and Physics.*[1]

It is the Institute's foremost objective to advance scientific knowledge in mathematics and physics and to create an environment where scientists can exchange ideas and fruitful collaborations can unfold. The best way of achieving this goal is to ensure that the ESI continues to interweave leading international scholars, both in mathematics and physics, and the local scientific community. In particular, the research and the interactions that take place at the Institute are meant to have a lasting impact on those who pursue their scientific education in Vienna. The Institute provides a place for focused collaborative research and aims at creating a fertile ground for new ideas.

In the following, we will give a brief overview of the institutional structure of the ESI and the various programmatic pillars of its scientific activities. Thematic programmes form their core, supplemented by workshops, graduate schools and lecture courses given by Senior Research Fellows at the ESI. All activities include strong educational components. Guided by strict scientific criteria and supported by an international Scientific Advisory Board (SAB), the various actual components of the scientific activities of the ESI are chosen on a competitive basis.

The Institute currently pursues its mission in a number of ways

(a) primarily, by running four to six *thematic programmes* each year, selected about two years in advance on the basis of the advice of the international ESI Scientific Advisory Board;

(b) by organising additional *workshops* which focus on topical recent developments;

(c) by a programme of *Senior Research Fellows* (SRF), who give lecture courses at the ESI for graduate students and post-docs;

(d) by setting up *summer/winter schools* for graduate students and postdocs;

[1] Already in 2008 the panel of the evaluation of the ESI at that time suggested that "consideration should be given to amending the name slightly by broadening the term "Mathematical Physics" in the title of the Institute.

(e) by a programme of *Junior Research Fellows* (JRF), which supports graduate students or recent postdocs to work on a project of their own that is either connected to a research direction carried out at the University of Vienna or to an ESI thematic programme; this JRF programme was restarted in January 2016;

(f) by a programme of *Research in Teams* (RiT), which offers groups of two to four *Erwin Schrödinger Institute Scholars* the opportunity to work at the Institute for periods of one to four months;

(g) by inviting *individual scientists* who collaborate with members of the local scientific community.

Scientific Activities in 2017

The list of research areas in mathematics and physics covered by the scientific activities of the Erwin Schrödinger Institute in 2017 shows a wide variety: The following thematic programmes took place:

– *Advances in Birational Geometry*
April 3 – May 26, 2017
(org.: Fedor Bogomolov (Courant Institute, NYU), Jean-Louis Colliot-Thélène (U Paris-Sud), Ludmil Katzarkov (U Vienna), Alexander Kuznetsov (Steklov Inst. Moscow), Alena Pirutka (Courant Institute, NYU), Yuri Tschinkel (Courant Institute, NYU))

– *Quantum Physics and Gravity*
May 29 – July 13, 2017
(org.: Markus Aspelmeyer (U Vienna), Caslav Brukner (U Vienna), Domenico Giulini (ZARM Bremen, U Hannover), Daniel Grumiller (TU Vienna), Soo-Jong Rey (Seoul National U))

– *Geometry and Relativity*
July 17 – September 8, 2017
(org.: Robert Beig (U Vienna), Piotr T. Chruściel (U Vienna), Michael Eichmair (U Vienna), Gregory Galloway (U Miami), Richard Schoen (UC, Irvine), local organization: Tim-Torben Paetz (U Vienna))

– *Tractability of High Dimensional Problems and Discrepancy*
September 11 – October 13, 2017
(org.: Josef Dick (U New South Wales, Sydney), Peter Grabner (TU Graz), Aicke Hinrichs (U Linz), Friedrich Pillichshammer (U Linz), Henryk Wzniakowski (Columbia U and U Warsaw))

– *Algorithmic and Enumerative Combinatorics*
October 16 – November 24, 2017
(org.: Mireille Bousquet-Mélou (CNRS, U de Bordeaux), Michael Drmota (TU Vienna), Christian Krattenthaler (U Vienna), Peter Paule (U Linz), Michael Singer (North Carolina State U, Raleigh))

A detailed account of these thematic programmes is given in subsequent sections of this report.

In addition to thematic programmes, several workshops and conferences took place at the ESI in 2017, complemented by visits of individual scholars who collaborated with scientists of the University of Vienna and the local community. Here is a list of these activities:

- *Geometry and Representation Theory*
  January 16 – 27, 2017
  (org.: Tomoyuki Arakawa (RIMS, U of Kyoto), Karin Baur (U of Graz), Victor Kac (MIT, Boston), Anne Moreau (U of Poitiers))

- *Geometric Transport Equations in General Relativity*
  February 20 – 24, 2017
  (org.: Håkan Andréasson (Chalmers U & U of Gothenburg), David Fajman (U Vienna), Jérémie Joudioux (U Vienna))

- *ESI-CECAM Workshop: Challenges across Large-Scale Biomolecular and Polymer Simulations*
  February 21 – 24, 2017
  (org.: Ivan Coluzza (U Vienna), Barbara Capone (U Vienna), Christoph Dellago (U Vienna), Samuela Pasquali (IBPC & U Paris), Tamar Schlick (New York U))

- *Elliptic Hypergeometric Functions in Combinatorics, Integrable Systems and Physics*
  March 20 – 24, 2017
  (org.: Christian Krattenthaler (U Vienna), Michael J. Schlosser (U Vienna), Masatoshi Noumi (Kobe U), Simon Ruijsenaars (U Leeds), Vyacheslav P. Spiridonov (JINR, Dubna and NRU HSE, Moscow), S. Ole Warnaar (U Queensland))

- *Thirring-Symposium*
  April 29, 2017
  (org.: Piotr Chruściel, Christoph Dellago, Stefan Fredenhagen, Harald Grosse, André H. Hoang, Heide Narnhofer, Wolfgang Reiter and Jakob Yngvason (all U Vienna))

- *Chruściel-Fest: A panorama of GR*
  August 17 – 18, 2017
  (org.: Robert Beig (U Vienna), Tim-Torben Paetz (U Vienna))

- *Systematic Approaches to Deep Learning Methods for Audio*
  September 11 – 15, 2017
  (org.: Monika Dörfler (NUHAG, U Vienna), Arthur Flexer (OFAI, Vienna))

- *Nonlinear Water Waves - an Interdisciplinary Interface*
  November 27 – December 7, 2017
  (org.: David Henry (U College Cork), Konstantinos Kalimeris (RICAM, Linz), Emilian Parau (U of East Anglia), Jean-Marc Vanden-Broeck (U College London), Erik Wahlén (Lund U))

- *ESI-CECAM Workshop: Physics and Chemistry at Fluid/Fluid Interfaces*
  December 11 – 13, 2017
  (org.: Pal Jedlovszky (Eszterházy Károly University, Eger, Hungary), Marcello Sega (Faculty of Physics, U Vienna))

In the summer of 2017 a very well attended graduate school took place:

– *Summer School on "Between Geometry and Relativity"*
July 17 – 21, 2017
(org.: Robert Beig (U Vienna), Piotr T. Chruściel (U Vienna), Michael Eichmair (U Vienna), Gregory Galloway (U Miami), Richard Schoen (UC Irvine), local organization: Tim-Torben Paetz (U Vienna))

As in previous years, within the *Senior Research Fellows* programme, the ESI offered lecture courses on an advanced graduate level.

In the summer term Tomáš Roubíček (Charles University, Prague) gave a course and problem class on *Mathematical Methods in Continuum Mechanics of Solids*.

In 2012 the Erwin Schrödinger Institute established the *Research in Teams Programme* as a new component in its spectrum of scientific activities. This programme provides the opportunity for research teams of a few people to work at the Institute in order to concentrate on new collaborative research in mathematics and physics. The interaction between the team members is a central component of this programme. The following five research teams worked at the ESI in 2017:

– Christoph Dellago (U Vienna), Phillip L. Geissler (UC Berkeley and Lawrence Berkeley National Laboratory), *Sampling rare self-assembly trajectories*, February 1 – May 1, 2017.

– Alan Compelli (Dublin Institute of Technology), Rossen Ivanov (Dublin Institute of Technology), Calin Iulian Martin (U Vienna), *Hamiltonian approach to modelling geophysical waves and currents with impact on natural hazards*, April 10 – June 30, 2017.

– Joseph Fitzsimons (Singapure University of Technology and Design and Center for Quantum Technologies), Philip Walther (U Vienna), *Quantum algorithms for privacy-preserving dada processing in computers*, June 15 – July 15, 2017.

– Henk Bruin (U Vienna), Dalia Terhesiu (Exeter U), Mike Todd (U St Andrews), *Renewal Theory and Thermodynamic Formalism for Flows*, June 19 – July 18, 2017.

– Piotr T. Chruściel (U Vienna), Luc Nguyen (Oxford U), *Nonlinear Elliptic Problems in Field Theory and Geometry*, July 1 – August 31, 2017.

In the year 2017 the following Junior Research Fellows visited the ESI to work on their research project:

– Madhusudan Manjunath, *Topics in Combinatorial Algebraic Geometry*, April 1 – July 21, 2017.

– Peter Wirnsberger, *Thermally Induced Monopoles*, May 8 – June 16, 2017.

– Annegret Burtscher, *Lorentzian curvature revisited*, July 16 – August 19, 2017.

In 2017 the Erwin Schrödinger Institute hosted also two events from the Vienna Doctoral School:

- *Physics Meets: Science and the Public* of the VDS in Physics took place on January 26, 2017.
- *Science meets: Applied Academia* on November 16, 2017 was the first joint meeting of the VDS mathematics and VDS physics.

The Institute's Management

Kollegium and Scientific Advisory Board

The ESI is governed at the organizational and scientific level by a board ('Kollegium') of six scholars, necessarily faculty members of the University of Vienna. Their term of office is three years. The members of this board are appointed by the President (Rektor) of the University after consultations with the Deans of the Faculties of Physics and Mathematics. On January 1, 2017, Michael Eichmair (Mathematics) and Stefan Fredenhagen (Physics) were newly appointed to the Kollegium replacing Joachim Schwermer and Piotr Chrusciel, who completed their second term in the Kollegium. Hence, in the period January 1 - December 31, 2017, the Kollegium consisted of A. Constantin (Mathematics), C. Dellago (Physics), M. Eichmair (Mathematics), S. Fredenhagen (Physics), A. Hoang (Physics), I. Perugia (Mathematics). All members of the Kollegium still act as professors at the University.

At the operational level, the ESI is managed by the director supported by two deputy directors. This team of directors is suggested by the Kollegium and appointed by the Rector of the University. Currently, the ESI is managed by Christoph Dellago (Director), André Hoang (Deputy Director) and Ilaria Perugia (Deputy Director).

The scientific activities of the ESI are supervised by the Scientific Advisory Board (SAB). The SAB also reflects the international ties which are essential for the ESI. In 2017, the SAB consisted of: Denis Bernard (ENS Paris), Mirjam Cvetic (U of Pennsylvania, Philadelphia), Helge Holden (U Trondheim) [chair], Daniel Huybrechts (U Bonn), Christian Lubich (U Tübingen), Stefano Ruffo (SISSA, Trieste), Catharina Stroppel (U Bonn), and Martin Zirnbauer (U Cologne). The ESI is very thankful to the members of the SAB for their extremely valuable advice and support.

Administration

There was no change in the administration of the ESI in 2017. The current administrative staff - Sophie Kurzmann, Maria Marouschek and Beatrix Wolf - continued to work with its customary efficiency for the benefit of our visitors, research fellows and scientific staff.

Christoph Dellago May 22, 2018

Director

Erwin Schrödinger International Institute for Mathematics and Physics

The ESI in 2017: facts and figures

Management and Administration:

Director: Christoph Dellago

Kollegium: Christoph Dellago (Director), André Hoang (Deputy Director), Ilaria Perugia (Deputy Director), Adrian Constantin, Michael Eichmair, Stefan Fredenhagen

Administration: Sophie Kurzmann, Maria Marouschek, Beatrix Wolf (Head)

Computing and networking support: Sascha Biberhofer, Thomas Leitner

International Scientific Advisory Board in 2017:

Denis Bernard (ENS Paris)
Miriam Cvetic (U Pennsylvania, Philadelphia)
Helge Holden (U Trondheim) [chair]
Daniel Huybrechts (U Bonn)
Christian Lubich (U Tübingen)
Stefano Ruffo (SISSA, Trieste)
Catharina Stroppel (U Bonn)
Martin Zirnbauer (U Cologne)

Budget and visitors: In 2017 the support of ESI received from the Austrian Federal Ministry of Education, Science and Research via the University of Vienna amounted to **€ 790 000**. In addition, the ESI obtained a total of € 257 426 in third party funds.

The total amount spent in 2017 on scientific activities was € 571 493 while the expenditures for administration (mainly salaries) and infrastructure (mainly rent) amounted to € 445 828.

The total number of scientists visiting the Erwin Schrödinger Institute in 2017 was 887, see pages 110 – 129.

ESI research documentation: Starting from January 2013, the ESI research output is tracked using the published articles and the arXiv database. The ESI website provides web links to these arXiv preprints and to the local ESI preprints collected until December 2013. It also contains the bibliographical data of the already published articles. Moreover, publications which appeared in 2017 but are related to past ESI activities, starting from 2011, have been tracked as well in order to provide a long-term evidence of the ESI research outcome success.

The total number of preprints and publications contributed to the ESI research documentation database in 2017 is 110 [related to the activities in 2017: 100, related to the activities in previous years: 10], see pages 102 – 109 for details.

Scientific Reports

Main Research Programmes

Advances in Birational Geometry

Organizers: Fedor Bogomolov (Courant Institute, NYU), Jean-Louis Colliot-Thélène (U Paris-Sud), Ludmil Katzarkov (U Vienna), Alexander Kuznetsov (Steklov Inst. Moscow), Alena Pirutka (Courant Institute, NYU), Yuri Tschinkel (Courant Institute, NYU)

Dates: April 3 – May 26, 2017

Budget: ESI € 25 200

Report on the programme

Introduction

Birational geometry is a major branch of algebraic geometry, focused on the study of function fields of algebraic varieties. Among its main classical questions, going back to Italian algebraic geometry, is to determine whether or not an algebraic variety X of dimension d over a field k is *rational*, i.e., birational to projective space $\mathbb{P}^d$, or equivalently, whether or not its function field $F = k(X)$ is a purely transcendental extension over k. Several related notions play an important role:

- *stable rationality*: $X \times \mathbb{P}^n$ is rational, for some n,
- *unirationality*: there exists a rational dominant map $\mathbb{P}^d \to X$.

The three notions coincide for surfaces over algebraically closed fields, but differ over non-closed fields and in higher dimensions. Apart from an intrinsic interest, rationality and unirationality properties have various applications, for example:

- (Inverse Galois problem) Let V be a faithful representation of a finite group G over an infinite field k. Assume that the field of invariants $F = k(V)^G$ is rational. Then G is a Galois group of k. E. Noether asked whether or not all such fields are rational; first counterexamples have been constructed by Saltman and Bogomolov.
- Unirationality of moduli spaces allows one to write down explicit equations for varieties in question, over the ground field, which is particularly useful in arithmetic geometry.

However, what makes the rationality problem especially appealing is that has stimulated, and continues to stimulate, major advances in algebraic geometry and number theory. Most notable examples of such are the breakthrough results from 1974, concerning nonrationality of certain 3-folds:

- Quartics in $\mathbb{P}^4$, via the group of birational automorphisms (Iskovskikh–Manin). This led to the development of the birational rigidity method (Corti, Pukhlikov, Cheltsov, De Fernex) and to extensive studies of birational models of 3-folds, which culminated in the classification results of Iskovskikh, Mori–Mukai, and finally in the Minimal Model Program.
- Cubics in $\mathbb{P}^4$, via intermediate Jacobians and Hodge theory (Clemens-Griffiths). This approach was further expanded in the work of Beauville [3] and Tyurin, and culminated in the work of Voisin [20].
- Conic bundles over rational surfaces, via torsion in $H^3(X,\mathbb{Z})$, i.e. the unramified Brauer group (Artin–Mumford). This triggered systematic studies of the unramified Brauer group and higher unramified cohomology of more general varieties by Colliot-Thélène–Ojanguren, Bogomolov, Kahn, Merkurjev, Parimala, Peyre, Pirutka, Totaro, Voisin, and others, (see, e.g. [7], [9], [18], [5], [16]) which produced, among other results, counterexamples to Noether's problem, and led to Bogomolov's anabelian geometry. The Merkurjev-Suslin theorem, connecting the Brauer group with K-theory, and via the Bloch–Ogus sequence to Chow groups, proved particularly fruitful in the work of Colliot-Thélène–Sansuc, Colliot-Thélène–Raskind, Parimala–Suresh, Kahn, Pirutka, Saito, and Voisin.

A new geometric method, via degenerations, was introduced by Kóllar in 1995 [14]: he proved that very general hypersurfaces $X_d \subset \mathbb{P}^{n_1}$ of degree $d \geq 2(n+3)/3$ are not rational.

Fresh ideas continue to enrich this branch of mathematics and to inspire further study of rationality properties. Here is a small sample of recent results, proving rationality of special varieties or uncovering new, subtle obstructions to rationality and stable rationality:

- Proof of rationality of moduli spaces of hypersurfaces in projective space, i.e. quotients V/G, where $G = PGL_n$, by Boehning and von Bothmer;
- Proof of nonrationality of moduli spaces of polarized K3 surfaces, by Gritsenko–Hulek–Sankaran, and unirationality of certain moduli spaces of curves of low genus by Farkas–Verra;
- Computations of unramified and stable cohomology of many finite groups, by Bogomolov and his collaborators, providing new counterexamples to Noether's problem;
- Seminal results on stable rationality by Voisin [19] and Colliot-Thélène–Pirutka [8] via the specialization and decomposition of the diagonal method; arguably, the most important achievement in the field of the last 20 – 30 years, followed by applications in the work of Beauville [4], Totaro [17], and Hassett–Kresch–Tschinkel [12].

At the same time, we do not yet have answers to some very basic questions, for example: Are cubic hypersurfaces of dimension ≥ 3 stably rational? Are nonrational cubic fourfolds dense in moduli?

There have been several conceptual advances in recent years, that might shed light on these and similar problems:

- Let X be a variety over an algebraically closed field. Then its function field $F = k(X)$ is determined by its first and second Milnor K-group (Bogomolov–Tschinkel).
- Let X be a variety over the algebraic closure of a finite field and G_F its pro-ℓ absolute Galois group. Then its function field is determined by the abelianization G_F^a and its canonical central extension $G_F^c = G_F/[[G_F, G_F], G_F]$ (Bogomolov–Tschinkel and Pop).
- Let X be a Fano variety, e.g., a hypersurface in $\mathbb{P}^n$ of small degree. Then X is determined by $D^b(X)$, the derived category of coherent sheaves on X (Bondal–Orlov).

The main question then is: how is rationality reflected, or detected, in these structures? In particular, since these are difficult to compute explicitely: the determination of $D^b(\mathbb{P}^n)$ by Beilinson in 1978 was a major achievement, even now very few derived categories are understood in terms of generators.

Results achieved

The main item in achievements is a totally unexpected connection: Mirror Symmetry. It originated in physics as a duality between $N = 2$ superconformal quantum field theories. In 1990, Maxim Kontsevich gave an interpretation of this duality in a consistent, powerful mathematical framework, called Homological Mirror Symmetry (HMS). The ideas put forth by Kontsevich in his Fields medal and ICM addresses have led to dramatic developments: they created a frenzy of activity in the mathematical community which has led to a remarkable synergy of diverse mathematical disciplines, notably symplectic geometry, algebraic geometry, and category theory. There are currently three directions motivated by HMS that should lead to progress on rationality problems:

1. The idea of homological projective duality developed by Kuznetsov [15]. Thomas and Addington [1] connected this duality with the work of Hassett [11] on rationality of cubic fourfolds and showed that in this instance, categorial and Hodge-theoretic descriptions are in fact equivalent.
2. The idea of categorical birational invariants, such as gaps of Orlov spectra and phantoms, introduced by Orlov [10], Katzarkov [2, 6], and their collaborators.
3. The idea that stable rationality and related questions about algebraic cycles can be studied via the monodromy of Landau-Ginzburg models arising in HMS, proposed by Katzarkov [13] and his group.

Here are specific conjectures formulated by Katzarkov [13], in the context of the theory of categorical linear systems.

Conjecture. Let X be an orbi-CY of dimension 3 or 4 with a non-trivial fundamental group. Then homological projective duality produces Fano varieties with non-trivial (categorical) Brauer group.

This conjecture was checked in many cases.

Conjecture. Let Y be an open Landau–Ginzburg, with torsion in the second cohomology of its sheaf of vanishing cycles. Then there exists a mirror with non-trivial (categorical) Brauer group.

The categorical Brauer group was defined.

In view of these developments, we conclude that the proposed special semester on new techniques in birational geometry was timely and productive. It has allowed a consolidation of results obtained so far, while simultaneously opening up new venues to attack classical unsolved questions on the rationality of varieties of dimension three, four and higher. We envision new collaborations between algebraists, arithmetic geometers, algebraic geometers, and geometers with strong backgrounds in categorical techniques and mirror symmetry.

The most important result in this direction is the result by Kontsevich and Tschinkel proving the specialization of rationality. The paper is to be published in Annals of Mathematics.

Organization

We have hold 3 conferences:

1. Recent developments in rationality questions, April 24 – 28, 2017
2. Categorical approach to rationality, May 2 – 5, 2017
3. Closing workshop - future directions, May 15 – 19, 2017

Additionally several individual talks were given, e.g. by A. Efimov, P. Griffiths and Y. Tschinkel.

Broader Impact

This special semester greatly facilitated and accelerated the development of the subject, by introducing researchers in algebraic geometry to new geometric ideas which have evolved in mathematical physics, and suggesting completely novel approaches to many classical problems. The semester helped to establish new connections across disparate areas of mathematics as well as relevant areas of physics. It contributed to the training of many talented young mathematicians in this field. Finally, this activity will consolidate the role of Vienna and the ESI as a centre for geometry and mathematical physics.

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[19] C. Voisin,*Infinitesimal invariants for cycles modulo algebraic equivalence and 1-cycles on Jacobians.* Algebr. Geom. 1 (2014), no. 2, 140165.

[20] C. Voisin, *On the universal CH_0 group of cubic hypersurfaces.* arXiv:1407.7261.

List of talks

Vienna - Budapest Seminar: April 21, 2017

Yuri Tschinkel	Rational points and rational varieties
Anton Mellit	Cohomology of character varieties

Workshop 1: Recent developments in rationality questions, April 24 – 28, 2017

Alena Pirutka	Irrationality problems I
Yuri Tschinkel	On the Arithmetics of surfaces
Jean-Louis Colliot-Thélène	Cubic hypersurfaces, I
Daniel Huybrechts	Motives of K3
Alena Pirutka	Irrationality problems II
Jean-Louis Colliot-Thélène	Cubic hypersurfaces, II
Keiji Oguiso	Higher dimensional projective manifolds with primitive automorphisms of positive entropy
Konstantin Shramov	Automorphism of Pointless Surfaces
Pranav Pandi	Categorical Kähler Geometry
Eric Sharpe	0,2 models of Fano spaces
Sergey Galkin	Relations between cycles on cubics
David Favero	A Toric Orlov Theorem via Landau-Ginzburg Models

Anthony Blanc	Generators in formal deformations of categories
Ted Spaide	Calabi-Yau structures, spherical functors, and shifted symplectic structures
Pranav Pandit	Gradient flows, iterated logarithms and semistability

Workshop 2: Categorical approach to rationality, May 2 – 5, 2017

Alexander Kuznetsov	Birational geometry and derived category of Gushel-Mukai fourfolds, I
Christian Boehning	Unramified Brauer groups of fourfold conic bundles, degenerations, and Gushel-Mukai fourfolds, I
Alexei Igorewitsch Bondal	Tilting relative generators and strict admissible filtrations
Alexander Kuznetsov	Birational geometry and derived category of Gushel-Mukai fourfolds, II
Christian Boehning	Unramified Brauer groups of fourfold conic bundles, degenerations, and Gushel-Mukai fourfolds, II
George Dimitrov	Stabilities and Norms
David Favero	Equivalences of derived categories from mirror symmetry constructions
Ed Segal	Homological Projective Dualities
Andrew Harder	Perverse sheaves of categories and noncommutative deformations
Sergey Galkin	On a derived involution on variety of lines on a cubic fourfold
Alexey Elagin	On exceptional collections of line bundles on weak del Pezzo surfaces
Tamás Hausel	Perverse Hirzebruch y-genus of Hitchin systems
Jihun Park	K-stability of del Pezzo surfaces

Workshop 3: Closing workshop - future directions, May 15 – 19, 2017

Valery Alexeev	Volumes of open surfaces
Alexander Efimov	Stability conditions and localizations
Morgan Veljko Brown	Characterization of toric log Calabi-Yau pairs
Fabian Haiden	Categories and Filtrations
Gabriel Kerr	Homological mirror symmertry and the toric minimal model program
Paul Horja	Toric schobers from GKZ D-modules
Marcello Bernardara	From noncommutative motivic measures to subgroups of the Cremona group
Yan Soibelman	Quantum geometry of Riemann-Hilbert correspondence
Ljudmila Kamenova	Hyperbolicity in hyperkaehler geometry
Anton Mellit	Rationality of Ueno-Campana manifolds
Ivan Cheltsov	Rational and irrational singular quartic threefolds
Ilya Karzhemanov	Birational invariants and covariants
Alexander Kuznetsov	D-equivalence, L-equivalence and families of quadrics
Alex Perry	Categorical joins
Sergey Galkin	Degenerations to Normal Cone as Relations for a Grothendieckuesque Group
Jong Hae Keum	Equations of Fake Projective Planes
George Dimitrov	Topology on certain class of triangulated categories (categories with phase gap)

Individual talks

Victor Przyjalkowski	Log Calabi-Yau compactifications of Landau-Ginzburg models
Emanuel Scheidegger	The hemisphere partition function and Landau-Ginzburg orbifolds
David Favero	Categorical Crepant Resolutions via LG models
Johanna Knapp	(Non-)birational Calabi-Yaus from physics
Carlos Simpson	Moduli spaces of stable bundles for intermediate values of c_2
Alexander Efimov	t-structures on triangulated categories with geometric exceptional collections
Phillip Griffiths	Positivity and singularities in Hodge theory

Invited scientists

Valery Alexeev, Marcello Bernardara, Anthony Blanc, Christian Boehning, Alexei Igorewitsch Bondal, Morgan Veljko Brown, Ivan Cheltsov, Jean Louis Colliot-Thélène, Colin Diemer, George Dimitrov, Alexander Efimov, Alexey Elagin, David Favero, Sergey Galkin, Phillip Griffiths, Fabian Haiden, Andrew Harder, Tamás Hausel, Paul Horja, Daniel Huybrechts, Ljudmila Kamenova, Ludmil Katzarkov, Ilya Karzhemanov, Gabriel Kerr, Jong Hae Keum, Johanna Knapp, Alexander Kuznetsov, Anton Mellit, Martin Mereo, Nicole Mestrano, Keiji Oguiso, Pranav Pandit, Jihun Park, Alex Perry, Aleksandar Petkov, Alena Pirutka, Victor Przyjalkowski, Emanuel Scheidegger, Joachim Schwermer, Ed Segal, Eric Sharpe, Konstantin Shramov, Carlos Simpson, Yan Soibelman, Leonardo Soriani Aleves, Theodore Spaide, Yuri Tschinkel, Egor Yasinsky, Shoji Yokura.

Quantum Physics and Gravity

Organizers: Markus Aspelmeyer (U Vienna), Caslav Brukner (U Vienna), Domenico Giulini (ZARM Bremen, U Hannover), Daniel Grumiller (TU Vienna), Soo-Jong Rey (Seoul National U)

Dates: May 29 – June 7, 2017

Budget: ESI € 13 920

Report on the programme

Quantum mechanics and gravity are two cornerstones of physics. Nevertheless, our understanding of their interplay remains limited, and their unification is expected to imply profound modifications of our understanding of physics.

The main rationale behind our ESI Thematic Programme “Quantum Physics and Gravity” was to tackle some of the outstanding issues and to engender discussions between otherwise separate communities as well as between theory and experiment.

Activities

We had 39 talks at ESI within our programme, 10 additional talks at ESI within a related COST miniworkshop and 8 supplementary topical talks at U Vienna or TU Vienna. A complete account of all activities is accessible at the webpage:
http://quark.itp.tuwien.ac.at/∼grumil/ESI2017/

Week 1 In the week May 29 - June 2 we had on average one talk per day at ESI and three supplementary talks at U Vienna and TU Vienna. Focus was on theory and most of the talks were accessible to PhD students. This week served partly as preparation for the more intense later weeks.

Week 2 In the week June 5 - 9 we had on average two talks per day at ESI, two supplementary talks at U Vienna and TU Vienna and two days of hosting a COST workshop “Noncommutative Geometry and Gravity” organized by Harold Steinacker. Again, the focus was mostly on theory, with one experimental talk on Friday.

Week 3 In the week June 12 - 16 we had a workshop on the first three days with 11 talks and a conference dinner. Thursday was a holiday and we organized an optional excursion to Schneeberg. On Friday we had one talk and a farewell dinner. Again, the focus was on theory.

Week 4 In the week June 19 - 23 we had 15 talks (plus one supplementary talk at U Vienna), some of which were specifically reserved for junior invitees. Particularly the talk by Roger Penrose on Tuesday was well-attended (to the limits of the ESI lecture hall). On Wednesday the TU choir performed "Bohemian Gravity" at ESI. We had both theory and experimental talks.

Week 5 The last week June 26 - 30 concluded with a talk by Mark Kasevich. Focus was on experiments.

Specific information on the programme

List of young researchers, prae- and post-docs:

External participants: Max Attems (U Barcelona), Marcela Cardenas (CECs Valdivia), Oscar Fuentealba (CECs Valdivia), Fabio Novaes (IIP Natal), Pulastya Parekh (ISER Pune), Andrea Puhm (Harvard U), Max Riegler (ULB Bruxelles), Miguel Angel Riquelme Osses (CECs Valdivia), Zodinmawia (IIT Kanpur)

Registered local participants: Abhiram Kidambi (TU Wien), Iva Lovrekovic (U Vienna), Ayan Mukhopadhyay (TU Vienna), Raphaela Wutte (TU Vienna)
In addition there were several non-registered local junior participants at selected talks.

Their contributions and benefits:
The following young researchers gave talks at ESI during ESI Programme:
Max Attems (U Barcelona), Oscar Fuentealba (CECs Valdivia), Iva Lovrekovic (U Vienna), Ayan Mukhopadhyay (TU Vienna), Fabio Novaes (IIP Natal), Pulastya Parekh (ISER Pune), Andrea Puhm (Harvard U), Max Riegler (ULB Bruxelles)

All of the external junior participants received per diems by ESI.
Additional benefits were the stimulating talks by senior researchers, the ensuing discussions at ESI or the lunch places around ESI and the numerous possibilities to exchange ideas with other junior and senior researchers.

Outcomes and achievements

The ESI Thematic Programme "Quantum Physics and Gravity" contributed to bridge the gap between communities and to bring together leading researchers from different fields that work on classical and quantum aspects of gravitational physics, including experts from quantum information, mathematical relativity and quantum gravity.

We discussed the conceptual challenges, latest developments and new perspectives in this field. Besides outstanding theoretical problems, many of which are associated with black holes, numerical relativity and quantum gravity, there are numerous phenomenological and experimental

challenges, such as determining the nature of dark matter and dark energy, or obtaining experimental bounds on quantum gravity models, all of which were addressed during our programme.

List of talks

Week 1: May 29 – June 2, 2017

Karl Landsteiner	Gravitational anomalies (in) matter
Emeri Sokatchev	Dualities for Wilson loop form factors
Max Riegler	Spectral Flow and Flat Space Holography in 3D
Frank Verstraete	Introduction to tensor networks

Week 2: June 6 – 7, 2017

Roberto Emparan	The singularity is near
Domenico Giulini	Elementary considerations concerning the relation between Quantum Mechanics & Gravity
Bill Unruh	Information loss
Arjun Bagchi	The BMS Bootstrap

COST Mini-Workshop in week 2: Noncommutative Geometry and Gravity, June 8 – 9 , 2017

Tuesday Topic:	*"Noncommutative geometry & symmetries"*
Andrzej Sitarz	Gravity and cosmological models on (almost) noncommutative spaces
Salvatore Minegmi	Generalized Snyder spaces and scalar fields
Jerzy Kowalski-Glikman	Quantum symmetries of flat quantum spacetime
Catharina Meusburger	Poisson homogeneous spaces in (2+1) gravity
Angel Ballesteros	From quantum groups to noncommutative spacetimes with cosmological constant
Friday Topic:	*"Emergent space(time) & gravity"*
Bergfinnur Durhuus	Random graphs and discretised gravity
John Barrett	Quantum Non-Commutative Geometry
Lisa Glaser	Non-commutative geometry on the computer
Harold Steinacker	Higher-spin theory and gravity from fuzzy 4-spheres
Maja Buric	Fuzzy de Sitter space

Workshop in week 3: June 12 – 16, 2017

Soo-Jong Rey	A String Theory That Isn't About String
Andrea Puhm	Black hole microstates and a rough end to spacetime
Ricardo Troncoso	Soft hairy black holes
Kostas Skenderis	Towards a general AdS/Ricci-flat correspondence
Valentin Reys	Exact entropy of 1/4-BPS black holes in N=4 supergravity and the mixed Rademacher expansion
Maximilian Attems	Non-conformal shock wave collisions
Steve Giddings	Nonviolent unitarization: postulates to soft quantum structure of black holes
Claus Kiefer	Can quantum-gravitational effects be observed in the cosmic microwave background?
Pulastya Parekh	Tensionless Strings: A perspective from the worldsheet
Daniel Greenberger	Some unexpected aspects of mass and proper time in quantum mechanics, and why they should be considered as dynamical objects, represented by Hermitian operators
Alfredo Perez	Boundary conditions for General Relativity on AdS3 and the KdV hierarchy
Fabio Novaes	Classical Conformal Blocks, Isomonodromy and Black Holes

Week 4: June 19 – 23, 2017

Joan Simon	EPR=ER in LLM
Oscar Fuentealba	Asymptotic structure of N=2 supergravity in 3D: extended super-BMS_3 and nonlinear energy bounds
Paul Romatschke	Lattice Simulations of 10d Yang-Mills in Toroidal Compatification
Ivette Fuentes Guridi	Gravity in the quantum lab
Roger Penrose	Dark Matter Decay? Possible Observational Tests - According to Conformal Cyclic Cosmology
Iva Lovrekovic	Asymptotic Symmetry Algebra of Conformal Gravity in four dimensions
Rafael Sorkin	The quantum measure - and how to measure it
Jakob Salzer	Aspects of Holography in Two-Dimensional Dilaton Gravity
Nikola Paunkovic	Symmetry protected entanglement between gravity and matter
Marko Vojinovic	Cosmological Constant in Regge Quantum Gravity
Holger Müller	Quantum measurements of gravitational and sub-gravitational interactions
Jörg Schmiedmayer	Probing quantum fields and their fluctuations with a quantum simulator
Hermann Verlinde	SYK, 2D CFT and Gravitational Scattering
Ayan Mukhopadhyay	Feynman diagrams and gravity join forces to crack the QGP
Dima Vassilevich	Parity anomaly in four dimensions

Individual talks

Ernst Rasel	Space-born Bose-Einstein condensation for precision interferometry
Mark Kasevich	Testing gravity and quantum mechanics with atom interferometry
Soo-Joung Rey	Introduction to little string theory (I + II)

Publications and preprints contributed

R. Basu, S. Detournay, M. Riegler, *Spectral Flow in 3D Flat Spacetimes*, arXiv:1706.07438 [hep-th].

R. Emparan, A. Fernandez-Pique, R. Luna, *Geometric polarization of plasmas and Love numbers of AdS black branes*, arXiv:1707.02777 [hep-th].

O. Fuentealba, J. Matulich, R. Troncoso, *Asymptotic structure of $N = 2$ supergravity in 3D: extended super-BMS_3 and nonlinear energy bounds*, arXiv:1706.07542 [hep-th].

Invited scientists

Peter Aichelburg, Markus Aspelmeyer, Maximilian Attems, Arjun Bagchi, Angel Ballesteros, Andreas Banlaki, John Barrett, Caslav Brukner, Maja Buric, Marcela Cardenas, Abhishek Chowdhury, Fabio Costa, Piotr Chrusćiel, Bergfinnur Durhuus, Roberto Emparan, Stefan Fredenhagen, Oscar Fuentealba, Mirah Gary, James Gaunt, Ivette Fuentes Guridi, Steven Giddings, Domenico Giulini, Lisa Glaser, Daniel Greenberger, Harald Grosse, Daniel Grumiller, Ehsan Hatefi, Ivan Hrechanyk, Thordur Jonsson, Mark Kasevich, Claus Kiefer, Dmitry Kliukin, Samuel Kovácik, Jerzy Kowalski-Glik-man, Ilya Kull, Karl Landsteiner, Iva Lovrekovic, Abhiram Mamandur Kidambi, Anastasija Marusmewko, Wout Merbis, Catherine Meusburger, Salvatore Mignemi, Ayan Mukhopadhyay, Holger Müller, Chau Nguyen, Fabio Magalijaes de Santos Novaes, Marius Oancea, Yasser Omar, Pulastya Parekh, Nikola Paunkovic, Roger Penrose, Alfredo Perez, Miguel Pino, Josef Pradler, Slobodan Prvanovic, Andrea Puhm, Voja Radovanovic, Ernst Rasel, Radoslav Rashkov, Anton Rebhan, Soo-Jong Rey, Benedikt Richter, Max Riegler, Miguel Angel Riquelme Osses, Tanja Rindler-Daller, Paul Romatschke, Jochen Schieck, Jörg Schmiedmayer, Maria Schimpf, Andrzej Sitarz, Joan Simon, Sukhbinder Singh, Kostas Skenderis, Emeri Sokatchev, Alexander Igor Soloviev, Rafael Sorkin, Marcus Sperling, Philipp Stanzer, Harold Steinacker, Pablo Rodriguez Tapia, Juraj Tekel, Jose David Tempo Rangel, Riccardo Troncoso, William Unruh,

Rupert Ursin, Philip Walther, Zizhu Wang, Dmitri Vassilevich, Herman Verlinde, Marko Vojinovic, Raphaela Wutte, Zodinmawia, Magdalena Zych.

Geometry and Relativity

Organizers: Robert Beig (U Vienna), Piotr T. Chruściel (U Vienna), Michael Eichmair (U Vienna), Gregory Galloway (U Miami), Richard Schoen (UC Irvine), local organization: Tim-Torben Paetz (U Vienna)

Dates: July 17 – September 8, 2017

Webpage:

`https://www.esi.ac.at/activities/events/2017/between-geometry-and-relativity`

Budget: ESI € 37 760 plus € 11 152 for the Summer School,
University of Vienna through the Gravitational Physics group: € 821
University of Vienna through a grant to Michael Eichmair: € 2 678
FWF through a grant to Michael Eichmair for travel expenses and accommodation: € 11 942
Further funding of the summer school: € 8 870 + USD 22 490 from the NSF. For further details see report of the summer school.

Report on the programme

The main focus of this thematic programme has been on geometric problems in the study of the Einstein equations, with special emphasis on the elliptic aspects thereof. Specifically, in recent years, there has been a surge of activity in the following areas, including breakthroughs on several longstanding questions:

- **Geometry of initial data sets.** New notions of mass, quasi-local mass, and centre of mass, as well as new proofs of the positive energy theorem yield deep insights to the geometry of initial data for the Einstein equations. The incompatibility of some of these notions raises difficult new challenges that are being explored. Important themes here also include new initial data singularity theorems based on topological properties, and progress on the geometry of initial data for stationary black holes.

- **Construction of initial data sets.** New gluing techniques for the constraint equations and progress on the solution of the classical conformal method allow for the construction of asymptotically flat initial data sets with unexpected properties. The situation for asymptotically hyperbolic initial data, though still in its infancy, is experiencing a rapid development.

- **Scalar Curvature.** Recent results on scalar curvature rigidity and the discovery of global effects of scalar curvature on the large scale isoperimetric structure of a Riemannian manifold have given impetus to this classical field and have opened broad new avenues for future research.

These areas have defined a natural focus for this thematic programme.

Our goal was to bring together promising young researchers and leading experts in the field to create a stimulating environment where new collaborations between and within the fields of mathematical relativity and geometric analysis can be formed and existing collaborations can be deepened.

Activities

In the first week of the programme, we organized a Summer School, with lecture series by M.-A. Bizouard, J. Corvino, M. Eichmair, D. Fajman, S. Gillessen, G. Galloway, L.-H. Huang, and R. Schoen to set the stage for the programme. We include the titles of their lectures below. The school was addressed to junior researchers in mathematics and theoretical physics with a keen interest in mathematical general relativity. The goal was to introduce them to main topics of current research, and to deepen their knowledge of the field. The 104 participants of the Summer School were a mix of postdoctoral researchers and Ph.D. students, with the audience further including some advanced Master students and several experienced researchers. Moreover, several participants of the research programme, as well as members of the Faculties of Mathematics and Physics of the University of Vienna and the Technical University of Vienna, attended lectures.

The school was particularly timely because of the milestone paper by R. Schoen and S.-T. Yau, released in April 2017, which proves positivity of the total energy of asymptotically flat scalar-non-negative manifolds in any dimension, generalising a result proved almost forty years ago by the same authors when the manifold dimension is below eight. In view of this exciting recent development, we adjusted the program, replacing the initially planned four hours of introductory lectures by R. Schoen by two lectures of L.-H. Huang and two lectures by M. Eichmair, and adding six lectures by R. Schoen on the new proof.

We have received very positive feedback from the participants of the summer school through an online questionnaire.

The school received financial support from the American Institute of Physics, the International Association of Mathematical Physics, the European Mathematical Society, the National Science Foundation, the FWF, and the University of Vienna through its doctoral schools, the Erwin Schrödinger Institute, the start-up grant of M. Eichmair, and the group budget of the Gravitational Physics group.

More information on the school, including a list of participants, can be found on the web site `http://www.univie.ac.at/AGESI_2017/school/index.html`.

In the second week of the programme, we organized a conference entitled “Geometry and Relativity”. The conference was focussed on elliptic problems arising in general relativity. We refer to Section “List of talks” for a complete list of the talks. Due to the large number of participants, the lectures took place in the Lise Meitner Lecture Hall of the Faculty of Physics.

In the last week of August we organized a week-long workshop covering all topics in mathematical general relativity. The workshop was very well attended. We refer again to Section “List of talks” for a complete list of the talks. A breakthrough result was announced by J. Szeftel, who gave a sketch of the proof, with S. Klainerman, of non-linear stability of Kerr black holes with respect to axi-symmetric perturbations that satisfy a polarisation condition.

The lectures of the summer school, the conference, and the workshop have been videotaped. Most lecturers have agreed to provide open access to their lectures. Once the editing is completed, their lecturers will be available under the following link:

Outcomes and achievements

The programme has initiated a large number of new collaborations, and has provided an opportunity to continue work on ongoing projects. We include here a few samples:

HÅKAN ANDRÉASSON primarily worked on the approximation of solutions of the Einstein equations coupled to a perfect fluid with vanishing pressure (dust) with solutions of the Einstein-Vlasov system. More precisely, in the seminal work by Oppenheimer and Snyder from 1939 it is shown that a homogeneous ball of dust undergoes gravitational collapse. Andréasson, in collaboration with G. Rein, has shown that this gravitational collapse can be approximated arbitrary well by solutions to the Einstein-Vlasov system. He made substantial progress on extending this result to the inhomogeneous case, which is crucial since there exist inhomogeneous data for dust which give rise to naked singularities. The relation between the dust solutions and the solutions to the Einstein-Vlasov system plays a key role in the understanding of the weak cosmic censorship conjecture.

ABHAY ASHTEKAR, during his three-week-visit, had extensive discussions with PIOTR CHRUSCIEL, GREGORY GALLOWAY, JAMES GRANT, VALENTINE KROON, and ROBERT WALD on various aspects of gravitational waves, positive energy theorems, and asymptotic structure of space-time. He completed two joint papers with Beatrice Bonga, which have meanwhile been finished.

VOLKER BRANDING, DAVID FAJMAN, and KLAUS KRÖNCKE worked on long-time existence of the Dirac-Wave map system on certain globally hyperbolic manifolds. D. Fajman and K. Kröncke continued their research on the Einstein flow which aims to generalize previous results in to the (massless and massive) Einstein-Vlasov system.

HUBERT BRAY, OTIS CHODOSH, MICHAEL EICHMAIR, and TOM ILMANEN worked on the possibility of generalizing the Riemannian Penrose Conjecture to all dimensions. The main challenge is figuring out how to handle co-dimension 7 singularities that naturally occur in minimal hypersurfaces. These singularities are also seen in the Schoen-Yau proof of the Positive Mass Theorem.

CARLA CEDERBAUM and ANNA SAKOVICH made substantial progress on a longterm project on asymptotic spacetime constant mean curvature foliations in initial data sets. Their work will be submitted for publication soon.

OTIS CHODOSH and MICHAEL EICHMAIR started work on new directions in their longterm collaboration related to bending energy and the uniqueness of the canonical foliation of asymptotically flat manifolds.

PIOTR CHRUŚCIEL, ERWANN DELAY, AND PAUL KLINGER made progress on two papers which have meanwhile been released on the arXiv. The first manuscript provides an existence proof of a large class of black hole solutions of the Einstein equations with negative cosmological constant under a non-degeneracy condition. The second proves this non-degeneracy for a wide class of black hole geometries.

CARLA CEDERBAUM, STEPHEN MCCORMICK, and ARMANDO CABRERA PACHECO made substantial progress on their project on the construction of Riemannian manifolds that extend prescribed Bartnik data with positive constant mean curvature. Cederbaum and SOPHIA JAHNS were able to bring their proof of a theorem related to the photon region in Kerr close to completion.

PIOTR CHRUŚCIEL, LUC NGUYEN, GREGORY GALLOWAY, and TIM PAETZ studied the invariance properties of the mass aspect function in asymptotically hyperbolic manifolds, and their implications. They were able to establish deformation theorems which have direct implications for the positivity of mass for such manifolds, a topic which is still poorly understood. Their results have already been submitted for publication.

PIOTR CHRUŚCIEL, LUC NGUYEN, PAUL TOD, and ANDRAS VASY proved a long-standing conjecture, of non-existence of "non-inheriting" asymptotically flat Einstein Maxwell fields. Here, the issue is whether there exist asymptotically flat solutions of the Einstein-Maxwell equations in which the metric is stationary but the Maxwell field is not. Examples of such solutions which however fail to be asymptotically flat are known. This question was raised many years ago and has seen several unsuccessful attempts of proving it. Their result has already been submitted for publication.

MICHAEL EICHMAIR, GREGORY GALLOWAY, and ERIC WOOLGAR discussed a promising new approach to the positive mass theorem in asymptotically hyperbolic spaces.

MICHAEL EICHMAIR, GERHARD HUISKEN, and MU-TAO WANG discussed spacetime analogues of isoperimetric mass and centre of mass, and quasi-local versions thereof.

MICHAEL EICHMAIR and RAFE MAZZEO discussed rigidity problems in asymptotically hyperbolic spaces as well as questions related to re-normalization of area in such geometries.

MICHAEL EICHMAIR and JAN METZGER discussed conjectures about the global uniqueness results of constrained Willmore surfaces in asymptotically flat spaces.

HELMUT FRIEDRICH had extensive discussions with several participants of the programme on the open issues concerning the notion of an isolated system in GR. These discussions have contributed to the paper "Peeling or not peeling - is that the question?" which has meanwhile been completed.

MELANIE GRAF, JAMES GRANT, MICHAEL KUNZINGER, and ROLAND STEINBAUER finished their work on a low-regularity version of the Hawking-Penrose singularity theorem. They intensified their scientific discussions with ETTORE MINGUZZI on causality theory and cone structures and also made contact with GREGORY GALLOWAY, who currently is host to Melanie Graf for her four month visit to the University of Miami in the course of a Marshall plan stipend. In addition, CLEMENS SÄMANN and Michael Kunzinger worked on developing a theory of Lorentzian length spaces, a project that is currently close to completion. Kunzinger also renewed contact with former master student, KLAUS KRÖNCKE.

LAN-HSUAN HUANG was able to disseminate her recent work with DAN LEE on the rigidity of the positive mass theorem and had several inspiring discussions with other participants, espe-

cially ABHAY ASHTEKAR, PIOTR CHRUŚCIEL, MICHAEL EICHMAIR, RICHARD SCHOEN, and MU-TAO WANG. She also gained further insights toward her continuing research project that connects the study of ADM mass and stationary initial data sets.

MARCUS KHURI, GILBERT WEINSTEIN, and SUMIO YAMADA studied stationary vacuum black holes in five dimensions and wrote parts of a paper on that topic, which has meanwhile been made available on the arXiv. There, the authors study existence of asymptotically flat bi-axially symmetric stationary solutions of the vacuum Einstein equations in 5-dimensional spacetime. They have already written up parts of a paper on this issue. The cross-section of any connected component of the event horizon is a prime 3-manifold of positive Yamabe type, namely the 3-sphere S^3, the ring $S^1 \times S^2$, or the lens space $L(p;q)$. The Einstein vacuum equations reduce to an axially symmetric harmonic map with prescribed singularities from $\mathbb{R}^3$ into the symmetric space $SL(3;\mathbb{R})/SO(3)$. Khuri, Weinstein, and Yamada solve the problem for all possible topologies. In particular, the first candidates for smooth vacuum non-degenerate black lenses are produced. In addition, a generalization of this result is given in which the spacetime is allowed to have orbifold singularities.

MARCUS KHURI and ERIC WOOLGAR initiated a study of the usefulness of the Bakry-Emery-Ricci tensor for the analysis of near-horizon geometries. They have already written two short papers on this.

MARC MARS collaborated with ISTVAN RACZ on the Penrose inequality in Minkowski space. The idea is to rewrite this inequality in terms of a scalar time-height function and the geometry of convex surfaces in Euclidean space. One would then the use of a support function, already considered in the literature in joint work with A. Soria, by the distance function from an interior point. He has also, in collaboration with B. Reina and R. Vera, finished a project aiming at deriving the so-called Hartle model for slowly rotating stars from first principles, i.e. by working consistently within second order perturbation theory and not making any ad hoc assumptions, neither on the structure of the perturbations, nor in the perturbed matching problem at the boundary of the star. This work is at present being written up.

VINCENT MONCRIEF worked mainly on extending a project with Nishanth Gudapati to derive a conserved, positive definite energy functional for the axi-symmetric perturbations of charged, rotating (Kerr-Newman) black holes. Their results, which are nearing completion, should contribute significantly to the ongoing program to prove the dynamical stability of such objects, and admit extension to the study of higher dimensional black objects and inclusion of a cosmological constant. Moncrief further worked with ANTONELLA MARINI on a project to apply their "Euclidean signature semi-classical" programme to the quantization of Yang-Mills fields in $3+1$ dimensions. They had enlightening discussions with RAFE MAZZEO on this, which might develop into a collaboration.

ROLAND STEINBAUER could renew many of his contacts to the mathematical relativity community. He had the opportunity to discuss with GREGORY GALLOWAY new ideas related to his recent work on low regularity singularity theorems. Also, he discussed with Marc Mars general low regularity issues in matched spacetimes.

PAUL TOD and LÁSZLÓ SZABADOS had extensive discussions on various aspects of a Bondi type mass in asymptotically de Sitter spacetimes: It turned out that their previous suggestion for the Bondi-type mass bis still finite and non-negative even under the weakest fall-off condi-

tion for the energy-momentum tensor that is required by the existence of the smooth conformal boundary. In addition, their strategy (i.e. using the Nester-Witten 2-form and a Witten-type positivity argument on asymptotically 'hyperboloidal' hypersurfaces) can be used to define analogous expressions in the asymptotically flat and asymptotically anti-de Sitter cases; and in both these cases, the boundary conditions for the Witten equation came out of the formalism and the requirement of the finiteness of the resulting expressions: They must be solutions of the 2-surface twistor equations, there is no freedom to choose the boundary conditions by hand. In particular, in the asymptotically flat case, these are just the spinor constituents of the BMS translations.

PETER TOPPING had enlightening conversations with ERIC WOOLGAR, JIM ISENBERG, and LUC NGUYEN, separately, any of which may eventually lead to finished research. He wrote elements of a set of lectures that have subsequently been given in Bonn. His visit to ESI inspired new ideas how some ongoing work of one of his Ph.D. students might be important in physics.

ROBERT WALD, in addition to many discussions with several participants of the program, worked on completing the write-up of his paper with Kartik Prabhu on electromagnetic stability of black holes to axi-symmetric perturbations.

List of talks

Detailed abstracts can be downloaded from the programme webpage:

`https://www.esi.ac.at/activities/events/2017/between-geometry-and-relativity`

Summer School: Between Geometry and Relativity, July 17 – 21, 2017

Marie-Anne Bizouard	Making waves, I - II
Justin Corvino	Constructing initial data for the Einstein equations, I - IV
Michael Eichmair	Positive energy theorems II (lectures 3 + 4)
David Fajman	Dynamics of general relativity, I - IV
Greg Galloway	Topology and general relativity, I - III
Stefan Gillessen	The black heart of our galaxy, I - II
Lan-Hsuan Huang	Positive energy theorems I (lectures 1 + 2)
Richard Schoen	Positive energy theorems III (lectures 5 - 10)

Conference: Between Geometry and Relativity, July 24 – 28, 2017

Alessandro Carlotto	From scalar curvature rigidity phenomena to min-max embedded geodesic lines
Mattias Dahl	Outermost apparent horizons with non-trivial topology
Michael Eichmair	The large-scale isoperimetric structure of initial data
Helmut Friedrich	Einstein-lambda-matter flows near future time-like infinity
Greg Galloway	Topology and singularities in general relativity
Lan-Hsuan Huang	Equality in the Spacetime Positive Mass Theorem
Gerhard Huisken	Inverse mean curvature flow for entire graphs
Nicolaos Kapouleas	Recent gluing constructions in Differential Geometry
Michael Kunzinger	Singularity theorems in regularity $C^{1,1}$
Marc Mars	Geometry of null shells

Jan Metzger	On the uniqueness of small surfaces minimizing the Willmore functional subject to a small area constraint
Pengzi Miao	Minimal hypersurfaces, isometric embeddings, and manifolds with nonnegative scalar curvature
André Neves	Weyl Law and the volume spectrum
Richard Schoen	The high dimensional positive energy theorem
Robert Wald	Canonical Energy
Mu-Tao Wang	Linear stability of Schwarzschild black hole: the Cauchy problem for metric coefficients
Neshan Wickramasekera	Regularity of stable CMC hypersurfaces

Workshop: Advances in General Relativity, August 28 – September 1, 2017

Thomas Bäckdahl	Symmetries and conservation laws for linearized gravity
Beverly Berger	When black holes collide: a new window on the universe
Sebastiano Bernuzzi	Modeling neutron star binaries and gravitational waves with numerical relativity
Lydia Bieri	Gravitational Radiation in Cosmological Spacetimes
Piotr Bizon	From AdS to BEC
Carla Cederbaum	Rigidity properties of the Schwarzschild manifold in all dimensions
Otis Chodosh	Global uniqueness for CMC foliations of asymptotically flat 3-manifolds
Mihalis Dafermos	Boundedness and polynomial decay for the Teukolsky equation on Kerr spacetimes
Ccile Huneau	High frequency back reaction for the Einstein equations
Christos Mantoulidis	Nonnegative scalar curvature fill-ins and quasi-local mass
Lorenzo Mazzieri	On the mass of static vacuum Einstein metrics with positive cosmological constant
Ettore Minguzzi	Causality theory for cone structures
Georgios Moschidis	A proof of the instability of AdS spacetime for the Einsteinnull dust system
Roger Penrose	The equations of conformal cyclic cosmology: implications as to the nature of dark matter, its decay, and possible observational tests
Harvey Reall	On the local well-posedness of Lovelock and Horndeski theories
Anna Sakovich	On geometric foliations and center of mass for isolated systems in general relativity
Jan Sbierski	The wave equation in the interior of black holes
Yakov Shlapentokh-Rothman	The asymptotically self-similar regime for the Einstein vacuum equations
Lszl Szabados	Gravity, as a classical regulator for the Higgs field, and the origin of rest masses and electric charge
Jrmie Szeftel	On the stability of black holes
Andrs Vasy	The stability of Kerr-de Sitter black holes

Individual talks

Håkan Andréasson	Approximating gravitational collapse for dust with Vlasov matter
Volker Branding	The supersymmetric nonlinear sigma model: Harmonic maps coupled to spinor fields
Hubert Bray	Flatly Foliated Relativity: A Stepping Stone between Special and General Relativity
Annegret Burtscher	On the asymptotic behavior of static perfect fluids
Stefan Haller	The heat equation on filtered manifolds
Jeremie Joudioux	The stability of Minkowski space as a solution to the Einstein-Vlasov system
Markus Khuri	Existence and Uniqueness for Near-Horizon Geometries in the Cosmological Setting
Luc Nguyen	Existence and uniqueness of Green's functions to a nonlinear Yamabe problem

Tim-Torben Paetz	Analysis of a Bianchi-like equation satisfied by the Mars-Simon tensor
Katharina Radermacher	Strong Cosmic Censorship and the initial singularity in Bianchi spacetimes
Martin Reiris	A classification theorem for static solutions of the vacuum Einstein equations
Peter Topping	Ricci flow and Ricci limit spaces
Juan Valiente-Kroon	On the construction of anti-de Sitter-like spacetimes
Gilbert Weinstein	Bi-axi-symmetric stationary solutions to the vacuum Einstein equation with non-spherical horizons
Eric Woolgar	Lorentzian Bakry-mery Theory

Publications and preprints contributed

B. Araneda, *Generalized wave operators, weighted Killing fields, and perturbations of higher dimensional spacetimes*, arXiv:1711.09872 [gr-qc].

A. Ashtekar, B. Bonga, *On a basic conceptual confusion in gravitational radiation theory*, arXiv:1707.07729 [gr-qc].

A. Ashtekar, B. Bonga, *On the ambiguity in the notion of transverse traceless modes of gravitational waves*, arXiv:1707.09914 [gr-qc].

V. Branding, K. Kroencke, *Global existence of wave maps and some generalizations on expanding spacetimes*, arXiv:11709.06520 [math.DG].

O. Chodosh, C. Mantoulidis, *Minimal surfaces and the Allen-Cahn equation on 3-manifolds: index, multiplicity, and curvature estimates*, arXiv:1803.02716 [math.DG].

P. T. Chruściel, E. Delay, P. Klinger, *On non-degeneracy of Riemannian Schwarzschild-anti de Sitter metrics*, arXiv:1710.07597 [gr-qc].

P. T. Chruściel, P. Klinger, *The annoying null boundaries*, arXiv:1801.06037 [gr-qc].

P. T. Chruściel, G. J. Galloway, E. Ling, *Weakly trapped surfaces in asymptotically de Sitter spacetimes*, arXiv:1803.02339 [gr-qc].

H. Friedrich, *Peeling or not peeling – is that the question ?*, arXiv:1709.07709 [gr-qc].

M. Graf, J. D. E. Grant, M. Kunzinger, R. Steinbauer, *The Hawking-Penrose singularity theorem for $C^{1,1}$-Lorentzian metrics*, arXiv:1706.08426 [math-ph].

S. Hadar, H. S. Reall, *Is there a breakdown of effective field theory at the horizon of an extremal black hole?*, arXiv:1709.09668 [hep-th].

J. L. Jauregui, *Lower semicontinuity of the ADM mass in dimensions two through seven*, arXiv:1804.04723 [math.DG].

M. Khuri, E. Woolgar, *Nonexistence of extremal de Sitter black rings*, arXiv:1708.03627 [hep-th].

M. Khuri, E. Woolgar, *Nonexistence of degenerate horizons in static vacua and black hole uniqueness*, arXiv:1710.09669 [gr-qc].

M. Khuri, G. Weinstein, S. Yamada, *Stationary vacuum black holes in 5 dimensions*, arXiv:1711.05229 [gr-qc].

T. Makino, *On slowly rotating axisymmetric solutions of the Einstein-Euler equations*, arXiv:1705.07392 [math.AP].

L. B. Szabados, *On gravity's role in the genesis of rest masses of classical fields*, arXiv:1802.04401 [gr-qc].

Invited scientists

Peter Aichelburg, Bernd Ammann, Michael Anderson, Håkan Andréasson, Abhay Ashtekar, Thomas Bäckdahl, Herbert Balasin, Robert Beig, Beverly Berger, Sebastiano Bernuzzi, Lydia Bieri, Piotr Bizoń, Marie-Anne Bizouard, Simon Blatt, Stefano Borghini, Volker Branding, Hubert Bray, Madeleine Burkhart, Annegret Burtscher, Armando Cabrera Pacheco, Lissa Campos, Andreas Cap, Jorge Cardona, Alessandro Carlotto, Carla Cederbaum, Otis Chodosh, Piotr T. Chruściel, Justin Corvino, Mihalis Dafermos, Mattias Dahl, Erwann Delay, Roland Donninger, Michael Eichmair, David Fajman, Helmut Friedrich, Greg Galloway, Sari Ghanem, Stefan Gillessen, Elena Giorgi, James Grant, Brian Harvie, Michael Hörzinger, Jahanur Hoque, Lan-Hsuan Huang, Gerhard Huisken, Cécile Huneau, Tom Ilmanen, James Isenberg, Sophia Jahns, Hyun Chul Jang, Jose-Luis Jaramillo, Jeffrey Jauregui, Jacek Jezierski, Florian Johne, Jeremie Joudioux, Nicolaos Kapouleas, Marcus Khuri, Paul Klinger, Mikolaj Korzynski, Klaus Kröncke, Michael Kunzinger, Robert Kusner, Eric Larsson, Adam Layne, Dan Lee, Iva Lovrekovic, Chao Lui, Siyuan Ma, Stephen McCormick, Colin MacLaurin, Tetu Makino, Christos Mantoulidis, Antonella Marini, Marc Mars, Daniel Martin, Rafe Mazzeo, Lorenzo Mazzieri, Jan Metzger, Pengzi Miao, Peter Michor, Ettore Minguzzi, Vincent Moncrief, Gabriel Montes de Oca, Georgios Moschidis, Anna Nakonieczna, Lukasz Nakonieczny, Christopher Nerz, André Neves, Luc Nguyen, Niall O Murchadha, Nobuhiko Otoba, Tim-Torben Paetz, Claudio Paganini, Roger Penrose, Daniel Pollack, Bruno Premoselli, Istvan Racz, Katharina Radermacher, Harvey Reall, Martin Reiris, Hans Ringström, Justin L. Ripley, Henri Roesch, Clemens Sämann, Anna Sakovich, Jan Sbierski, Richard Schoen, Yakov Shlapentokh-Rothman, Roland Steinbauer, László Szabados, Jérémie Szeftel, Victoria Tiki, Paul Tod, Peter Topping, Tin Yau Tsang, Helmuth Urbantke, Caterina Valcu, Juan Valiente Kroon, Maxime Van de Moortel, András Vasy, Robert Wald, Piotr Waluk, Mu-Tao Wang, Gilbert Weinstein, Neshan Wickramasekera, Jarrod Lewis Williams, David Wiygul, Eric Woolgar, Damin Wu, Sumio Yamada.

Tractability of High Dimensional Problems and Discrepancy

Organizers: Josef Dick (U New South Wales, Sydney), Peter Grabner (TU Graz), Aicke Hinrichs (U Linz), Friedrich Pillichshammer (U Linz), Henryk Wózniakowski (Columbia U and U Warsaw)

Dates: September 11 – October 13, 2017

Budget: ESI € 31.520

Report on the programme

Many important scientific and engineering problems have continuous mathematical formulations. They occur in numerous areas, including physics, chemistry, finance, economics, statistics, and all computational sciences. Such problems often lead to ordinary or partial differential equations, integral equations, stochastic differential equations, high-dimensional and path integration, nonlinear equations (including systems of polynomial equations), and various types of optimisation problems.

These problems can almost never be solved analytically, but rather only approximately to within some error threshold. Computational complexity is an area of applied mathematics and theoretical computer science that studies the minimal computational resources needed for the approximate solution of such problems. Often the resource of interest is time. The minimal computational time can be measured in different settings and for different error criteria. As we

study the computational complexity of continuous problems, we encounter many challenging research problems.

High dimensional problems usually suffer from the curse of dimensionality if we consider them over spaces where all variables play the same role. A challenging problem is to find a way of structuring such problems that will allow us to vanquish the curse. This exciting research area studies the tractability of such problems. There are already several positive results in this direction. Examples include problems defined over spaces equipped with product, finite-order and other weights, as well as problems defined over spaces of increasing smoothness with respect to successive variables.

For some problems the curse of dimensionality in the worst case setting can be vanquished by switching to a more lenient setting such as the randomized or average case setting. Then the complexity is only polynomial in the dimension. Sometimes we can even prove that the number of function values needed to solve the problem approximately does not depend on the dimension. We believe that this is only the beginning, and that we will find many other ways to structure these problems in a way that will allow us to break the curse. Furthermore, we also believe that high-dimensional problems occurring in computational practice are structured so that the curse of dimensionality does not hold. This would explain why practically important high-dimensional problems can be solved with reasonable computational effort.

Discrepancy theory is directly related to the quality of quasi-Monte Carlo methods for the approximation of integrals. It deals with the problem of distributing points as uniformly as possible and estimating the inevitable errors from approximating a continuous distribution by a discrete one. Naturally, discrepancy is intimately related to tractability studies. Although the classical theory has already answered many questions for low dimensional problems, the high dimensional situation is not well understood and many challenging fundamental problems still need to be studied.

The governing idea of this programme was to bring together researchers from different mathematical disciplines with the main aim to intensify cooperation between them and to obtain significant progress in the interplay between the different disciplines with respect to discrepancy, quasi-Monte Carlo methods, and the complexity of high dimensional problems and stochastic computation.

Activities

During the programme, two workshops were organised, entitled “Tractability of high dimensional problems” and “Discrepancy and quasi-Monte Carlo methods”, which covered the following topics:

- **Discrepancy theory and quasi-Monte Carlo methods, September 25 – 29, 2017**
  This workshop consisted of 20 presentations which covered the following topics:
  - irregularity of distribution of point sets
  - sequences with optimal order of L_p-discrepancy
  - minimal dispersion of point sets
  - QMC algorithms
  - tractability of star-discrepancy
  - point distributions on the sphere and other manifolds
  - pseudorandom measures

  - randomisation in discrepancy theory (jittered sampling)

- **Tractability of high dimensional problems, October 9 – 23, 2017**
  This workshop consisted of 30 presentations which covered the following topics:

  - approximation of random fields
  - high dimensional function approximation
  - tractability of star-discrepancy
  - tractability of linear tensor product problems
  - Euler scheme for SDEs
  - tractability in the presence of noise
  - stochastic integration
  - inverse of dispersion
  - randomized algorithms (Smolyak, lattice rules, MDM)

  In the weeks before the two workshops we organized two short series of introductory lectures related to discrepancy theory and to tractability theory. The first introductory lecture was given by Christoph Aistleitner, September 19 – 21, 2017 and the second one by Henryk Woźniakowski, October 2 – 6, 2017.

  The remaining time was used for various interactions, which should lead to publications in the near future.

  The organisers want to especially emphasise that the ESI staff was very helpful and efficient during the whole programme as well as in the period of preparation. Without their continuous support a programme of this size would have been impossible to organise. The ESI facilities offering office space for every participant and ample space for discussion and informal meetings was also essential for the success of the programme.

Specific information on the programme

It was a major goal of the programme to invite PhD-students and young PostDocs; especially from the co-supporting SFB "Quasi-Monte Carlo Methods: Theory and Applications" but also from abroad. Special introdutcory lectures were organised for these participants. The following young participants (PhD-students or young PostDocs) took part in the programme: Bence Borda, Sonja Cox, Mahadi Ddamulira, Alexander Gilbert, Stefan Kremsner, David Krieg, Ralph Kritzinger, Robert Kunsch, Ryan Matzke, Clemens Müllner, Mario Neumüller, Lukas Spiegelhofer, Tanja Stepaniuk, Stefan Steinerberger, Wolfgang Stockinger, Michaela Szölgyenyi, Marcin Wnuk.

Furthermore, the present programme should also be seen in combination with the ESI programme "Minimal Energy Point Sets, Lattices and Designs", September 29 – November 21, 2014. At this workshop several young researchers met for the first time to discuss problems concerning point distributions on the sphere and related questions which later led to a considerable amount of ideas and publications. Examples are Dmitriy Bilyk, Johann Brauchart and Martin Ehler, who presented their results at the present programme, and the co-organizer Josef Dick. This is one example which documents the success of the ESI programmes.

Outcomes and achievements

The following list contains a selection of specific collaborations and individual work that participants had begun or continued at the Institute.

- *M. Ullrich and V. Temlyakov* both gave talks on the dispersion problem of finding the largest empty axis parallel box amongst a finite point set in the unit cube. The further discussions lead to a series of papers which are listed below in the section of submitted contributions.

- *M. Gnewuch, A. Hinrichs, M. Hefter and K. Ritter* continued and almost finished work on a paper with the title "Increasing smoothness and weights". The approach taken in this research is a novel application of embedding results of spaces of increasing smoothness and weighted spaces to analyse the complexity of integration and approximation of infinite variate functions.

- *M. Ehler, A. Hinrichs and M. Ullrich* discussed the power of optimally weighted cubature rules, where the to formerly separate groups are expected to join forces.

- *I.H. Sloan and H. Woźniakowski* finished a paper with the title "Multivariate approximation for analytic functions with Gaussian kernels", which was submitted and already accepted in the Journal of Complexity.

- *P. Kritzer and H. Woźniakowski* jointly worked on open problems in the context of new tractability notions for multivariate problems. This cooperation will most likely result in a joint publication.

- *D. Krieg and D. Rudolf* continued work on the recovery problem of low rank tensors and later finished a paper with the title "Recovery algorithms for high-dimensional rank one tensors".

- *A. Hinrichs, P. Kritzer and F. Pillichshammer* continued the work on a joint paper with G. W. Wasilkowski with the title "Truncation dimension for linear problems on multivariate function spaces". The truncation dimension problem is also closely related to the embedding results and applications thereof treated by M. Gnewuch, A. Hinrichs, M. Hefter, K. Ritter, G. W. Wasilkowski mentioned in this list.

- *A. Hinrichs, J. Prochno and M. Ullrich* worked on a paper with the title "The curse of dimensionality for numerical integration in general domains". This work solves an open problem about the complexity of integration by combining tools from asymptotic convex geometry and information based complexity in a novel way.

- *D. Bilyk, A. Hinrichs and K. Ritter* worked on an application for funding of a programme on "Complexity of continuous problems" at the Leibniz-Center for Informatics at Schloss Dagstuhl in 2019. This programme will be very much related to the ESI programme reported on here.

- *D. Krieg and E. Novak* have started a further investigation into the power of standard information compared to general linear information in the setting of approximation problems in Hilbert spaces. The focus here is on expectations with respect to randomized information operators.

- *M. Levin, A. Hinrichs, F. Pillichshammer and R. Tichy* discussed recent developments in discrepancy theory, especially new results on lower bounds and possible connections to other mathematical disciplines as, e.g., in Statistical Physics.

- *F. Pillichshammer* finished a paper entitled "Tractability properties of the weighted star discrepancy of regular grids" and benefited from several important suggestions by *H. Woźniakowski*.

- *C. Geiss and M. Szölgyenyi* discussed necessary conditions for the solution of a BSDE to be a semimartingale. This would be necessary for proving existence and uniqueness of the solution of the BSDE by a transformation based argument.

- *A. Neuenkirch and M. Szölgyenyi* discussed possible issues that appear when implementing an adaptive Euler scheme for the solution of SDEs with discontinuous drift coefficient. In particular, for certain drift functions, the used number of simulations could be too low, as paths that cross the discontinuity appear only rarely.

- *S. Steinerberger and W. Stockinger* discussed some problems related to pair correlation properties of one-dimensional sequences in the unit interval. In particular, some possible explicit constructions of sequences having so-called Poissonian pair correlations were considered (so far only metrical results are known).

- *R. Kritzinger and M. Passenbrunner* discussed applications of Haar functions in the theory of discrepancy. Since classical Haar function are mainly suited for the study of digital nets, Markus Passenbrunner suggested to use more general versions of Haar function in order to investigate the discrepancy of other point sets. The possibility of finding exact formulas for the L_2 discrepancy of digital nets was also discussed and led to a paper by R. Kritzinger.

- *J. Dick, G. Leobacher and F. Pillichshammer* discussed integration in weighted Hermite spaces and how to estimate/calculate the corresponding reproducing kernels. One problem arising for numerical estimation is that the decay rate of kernel coefficients for spaces of low smoothnessare slow as well and therefore numerical summation is expensive. This relates to previous work of Dick, Irrgeher, Leobacher and Pillichshammer.

- *P. Kritzer, G. Leobacher and M. Szölgyenyi* discussed applications of high-dimensional integration to models built on piecewise deterministic Markov processes. The problem here is that the integrands are usually not smooth and therefore do not belong to one of the spaces for which error bounds can be given. They try to use a smoothing technique to overcome this difficulty.

- *J.S. Brauchart, P. Grabner and I.H. Sloan* continued/restarted a collaboration together with R.S. Womersley on spherical Needlets which provide an elegant multiresolution sequence of polynomials on the sphere. The aim of their work is to relax exactness requirements for polynomials of high degree.

- *J.S. Brauchart and I.H. Sloan* also discussed the problem of how to prove that well-known point set constructions on the sphere form QMC design sequences (i.e., have optimal order of decay of the worst-case error for functions up to a given Sobolev smoothness). One outcome is a future joint project with R.S. Womersley on properties of HEALPIX points (Hierarchical Equal Area Iso Latitude pixelation of the sphere). Of particular interest is if such point sets form a QMC design sequence.

- *J.S. Brauchart and M. Ehler* discussed optimally weighted cubature rules based on random points on the sphere. The first author together with R.S. Womersley has done some preliminary unpublished work on this problem.
- *I.H. Sloan and K. Hesse* collaborated on smoothing with radial basis functions and polynomials on the sphere. This cooperation is likely to result in two papers (jointly coauthored with R.S. Womersley).

List of talks

Introductory talks and talks outside the workshops

Christoph Aistleitner	Tutorial I: Introduction to discrepancy theory: Uniform distribution and discrepancy: Analytic, number-theoretic and computational aspects, I - III
Henryk Woźniakowski	Tutorial II; ABC on IBC and Tractability, I - V
Kertin Hesse	Radial basis function approximation of noisy scattered data on the sphere

Workshop 1: Discrepancy theory and quasi-Monte Carlo methods, September 25 – 29, 2017

Vladimir Temlyakov	Universal discretization
Benjamin Doerr	A Sharp Discrepancy Bound for Jittered Sampling
Daniel Rudolf	An Upper Bound of the Minimal Dispersion via Delta covers
Takashi Goda	Richardson extrapolation of polynomial lattice rules for smooth functions
Oliver Roche-Newton	New bounds for the cardinality of the set AA+A
Mordechey Levin	On L_p low discrepancy sequences
Ralph Kritzinger	Point Sets and sequences with the optimal order of L_p-discrepancy
Stefan Steinerberger	One Gaussian to rule them all: pair correlation, irregularities of distribution and quadratures
Mike Giles	QMC and thinning for empirical datasets
Martin Ehler	Quasi-Monte Carlo methods and importance sampling on the Grassmannian
Friedrich Pillichshammer	Tractability properties of the weighted star discrepancy of regular grids
Dmitriy Bilyk	On some problems of uniform distribution and energy minimization on the sphere
Ryan Matzke	Stolarsky principle and the geodesic distance energy on the sphere
Johann Brauchart	Hyperuniformity on the sphere: deterministic constructions
Maxim Skriganov	Point distributions in two-point homogeneous spaces
Bence Borda	The discrepancy of random walks
Markus Passenbrunner	A spline version of the Martingale Convergence Theorem
Arne Winterhof	Measures of Pseudorandomness: A partial hierarchy
Radhakrishnan Nair	Unique Ergodicity and two rotations
Gunther Leobacher	On the length of arcs in labyrinth fractals

Workshop 2: Tractability of high dimensional problems, October 9 – 23, 2017

Ian H. Sloan	On the generation of random fields
Christel Geiss	Random-walk approximation of (backward) SDEs: L_2-rate
Mario Hefter	Random bit quadrature and approximation of distributions on Hilbert spaces
Hans Georg Feichtinger	Wiener amalgam spaces and iterative methods for irregular sampling
Mario Ullrich	The inverse of the dispersion depends logarithmically on the dimension

Alexander Gilbert	Applying QMC integration to a stochastic eigenproblem
Marcin Wnuk	Randomized Smolyak algorithms
Marguerite Zani	Approximation complexity of random fields
Joscha Prochno	Entropy numbers for embeddings of Schatten classes
Paweł Siedlecki	(s,t)-weak tractability of Euler and Wiener integrated processes
Sergei V. Pereverzyev	On complexity reduction of learning tasks
Martin Ehler	Approximating functions on the Grassmannian from sampling values
Georg Pflug	Scenario tree generation (probability quantification) for multistage stochastic programs
David Krieg	Optimal Monte Carlo Methods for L_2-Approximation
Stephan Dahlke	Besov regularity for linear and nonlinear parabolic PDEs
Erika Hausenblas	Existence of a density on finite projections of the 2Dim stochastic Navier Stokes Equation driven by Levy processes or fractional Brownian motion
Michaela Szölgyenyi	Strong convergence of the Euler-Maruyama scheme for SDEs with discontinuous drift
Andreas Neuenkirch	An adaptive Euler scheme for SDEs with discontinuous drift coefficients
Leszek Plaskota	Some results on tractability in the presence of noise
Sonja Cox	Stochastic integration in quasi-Banach spaces: what Besov regularity does the stochastic heat equation possess?
Arnulf Jentzen	Stochastic approximation algorithms for second-order parabolic partial differential equations
Klaus Ritter	Integration and L_2-Approximation of tensor products of Korobov spaces of increasing smoothness
Michael Gnewuch	Randomized multivariate decomposition methods for infinite-dimensional integration
Stefan Geiss	Approximating sequences of stochastic games for Perron solutions of the p-Laplace equation
Paweł Przybyłowicz	Recent developments in optimal global approximation of solutions of jump-diffusion SDEs
Peter Kritzer	Randomized lattice rules with nearly optimal error convergence
Mario Neumüller	Metrical star discrepancy bounds for lacunary subsequences of digital Kronecker sequences and polynomial tractability
Robert Kunsch	High-dimensional function approximation: Breaking the curse with Monte Carlo methods
Henryk Woźniakowski	QPT of LTP for Λ^{std}

Publications and preprints contributed

D. Bilyk, F. Dai, S. Steinerberger, *General and Refined Montgomery Lemmata*, arXiv:1801.07701 [math.CA].

S. Dahlke, C. Schneider, *Besov Regularity of Parabolic and Hyperbolic PDEs*, Bericht Mathematik Nr. 2017-03 des Fachbereichs Mathematik und Informatik, 2017

M. Ddamulira, C. A. Gomez, F. Luca, *On a problem of Pillai with k-generalised Fibonacci numbers and powers of 2*, https://doi.org/10.1007/s00605-018-1155-1, DOI: 10.1007/s00605-018-1155-1

E. Hausenblas, T. Randialasolo, M. Thalhammer, *The stochastic Gray Scott model - existence and uniqueness and its numerical modelling*, submitted.

A. Hinrichs, P. Kritzer, F. Pillichshammer, G.W. Wasilkowski, *Truncation Dimension for Linear Problems on Multivariate Function Spaces*, arXiv:1701.06778 [math.NA].

D. Krieg, D. Rudolf *Recovery algorithms for high-dimensional rank one tensors*, arXiv:1711.03986 [math.NA].

P. Kritzer, G. Leobacher, M. Szölgyenyi, S. Thonhauser, *Approximation methods for piecewise deterministic Markov processes and their costs*, arXiv:1712.09201 [math.PR].

R. Kritzinger, *Finding exact formulas for the L2 discrepancy of digital (0,n,2)-nets via Haar functions*, arXiv:1711.06058 [math.NT].

A. Neuenkirch, M. Szölgyenyi, L. Szpruch, *An adaptive Euler-Maruyama scheme for stochastic differential equations with discontinuous drift and its convergence analysis*, arXiv:1802.04521 [math.NA].

F. Pillichshammer, *Tractability properties of the weighted star discrepancy of regular grids*, arXiv:1710.00573 [math.NA].

I.H. Sloan, H. Woźniakowski, *Multivariate approximation for analytic functions with Gaussian kernels*, J. Complexity, to appear, https://doi.org/10.1016/j.jco.2017.11.001, DOI: 10.1016/j.jco.2017.11.001

L. Spiegelhofer, *Discrepancy results for the Van der Corput sequence*, arXiv:1710.01560 [math.NT].

V. Temlyakov, *Dispersion of the Fibonacci and the Frolov point sets*, arXiv:1709.08158v2 [math.NA].

V. Temlyakov, *Fixed volume discrepancy in the periodic case*, arXiv:1710.11499v1 [math.NA].

M. Ullrich, *A note on the dispersion of admissible lattices*, arXiv:1710.08694 [cs.CG].

Invited scientists

Christoph Aistleitner, Daurenbek Bazarkhanov, Dmitriy Bilyk, Bence Borda, Johann Brauchart, William Chen, Sonja Cox, Ligia Loretta Cristea, Stephan Dahlke, Mahadi Ddamulira, Steffen Dereich, Josef Dick, Benjamin Doerr, Dinh Dung, Martin Ehler, Hans Georg Feichtinger, Christel Geiss, Stefan Geiss, Alexander Gilbert, Mike Giles, Michael Gnewuch, Takashi Goda, Peter Grabner, Karlheinz Gröchenig, Erika Hausenblas, Mario Hefter, Kerstin Hesse, Aicke Hinrichs, Arnulf Jentzen, Stefan Kremsner, David Krieg, Peter Kritzer, Ralph Kritzinger, Robert Kunsch, Gunther Leobacher, Mordechey B. Levin, Peter Mathé, Ryan Matzke, Klaus Meer, Clemens Müllner, Radhakrishnan Nair, Andreas Neuenkirch, Mario Neumüller, Erich Novak, Markus Passenbrunner, Sergei V. Pereverzyev, Georg Pflug, Friedrich Pillichshammer, Leszek Plaskota, Joscha Prochno, Paweł Przybyłowicz, Klaus Ritter, Oliver Roche-Newton, Daniel Rudolf, Wolfgang Ch. Schmid, Christoph Schwab, Paweł Siedlecki, Maxim Skriganov, Ian H. Sloan, Lukas Spiegelhofer, Tetiana Stepaniuk, Stefan Steinerberger, Wolfgang Stockinger, Michaela Szölgyeni, Vladimir Temlyakov, Robert Tichy, Mario Ullrich, Arne Winterhof, Henryk Woźniakowski, Marcin Wnuk, Marguerite Zani.

Algorithmic and Enumerative Combinatorics

Organisers: Mireille Bousquet-Mélou (CNRS, U de Bordeaux), Michael Drmota (TU Vienna), Christian Krattenthaler (U Vienna), Peter Paule (U Linz), Michael Singer (North Carolina State U, Raleigh)

Dates: October 16 – November 24, 2017

Budget: ESI € 43 440,
€ 12 000 SFB of the Faculty of Mathematics

Report on the programme

Activities

The programme brought together around 70 researchers at the interface of the three broad areas (1) *Enumerative Combinatorics*; (2) *Analytic Combinatorics*; (3) *Algorithmic Combinatorics*; including researchers from *Algebraic Combinatorics*, *Probabilistic Combinatorics*, *Number Theory*, *Statistical Physics*, and *Computer Algebra*. Researchers from all generations were present, leading senior researchers as well as Ph.D. students and post-docs. The programme has been a place of fruitful interaction between people with often very different background.

During the programme, two workshops took place, the first on *"Enumerative Combinatorics"* (October 16–20, 2017), and the second on *"Computer Algebra and Combinatorics"* (November 13–17, 2017). Both workshops featured series of introductory lectures at the beginning: at the first workshop, introductory lectures were given by MIHYUN KANG and by MICHAEL SINGER, at the second workshop, introductory lectures were given by ALIN BOSTAN and by ROBIN PEMANTLE.

In between the two workshops, two seminar talks were given, one by ALI UNCU, and the second one by ANDREW RECHNITZER.

Members of the combinatorics groups at the Fakultät für Mathematik of the Universität Wien and at the Institut für Diskrete Mathematik und Geometrie of the Technische Universität Wien, as well as the combinatorics and computer algebra groups at the Johannes Kepler Universität Linz and the Johann Radon Institute for Computational and Applied Mathematics (ÖAW, Linz) used the opportunity to discuss and interact with the outside visitors of the programme amply, in particular also students and post-docs from these institutions.

Specific information on the programme

BACKGROUND ON THE SCIENTIFIC AREA. *"Algorithmic and Enumerative Combinatorics"* is the general research area which is defined by the interplay of Enumerative Combinatorics, Analytic Combinatorics, and Algorithmics.

Enumerative Combinatorics is the oldest and the classical branch of these three. Its aim is the development and provision of methods for the enumeration of combinatorial objects as they arise in various fields of mathematics, physics, computer science, such as analysis of algorithms, combinatorics (of course), commutative algebra, geometry, group theory, representation theory, statistics, statistical physics. This concerns in the first place methods for *exact* enumeration.

Of equal intrinsic interest is *asymptotic* enumeration. Here, the branch which is known as *Analytic Combinatorics* comes in. Starting from expressions delivered from exact enumeration, methods are supplied to extract asymptotic information as the combinatorial objects become large. Since in most of the cases one starts from generating functions, functional or differential equations for those, or from recurrences for the counting sequences, it is mostly tools from complex analysis which are used here.[2] It is obvious that (exact) *Enumerative Combinatorics* and *Analytic Combinatorics* strongly depend on each other and consequently stimulate each other mutually.

[2]Of course, such methods may (and actually do) also apply in non-combinatorial contexts; in this sense the term "Analytic Combinatorics" is slightly misleading.

The youngest branch in this context is (necessarily) *Algorithmics*. In the ideal case, computer algorithms should be able to perform the task of solving (exact or asymptotic) enumeration problems. In the beginning, this has been more successful for the asymptotic side, where the celebrated singularity analysis of Flajolet and Odlyzko and Hayman's saddle point theorem for "admissible" functions both lend themselves to an automatic treatment. On the exact side, the breakthrough came with the results around the "holonomic paradigm". This led to the development of extremely useful tools for the manipulation and verification of combinatorial (and special function) identities, which have found many applications, not only in combinatorics, but as well in other fields of mathematics, in mathematical physics, in computer science, and even in engineering.

THE RESEARCH AREAS DISCUSSED DURING THE PROGRAMME. As said above, researchers with a wide range of expertise gathered during the programme. Despite this variety, scientific exchange between them was intense and worked extremely well.

The main topics of the programme were:

- Enumeration of plane partitions, tilings, tableaux, and related objects
- Combinatorial models from Statistical Physics
- Lattice path enumeration
- Graph and map enumeration
- Multivariate asymptotics
- Classification of power series
- Computer algebra tools for handling power series
- Computer algebra tools for asymptotic analysis
- Effective linear algebra and desingularisation over operator algebras

Outcomes and achievements

In the following paragraphs, brief summaries about the progress on the above topics which has taken place during the programme are provided.

Enumeration of plane partitions, tilings, tableaux, and related objects. Over the past forty years, the strongest impetus to exact enumeration came from the enumeration problems arising for plane partitions and alternating sign matrices and related objects (such as tableaux and rhombus tilings). *Plane partitions* were introduced by MacMahon in the early 1900s, while *alternating sign matrices* arose in the work of Mills, Robbins and Rumsey on a generalisation of the determinant around 1980. This area is, and has always been, full of intriguing conjectures, and has become one big field of investigation in the past fifteen years.

Much attention centers currently around hook length formulae, and in particular on hook length formulae for *skew* shapes. This has been initiated by a recent paper by Naruse, who showed how to use Schubert calculus to derive — for the first time — an elegant hook formula for standard tableaux of skew shape. In a series of paper, Morales, Pak and Panova (talk at the first Workshop) have given new proofs of Naruse's formula, have found numerous extensions

and variations, and exciting applications. J.-S. Kim and Yoo (talk at the first Workshop and arχiv preprint) showed how to use q-integrals to prove Peterson and Proctor's hook-length property for all d-complete posets, providing the first complete written proof of these important enumerative results. These developments have since then led to the breakthrough result of Naruse and Okada (arχiv preprint), providing *skew* hook formulae for *all* d-complete posets.

In a different direction, fascinating factorisation results for Schur functions were reported by Behrend and Fischer (talk at the first Workshop). These widely generalise earlier results by Ciucu and Krattenthaler. In particular, the proof method — being based on a clever manipulation of determinants — is extremely interesting. Without, it would not have been possible to derive these generalisations.

How to attack the evaluation of (certain) determinants by computer algebra methods was demonstrated by Koutschan and Thanatipanonda (talk at the second Workshop, arχiv preprint). Not only are they able to prove a 40 year old conjecture of George Andrews, their results go far beyond. The results have their bearing on the enumeration of rhombus tilings, and, if the combinatorial structure is combined with the recursive approach via computer algebra, even stronger results can be derived.

Other research directions at the interface of enumerative and algebraic combinatorics that were discussed were: (1) the Delta Conjecture of Haglund, Remmel and Wilson in symmetric functions theory, which moves one step ahead of the Shuffle Conjecture that has recently been established by Carlsson and Mellit. Haglund (talk at the first Workshop, arχiv preprint) reported about recent progress, partial results, and the difficulties in approaching this important problem; (2) a poset structure on the alternating group generated by 3-cycles, introduced by Mühle and Nadeau (talk at the first Workshop, arχiv preprint); (3) new order relations that refine the classical Bruhat and absolute orders on finite Coxeter groups introduced by Biane and Josuat-Vergès (talk at the first Workshop, arχiv preprint).

Combinatorial models from Statistical Physics. The enumerative analysis of classes of combinatorial objects, in both the exact and the asymptotic sense, links *"Enumerative Combinatorics,"* with — as some say nowadays — *"Combinatorial Physics"*. Many models in Statistical Physics are combinatorial by nature, such as the Ising model, the Potts model, and other vertex models on graphs and lattices, particle models such as ASEP (partially asymmetric exclusion process), or various growth processes. The task is to study the behaviour of these models "when the system size tends to infinity." Starting point of such analyses must necessarily be exact enumerative formulae for *finite* portions of these systems. This is then followed by an asymptotic analysis of these formulae as the size of the system tends to infinity. This explains why the interaction between researchers in Enumerative Combinatorics, Probability Theory, and Statistical Physics is so desirable. Indeed, over the past roughly 20 years, intense collaboration between the researchers in these fields has developed, and led to significant advance and stunning breakthroughs.

During the programme, Linusson (talk at the first Workshop) presented work on intriguing conjectures on the ASEP model on a ring. While the full conjectures seem still out of reach, at least partial results could be obtained. Bouttier, on the other hand, presented joint work with Betea, Boutillier, Chapuy, Corteel and Vuletić on Schur processes (talk at the first Workshop). A longer development stands behind this work, which started with new tiling models (steep tilings and tilings on so-called railyard graphs) unifying several previous ones. Remarkably, in these models all correlation functions can be explicitly computed, something which is very rare. In another direction, but still on tilings, Di Francesco, Guitter and Lapa (talk at the second Workshop, arχiv preprints) have developed a striking new method for the determination of

arctic curves in path models (respectively, what is equivalent, in models of rhombus tilings), which they call the "tangent method". These "arctic curves" (if they exist) separate domains in these models which, with probability tending to 1, exhibit a fixed structure from domains which behave "randomly". It is certain that this method will see many more applications and further development. Again in another direction, Broadhurst (talk at the first Workshop) provided a panorama of Feynman integrals and the computational challenges they pose, together with astonishing sample results for small values of the parameters. Guttmann and Zinn-Justin (talk at the first Workshop, arχiv preprint) applied computational methods from Statistical Physics, combined with new insight in the structure of the problem, in order to improve the known bounds on the numbers of 1324-avoiding permutations, a notoriously difficult enumeration problem that, even after more than 30 years of intensive investigations, still has no solution, and the nature of the generating function of these numbers is widely open as well (although there is some evidence that it may not be D-finite, meaning that it does not satisfy a linear differential equation with polynomial coefficients).

Lattice path enumeration and classification of power series. A rich source of challenging enumeration problems, from the theoretical side and from the algorithmic side, is the study of walks restricted to the quarter plane. In principle, the arising enumeration problems are suited for the application of the so-called kernel method; however, it turns out that frequently cases are met where the known variants of this method do not suffice to actually solve the problem. Further improvements and developments are needed. Some of these have led to new techniques from computer algebra, such as, for example, the recent use of automated asymptotics for proving non-D-finiteness of more than 50 different lattice walk models in the quarter plane by Bostan, Raschel, and Salvy, the approach by Kauers and Zeilberger for finding recurrence equations for excursions, or the technique invented by Bostan and Kauers to show that Gessel's path model is algebraic.

Two series of introductory lectures were devoted to this circle of problems. Bostan (second Workshop) provided an overview of the research area. In particular, he explained the various tools from computer algebra to attack problems of characterisation of generating functions for lattice paths restricted to a quadrant. He concentrated particularly on (what he calls) the "Guess'n'Prove paradigm", meaning to use the computer to generate data for paths of smaller length, then analyse these data in a heuristic fashion in order to come up with a conjecture ("guess"), and finally prove that conjecture. For all these three steps — data generation, guessing, proving — powerful methods and ideas have been developed over the past roughly 10 – 15 years, all of which requiring the clever use of computer algebra. A question that has been posed, respectively attacked, only relatively recently is the one whether some of the generating functions arising in lattice path enumeration known to not be D-finite are *differentially algebraic* (meaning that the function together with its derivatives and the variable satisfies a polynomial equation) or not. Since, so far, not much research has gone into this question, not many tools are available, and consequently results are scarce. Dreyfus, Hardouin, Roques and Singer (introductory lectures at first Workshop, arχiv preprint) have developed methods based on difference Galois theory to attack the above question. This has led to spectacular proofs of conjectural non-differential algebraicity of several of these lattice path generating functions. The discussion has been rounded up by the presentation of a SageMath package for the numerical evaluation of D-finite functions by Mezzarobba (presentation at second Workshop).

Multivariate asymptotics. Univariate asymptotic expansions are a very well established field in combinatorics and many different techniques have been developed (portrayed in the 2009 classic *Analytic Combinatorics* by Flajolet and Sedgewick). Several of these techniques can

be made automatic by computer algebra methods (implemented, for example, in the `Maple` package by Salvy and his group). It is possible to derive multivariate asymptotics by iterating univariate methods, but this is only applicable under quite restricted assumptions. Only very recently, Pemantle and Wilson initiated a systematic study of multivariate asymptotic expansions. This is an extremely challenging and evolving field with many open problems. The state of art of 2013 is summarised in their book *"Analytic Combinatorics in Several Variables"*. Also here, the problem of an algorithmic treatment is of utmost significance in applications. Moreover, the complexity of the problem — even in the "simplest" case of multivariate asymptotics of coefficients of rational functions — makes it a necessity to integrate computer algebra in solution methods.

Both "protagonists" of "Analytic Combinatorics in Several Variables" (ACSV), Pemantle and Wilson, were present during the second Workshop (together with postdoc Melczer). Pemantle (introductory lectures at second Workshop) gave an outline of the basic ideas, coming from complex analysis and differential geometry, while Wilson (talk at second Workshop) posed challenges for computer algebra that arise in this Multivariate Singularity Analysis. Melczer (talk at second Workshop) presented a nice application of ACSV on the enumeration of regions in hyperplane arrangements. Salvy (talk at second Workshop) showed computer algebra tools for the determination of the asymptotics of diagonals of multivariate power series, the starting point being the ACSV as developed by Pemantle and Wilson.

Graph and map enumeration. The enumeration of planar maps goes back to Tutte in the 60's, where the concept of the so-called quadratic method was developed. For the last two decades planar maps (and related structures) got more and more scientific attention which is due to several spectacular achievements. In the late 1990's, Schaeffer introduced a bijection between quadrangulations and certain labelled plane trees which made it possible to reprove Tutte's formulae and to discuss the asymptotic distribution of the radius of quadrangulations. Later, Schaeffer's bijection was widely generalised by Poulalhon and Schaeffer and by Bouttier, Di Francesco, and Guitter. This re-stimulated the asymptotic and probabilistic analysis of (random) planar maps (based on important results by Bender, Canfield, Gao, and Wormald).

A research direction which was in the air for the past 40 years or so, but gained focus only recently is the (asymptotic) enumeration of graphs on surfaces. Kang (introductory lectures at first Workshop) gave a survey of the state of art of results and methods at this point, and in the second part concentrated on research that she has done with collaborators over the past two or three years. Her co-workers Fang and Sprüssel (talks at first Workshop) complemented this general overview with reports on special topics of graph and map enumeration. Chapuy (talk at first Workshop) takes a slightly different angle by considering the problem of (asymptotic) counting of triangulated manifolds in d dimensions. Indeed, this is a very challenging problem, where results are, at this moment, very partial.

Effective linear algebra and desingularisation of systems of differential and difference equations. Desingularisation of systems of differential/difference equations means the following. Given a system of differential/difference equation, the task is to find a (gauge) equivalent system such that the finite singularities of the latter agree with the apparent singularities of the former. It is an important concept which has many applications.

For differential systems, this is classical. How to this in practise — that is, in an algorithmic fashion such that a computer can efficiently perform this task — has been investigated over the past 20 years, for differential systems, for difference systems, and — more generally — for Ore operators (which, in their most simple form are operators built from differential *and* difference operators). For single operators, efficient algorithms exist now due to work by

Abramov and van Hoeij, of Tsai, of Abramov, Barkatou and van Hoeij, and of Chen, Jaroschek, Kauers and Singer. For systems, this problem has only recently been approached, in the first place by Barkatou. At the second Workshop, he provided an overview of the state of art in the desingularisation of differential systems. Jaroschek (talk at second Workshop) discussed the meaning of desingularisation for systems of difference equations and how to approach it. Together, Barkatou and Jaroschek (arχiv preprint) propose the first algorithm for the desingularisation of first order linear difference systems with rational coefficients. Labahn (talk at the second Workshop) addressed the solution of linear differential systems via normal forms of operator matrices. Giesbrecht, Haraldson and Labahn (talk at the second Workshop, arχiv preprint) made a link between degree bounds for normal forms of matrix polynomials and the quasideterminants of Gelfand and Retakh.

List of talks

Workshop 1: Enumerative Combinatorics, October 16 – 20, 2017

Mihyun Kang	Introductory Talk: Enumeration of graphs on surfaces, I
Michael Singer	Introductory Talk: A Galoisian approach to counting walks, I
Mihyun Kang	Introductory Talk: Enumeration of graphs on surfaces, II
Michael Singer	Introductory Talk: A Galoisian approach to counting walks, II
David Broadhurst	Combinatorics of Feynman integrals
Paul Zinn-Justin	1324-avoiding permutations revisited
Shishuo Fu	A unifying combinatorial approach to refined little Göllnitz and Capparelli's companion identities
Jiang Zeng	Some multivariate master polynomials for permutations, set partitions, and perfect matchings, and their continued fractions
Matthieu Josuat-Vergès	Noncrossing partitions, Bruhat order, and the cluster complex
Philippe Nadeau	The alternating group and noncrossing partitions
Greta Panova	Hook formulas for skew shapes: combinatorics and asymptotics
Sergi Elizalde	Cyclic descents of standard Young tableaux
Jim Haglund	Recent progress on the Delta conjecture
Jang Soo Kim	Hook length property of d-complete posets via q-integrals
Guillaume Chapuy	Counting triangulated d-manifolds, asymptotically
Wenjie Fang	Planar maps and Tamari-like intervals
Philipp Sprüssel	Unlabelled planar graphs and symmetries of triangulations
Roger Behrend	Schur function factorizations, with applications to alternating sign matrices and plane partitions
Jérémie Bouttier	The free boundary Schur process and applications
Soichi Okada	Symplectic Schur Q-functions
Tony Guttmann	The growth of groups, with application to Thompson's group F
Hsien-Kui Hwang	Limit laws for linear recurrences of Eulerian type
Jay Pantone	Sorting with C-machines
Svante Linusson	Continuous multiline queues and the TASEP on a ring
Michael Borinsky	Hopf algebras and factorial divergent power series: Algebraic tools for graphical enumeration

Workshop 2: Computer Algebra and Combinatorics, November 13 – 17, 2017

Alin Bostan	Introductory Talk: Computer algebra for lattice path combinatorics, I
Robin Pemantle	Introductory Talk: Automatic computation of multivariate asymptotics

Alin Bostan	Introductory Talk: Computer algebra for lattice path combinatorics, II
Stephen Melczer	Multivariate singularity analysis and hyperplane arrangements
Mark Wilson	ACSV: help wanted from computer algebra(ists)
Bruno Salvy	Algorithmic tools for the asymptotics of diagonals
Dan Romik	The Taylor expansion of the Jacobi theta function at $x = 1$
Armin Straub	Properties of Laurent coefficients of multivariate rational functions
Frédéric Chyzak	Computing solutions of linear Mahler equations
Tom Roby	A path formula for birational rowmotion on a product of two chains
Moulay Barkatou	Algorithms for removing apparent singularities of linear differential systems
Maximilian Jaroschek	How not to define desingularization
Georg Regensburger	Consequences of the fundamental theorem of calculus in differential rings
Philippe Di Francesco	Arctic curves in path models from the tangent method
George Labahn	Computation of normal forms for polynomial and maybe Ore matrices
Guoce Xin	Some progress on the sweep maps
Christoph Koutschan	Symbolic evaluation of determinants and rhombus tilings of holey hexagons
Marc Mezzarobba	Numerical evaluation of D-finite functions in `SageMath` with applications
Marko Petkovšek	Convolutions as solutions of linear recurrences
Tanguy Rivoal	Algorithmic determination of exceptional algebraic values of E-functions
David Broadhurst	Applications of integer relation algorithms
Mark Giesbrecht	Quasideterminants, degree bounds and "fast" algorithms for matrices of differential and difference polynomials
Sergei Abramov	On the arithmetic and shift complexities of inversion of difference operator matrices

Individual talks

Ali Uncu	Heights of q-rising factorials and some related series
Andrew Rechnitzer	An introduction to the kernel method
Arvind Ayyer	The combinatorics of odd and chiral partitions

Publications and preprints contributed

S. A. Abramov, M. Petkovšek, H. Zakrajšek, *Convolutions of Liouvillian Sequences*, arXiv:1803.08747 [cs.SC].

B. Adamczewski, T. Rivoal, *Exceptional values of E-functions at algebraic points*, arXiv:1708.00217 [math.NT].

R. M. Adin, S. Elizalde, Y. Roichman, *Cyclic descents for near-hook and two-row shapes*, arXiv:1801.00044 [math.CO].

M. A. Barkatou, M. Jaroschek, *Desingularization of First Order Linear Difference Systems with Rational Function Coefficients*, arXiv:1802.01150 [cs.SC].

D. Betea, J. Bouttier, P. Nejjar, M. Vuletić, *The free boundary Schur process and applications*, arXiv:1704.05809 [math.PR].

P. Biane, M. Josuat-Vergès, *Noncrossing partitions, Bruhat order and the cluster complex*, arXiv:1801.06078 [math.CO].

A. R. Conway, Anthony J. Guttmann, P. Zinn-Justin, *1324-avoiding permutations revisited*, arXiv:1709.01248 [math.CO].

P. Di Francesco, E. Guitter, *Arctic curves for paths with arbitrary starting points: a tangent method approach*, arXiv:1803.11463 [math-ph].

P. Di Francesco, M. F. Lapa, *Arctic Curves in path models from the Tangent Method*, arXiv:1711.03182 [math-ph].

T. Dreyfus, C. Hardouin, J. Roques, M. F. Singer, *Walks in the quarter plane, genus zero case*, arXiv:1710.02848 [math.CO].

A. Garsia, J. Haglund, J. B. Remmel, M. Yoo, *A proof of the Delta Conjecture when* $q = 0$, arXiv:1710.07078 [math.CO].

M. Giesbrecht, J. Haraldson, G. Labahn, *Computing Lower Rank Approximations of Matrix Polynomials*, arXiv:1712.04007 [cs.SC].

J. S. Kim, M. Yoo, *Hook length property of d-complete posets via q-integrals*, arXiv:1708.09109 [math.CO].

C. Koutschan, T. Thanatipanonda, *A Curious Family of Binomial Determinants That Count Rhombus Tilings of a Holey Hexagon*, arXiv:1709.02616 [math.CO].

H. Mühle, P. Nadeau, *A Poset Structure on the Alternating Group Generated by 3-Cycles*, arXiv:1803.00540 [math.CO].

G. Musiker, T. Roby, *Paths to Understanding Birational Rowmotion on Products of Two Chains*, arXiv:1801.03877 [math.CO].

H. Naruse, S. Okada, *Skew hook formula for d-complete posets*, arXiv:1802.09748 [math.CO].

M. Petkovšek, *Definite Sums as Solutions of Linear Recurrences With Polynomial Coefficients*, arXiv:1804.02964 [cs.SC].

Invited scientists

Youssef Abdelaziz, Florian Aigner, Marie Albenque, Andrei Asinowski, Arvind Ayyer, Cyril Banderier, Moulay Barkatou, Roger Behrend, Gaurav Bhatnagar, Michael Borinsky, Alin Bostan, Mireille Bousquet-Melou, Jeremie Bouttier, David Broadhurst, Manfred Buchacher, Guillaume Chapuy, Frederic Chyzak, Gwendal Collet, Diego Dominici, Thomas Dreyfus, Michael Drmota, Sergi Elizalde, Wenjie Fang, Ilse Fischer, Philippe Di Francesco, Shishou Fu, Samuel Asefa Fufa, Eric Fusy, Mark Giesbrecht, Ting Guo, Tony Guttmann, Jim Haglund, Hans Höngesberg, Hsien-Kuei Hwang, Maximilian Jaroschek, Matthieu Josuat-Verges, Mihyun Kang, Manuel Kauers, Jang Soo Kim, Christoph Koutschan, Christian Krattenthaler, George Labahn, Mathias Lepoutre, Svante Linusson, Baptiste Louf, Ivica Martinjak, Stephen Melczer, Marc Mezzarobba, Johannes Middeke, Philippe Nadeau, Gabor Nagy, Peter Nejjar, Evans Doe Ocansey, Soichi Okada, Greta Panova, Jay Pantone, Peter Paule, Robin Pemantle, Marko Petkovsek, Veronika Pillwein, Samu Potka, Clemens Raab, Andrew Rechnitzer, Georg Regensburger, Clément Requilé, Tanguy Rivoal, Tom Roby, Dan Romik, Manjil Saikia, Bruno Salvy, Michael Schlosser, Carsten Schneider, Michael Singer, Christian Sprssel, Armin Straub, Christian Stump, Thibaut Verron, Ali K. Uncu, Guoce Xin, Michael Wallner, Mark Wilson, Guan-Ru Yu, Jiang Zeng, Yi Zhang, Paul Zinn-Justin.

Workshops organized independently of the Main Programmes

Geometry and Representation Theory

Organizers: Tomoyuki Arakawa (RIMS, U of Kyoto), Karin Baur (U of Graz), Victor Kac (MIT, Boston), Anne Moreau (U of Lille)

Dates: January 16 – 27, 2017

Budget: ESI: € 29 200

Other sources:

1. NSF: $ 20 000
2. ERC (ERC Grant Agreement number 647353 Qaffine): € 2 062
3. GDR TLAG: € 800
4. DK Discrete Mathematics (FWF DK-1230), Graz/Leoben: € 340
5. University of Kyoto: € 10 000
6. JSPS KAKENHI Grant Numbers 25287004, 26400040, 16K05055 : € 10 000
7. Vienna Convention Bureau: € 1 500
8. Laboratoire de Poitiers: € 1 000
9. ANR GERCHER (project ANR-15-CE40-001): € 3 600

Report on the workshop

Geometric methods have been one of the major trends in the modern development of representation theory. Perhaps the most important turning point is the appearance of the Kazhdan-Lusztig conjecture on the characters of irreducible highest weight representations of semisimple Lie algebras that was proved by Beilinson-Bernstein and Brylinski-Kashiwara by the method of D-modules and the Riemann-Hilbert correspondence. The development in this field has been accelerated by the influence of quantum field theory and of string theory, which in particular led Beilinson and Drinfeld to introduce the influential geometric Langlands program.

At the same time, the importance of studying infinite dimensional algebras such as affine Kac-Moody algebras or, more generally, as vertex algebras (e.g. (affine) W-algebras) became apparent.

For instance, vertex algebras or chiral algebras, their geometric versions, have been playing an essential role in the geometric Langlands program. Affine Kac-Moody algebras also play a fundamental role in the theory of categorification, which was developed by Rouquier, Ariki, Brundan-Kleshchev, Stroppel and many others. Furthermore, the appearance of the AGT conjecture in physics led many researchers towards the so-called W-algebras introduced and developed by Zamolodchikov, Fateev-Lukyanov, Feigin-Frenkel and Kac-Roan-Wakimoto, while their finite-dimensional analogues, the finite W-algebras introduced by Premet, have caught attention for different reasons that are mostly related with more classical problems of representation theory.

The aim of the conference was to bring together researchers in representation theory coming from different backgrounds, and to present the above described recent developments in representation theory that interacts with other areas of Mathematics, such as mathematical physics or algebraic geometry, exploiting various branches of Lie Theory. In particular, we emphasized the use of geometric methods in representation theory.

The main areas that we dealt with during the workshop were the following:

Algebraic D-modules/Intersection cohomology, Vertex algebras, Affine Grassmanians and their variants, Spherical varieties and arc spaces, R-matrices and affine quantum groups.

Activities

The first week (January 16 - 20, 2017) was devoted to mini-courses and talks given by participants. More precisely, the first week included seven lectures given by experts in representation theory, mostly addressed to young researchers in representation theory. These lectures were about the topics as developed above. The following experts gave a mini-course:

1. Pramod Achar, Louisiana State U, Baton Rouge
2. Victor Batyrev, U Tübingen
3. Pavel Etingof, MIT Boston
4. Dennis Gaitsgory, Harvard U
5. David Hernandez, U Paris-Diderot
6. Ivan Mirkovic, U of Massachusetts Amherst
7. Guido Pezzini, U of Rome, “La Sapienze”

In addition, we had four one-hour talks given by renowned researchers, and a session devoted to short talks given by Masters or PhD students (10 talks).

The second week (January 23 - 27, 2017) was devoted to talks given by participants. In more detail, we had 25 talks (one hour or half an hour talks) given by renowned researchers and younger researchers. We also had a session of short talks given by Masters or PhD students in the second week (9 talks).

Specific information on the workshop

Many young researchers attended the workshop. Below is the list of Masters, PhD students or young researchers (post-doctoral) who participated in the program. Most of them attended both weeks.

Some of them (Ruy Fujita, Sylvain Carpentier, Tina Kanstrup, Auguste Herbert, Raeez Lorgat and Raphaël Achet) have accepted to take note of the mini-course lectures. These notes are now available on the webpage of the conference:

`http://imsc.uni-graz.at/baur/ESI2017/minicourses.html`

Note that Pavel Etingof provided the notes of his lectures himself. They are also available on the webpage.

As explained above, several sessions were devoted to short talks (five minutes talks) given by Master or PhD students. The names of the young researchers are given in the list below, with the titles of the short talks where appropriate.

Raphael Achet	Picard group of the forms of the affine line and of the additive group
Francesco Allegra	Generators for W-algebras of type A
Léa Bittmann	Baxter relations and quantum Grothendieck rings
Sylvain Carpentier	Integrable operators
Elie Casbi	
Masahiro Chihara	Langlands duality for characters of finite dimensional representations of simple Lie algebras
Jens Eberhardt	A Formalism of Mixed Sheaves in Positive Characteristic
Laura Fedele	Quantum finite W-algebras in type A
Ryo Fujita	Tilting modules in affine highest weight categories
Matteo Gardini	Quantum Vertex Operators Algebra
Naoki Genra	W-algebras, Screening operators and Wakimoto representations
Auguste Hebert	Gindikin-Karpelevich finiteness for Kac-Moody groups over local fields
Thorge Jensen	The p-canonical basis of Hecke algebras and p-cells
Nilamsari Kusumastuti	Kostant principal filtration and paths in weight lattices
Raeez Lorgat	Opers and Quantum Curves
Jacob Matherne	A combinatorial Fourier transform for quiver representation varieties in type A
Leonardo Patimo	The Neron-Severi Lie algebra of a Schubert Variety
Tomasz Przezdziecki	The Suzuki functor at the critical level
Yang Ruotao	Another definition of singular support for D-modules
Veronica Vignoli	Integrable Hamiltonian Hierarchies Associated to Classical Affine W-Algebras for $\mathfrak{gl}_n$
Giovanni Zaccanelli	

Outcomes and achievements

Below is a (probably non exhaustive) list of publications appeared during, or right after, the conference by participants that are in direct connection with the topic of the conference.

Most of them profited greatly from the collaboration of several participants during the conference.

1. *Representations of superconformal algebras and mock theta functions*, Victor G. Kac, Minoru Wakimoto, arXiv:1701.03344.

2. *Parafermion vertex operator algebras and W-algebras*, Tomoyuki Arakawa, Ching Hung Lam, Hiromichi Yamada, arXiv:1701.06229.

3. *Coset Vertex Operator Algebras and W-Algebras*, Tomoyuki Arakawa, Cuipo Jiang, arXiv:1701.06880.

4. *On the tensor semigroup of affine Kac-Moody Lie algebras*, Nicolas Ressayre, arXiv:1701.02176.

5. *On classification of non-equal rank affine conformal embeddings and applications*, Drazen Adamovic, Victor G. Kac, Pierluigi Moseneder Frajria, Paolo Papi, Ozren Perse, arXiv:1702.06089.

6. *On seaweed subalgebras and meander graphs in type D*, Dmitri Panyushev, Oksana Yakimova, arXiv:1702.07879.

7. *A remark on Mishchenko-Fomenko algebras and regular sequences*, Anne Moreau, arXiv:1703.00880.

8. *Horospherical stacks*, Ariyan Javanpeykar, Kevin Langlois, Ronan Terpereau, arXiv:1703.00488.
9. *Self-dual and logarithmic representations of the twisted Heisenberg-Virasoro algebra at level zero*, Drazen Adamovic, Gordan Radobolja, arXiv:1703.00531.

In addition, David Hernandez has given a lecture at *Séminaire Bourbaki* in Paris (Institut Henri Poincaré) the 11th of March, 2017 entitled "*Avancées concernant les R-matrices et leurs applications [d'après Maulik-Okounkov, Kang-Kashiwara-Kim-Oh...]*". It was a condensed version of his three lectures given at ESI. David Hernandez thanks ESI, and the participants of the conference, in the text of the presentation which will be published in *Astérisque, Société mathématique de France*.

List of talks

Below is the list of speakers with the title of their talks (for the short talks, we refer to "Specific information on the workshop"), by chronological order. Names in bold refer to the speakers of mini-courses.

Week 1: January 16 – 20, 2017

Pramod Achar	Introduction to affine Grassmannians and the geometric Satake equivalence, I - III
Guido Pezzini	Geometry and combinatorics of spherical varieties, I - II
Ivan Mirkovic	Generalized loop Grassmannians I: Commutative case and Class Field Theory Generalized loop Grassmannians II: More "loop Grassmannians" via local spaces More "loop Grassmannians" via local spaces III: Drinfeld's formulation of interesting subspaces in terms of classifying pairs
Pavel Etingof	Introduction to D-modules, I - III
Pierre Baumann	Bases for tensor products and geometric Satake correspondence
David Hernandez	R-matrices, affine quantum groups and applications, I - III
Maria Gorelik	Duflo-Serganova functor for affine Lie superalgebras
Dennis Gaitsgory	Chiral algebras, I - III
Victor Batyrev	Spherical varieties and arc spaces, I - II
Alexander Premet	Classification of the maximal subalgebras of exceptional Lie algebras in good characteristic
Daniel Juteau	Support of the spherical representation of the rational Cherednik algebra

Week 2: January 23 – 27, 2017

Laurent Manivel	New constructions of Calabi-Yau varieties
Laura Rider	Tilting Modules and the centralizer of a regular nilpotent
Wolfgang Sörgel	Equivariant motives in representation theory
Reimundo Heluani	Rationality of vertex algebras and higher chiral homology
Ronan Terpereau	A symplectic version of the Chevalley restriction theorem
Catharina Stroppel	R-matrices and convolution algebras for Grassmannians
Drazen Adamović	Conformal embeddings of affine vertex algebras in W-algebras ant their applications
Jethro van Ekeren	Modularity of Relatively Rational Vertex Algebras
Alberto de Sole	W-algebras in type A
Andrew Linshaw	Orbifolds and Cosets of W-algebras
Kazuya Kawasetsu	Quasi-lisse vertex algebras and modular linear differential equations
Minoru Wakimoto	Modular invariance in representation theory of superconformal algebras: the case of big N = 4 SCA — joint work with Victor Kac
Nicolas Ressayre	On the tensor semigroup of an affine Kac-Moody Lie algebra

Oleksandr Tsymbaliuk	Shifted Quantum Affine Algebras
Oksana Yakimova	Index of a seaweed subalgebra and meander graphs in the classical type — joint with D. Panyushev
Iva Halacheva	A cactus group action on crystals and the monodromy of moduli spaces
Clélia Pech	Rational curves on horospherical varieties of Picard rank one
Fedor Malikov	Strongly homotopy chiral algebroids
Vlad Bavula	The classical left regular left quotient ring of a ring and its semisimplicity criteria
Avraham Aizenbud	Bounds on multiplicities of spherical spaces over finite fields
Stéphane Gaussent	Kac-Moody groups, Masures and Iwahori-Hecke algebras
Tina Kanstrup	Categorical braid group actions
Simon Goodwin	Modular W-algebras and reduced enveloping algebras
Tanmay Deshpande	Character sheaves and modular categories
Maxim Nazarov	Cherednik algebras and Zhelobenko operators

Publications and preprints contributed

D. Adamovic, G. Radobolja, *Self-dual and logarithmic representations of the twisted Heisenberg-Virasoro algebra at level zero*, arXiv:1703.00531 [math.QA].

D. Adamovic, V. G. Kac, P. Moseneder Frajria, P. Papi, O. Perse, *On classification of non-equal rank affine conformal embeddings and applications*, arXiv:1702.06089 [math.RT].

T. Arakawa, C. Jiang, *Coset Vertex Operator Algebras and W-Algebras*, arXiv:1701.06880 [math.RT].

T. Arakawa, C. H. Lam, H. Yamada, *Parafermion vertex operator algebras and W-algebras*, arXiv:1701.06229 [math.RT].

A. Javanpeykar, K. Langlois, R. Terpereau, *Horospherical stacks*, arXiv:1703.00488 [math.RT].

V. G. Kac, M. Wakimoto, *Representations of superconformal algebras and mock theta functions*, arXiv:1701.03344 [math.RT].

A. Moreau, *A remark on Mishchenko-Fomenko algebras and regular sequences*, arXiv:1703.00880 [math.RT].

D. Panyushev, O. Yakimova, *On seaweed subalgebras and meander graphs in type D*, arXiv:1702.07879 [math.RT].

N. Ressayre, *On the tensor semigroup of affine Kac-Moody lie algebras*, arXiv:1701.02176 [math.AG].

Invited scientists

Pramod Achar, Raphael Achet, Drazen Adamovic, Avraham Aizenbud, Francesco Alberto Allegra, Tomoyuki Arakawa, Victor Batyrev, Karin Baur, Pierre Baumann, Vlad Bavula, Léa Bittmann, Alexandre Bouayad, Michael Bulois, Sylvain Carpentier, Nils Carqueville, Elie Casbi, Reda Chhaibi, Tanmay Deshpande, Alberto de Sole, Jens Niklas Eberhardt, Inna Entova-Aizenbud, Pavel Etingof, Laura Fedele, Ryo Fujita, Dennis Gaitsgory, Iordan Ganev, Matteo Gardini, Stephane Gaussent, Naoki Genra, Simon Goodwin, Maria Gorelik, Iva Halacheva, Auguste Hébert, Reimundo Heluani, David Hernandez, Estanislao Herscovich Ramoneda, Crystal Hoyt, Lars Thorge Jensen, Daniel Juteau, Victor Kac, Tina Kanstrup, Kazuya Kawasetsu, Nilamsari Kusumastuti, Andrew Linshaw, Raeez Lorgat, Fedor Malikov, Laurent Manviel, Chihara Masahiro, Jacob Matherne, Joanna Meinel, Ivan Mirkovic, Sven Möller, Anne Moreau, Maxim Nazarov, Pranav Pandit, Dmitri I. Panyushev, Nikos Papalexiou, Paolo Papi, Leonardo Patimo, Clelia Pech, Ozren Perse, Guido Pezzini, Alexander Premet, Tomasz Przezdziecki, Shifra Reif, Nicolas Ressayre, Laura Rider, Yang Ruotao, Preena Samuel, Yoshihisa Saito, Alexey Sevastyanov, Wolfgang Srgel, Thomas Strobl, Catharina Stroppel, Matthew Szczesny, Ronan Terpereau, Lewis Topley, Oleksandr Tsymbaliuk, Jethro van Ekeren, Veronica Vignoli, Minoru Wakimoto, Oksana Yakimova, Hiromichi Yamada, Rupert Yu, Giovanni Zaccanelli.

Geometric Transport Equations in General Relativity

Organizers: Håkan Andréasson (Chalmers U), David Fajman (U Vienna), Jérémie Joudioux (U Vienna)

Dates: February 20 – 24, 2017

Budget: ESI € 13 024
Other sources: U Vienna € 2 000, Chalmers U € 2 000, French national research agency grant ANR-12-BS01-012-01 - "Asymptotic analysis in General Relativity" € 2 000, European Mathematical Society - Committee for developing countries € 800, European Physical Society € 500

Report on the workshop

Scientific purposes

Until the organization of this workshop, problems for the Einstein-Vlasov system have been discussed either in the frame of programs on General Relativity *or* Kinetic theory. It was our aim to organize the first workshop exclusively dedicated to the study of the Einstein-Vlasov system. The purpose was to enable the participating community to focus solely on problems related to the Einstein-Vlasov system and concentrate the efforts to make progress on important open problems in the field. The diversity of the field requires a broad selection of experts in different fields such as nonlinear wave equations, transport equations and differential geometry. In addition, knowledge about numerical methods for solving the Einstein equations are required for investigating important issues.

Research directions emphasized during the workshop

In kinetic theory matter is described as an ensemble of particles. These individual "particles" may in fact be very different objects depending on the physical situation, e.g. atoms in a neutral gas and ions in a plasma. In a gravitating system, the particles can be stars, galaxies or even clusters of galaxies. The kinetic model is statistical and the particle distribution is given by a density function f in phase space. In stellar systems collisions are rare and it is standard to assume that the "gas" is collisionless. Such a gas is called Vlasov matter. In the non-relativistic case the resulting system of equations is the Vlasov-Poisson system, whereas in the general relativistic case it is the Einstein-Vlasov system. These are non-linear systems of partial differential equations.

Vlasov matter is a widely used model in astrophysics and in cosmology both as a theoretical model and in comparison with actual observations: this simplified model provides an important understanding of astrophysical phenomena and of the large scale behaviour of the universe. Despite the interest from the astrophysical community, the rigorous mathematical study of the Einstein-Vlasov system has still an enormous potential for development.

In the original proposal, the focus was on three key topics: the cosmic censorship conjectures, the stability of spherically symmetric steady states, and the stability of the Minkowski space.

Specific activities

The workshop hosted 22 talks by experts in the field, which constituted the main part of the workshop. We tried to organize the schedule of the workshop in such a way that discussions

can occur between the participants of the workshop (long time break, and two free afternoons), which were allowing longer and active discussions. This provided an atmosphere of intensive exchange between the participants of the main areas present at the workshop. Those areas were *the mathematical study of the Einstein-Vlasov system related problems*, *numerical study of the Einstein-Vlasov system related systems*, and *the mathematical study of kinetic theory*. We provide in the following the list of talks given at the workshop in these categories:

- *Einstein-Vlasov system*: Ringström, Nungesser, LeFloch, Taylor, Velazquez, Smulevici, Dafermos, Blue, Tod, Lee, Luk.
- *Numerical studies*: Gundlach, Sarbach, Ames, Yoo, Rinne.
- Kinetic theory: Hadzic, Lemou, Dolbeault, Thaller, Rein.

In addition to these specialized lectures there was an Erwin Schrödinger Lecture given by Mihalis Dafermos which had an outstanding attendance of a general scientific audience from several Vienna research institutions such as the Faculties of Mathematics and Physics of the University of Vienna as well as of the Technical University.

Collaborations during the workshop, and related achievements

We list here the scientific collaborations that were supported by the organization of the workshop, and the the related achievement known to the organizers.

One problem was the *nonlinear stability of Minkowksi space for the massive Einstein-Vlasov system* which was covered by the talks of Smulevici and Taylor. Both speakers presented complementary ideas to address the problem. The workshop was a good opportunity to exchange ideas between the two groups (Fajman-Joudioux-Smulevici, and Lindblad-Taylor) and opinions to solve the problems. The outcome of this research was pre-published on the arxiv in July 2017 by both groups.

Another problem concerns the relation between the Einstein-Vlasov and the Einstein-dust system. Talks on this issue have been given by Yoo and Rein. Andréasson and Rein have recently obtained new results on this topic.

Lee and Nungesser both gave talks at the workshop and recently they finished a collaboration on the Einstein-Boltzmann system for cosmological models, and led to a global existence for some Bianch 1 type solutions.

Hadzic and Rein started a collaboration on instability of certain static solutions to the Einstein-Vlasov system and results will soon be published.

Andréasson, Robertson and Thaller initiated a collaboration on the numerical study of the Einstein-Vlasov system with Gowdy symmetry and a code has been written and results are expected this year.

Blue and Joudioux (originally, as well, with Andersson) carried on extending their work on the massless transport equation on Kerr black holes. This work is still ongoing.

The collaboration between Sarbach and Rioseco (fueled by discussion with Blue during the workshop) are leading to new results for the study of massive fields on black hole backgrounds.

Funding of the workshop

One third of the conference budget was coming from external funding that the organizers managed to secure. It must be noted that the funding from the scientific societies was originally intended to fund the travel of a colleague from Cameroun, whose visa has been refused by the authorities representing Austria in Cameroun. Hence, the funding of the European Mathematical Society has been lost, and had to be wired back.

The use of the external funding (6 500 €) is split as follows:

1. 25% is devoted to fund travel of post doc and students (in particular, ca. 50% was used to fund the travel from Mexico of Paola Rioseco, PhD student of O. Sarbach.

2. 70% was used for social events (fund collations during the workshop, and the conference dinner).

To the knowledge of the organizers, the funding of the workshop was such that every participant requiring funding was funded.

List of talks

Hans Ringström	On the cosmic no-hair conjecture in the Einstein-Vlasov setting
Ernesto Nungesser	Self-similarity breaking of cosmological solutions with collisionless matter
Mahir Hadžić	Nonlinear stability of expanding stars in the mass-critical Euler-Poisson system
Carsten Gundlach	Static solutions of the spherically symmetric Einstein-Vlasov system and their perturbation spectrum
Philippe LeFloch	Hyperboloidal foliations and self-gravitating massive fields
Martin Taylor	Global nonlinear stability of Minkowski space for the massless Einstein–Vlasov system
Jacques Smulevici	Sharp asymptotics for small data solutions of the Vlasov-Nordström system in three dimensions
Mihalis Dafermos	*On the Einstein-Vlasov system under surface symmetry*
Pieter Blue	Decay of fields outside black holes: Massless Vlasov outside a very slow Kerr
Olivier Sarbach	Accretion of a relativistic collisionless kinetic gas into a Schwarzschild black hole
Ellery Ames	Stationary Solutions to the Einstein-Vlasov System in Axisymmetry
Chulmoon Yoo	3D simulation of Spindle Gravitational Collapse of a Collisionless Particle System
Oliver Rinne	Einstein-Vlasov evolution in axisymmetry
Juan Velázquez	Veiled singularities for the massless Einstein-Vlasov system
Paul Tod	Isotropic singularities in Einstein-Vlasov and Einstein-Boltzmann
Ho Lee	Late time behaviour of Israel particles in a FLRW spacetime with $\Lambda > 0$
Jonathan Luk	High frequency limits in general relativity
Mohammed Lemou	Extended rearrangement inequality and quantitiative orbital stability for gravitational Vlasov-Poisson and HMF models
Mihalis Dafermos	Erwin Schrödinger lecture: On falling into black holes
Jean Dolbeault	On a result of symmetry based on nonlinear flows
Maximillian Thaller	On static solutions of the Einstein-Vlasov system
Gerhard Rein	Gravitational collapse - dust versus Vlasov

Publications and preprints contributed

D. Fajman, J. Joudioux, J. Smulevici, *The Stability of the Minkowski space for the Einstein-Vlasov system*, arXiv:1707.06141 [gr-qc].

D. Fajman, J. Joudioux, J. Smulevici, *Sharp asymptotics for small data solutions of the Vlasov-Nordström system in three dimensions*, arXiv: 1704.05353 [math.AP].

H. Lee, E. Nungesser, *Late-time behaviour of the Einstein-Boltzmann system with a positive cosmological constant*, arXiv:1709.05223 [gr-qc].

H. Ringström, *Linear systems of wave equations on cosmological backgrounds with convergent asymptotics*, arXiv:1707.02803 [gr-qc].

Attendance of the workshop

The conference was attended by 60 participants. Amongst these participants, 17% of them were post doctoral researchers, and 22% were master and phd students. In total, almost 40% of the audience was constituted of young researchers.

One of the purpose of the conference was to mix two communities of researchers working on the one hand on the relativistic Vlasov system, and the classical Vlasov system. If the major part of the audience attending the conference consisted of researchers in relativity, established researchers working on the classical transport equations have attended the workshop and presented their work (M. Lemou, J. Dolbeault, G. Rein, J. Velazquez, for instance).

Invited scientists

Peter Aichelburg, Ellery Ames, Håkan Andréasson, Herbert Balasin, Hamed Barzegar, Shabnam Beheshti, Robert Beig, Piotr Bizon, Pieter Blue, Volker Branding, Yann Brenier, Annegret Burtscher, Simone Calogero, Piotr Chrusciel, Joao Costa, Mihalis Dafermos, Jean Dolbeault, Michael Eichmair, Peter Eigenschink, David Fajman, Joachim Frenkler, Helmut Friedrich, Alfonso Garcia-Parrado, Edgar Gasperin Garcia, Melanie Graf, James Grant, Carsten Gundlach, Mahir Hadzic, Michael Hörzinger, Jérémie Joudioux, Paul Klinger, Jan Kohlrus, Wojciech Kulczycki, Michael Kunzinger, Ho Lee, Philippe LeFloch, Mohammed Lemou, Anders Logg, Jonathan Luk, Filipe Mena, Georgios Moschidis, Ernesto Nungesser, Tim Torben Paetz, Michal Pirog, Dennis Rätzel, Gerhard Rein, Natacha Riahi, Hans Ringström, Oliver Rinne, Paola Rioseco, Calum Robertson, Clemens Sämann, Oliver Sarbach, Christoph Schaman, Walter Simon, Jacques Smulevici, John Stalker, Roland Steinbauer, Martin Taylor, Maximillian Thaller, Paul Tod, Helmuth Urbantke, Juan Valiente-Kroon, Juan J. L. Velazquez, Chulmoom Yoo.

ESI-CECAM Workshop: Challenges across Large-Scale Biomolecular and Polymer Simulations

Organizers: Ivan Coluzza (U Vienna), Barbara Capone (U Vienna), Christoph Dellago (U Vienna), Samuela Pasquali (IBPC & U Paris), Tamar Schlick (New York U)

Dates: February 21 – 24, 2017

Budget: ESI € 6 800,
CECAM € 12 336

Report on the workshop

Molecular modelling is the science of studying molecular structure and function through model building and computation. In the 1960s, the development of molecular mechanics force fields

with energy minimisation for refinement of crystal structures led to the development of molecular dynamics (MD) approaches now available in simulation packages such as NAMD, Desmond, or GROMACS. MD simulations have evolved from the first 1-microsecond simulation of a villin-headpiece in 1998 to the current simulations of much larger biomolecular systems (e.g., an entire satellite mosaic virus with one million atoms) as well as longer time frames (e.g. B-DNA dodecamer, ubiquitin, and beta2 AR protein receptor) for over 1 microsecond, and small proteins for 1 millisecond with specialised MD programs and dedicated supercomputers. For some proteins, fully atomistic folding simulations can be very successful, and similarly for nucleic acids both atomistic and coarse-grained ribosomes and long DNA minicircles and plasmids. At the same time, coarse-grained models and combinations of enhanced sampling methods are emerging as viable alternatives for simulating complex biomolecular systems. Various scale coarse-graining allowed to address fundamental questions in protein folding with applications to diseases, such as Alzheimer, RNA folding, DNA assemblies and topologies, protein-protein interactions, DNA chromatin structure and condensation, and many others. The quantitative accuracy reached by all the description levels allows for a flux of information from the atomistic detail up to complex simulations of cellular mechanisms done with event-driven algorithms, up to simulations of whole cells. In parallel, polymer physics, starting from the pioneering work of P.G. de Gennes, has been developing approaches to the study of complex polymer systems both on the size and time scales and o the complexity of the components.

Activities

Quoting the Nobel Prize for chemistry 2013 today the computer is just as important a tool for chemists as the test tube. Simulations are so realistic that they predict the outcome of traditional experiments (http://www.nobelprize.org). Such a statement might appear bold but it does describe the growing importance of computer modelling across modern Biochemical research. For instance, polymers are still a central material in the modern industrial production. The design and development of novel smart materials with environmental response or complex composite material could profit enormously from advanced large-scale computer simulations capable of scanning a wide spectrum of combinations faster and cheaper than what can be done with experiments. For medical applications, the field of drug design is in desperate need of a better understanding of protein-protein, protein-drug and protein-DNA/RNA interactions. The solution of the latter could open the way to a larger use of computational methods to speed up and to reduce the costs of the search for new drugs. All the topics above have been extensively discussed during the meeting and there was an opportunity to have a debate on the role of science in the development of sustainable technologies. From the program of the workshop, it is immediately clear that the topic is highly interdisciplinary and has a wide spectrum of social and industrial impacts.

During the workshop the speakers presented their work that attracted the interested of the audience as demonstrated by the extensive discussions that followed the talks. Moreover, there has been a considerable amount of interactions taking place during the coffee and lunch breaks that resulted in the initiation of several scientific collaborations.

During the meeting, several discussion occurred about funding options to support research collaboration within Europe (e.g. Horizon2020 and ETN network grants) and between Europe and USA. For the latter, we found that list option was rather limited and strongly variable from country to country. It became rapidly evident that it was necessary to formulate a strategy to fill such a gap. The funding necessary to keep alive a regular meeting on the subject was found as a crucial initial step to support the collaborations.

Specific information on the workshop

We had an unusually high number of participants (59) coming from all around the world. We were particularity proud of having attracted many young scientists among the speakers and the participants.

Outcomes and achievements

The workshop emphasised the need to continuously develop and integrate three components of simulations, namely model development, sampling algorithms, and infrastructural tools for trajectory simulation, analysis and visualisation.

Model building: This area comprises the development of models at different scales from atomistic to mesoscopic. The atomistic force fields for proteins appear to have reached a satisfactory level and are indeed used for long simulations of large systems, while nucleic acids force fields are still an active area of development, in particular for the study of systems departing from double helical DNA. Polarizable force fields are still under active development and are still too expensive computationally to be included in most simulations. A variety of coarse-grained models of different resolution has been developed for both proteins and nucleic acids, aiming at various purposes, from folding to rational design. One of the main difficulties in developing such models is the parametrization, which requires the integration of many different sources of data (for instance, thermodynamic, structural, and kinetic data). Still, these methods have proven their usefulness to overcome the sampling problems of atomistic simulations. Mesoscopic models are able to address the dynamics of proteins such as molecular motors as a whole, adopting a continuum description of the system, or study the properties of long stretches of DNA. They often integrate concepts and techniques from polymer physics as well as from the engineering of macroscopic systems. Winning strategies in model building are integrating different levels of description for the systems into multi-scale simulations.

Sampling: Simulations of large macromolecular objects require the use and further development of enhanced sampling techniques. When the initial and final states are known, path sampling and biased dynamics are efficient tools to study the transition and unveil transition pathways, kinetic barriers, and metastable states. Experimental information, when available, can also be integrated into some simulations, in particular by coarse-grained and mesoscopic models, where this is practically more feasible than in atomistic simulations. The advantage of simulations is their ability to generate a multitude of possible states for a given system. Simulations now focus on generating ensembles of conformations rather than on obtaining a single structural prediction.

Analysis tools: All the non-standard models and methods described above require a specific treatment of the data they generate. Most research groups develop their own trajectory descriptors, order parameters, topology and architecture descriptor. It would be useful to have a more wide communications on these tools (a web repository?) to share these tools with the community. New technologies open the way to innovative tools to analyse simulation data with the interplay between state-of-the-art visualisation tools (3D, virtual reality,...) and embedded analysis.

The participation at the meeting of scientists from the biomolecular and polymer simulation communities further expanded the discussion of the themes mentioned above. Within the biomolecular community, an important result of the meeting was to bring together scientists working on the modelling of both proteins and DNA/RNA. The development of hybrid protein/DNA models is an important future step that the biomolelcular simulation community is

investing considerable effort in achieving and was a central discussion point.

List of talks

Tamar Schlick	In Memoriam: Klaus Schulten
Gerhard Hummer	Modeling Membrane Sensing and Remodeling Dynamics
Angel Garcia	Free-energy landscape of a hyperstable RNA tetraloop
Samuela Pasquali	Predicting and Exploring Complex Nucleic Acids Architectures through a Coarse-Grained Model
Angelo Rosa	Chromosome organization and the Physics of crumpled polymers
Jonathan Doye	Large-scale DNA simulations with oxDNA
Doros Theodorou	Multiscale Molecular Simulations of Polymer-Matrix Nanocomposites
Barbara Capone	Multiscale Coarse Graining of Polymer Solutions
Pietro Faccioli	Self-Consistent Atomistic Calculation of Protein Folding Pathways
Raffaello Potestio	Multi-resolution modelling for biomolecular simulations
Cristian Micheletti	Pore translocation of knotted polymer chains: how friction depends on knot complexity
Karissa Sanbonmatsu	Simulating movement of the 30S head during translocation
Peter Bolhuis	Multiscale Simulations of Patchy Particle Systems Combining Molecular Dynamics, Path Sampling and Green's Function Reaction Dynamics
Dave Thirumalai	Understanding RNA folding
Marc Baaden	Large-scale Data Exploration and Analysis across Biomolecular Simulations
Bert de Groot	Challenges and opportunities in large scale alchemical free energy simulations
Wonpil Im	CHARMM-GUI Toward Large-Scale Biomolecular and Polymer Simulations
Gianluca Lattanzi	Challenges in computational biophysics: from membrane proteins to biosensors
Peter Freddolino	Modeling Protein-Nucleic Acid Interactions from Atomistic to Cellular Scales
Modesto Orozco	Advances and challenges in the simulation of DNA
Michele Vendruscolo	Structural basis for the different aggregation propensities of Abeta40 and Abeta42
Chris Oostenbrink	Reversible guest-host interactions from extensive simulations
Ron Elber	Electric Fields Across Heterogeneous Membranes
Ivan Coluzza	Artificial Chaperonins
Ewa Anna Oprzeska-Zingrebe	Interactions Between a Short DNA Oligonucleotide and Urea in the Light of Kirkwood-Buff Theory: a Molecular Dynamics Simulation Study
Martin Goethe	Prediction of Protein Configurational Entropy (Popcoen)
Lennart Nilsson	Codon Recognition on the Ribosome - Free Energy and QM/M Calculations
Helmut Grubmüller	Atomistic Simulation of Single Molecule Experiments: Molecular Machines and a Dynasome Perspective
Jeremy C. Smith	Proteins: Forever Aging
Simone Melchionna	Macromolecules and hydrodynamics: a simulation approach
Yassmine Chebaro	Role of intrinsically disordered regions in the nuclear receptors architecture
Sarah Harris	Multiscale Modelling of Biomolecules: From atomistic Molecular Dynamics to the continuum limit with Fluctuating Finite Element Analysis
Amir Lohrasebi	The influence of a 2450 MHz electric field on the microtubule mechanical properties: a multi scale modeling approach

Othmar Steinhauser	Protein in Reverse Micelles - The Dielectric Approach
Stefan Boresch	Playing the Devil's Advocate: Some Challenges with Respect to Large-scale Biomolecular Simulations

Invited scientists

Natasa Adzić, Marc Baaden, Valentino Bianco, Peter Bolhuis, Stefan Boresch, Paolo Callgari, Barbara Capone, Chiara Cardelli, Yassmine Chebaro, Ivan Coluzza, Bert De Groot, Elisa De Llano, Christoph Dellago, Nadiv Dharan, Jonathan Doye, Ron Elber, Pietro Faccioli, Peter Freddolino, Elisa Frezza, Angel Garcia, Arthur Garon, Martin Goethe, Stefan Güssregen, Helmut Grubmüller, Sarah Harris, Gerhard Hummer, Wonpil Im, Tadija Kerić, Serdal Kirmizialtin, Katarzyna Kulczycka-Mierzejewska, Ansuman Lahiri, Gianluca Lattanzi, Emanuele Locatelli, Amir Lohrasebi, Simone Melchionna, Cristian Micheletti, Halima Mouhib, Francesca Nerattini, Lennart Nilsson, Chris Oostenbrink, Ewa Anna Oprzeska-Zingrebe, Modesto Orozco, Samuela Pasquali, Stefano Piotto, Raffaello Potestio, Angelo Rosa, Joseph Rudzinski, Karissa Y. Sanbonmatsu, Tamar Schlick, Jeremy C. Smith, Othmar Steinhauser, Doros Theodorou, Dave Thirumalai, Luca Tubiana, Michele Vendruscolo, Jürgen Walther, Pauline Walton, Marcus Wieder, Olav Zimmermann.

Elliptic Hypergeometric Functions in Combinatorics, Integrable Systems and Physics

Organizers: Christian Krattenthaler (U Vienna), Michael J. Schlosser (U Vienna), Masatoshi Noumi (Kobe U), Simon Ruijsenaars (U Leeds), Vyacheslav P. Spiridonov (JINR, Dubna and NRU HSE, Moscow), S. Ole Warnaar (U Queensland)

Dates: March 20 – 24, 2017

Budget: ESI € 17 360,
FWF € 5 000

Report on the workshop

Elliptic hypergeometric functions are a relatively new class of special functions which first appeared 30 years ago implicitly as "elliptic $6j$-symbols" in the work on the Yang–Baxter equation by E. Date, M. Jimbo, A. Kuniba, T. Miwa, and M. Okado. Since then, they have been shown to be related to various areas of mathematics, including integrable systems, combinatorics and mathematical physics. This workshop brought together leading experts on elliptic hypergeometric functions from different areas. The presentations and discussions focused around the following five topics:

- Elliptic integrable systems and elliptic Painlevé equations
- Univariate and multivariate elliptic hypergeometric series and biorthogonal functions
- Elliptic determinants and theta functions on root systems
- Combinatorics of elliptic hypergeometric functions
- Elliptic hypergeometric integrals in quantum field theory

Activities

The full schedule of the workshop is available at workshop's home page:
`http://www.mat.univie.ac.at/~schlosse/esi/EHF2017/`

The program consisted of 5 introductory lectures, 9 plenary lectures, 13 regular invited lectures and a poster session (with 9 contributed posters). The presentations were held each day in the week (March 20 – 24, 2017), mornings and afternoons, with the exception of Wednesday afternoon which was held free for discussion and colloquia talks (one by Andrei Okounkov) in the Department of Mathematics of the University of Vienna.

The following introductory lectures were given on the first three mornings, aimed at a general audience:

- Fokko van de Bult, *Hypergeometric functions and integrals*
- Masatoshi Noumi, *Discrete Painlevé equations and special functions*
- Simon Ruijsenaars, *Quantum integrable systems of elliptic Calogero–Moser type*
- Michael J. Schlosser, *Elliptic hypergeometric combinatorics*
- Vyacheslav P. Spiridonov, *Applications of the elliptic hypergeometric integrals*

Specific information on the workshop

There was an excellent group of junior researchers (including Youssef Abdelaziz, Kayed Al-Quasemi, Farrokh Atai, Frederic Brünner, Tamas Görbe, Linnea Hietala, Alexander Kalmynin, Yakov Kononov, Katarina Kukić, Jules Lamers, Nobutaka Nakazono, Manjil Saikia, Takao Suzuki) present at the Workshop, thanks to the support from ESI and (to a smaller extent) to funds from FWF. Altogether there were 57 participants, the full list can be found at the workshop website.

The introductory lectures by Fokko van de Bult, Masatoshi Noumi, Simon Ruijsenaars, Michael Schlosser, and Vyacheslav Spiridonov, and also the special plenary talk by Andrei Okounkov were appreciated by the regular participants and a large number of people from outside the workshop. There was also a session on open problems and general discussion which concluded the workshop, but, nevertheless, was involving the majority of the participants and contained quite interesting conversations around a few topics which were not sufficiently well presented in the main program.

Outcomes and achievements

The organizers received very positive feedback from the participants on the extent of collaborative activity initiated by those being present at the meeting. Overall the workshop met its goals, in particular, by bringing people (from at least 17 countries) working on Elliptic Hypergeometric Functions from different perspectives together and stimulating interaction between them. Young and senior researchers were able to exchange ideas. Groups formed around particular interests such as supersymmetric indices in conformal field theory (Gahramanov, Kim, Razamat, Spiridonov, Yagi), elliptic integrable models (Chicherin, Gahramanov, Noumi, Ruijsenaars, Spiridonov, Stokman, Takemura, Yagi, Zotov), elliptic hypergeometric identities (Bhatnagar,

van de Bult, Ito, Kels, Rosengren, Schlosser, Warnaar) or elliptic difference systems (Noumi, Okounkov, Rains, Takemura, Yamada) which stimulated various ongoing collaborations. New research projects were launched (e.g., inspired by the talks by Kim on $5d$ theories and Spiridonov's discussion of the elliptic Fourier transformation; or collaboration between Katori and Schlosser on elliptic probability; also the work by Nieri et al. on further development of the elliptic conformal field theory got stimulated, etc.). There was also considerable interaction between the different specialities represented at the workshop. In particular, the poster session brought many people together, and especially younger researchers could present their work in an easy informal manner. The multidisciplinary nature of the workshop allowed a fruitful interchange of results between physicists and mathematicians, which were not known to different members of the community before the meeting.

Slides from many of the talks and posters are available at:

`http://www.mat.univie.ac.at/~schlosse/esi/EHF2017/schedule.html`.

Thus, the workshop content is available to the general mathematics and physics community. There is also feedback from people who were not able to come to the conference; they were quite interested in getting the materials in the form of slides. Shortly after the Workshop, A. Kalmynin and V. Spiridonov gave a special long seminar talk at the Department of Mathematics of the Higher School of Economics (Moscow) to describe the workshop content and outline the most interesting new results.

We believe that this Workshop will benefit the scientific community not only short-term, but also in the long run. We expect sufficiently many papers to be published in the next following years on various topics of the Workshop which were partially (or completely) influenced by this Workshop.

List of talks

Fokko van de Bult	**Introductory Talk 1:** Hypergeometric functions and integrals
Vyacheslav P. Spiridonov	**Introductory Talk 2:** Applications of the elliptic hypergeometric integrals
Sergey Derkachov	Spin chains and Gustafson's integrals
Dmitri Chicherin	Elliptic solutions of the Yang–Baxter equation
S. Ole Warnaar	Known and unknown conjectures from the theory of elliptic hypergeometric functions
Junichi Shiraishi	Some conjectures about the Macdonald polynomials of type C
Masatoshi Noumi	**Introductory Talk 3:** Discrete Painlevé equations and special functions
Michael J. Schlosser	**Introductory Talk 4:** Elliptic hypergeometric combinatorics
Meesue Yoo	Elliptic rook and file numbers
Hjalmar Rosengren	Basic hypergeometry and biorthogonal functions related to supersymmetric dualities
Makoto Katori	Elliptic Dyson models
Simon Ruijsenaars	**Introductory Talk 5:** Quantum integrable systems of elliptic Calogero–Moser type
Andrei Okounkov	Elliptic stable envelopes
Wadim Zudilin	Elliptic dilogarithm and Mahler measures
Eric M. Rains	The monodromy of an elliptic difference equation
Hitoshi Konno	Elliptic weight functions and finite dimensional representations of elliptic quantum groups
Simon Ruijsenaars	Hilbert–Schmidt integral operators vs. systems of elliptic Calogero–Moser type
Kouichi Takemura	Degenerations of Ruijsenaars–van Diejen operator, q-Painlevé equations and q-Heun equations
Jasper Stokman	Elliptic integrable structures arising from harmonic analysis on affine symmetric spaces

Masahiko Ito	A determinant formula associated with the elliptic hypergeometric integrals of type BC_n
Yi Sun	Affine Macdonald conjectures and special values of Felder–Varchenko functions
Takashi Takebe	Q-operators for higher spin eight vertex models
Shlomo S. Razamat	$\mathcal{N} = 1$ SCFTs, dualities, and integrable models
Junya Yagi	String theory and integrable lattice models
Yashiko Yamada	q-Garnier system and its autonomous limit
Andrei Zotov	Quantum and classical counterparts of quantum-classical correspondence in integrable systems
Hee-Cheol Kim	Duality domain walls in 5d supersymmetric gauge theories
Ilmar Gahramanov	Integrable lattice spin models from supersymmetric gauge theories

Publications and preprints contributed

H. Baba, M. Katori, *Excursion Processes Associated with Elliptic Combinatorics*, arXiv:1711.00389v1 [math-ph].

G. Bhatnagar, M. J. Schlosser, *Elliptic well-poised Bailey transforms and lemmas on root systems*, arXiv:1704.00020 [math.CA].

M. Katori, *Elliptic Determinantal Processes and Elliptic Dyson Models*, arXiv:1703.03914v2 [math.PR].

A. P. Kels, M. Yamazaki, *Elliptic hypergeometric sum/integral transformations and supersymmetric lens index*, arXiv:1704.03159 [math-ph].

P. Jefferson, H.-C. Kim, C. Vafa, G. Zafir, *Towards classification of 5d SCFTs: Single gauge node*, arXiv:1704.00020 [math.CA].

N. Joshi, N. Nakazono, *Elliptic Painlevé equations from next-nearest-neighbor translations on the* $E_8^{(1)}$ *lattice*, arXiv:1703.03498 [math-ph].

A. Zabrodin, A. Zotov, *Self-dual form of Ruijsenaars-Schneider models and ILW equation with discrete Laplacian*, arXiv:1711.01036 [math-ph].

Invited scientists

Youssef Abdelaziz, Kayed Al-Qasemi, Farrokh Atai, Gaurav Bhatnagar, Frederic Brünner, Dmitri Chicherin, Sergey Derkachov, Omar Foda, Ilmar Gahramanov, Wellington Galleas, Tamas F. Görbe, Harald Grosse, Martin Hallnäs, Linnea Hietala, Masahiko Ito, Alexander Kalmynin, Makoto Katori, Andrew Kels, Hee-Cheol Kim, Hitoshi Konno, Iakov Kononov, Tom Koornwinder, Peter Koroteev, Christian Krattenthaler, Katarina Kukić, Jules Lamers, Edwin Langmann, David Masser, Anton Mellit, Nobutaka Nakazono, Fabrizio Nieri, Masatoshi Noumi, Soichi Okada, Andrei Okounkov, Eric M. Rains, Shlomo Sergei Razamat, Hjalmar Rosengren, Simon Ruijsenaars, Manjil Saikia, Michael J. Schlosser, Koushik Senapati, Juníchi Shiraishi, Vyacheslav P. Spiridonov, Jasper Stokman, Yi Sun, Takao Suzuki, Takashi Takebe, Kouichi Takemura, Tomoyuki Takenawa, Fokko van de Bult, S. Ole Warnaar, Timm Wrase, Junya Yagi, Yashiko Yamada, Meesue Yoo, Andrei Zotov, Wadim Zudilin.

Thirring-Symposium

Organizers: Piotr Chruściel, Christoph Dellago, Stefan Fredenhagen, Harald Grosse, André H. Hoang, Heide Narnhofer, Wolfgang Reiter and Jakob Yngvason (all: U Vienna)

Dates: April 29, 2017

Budget: The event was organized with the support of the Erwin Schrödinger International Institute for Mathematics and Physics of the University of Vienna, the Association "Erwin Schrödinger International Institute for Mathematical Physics" and the Faculty of Physics of the University of Vienna.

Report on the symposium

Walter Thirring (April 29, 1927 – August 18, 2014) was one of Austria's most distinguished physicists during his long professional career. He made seminal contributions to many areas of physics and was a pioneer of modern mathematical physics. He was the founding president and first director of the Erwin Schrödinger Institute for Mathematical Physics. On the occasion of his 90th birthday a symposium was held at ESI dedicated to his memory and scientific legacy. The symposium was organized jointly by the research center ESI, the ESI Association, and the Faculty of Physics of the University of Vienna.

Activities

The symposium started with a welcome address by the director of ESI, Christoph Dellago, who in particular emphasised Thirring's decisive role in the creation of the institute. It was followed by an introduction to Thirring's biography and scientific achievements, presented by Jakob Yngvason. He drew attention to Thirring's *Selected papers*, published by the American Mathematical Society in 1998 with commentaries by the author himself, as well as the autobiographical works *Die Lust am Forschen* and *Kosmische Impressionen* which are valuable sources on further aspects of Thirring's rich intellectual life.

The scientific programme consisted of five lectures, two in the morning and three in the afternoon.

The lecture of Otto Nachtmann, a former PhD student of Thirring, gave an overview of important contributions of Thirring to high energy physics, including quantum electrodynamics, dispersion relations and the quark model.

Quantum many-body physics was one of the focal points of Thirring's work and Jan Philip Solovej reported in his lecture on a rigorous approch to the Bogoliubov approximation for Bosonic systems via a variational principle for quasi free states.

Erling Størmer talked about positive maps and separable states on operator algebras, a topic with relations to Thirring's interest in quantum information theory.

In 1958 Thirring introduced a model for an integrable quantum field theory that bears his name. It has inspired much work on integrable models ever since and Jörg Teschner presented a survey of this research area.

Helmuth Urbantke reviewed Thirring's contributions to classical and relativistic gravitation. In particular he discussed Thirring's work on stellar equilibrium and negative specific heat of gravitating bodies as well as his alternative approach to General Relativity.

The scientific program was followed by a reception during which former friends and colleagues of Walter Thirring as well as members of his family shared their memories of him. The contributors were Peter Aichelburg, Bernhard Baumgartner, Harald Posch, Peter Thirring, and via video recording Stanley Deser and Harald Grosse.

List of talks

Christoph Dellago, Vienna	Welcome
Jakob Yngvason, Vienna	Introduction
Otto Nachtmann, Heidelberg	From QED to the Quark Model: some highlights of Walter Thirring's contributions to particle physics
Jan Philip Solovej, Copenhagen	On the variational approach to the Bogoliubov approximation for Bose gases
Erling Størmer, Oslo	Mapping cones of positive maps and separable states
Jörg Teschner, Hamburg	The uses of integrability
Helmuth Urbandtke, Vienna	Thirring and Gravitation

A video recording of the talks can be found on the website `http://phaidra.univie.ac.at/o:560341`.

Summer School on "Between Geometry and Relativity"

Organizers: Robert Beig (U Vienna), Piotr T. Chruściel (U Vienna), Michael Eichmair (U Vienna), Gregory Galloway (U Miami), Richard Schoen (UC Irvine), local organization: Tim-Torben Paetz (U Vienna)

Dates: July 17 – 21, 2017

Report on the school

The school was addressed to those junior researchers in mathematics and theoretical physics who are interested in mathematical general relativity. The aim of the school was to introduce them to the main topics of current research, and to deepen their knowledge of the field.

The 104 participants of the Summer School were a mixture of postdocs and PhD students, with the audience further including some advanced Master Students and academics. In addition, several participants of the research programme "Geometry and Relativity", as well as academics from the Faculties of Mathematics and Physics of the University of Vienna and the Technical University of Vienna, attended some lectures in the school; they are not counted above.

The official school participants were chosen from a poll of 133 applications on a dedicated website. Participants stemmed from all continents. We were very pleased to have 19 female participants in the audience.

Due to the large number of participants, the lectures were moved from the ESI Lecture Hall to the Lise Meitner Lecture Hall at the Faculty of Physics of University of Vienna.

All lectures have been videotaped, and are being made publicly available as editing progresses. Eichmair, Gillessen and Schoen have asked to limit access to the videos of their lectures to participants of the school (access by password for about six months) and to members of Vienna University (access by IP numbers, no time limit). All remaining lectures will be openly accessibly to everyone at the website: `http://phaidra.univie.ac.at/o:560318`

A website for the school: `http://www.univie.ac.at/AGESI_2017/school/index.html`

was set up to facilitate the exchange of information with the participants. It remains accessible and contains further information about the school, with links to the videos added as the videos are being finalised.

A poster session was organised during the school, with about 20 posters displayed. This allowed the students to present their research to their fellow participants, lecturers, as well as participants of the ESI research programme on the same topics.

A social meeting was organised on Wednesday evening, in the middle of the school, in a typical Viennese vineyard restaurant ("Heuriger"), to stimulate interaction between students, as well as between students and lecturers.

The school was particularly timely because of the milestone paper by Richard Schoen and Shing-Tung Yau, released in April 2017, which proves positivity of the total energy of asymptotically flat scalar-positive manifolds in any dimension, generalising a result proved several years ago by the same authors in dimension three, and shortly thereafter in dimensions up to seven by Schoen. In view of this paper we adjusted the program, replacing the initially planned four hours of introductory lectures by Schoen by two lectures of Lan-Hsuan Huang and two lectures by Michael Eichmair, and adding six lectures by Schoen presenting the new proof.

The lectures

Despite the necessary variations in the amount of detail between and sometimes within lectures, the speakers succeeded in giving the audience a firm background for reading the original literature (to which the lecturers themselves are important contributors), and for further research, as well as presenting the state of the art of their topics in their last lectures.

A questionnaire was made available online to receive feedback from the students. The responses were mainly positive, with many enthusiastic. One of the main intentions to organize a summer school is to increase interest in the topics covered, and to provide a solid and beneficial introduction for the participants. As the survey shows this has been very successfully accomplished.

Hans Ringström, who was initially supposed to lecture on the general relativistic evolution problem, cancelled attendance for personal reasons, and his initially-planned four lectures were replaced by three lectures on the same topic by David Fajman.

During the school, the following lectures were given:

Marie-Anne Bizouard (Orsay, 2 lectures) "Making waves"

Abstract: The observation of the merger of a binary black hole system from LIGO in September 2015 has opened up a new window onto the Universe. Thanks to gravitational waves emitted by massive compact objects or cataclysmic events, one can observe the Universe with a probe that is barely affected by matter. Gravitational waves provide also a unique means to test the consistency in the general relativity in the strong field regime. In my lectures I will review the state of the art of gravitational wave searches from ground based detectors, space missions, and pulsar timing arrays. In addition, I will explain the different challenges of such searches and show (with many examples) the richness of the newly emerged field of gravitational wave astronomy.

Justin Corvino (Lafayette, 4 lectures) "Constructing initial data for the Einstein equations"

Abstract: Initial data sets for the Einstein equation must satisfy a nonlinear elliptic system, the Einstein constraint equations. We formulate the constraint equations in the context of initial data sets, and develop methods to produce solutions of these equations. In particular, we will discuss interesting solutions which can be constructed by gluing techniques. Such techniques can be used for connecting multiple initial data sets, or for understanding the asymptotic struc-

ture of isolated systems.

Michael Eichmair (Vienna, 2 lectures) "Positive energy theorems"

Abstract: In this lecture, we explore a fundamental observation of R. Schoen and S.-T. Yau which, together with the ideas from the lecture of Lan-Hsuan Huang, leads to a proof of the positive mass theorem in dimension three (in fact in all low dimensions): A Riemannian three-manifold with positive scalar curvature does not admit an area-minimizing torus.

David Fajman (Vienna, 3 lectures) "Dynamics of general relativity"

Abstract: The lectures discuss dynamical properties of solutions to the Einstein equations: On a suitable foliation of spacetime the Einstein equations take the form of a geometric flow: a system of hyperbolic PDEs that describes the evolution of a metric and a second fundamental form on a given 3-manifold. We outline one particular approach to resolve the local-existence problem for this geometric flow and apply this to study the global existence problem and stability of some cosmological spacetimes. Eventually, we give an overview on major results and open problems in this area.

Greg Galloway (Miami, 4 lectures) "Topology and general relativity"

Abstract: An initial data set in spacetime consists of a spacelike hypersurface V, together with its induced (Riemannian) metric h and its second fundamental form K. A solution to the Einstein equations influences the curvature of V via the Einstein constraint equations, the geometric origin of which are the Gauss-Codazzi equations. After a brief introduction to Lorentzian manifolds and Lorentzian causality, we will study some topics of recent interest related to the geometry and topology of initial data sets. In particular, we will consider the topology of black holes in higher dimensional gravity, inspired by certain developments in string theory and issues related to black hole uniqueness. We shall also discuss recent work on the geometry and topology of the region of space exterior to all black holes, which is closely connected to the notion of topological censorship. Many of the results to be discussed rely on the recently developed theory of marginally outer trapped surfaces, which are natural spacetime analogues of minimal surfaces in Riemannian geometry.

Stefan Gillessen (MPI Garching, 2 lectures) "The black heart of our galaxy"

Abstract: I will review the existing evidence for the existence of a black hole in the centre of our galaxy, and discuss the associated theoretical and observational challenges.

Lan-Hsuan Huang (Connecticut, 2 lectures) "Positive energy theorems"

Abstract: We will discuss the analytic background for the positive mass theorem on the scalar curvature deformation. Using those deformation results, one can reduce the general case of the positive mass theorem to the special case of initial data sets that have harmonic asymptotics or can be further compactified. The equality case of the positive mass theorem will be also discussed.

Richard Schoen (Irvine, 6 lectures) "Positive energy theorems"

Abstract: We will introduce positive energy/mass problems in general relativity and discuss methods for solving some of them. The methods will involve minimal hypersurfaces and marginally outer trapped surfaces and require an understanding of existence problems as well as the second variation and stability notions for these hypersurfaces. We will also introduce Penrose inequalities which give stronger versions of positive energy theorems for black hole spacetimes. We will describe the flow approaches which have been developed to prove the Riemannian Penrose inequality.

The budget

The school has been made possible by the financial support of several Institutions. We are very grateful to all our sponsors.

Income:

American Institute of Physics: € 914 ($ 1000)
International Association of Mathematical Physics: € 2 000
Erwin Schrödinger Institute: € 11 152
European Mathematical Society: € 3 000
National Science Foundation, leftover from travel grants: € 474 ($ 569)
University of Vienna through the Gravitational Physics group: € 257
University of Vienna through a grant to Michael Eichmair (Berufung): € 322
University of Vienna through Vienna Doctoral Schools: € 1 903

Total income: € 20 022

National Science Foundation (travel grants for US students, administered directly by Lafayette College, PA; funding for 2 postdocs, 1 just finished PhD/starting postdoc, 12 graduate students): **$ 22 490**

Expenses:

Support to participants (per diems to cover living and housing expenses in Vienna, € 300 /supported student): € 11 580
Morning breaks of the school: € 2 654
Travel costs + per diem speakers summer School: € 2 398
Afternoon breaks of the school: € 2 058
Contribution to social meetings with lecturers and participants: € 541
Mineral water, orange juice during breaks: € 484
Posters advertising the school: € 307

Total expenses: € 20 022 + NSF $ 22 490

Invited scientists

Aghil Alaee Khangha, Philippe Allard Guérin, Adam Almakroudi, Bernardo Araneda, Nikolaos Athanasiou, Rodrigo Avalos, Ana Lucia Baez Camargo Aguibr, Irena Barjasic, Hamed Barzegar, Robert Benkel, Flavio Bombacigno, Stefano Borghini, Joseph Raphael Bunao, Madeleine Burkhart, Armando Carbera Pacheco, Lissa Campos, Giovanni Canepa, Matteo Capoferri, Jorge Cardona, Diego Antonio Carranza Ortiz, Saikat Chakraborty, Federico Di Gioia, Alberto Isaac Diaz Saldana, Leon Dario Escobar Diaz, Axel Fehrenbach, Filip Ficek, Simon-Raphael Fischer, Ales Flandera, Mattia Fogagnolo, Alexander Friedrich, Christopher Gallagher, Edgar Gasperin Garcia, Penelope Gehring, Elena Giorgi, Jonathan Glöckle, Melanie Graf, Olivier Graf, Luka Gulin, Brian Harvie, Jahanur Hoque, Albert Huber, Igor Itkin, Sophia Jahns, Hyun Chul Jang, Pavel Jefremov, Florian Johne, Christophf Kehle, Kamran Khan, Eliska Klozová, Jerzy Knopik, Jan Kohlrus, Ivan Kolar, Frederic Lamy, Jae Min Lee, Carmen Ka ki Li, Chao Liu, Tyson Loudon, David Lundberg, Siyuan Ma, Colin MacLaurin, Mattia Manfredonia, Daniel Martin, Stephen McCormick, Pierre Mourier, Ahmad Pundeer Naeem, Anna Nakoniecna, Lukasz Nakonieczny, Jóse Eduardo Nunez Ortíz, Andrea Ottolini, Michal Pirog, Annachiara Piubella, Alessia Platania, Aaron Poole, Leonel Quinta Queimada, Jillur Rahman, Nikita Reichelt, Tomas Reis,

Justin Ripley, Henri Roesch, Mieszko Rutkowski, Romain Ruzziconi, Rohit Sachdev, Pedro Sanchez, Yafet Sanchez Sanchez, Jessica Santiago Silva, Oliver Schn, Sebastian Schuster, Julian Seipel, Katarzyna Senger, James Siene, Tomasz Smolka, Aleksandra Sroda, Vinzenz Stampf, Rita Barrocas Dias Teixeira da Costa, Philip Thonke, Tin Yau Tsang, Rashmi Uniyal, Maria Caterina Valcu, Adriano Vigano, Piotr Waluk, Jarrod Lewis Williams, Vojtech Witzany, David Wiygul, Markus Wolff.

Chruściel-Fest: A panorama of GR

Organizers: Robert Beig (U Vienna), Tim-Torben Paetz (U Vienna)

Dates: August 17 – 18, 2017

Report on the symposium

Piotr Chruściel - on the occasion of his sixtieth birthday

Piotr T. Chruściel received a PhD in Physics at the Institute for Theoretical Physics of the Polish Academy of Sciences in Warsaw in the year 1986. He has held professorships at the Department of Mathematics of the University of Tours and at the Mathematical Institute of the University of Oxford. Since 2010 he is Professor of Gravitational Physics at the University of Vienna. He has held fellowships and visiting positions at prestigious institutions too numerous to being mentioned here. He is a Life Member of Clare Hall, Cambridge, an elected Western Europe representative of the International Committee on General Relativity and Gravitation and a member of the Polish Academy of Sciences. He has served and still serves on several international boards including the editorial board of the journal Communications in Mathematical Physics. Important for ESI, he has been a member of the ESI Scientific Governing Board between 2011 and 2016. He has organized and continues to organize numerous international workshops and conferences including several at ESI. He is founder of the Central European Seminar on Mathematical Relativity, held each year since 2011, with the purpose of giving a platform in particular to young researchers in the field.

The subject of Mathematical Relativity rests on techniques from fields as diverse as Riemannian and Lorentzian Geometry and, on the analysis side, Elliptic and Hyperbolic Partial Differential Equations. Piotr being a master in all these methods, has been able to contribute to an amazing variety of topics and problems in the field, which we can mention here only in a sweeping fashion: the asymptotics of the gravitational field, including positive-energy theorems, the initial value problem, in particular long-time evolution and aspects of cosmic censorship, the characteristic Cauchy problem, the theory of black holes, causality theory, the study of the constraint equations of General Relativity. Needless to say, this is essentially a summary of the area of Mathematical Relativity. It is no exaggeration that, in his combination of profoundness and breadth, Piotr Chruściel is unique in the whole field of Mathematical Relativity. In light of his unchanging energy in the past, we expect many more important results from him in years to come.

This symposium

was held on the occasion of the sixtieth birthday of Professor Piotr T. Chruściel. It brought together several of Piotr's collaborators, who were either present at ESI as participants of the then ongoing workshop on Geometry and Relativity or came for the occasion. Their talks dealt

with some of the many areas of Mathematical Relativity to which Chruściel has contributed, in particular: Global Lorentzian Geometry, Asymptotics of the Gravitational Field, the theory of singularities in GR and Black Hole theory. The symposium was opened with a welcome address by the director of ESI, Christoph Dellago, and the Vice-Dean of the Faculty of Physics, Philip Walther. Robert Beig gave an introduction about the work of Piotr Chruściel. There were plenty of discussions among speakers and the audience. The reception at the end of the first day was sponsored by the Faculty of Physics, which is gratefully acknowledged.

List of talks

Jim Isenberg	Complementing Piotr: On Neckpinch Singularities in Ricci Flow and in Mean Curvature Flow
Greg Galloway	Some results on the C^0 (in)extendibility of spacetime
Helmut Friedrich	Peeling or not peeling – is that the question?
Hans Ringström	Linear systems of wave equations on cosmological backgrounds with convergent asymptotics
Vince Moncrief	A positive definite energy functional for the axisymmetric perturbations of Kerr-Newman BHs
Paul Tod	Black hole uniqueness and non-inheriting Einstein-Maxwell solutions

Systematic Approaches to Deep Learning Methods for Audio

Organizers: Monika Dörfler (NUHAG, U Vienna), Arthur Flexer (OFAI, Vienna)

Dates: September 11 – 15, 2017

Budget: ESI € 10 000

Report on the workshop

Activities

As planned, the workshop took place from Monday, September 11th, 8.30 to Friday, September 15th, early afternoon. We had five talks per day on average (precise program see below) and each day was closed by a discussion session, which we termed ”wrap-up”. The talks of the workshops were organized around the five topics

- mathematical understanding of deep learning
- introspection in deep learning
- end-to-end learning in MIR
- signal representations in deep learners vs. adaptive signal transforms
- scattering transforms and signal representations in deep learners

as indicated in the proposal. For each day, two scientists were invited to guide the ”wrap-up” discussion session at the end of the day. An important aspect of these closing sessions was the fact, that we always chose one colleague with a more mathematical and one with

a more deep learning background. These sessions therefore were very successful and led to lively interactions even between guests coming from different fields (mathematics, computer science, music information retrieval, machine learning), which had been the initial motivation for introducing these more formal discussions.

Specific information on the workshop

In this workshop, we were able to give particularly many PhD students a chance to present their work, namely:

- Roswitha Bammer, University of Vienna, Austria
- Stefan Balke, Audiolabs Erlangen. Germany
- Matthias Dorfer, Johannes Kepler University, Linz, Austria
- Hendrik Vincent Koops, Utrecht University, The Netherlands
- Jan Schlüter, OFAI, Vienna, Austria
- Olga Slizovskaia, University Pompeu Fabra, Barcelona, Spain
- Karen Ullrich, University of Amsterdam, The Netherlands
- Pavol Harar, Brno University of Technology, Czech Republic
- Mishra Saumitra, Queen Mary University London, United Kingdom

Furthermore, many Post-docs presented their work as well. This reflects the fact that deep learning in general and theories for deep learning in music actually is a rather new field which thus gives the chance to younger researchers to develop their own profile. Our workshop has contributed to giving these young researchers a chance to promote their career both by gaining visibility and setting up collaborations with colleagues from the field, be it more experienced ones or other Pre- and Postdocs.

Outcomes and achievements

The method of deep learning has gained tremendous interest due to recent impressive successes in areas such as image processing, speech recognition and artificial intelligence/human-machine interaction, making deep learners the most prospering artificial intelligence method at the moment. Given the impressive success of deep learning, there is, however, surprisingly little systematic knowledge and formal understanding of its principles of operation. It is our conviction, that the ESI workshop helped to advance the formulation of mathematical theory explaining the achievements of deep learning. It became clearer, that indeed recently developed methods from applied harmonic analysis are able to address and explain aspects of the structure of deep learning algorithms. There seemed to be a consensus among the assembled scientists from both applied mathematics and computer science, that this will help the advancement of a systematic formal understanding of the underlying structures and principles of deep learning.

The ESI workshop also attracted the interest of both music and general machine learning industry partners, with three representatives giving talks and participating for the whole week: Simon Durand (Spotify Limited, London, United Kingdom), Sander Dielemann (Google DeepMind,

London, United Kingdom) and Oriol Nieto (Pandora, USA). Since such a direct exchange of ideas between mathematics and industry is rather the exception than the rule, it can be seen as an additional achievmenet of the ESI workshop that such a discourse has been made possible.

As a concrete outcome of the ESI workshop, it was decided during the last "wrap-up" session that an overview article will be written jointly by several participants. This overview article will reflect both the state-of-the-art, which was presented at the workshop, and give an outlook on the current and future work, partially fuelled by the discussions during the workshop.

List of talks

Jan Schlüter	Deep learning as an engineer: The nuts and bolts and dirty tricks
Philipp Grohs	Deep learning as a mathematician: Conjectures, proofs and open questions
Fabio Anselmi	Invariant and selective and representations with applications to Deep learning
Emmanuel Vincent	When mismatched training data outperform matched data
Irene Waldspurger	Inversion of the wavelet transform modulus
Joakim Andén	Joint Time-Frequency Scattering Networks
Vincent Lostanlen	The spiral and the snowball: deeper enhancements to time-frequency scattering
Roswitha Bammer	Invariance and Stability of Gabor Scattering for Music Signals
Antoine Deleforge	Reversed Mixture-of-Experts Networks for High- to Low-Dimensional Mapping
Simon Durand	Automatic downbeat tracking of music audio signals
Stefan Balke	Literature Review: Deep Neural Networks in MIR
Pavol Harar	Voice Pathology Detection Using Deep Learning: a Preliminary Study
Aggelos Gkiokas	Causal Time Series Processing with Convolutional Neural Networks. An application to Real Time Beat Tracking
Karen Ullrich	Bayesian Neural Networks: Techniques and Applications
Andre Holzapfel	Bayesian meter tracking on learned signal representations
Guido Montufar	Exponential advantages of deep and distributed representations
Grégoire Montavon	Explaining the Predictions of Deep Neural Networks
Hendrik Vincent Koops	Learning Shared Chord Representations for Annotator Subjectivity
Sebastian Stober	Automatic Speech Recognition (on a Budget) - Transfer Learning and Introspection
Olga Slizovskaia	Correspondence between audio and visual deep models for musical instrument detection in video recordings
Mishra Saumitra	Interpretable machine learning for music content analysis
Matthias Dorfer	Learning Correspondences between Audio and Sheet-Music Images
Oriol Nieto	Cold-Start Music Recommendation Using Multimodal Deep Architectures
Sander Dielemann	Deep learning for music recommendation and generation

Publications and preprints contributed

M. Dörfler, T. Grill, R. Bammer, A. Flexer, *Basic Filters for Convolutional Neural Networks Applied to Music: Training or Design?*, arXiv: 11709.02291 [cs.LG].

P. Harar, Z. Galaz, J. B. Alonso-Hernandez, J. Mekyska, R. Burget, Z. Smekal, *Towards Robust Voice Pathology Detection*, Neural Comput & Applic (2018), https://doi.org/10.1007/s00521-018-3464-7.

A. Seigal, G. Montufar, *Mixtures and Products in two Graphical Models*, arXiv: 1709.05276 [stat.ML].

Invited scientists

Joakim Andén, Fabio Anselmi, Stefan Balke, Roswitha Bammer, Sebastian Böck, Carlos Cancino Chacon, Antoine Deleforge, Sander Dielemann, Matthias Dorfer, Monika Dörfler, Simon Durand, Roman

Feldbauer, Arthur Flexer, Zoltan Galaz, Michael Gastegger, Aggelos Gkiokas, Thomas Grill, Philipp Grohs, Pavol Harar, Nicki Holighaus, Andre Holzapfel, Ananid Jalali, Gaspard Jankowiak, Hendrik Vincent Koops, Vincent Lostanlen, Andres Marafioti, Saumitra Mishra, Ondrey Mokry, Guido F Montufar, Grégoire Montavon, Oriol Nieto, Dietmar Schabus, Alexander Schindler, Jan Schlüter, Olga Slizovskaia, Sebastian Stober, Martin Trapp, Karen Ullrich, Emmanuel Vincent, Irene Waldspurger, Christoph Wiesmeyr, Pavel Zaviska.

Nonlinear Water Waves - an Interdisciplinary Interface

Organizers: David Henry (U College Cork), Konstantinos Kalimeris (Cambridge U), Emilian Părău (U of East Anglia), Jean-Marc Vanden-Broeck (U College London), Erik Wahlén (Lund U)

Dates: November 27 – December 7, 2017

Budget: ESI € 19 520,
€ 2 000 Science Foundation Ireland

Report on the workshop

The motion of water is governed by a set of mathematical equations which are highly complicated and intractable, which is not surprising when one considers the highly diverse and intricate physical phenomena which may be exhibited by a given body of water. However, recent mathematical advances have enabled researchers to make major progress in this field, as reflected by the topics we feature in the workshop themes outlined below. Cutting-edge techniques and tools from mathematical analysis have generated strong rigorous results concerning the qualitative and quantitative physical properties of solutions of the governing equations. Furthermore, accurate numerical computations of fully-nonlinear steady and unsteady water waves in two and three dimensions have contributed to the discovery of new types of waves. Model equations have been derived in the long-wave and modulational regime using Hamiltonian formulations and solved numerically.

Additionally, while research in nonlinear water waves has an inherent symbiotic relationship with the generation of powerful mathematical advances, it is also a subject which has vast potential for interdisciplinary collaborations. In many instances throughout science a numerical or experimental exploration is the first approach to obtaining important information about the behaviour of solutions of differential equations. Conversely, behaviour which is predicted by mathematical theory may subsequently be observed and expanded upon in experimental or numerical work.

The aim of this interdisciplinary workshop was to examine recent progress in the broad research area of nonlinear water waves with a view to stimulating future research and collaborations. The workshop has combined the two primary thrusts of research in nonlinear water waves, namely the analytical and computational approaches to studying the governing equations. International experts in the broad domain of fluid dynamics have been present, with featured interdisciplinary expertise ranging from pure and applied mathematicians, to physicists, oceanographers, experimentalists and engineers. The workshop was an engaging forum for discussions and interactions between all scientific researchers in attendance and in the local community.

The workshop was organised around five main themes:

- Nonlinear wave-current interactions
- Geophysical water waves
- Analysis and justification of asymptotic models for water waves
- Numerical computations of water waves
- Nonlinear surface waves in related physical problems

Activities

The workshop took place over two weeks, with more applied talks in the first week and more theoretical talks in the second week. In total there were 37 research seminars, including 2 introductory talks. Both weeks started with one introductory talk on the first day which were for the benefit of the local community. There were between three to five talks each day, with plenty of time for discussions and collaborations during coffee breaks, lunches and after talks.

Specific information on the workshop

The following local and non-local PhD students have participated in the workshop: Dominc Amann, Berry Bakker, Alex Doak, Tao Gao, Dane Grundy, Suzanna Haziot, Ying Huang, Mateusz Kluczek, Dag Nillson, Adrian Rodriguez Sanjurjo, Douglas Svensson Seth, Tien Truong, Adam Yorkston The postdocs who participated were Carlos Galeano-Rios, Evgeniy Lokharu, Calin Martin, Olga Tricthchenko, Miles Wheeler. Some of the PhD students and postdocs gave lectures during the two-week workshop.

Outcomes and achievements

The long term goal of this workshop is to stimulate and develop interdisciplinary collaborations which will formulate new approaches in the research of nonlinear water waves. In the process, these researchers will implement pure and applied mathematical techniques to provide new insight into important, yet poorly-understood, physical phenomena. Based on the discussions which were initiated by the workshop, and the feedback obtained from the participants, we believe that this objective was attained and will be brought to fruition in future research developments. Scientists based in 14 different countries attended the workshop, including a number of locally based-scientists. The workshop schedule which was designed to give the participants ample opportunity to develop new interactions and discussions. The workshop atmosphere was very positive and constructive, making full use of the excellent research facilities provided by the ESI. Particular research collaborations which were developed during the workshop include: O. Trichtchenko, E. I. Părău, Paul Milewski and J.-M. Vanden-Broeck continued working on nonlinear flexural gravity-waves; B. Deconinck, R. Kollár and O. Trichtchenko continued working on Krein signatures. T. Truong, E. Wahlén and M. Wheeler started working on solitary waves of the Whitham equation. E. Wahlén and S. Walsh continued working on water waves with point vortices. C. Galeano-Rios, P. Milewski and J.-M. Vanden-Broeck have continued discussing about bouncing droplets on a vibration bath. A. Geyer and R. Quirchmayr worked on model equations for equatorial shallow water waves.

List of talks

Week 1: November 27 – December 1, 2017

Jean-Marc Vanden-Broeck	Numerical and analytical investigations of nonlinear water waves and related problems (**Introductory talk**)
Paul Milewski	Understanding complexed dynamics of Faraday droplets
Emilian I. Părău	Nonlinear hydroelastic waves
Benjamin Akers	Overturned Traveling Interfacial Waves
Philippe Guyenne	Numerical study of solitary wave attenuation in a fragmented ice sheet
Andre Nachbin	Surface waves over highly irregular topographies
Bernard Deconinck	The stability of solutions of integrable equations
Karima Khusnutdinova	On KP and Ostrovsky-type models
Olga Trichtchenko	Stability of periodic travelling wave solutions to Korteweg-de Vries and related equations
Dane Grundy	Interfacial solitary waves with surface stress
Onno Bokhove	On variational water wave modelling
Tao Gao	Numerical investigation on the bifurcation structures of nonlinear water waves
Alex Doak	Travelling wave solutions on a ferrofluid jet
Victor Shrira	Waves on jet currents: a new paradigm and novel mechanisms of freak wave formation
Wooyoung Choi	Spectral formulation for nonlinear water waves and its generalization to two-layer flows
Katie Oliveras	Nonlinear traveling internal waves in depth-varying currents
Magda Carr	Investigation of mode-2 internal-solitary-like waves
Ricardo Barros	Large amplitude internal waves in three-layer flows
Richard Kollár	How extensions of eigenvalue problems can help to study stability problems and decay rates of internal waves in stratified fluids
Dominic Amann	Numerical approximation of an asymptotic expansion for steady periodic water waves
Berry Bakker	Spatial Dynamics in Nonlocal Equations

Week 2: December 4 – 7, 2017

Boris Buffoni	Steady three-dimensional rotational flows: variational structure and Nash-Moser iteration
Mark Groves	Fully localised solitary gravity-capillary water waves
Mariana Haragus	Formation of Kerr optical frequency combs a water waves bifurcation scenario
David Lannes	The water waves equations and asymptotics (**Survey lecture**)
Gareth Thomas	Prediction of the free-surface elevation for rotational water waves using the recovery of pressure at the bed
Ton van den Bremer	Experimental validations of various aspects of the wave-induced mean flow for surface gravity wave groups
Raphael Stuhlmeier	Evolution of statistically inhomogeneous degenerate water wave quartets
Vera Hur	Stokes waves with constant vorticity: numerical computation
Guido Schneider	The KdV and the NLS equation on periodic metric graphs and relations to the water wave problem
Mats Ehrnström	Enhanced existence time in fractional KdV equations
Konstantinos Kalimeris	Non-local formulations for water waves
Ronald Quirchmayr	Singular traveling waves of a highly nonlinear shallow water equation
Eugen Varvaruca	Large-amplitude steady water waves with constant vorticity
Sam Walsh	Existence, nonexistence, and asymptotics of deep water solitary waves with localized vorticity

Delia Ionescu-Kruse	On the short-wavelength stabilities of some geophysical flows
Anna Geyer	Spectral stability of periodic waves in the generalized reduced Ostrovsky equation

Publications and preprints contributed

The organisers have been invited to edit a book volume in the new, exciting and prestigious, Birkhäuser series *Tutorials, Schools, and Workshops in the Mathematical Sciences*. This volume, featuring almost 20 chapters, will be based on the ESI workshop we organised, featuring contributions from participants which will range from material presented during the workshop to new research developments which were inspired by interactions during the workshop. Additional to this, from feedback and discussions with participants subsequent to the workshop, it is expected that quite a number of publications will appear in future which will acknowledge the support of the ESI and the stimulating environment provided by this workshop. For example, one already published is:

K.R. Khusnutdinova, Y.A. Stepanyants, and M.R. Tranter, *Soliton solutions to the fifth-order Korteweg-de Vries equation and their applications to surface and internal water waves*, arXiv: 1801.09035 [physics.flu-dyn].
See also: Physics of Fluids, 30, 022104 (2018), `https://doi.org/10.1063/1.5009965`, DOI: doi.org/10.1063/1.5009965.

Invited scientists

Benjamin Akers, Dominc Amann, Berry Bakker, Biswajit Basu, Boris Buffoni, Onno Bokhove, Magda Carr, Wooyoung Choi, Adrian Constantin, Bernard Deconinck, Alex Doak, Mats Ehrnström, Carlos Galeano-Rios, Tao Gao, Anna Geyer, Mark Groves, Dane Grundy, Philippe Guyenne, Mariana Haragus, Susanna Haziot, David Henry, Ying Huang, Vera Hur, Delia Ionescu-Kruse, Konstantinos Kalimeris, Mateusz Kluczek, Richard Kollár, Karima Khustnutdinova, David Lannes, Emmanuel Letellier, Evgeniy Lokharu, Ricardo Lopes-Barros, Tony Lyons, Ola Isaac Høgåsen Mæhlen, Calin Martin, Anca-Voichita Matioc, Paul Milewski, André Nachbin, Dag Nilsson, Katie Oliveras, Emilian Părău, Ronald Quirchmayr, Filippo Remonato, Adrian Rodriguez Sanjurjo, Guido Schneider, Raphael Stuhlmeier, Douglas Svensson Seth, Victor Shrira, Gareth Thomas, Olga Trichtchenko, Tien Truong, Ton van den Bremer, Jean-Marc Vanden-Broeck, Eugen Varvaruca, Erik Wahlén, Samuel Walsh, Miles Wheeler, Adam Yorkston.

ESI-CECAM Workshop: Physics and Chemistry at Fluid/Fluid Interfaces

Organizers: Pal Jedlovszky (Eszterházy Károly University, Eger, Hungary), Marcello Sega (U of Vienna)

Dates: December 11 – 13, 2017

Budget: ESI € 5 600,
CECAM € 12 000

Report on the workshop

The molecular properties of liquid/liquid interfaces have been studied by computer simulations since the very beginning of the field itself but, differently from the solid/liquid interfaces,

fundamental questions such as the shape of the interface itself, as well as the structural and dynamical properties of the molecular layers at the interface are still lively debated: new results on simple liquids, backed by novel theoretical analysis, have recently shown that the widely accepted capillary wave theory has in fact some important limitations, and that lateral correlations are playing an important role; the organization of ions at interfaces is another example of a seemingly simple system, where the fine balance between different effects has a major impact on the structure and properties of charged interfaces, as well as on the deviations from the Hofmeister series; our understanding of chemical reactions in the vicinity of interfaces happens to be sensitive to the surface roughness, requiring novel theoretical approaches; the problems related to the non-locality of the stress have also been studied intensively in recent years. In addition, non-equilibrium phenomena such as Super-and Sub-Maxwellian kinetic distributions, or the formation of interfaces in active matter are examples of active fields of research that are testing the limits of validity and applicability or thermodynamics in our understanding of the physics and chemistry at fluid/fluid interfaces.

The focus of the workshop has been on the following aspects of liquid/liquid interfaces: intrinsic properties and molecular layers, partially miscible fluids, interfaces of biological relevance, active matter, evaporation and dissolution, cavitation phenomena.

Activities

The workshop was organized with the main idea of being a forum for discussions, rather than just for the presentation of latest scientific results from the participants. The measures taken to ensure this were: a limited number of oral contributions (15); dedicated sessions to discuss the material presented during oral reports; a small number of selected participants (30). The talks, each 30 minutes long with the exception of the keynote lecture, were grouped thematically, and discussion sessions were arranged at the end of each group of presentation. A conference dinner was organized during the first evening. Poster sessions for younger participants were organized during the first and second afternoons.

Specific information on the workshop

The young researchers that took part in the workshop were

- Ailo Aasen (SINTEF Energy Research, Norway)
- Aristizabal Andres Henao (Universitt Paderborn, Germany)
- Balazs Fabian (Budapest University of Technology and Economics, Hungary)
- Amal Kanta Giri (University of Porto, Portugal)
- Daniel Holy (IOCB, CAS, Prague, Czech Republic)
- Abeer Khedr (University College London, UK)
- Sebastian Schttl (University of Regensburg, Germany)
- Jemma Trick (King's College London, UK)

Outcomes and achievements

During the discussion session several topics were debated:

Edward Smith proposed an alternative definition of the local pressure tensor through control volumes; the problem of defining and interpreting the local stress was pointed out by several researchers as a relevant and still unsolved one: the absence of an experiment that can probe the local stress with enough resolution, for example at the molecular scale, as discussed by Samuli Ollila is a major impediment towards identifying an operative definition for this quantity. Likewise, it emerged that the community is very interested in the developments of all kinds of new experimental techniques that can probe interfacial properties, like the 2D sum frequency generation spectroscopy discussed by James Skinner.

Patrice Malfreyt reported on recent results on the calculation of the surface tension in different geometrical setups. No clear consensus emerged about the possibility of defining in a unique way the surface tension of arbitrarily curved interfaces, although at the practical level simulation results showed consistent results when free energy perturbation methods are applied to cylindrical and spherical droplets.

The keynote lecture of Pavel Jungwirth opened the debate on the dramatic impact that the interpretation of experimental and simulation data can have in building our view on the role of interfacial water in biological systems.

Room temperature ionic liquids received a great deal of attention recently, and it turned out that their particularly rich phenomenology also extends to their interfacial properties, as pointed out by Martin Lisal and Miguel Jorge.

The phase behaviour of mixtures of water and organic solvents have been discussed by David van der Spoel, Dominik Horinek and Ilan Benjamin, while Natalia Cordeiro addressed the behaviour of more complex interfaces like those formed by the thermoresponsive PNIPAAm.

Christoph Dellago discussed the physics of interfaces at negative pressure, in particular regarding the bubble nucleation of water under tension.

Last, but not least, there has been much interest in the possible analogies between equilibrium thermodynamics and the phase behaviour of active fluids with boundaries. Novel approaches to simulation and theory for these systems have been discussed by Laura Filion.

List of talks

Edward Smith	A control volume study of the pressure tensor across a liquid-vapour interface
Patrice Malfreyt	Calculation of the interfacial tension from molecular simulations: a routine job ?
Samuli Ollila	Inhomogeneous tension at biological lipid interfaces from molecular dynamics simulations
Pavel Jungwirth	Biological water or rather water in biology?
James L. Skinner	Water at air, lipid and surfactant interfaces - structure, dynamics, and spectroscopy
Martin Lisal	Surface structures of binary mixtures of ionic liquids: insight from experiment, thermodynamics and molecular simulations
Miguel Jorge	Intrinsic analysis of ionic liquids at fluid interfaces
Dominik Horinek	Octanol/water interfaces - from planar interfaces to surfactant-free microemulsions
David van der Spoel	Solvation free energies and other properties from liquid simulations
Ilan Benjamin	Water miscibility at the water/oil interface. molecular dynamics study of thermodynamics, dynamics and mechanism

Christoph Dellago	Bubble nucleation and the stability limit of water under tension
Maria Lbadaoui-Darvas	Unfolding the köhler theory by atomistic molecular dynamics simulations
Natalia Cordeiro	Probing the fluid behaviour near polymeric surfaces by molecular simulations
Laura Filion	Predicting phase behaviour of mixtures of active spherical particles

Invited scientists

Ailo Aasen, Ioan Andricioaei, Andres Henao Aristizabal, Ilan Benjamin, Natalia Cordeiro, Christoph Dellago, Elise Duboue-Dijon, Sabine Enders, Balazs Fabian, Laura Filion, Johann Fischer, Amal Kanta Giri, Daniel Holy, Dominik Horinek, Pal Jedlovszky, Miguel Jorge, Pavel Jungwirth, Abeer Khedr, Maria Lbadaoui-Darvas, Martin Lisal, Sergey Lishchuk, Patrice Malfreyt, Samuli Ollila, Sebastian Schöttl, Marcello Sega, James L. Skinner, Edward Smith, Othmar Steinhauser, Jemma Trick, David van der Spoel, Iuliia Voroshylova, Øivind Wilhelmsen, Tim Zeiner.

Research in Teams

Rit Project 1: Sampling rare self-assembly trajectories

Collaborators: Christoph Dellago (ESI, U Vienna) and Phillip L. Geissler (UC Berkeley and Lawrence Berkeley National Laboratory)

Dates: February 1– May 1, 2017

Budget: ESI € 7 200

Report on the project

Scientific Background

Rare trajectories, e.g., those that spontaneously cross high energy barriers, figure importantly throughout molecular science. They determine mechanisms and time scales of chemical reactions, phase transitions, changes in protein structure, and more. Their study thus offers insight into the underpinnings of processes that define many frontiers of physical science. The use of computer simulation to harvest and examine these trajectories, however, is severely hampered by the very rareness that makes them interesting.

Methods of transition path sampling offer in principle a generic solution to this problem. Grounded in the statistical mechanics of dynamical pathways, this approach amounts to a random walk through the space of trajectories, with a controlled bias on emergent features of interest. Successful applications have provided new understanding of diverse problems – from autoionization of water molecules to protein folding and structural transformation of nanocrystals.

Many processes of modern interest, however, are not amenable to existing methods of path sampling. Self-assembly phenomena in particular, evolving over time scales much longer than those of chaos and navigating diverse routes through deeply pockmarked landscapes, profoundly challenge the Monte Carlo procedures that facilitate exploration of rare trajectories.

Project aims and scope

This project aimed to extend the tools of transition path sampling to be applicable to the slow dynamics of self-organization, and to begin exploring the kinetics of a few exemplary molecular assembly phenomena.

Our strategy is based on a seasoned appreciation of pitfalls in the importance sampling of long, intermittent pathways. Their strong tendency to decorrelate impedes executing the small steps that comprise an efficacious random walk. Previous efforts to curtail this decorrelation carry a practical cost that greatly limits the efficiency of sampling, in a way that is formally analogous to the limits on mechanical efficiency that arise from the second law of thermodynamics.

We set out to devise Monte Carlo methodologies that circumvent this problem, and to apply them in the contexts of several problems of modern interest. In particular, we aimed to explore the kinetics and mechanisms of (a) a biophysical assembly phenomenon in which polyhedral microcompartments emerge spontaneously from the association of cargo and shell proteins; (b) the exchange of cations within inorganic nanostructures; and (c) topological changes in the state of lipid bilayers, which accompany many important events in cell biology.

Outcomes and achievements

The thermodynamic analogy mentioned above likens the process of Monte Carlo sampling to driving a physical system out of equilibrium. Each proposed Monte Carlo move would act to push the model system away from an equilibrium distribution. Its conditional acceptance restores equilibrium by discarding trial moves with a bias on the amount of dissipation they would entail. A simple but important lesson from this perspective is that sampling efficiency declines rapidly with the amount of dissipation, which is in turn proportional to a system's size in space and in time. In the case of path sampling, attempts to engineer correlation among trial trajectories of large systems over long times face a daunting challenge – acceptance rates that are exponentially small in the product of temporal length and the number of particles. This fact rules out use of a wide array of sampling approaches for self-assembly trajectories.

We have sought to manage this dissipation problem by reducing the scale of Monte Carlo moves, i.e., proposing changes that impact only modest intervals in time and a modest number of particles. Acceptance probabilities should be much more permissive as a result, allowing aggressive perturbations that assist navigating metastable states and exploring diverse mechanistic routes. Key to this procedure is an ability to manipulate trajectory segments with both initial and final conditions constrained, which amounts to generating "bridges" in space-time. Such bridges can be constructed exactly for simple Brownian motion; for interacting systems, forces can be accounted for during the acceptance stage of a Monte Carlo move. We implemented this approach for several illustrative models, including low-dimensional double-well potentials as well as clusters comprising a handful of Lennard-Jones particles. These proofs of principle demonstrate basic feasibility but also point to challenges that must be addressed in continuing work. For example, an "annealing" perturbation that gradually raises and then lowers temperature over the course of path sampling generates dissipation that can decay very slowly with annealing rate. We are currently implementing this approach for a model lipid membrane and will soon examine trajectories of lipid "flipping" from one bilayer leaflet to the other. (A paper describing this development will be written within the next year.)

As a prelude to applying this methodology to processes of microcompartment assembly and cation exchange in nanostructures, we have completed exploratory work in both cases. We constructed a microscopic model for the self-assembly of carboxysomes, bacterial microcompartments that house molecular machinery essential for carbon fixation. Typical trajectories of self-organization paint an interesting and unconventional picture, in which assembled structures do not represent stable equilibrium states, but instead kinetically trapped products of a competition among elastic energy, macroscopic thermodynamics, and dynamical imbalances in binding rates of different species. (A paper on this work, cited below, will soon appear in *Proc. Natl. Acad. USA*.) Our new path sampling approach will allow exploring rare trajectories that clarify and elaborate this scenario.

For the case of cation exchange, we have established quantitative equilibrium statistical mechanics of a rich but simple model for compositional fluctuations. In its simplest form this description simply endows an Ising-like lattice gas with mechanical degrees of freedom that depend on local composition. Using computer simulations and mean field theory, we have established an equilibrium phase diagram with many interesting features, including superlattice phases and unconventional coexistence scenarios. These properties at the macroscopic scale (which will be reported in a paper that is in preparation) are echoed in nanoparticles, with profound finite size effects that we are still characterizing. Enhanced path sampling methodology will allow us to study trajectories of compositional change and concomitant structural transformation.

Publications and preprints contributed

G. M. Rotskoff and P. L. Geissler, *Robust nonequilibrium pathways to microcompartment assembly*, arXiv:1709.00321.

C. Moritz, M. Sega, P. L. Geissler, and C. Dellago, *Nucleation mechanisms from transition trajectories in periodic systems at coexistence*, in preparation.

L. Frechette, C. Dellago, and P. L. Geissler, *Superlattice phases in cation exchange nanocrystals*, in preparation.

Rit Project 2: Hamiltonian approach to modelling geophysical waves and currents with impact on natural hazards

Collaborators: Alan Compelli (Dublin Institute of Technology), Rossen Ivanov (Dublin Institute of Technology), and Calin Iulian Martin (U Vienna)

Dates: April 10 – June 20, 2017

Budget: ESI € 10 480

Report on the project

Scientific Background

The study of fluid systems is a seemingly well established area. Zakharov's significant findings in 1968 that the equations for the surface waves of a deep inviscid irrotational water have a canonical Hamiltonian formulation [1] provide the foundations for many studies of fluids using the Hamiltonian approach. Following on from Zakharov's findings authors have extended the findings to include finite depth (but with a flat bottom) such as [2] and the consideration of stratification, that is considering internal waves between layers of different density [3]. Additionally, studies in a rotational context have also been considered in, for example, [4, 5, 6, 7, 8, 17].

However, the addition of a non-uniform bottom opens a rich vein in terms of new mathematical models with significant potential applications to oceanography and marine engineering. Several studies have already been completed, see [9,10].

The Hamiltonian framework allows for approximations taking into account different scales when considering shallow water and long-wave regimes. As a result the arising model equations are of the type of well known shallow water equations like the Korteweg-de Vries (KdV) and Boussinesq equations.

The problem of waves with a variable bottom has a long history. In the pioneering work of Johnson [11] a perturbed KdV equation is derived as a model for surface waves from Euler's governing equations for irrotational inviscid fluid *(cf.* also with [12]). The problem has been studied further by Johnson [11, 13] and several other authors, e.g. in [14,15].

Boussinesq-type models with variable bottom have been derived and analysed in [18, 19].

Project aims and scope

The aims of the team are:

1. To consider the dynamics of a single incompressible, inviscid, irrotational fluid medium bounded by a free surface and varying bottom.
2. To express the Hamiltonian of the system in terms of the Dirichlet-Neumann operators.
3. To establish Boussinesq and KdV approximations taking into account the effect of the slowly varying bottom.
4. To consider the scaling regime adopted in [11] within the Hamiltonian framework of waves under the variable bottom of Craig *et al* [9, 10].
5. To use numerical solutions of Johnson's equation in order to analyse the effects of the propagation of solitary waves over a variable bottom.
6. To study numerically the KdV equation with variable coefficients when the initial condition is in the form of the one soliton solution for the initial depth.
7. To consider the effect on the equations of vorticity.
8. Prove existence of solutions to the full nonlinear geophysical water wave equations in the equatorial f-plane approximation.
9. Allow for a discontinuous distribution of the vorticity in the water flow that is able to capture sheared superposed currents
10. Perform a more detailed analysis of water flows with a piecewise constant distribution of the vorticity.
11. Provide whenever possible quantitative estimates pertaining to the physical quantities involved in the water flows.

Outcomes and achievements

1. The addition of a varying bottom produced contributions to the Hamiltonian and associated equations that correlate strongly with expectations based on physical considerations.
2. The Hamiltonian was represented using Dirichlet-Neumann opeators.
3. Boussinesq and KdV approximations were established.
4. Johnson's equation and Burgers' equation were recovered.
5. A soliton solution was derived.
6. Numerical studies of the solitons were performed and several key scenarios were considered.
7. The implications of a rotational consideration has been analysed (ongoing).
8. Visualisation of the evolution of the solitons was achieved with collaboration with Prof. Mihail Todorov, Department of Differential Equations, Tehnicheski Universitet Sofija.
9. Rossen Ivanov has presented a talk based on the joint research at the Nonlinear Water Waves workshop held at the Isaac Newton Institute for Mathematical Sciences held 31st July 2017 to 25th August 2017 at the University of Cambridge, United Kingdom.

10. Alan Compelli has presented a talk at the 9th Conference of the Euro-American Consortium for Promoting the Application of Mathematics in Technical and Natural Sciences held from 21st to 26th June 2017 in Albena, Bulgaria.

11. In [16] the equations for geophysical water waves in the f-plane approximation were expressed in an equivalent weak form that allowed for the incorporation of a discontinuous vorticity.

12. By using a local bifurcation approach in the spirit of Crandall-Rabinowitz the existence of a local curve of solutions (representing waves of small amplitude) was obtained in [16]

13. The derivation of the dispersion relation for the case of piecewise constant vorticity with two rotational layers. This relation indicates how the relative speed of the bifurcating laminar flow at the free surface varies with respect to certain parameters like the wavelength, the mean depth of the flow, and – in the case of a piecewise constant vorticity – the position of the vorticity jumps.

14. For certain vorticities γ_1, γ_2, of the above mentioned layers, we also provide estimates for the wave speed c in terms of the speed at the surface of the bifurcation inducing laminar flows.

Publications and preprints contributed

A. Compelli, R. Ivanov, M. Todorov, *Hamiltonian models for the propagation of irrotational surface gravity waves over a variable bottom*; accepted in Philosophical Transactions of the Royal Society A; DOI 10.1098/rsta.2017.0091, arXiv:1708.06791 [physics.flu-dyn].

A. Compelli, *Solitary wave solution of flat surface internal geophysical waves with vorticity*; submitted for publication to the American Institute of Physics (AIP);
arXiv:1708.06653 [physics.flu-dyn].

C. I. Martin, *On periodic geophysical water flows with discontinuous vorticity in the equatorial f-plane approximation*, accepted in Philosophical Transactions of the Royal Society A., DOI: 10.1098/rsta.2017.0096.

Further research with additional vorticity considerations is ongoing with expected publication.

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Rit Project 3: Quantum algorithms for privacy-preserving dada processing in computers

Collaborators: Joseph Fitzsimons (Singapur U), Philip Walther (U of Vienna)

Dates: June 15 – July 15, 2017

Budget: ESI € 2 400

Report on the project

This project was crucial for the development of privacy-preserving random-walk quantum computation protocols that are ideally suited for photonic quantum computers. Existing photonic

quantum computers at the Faculty of Physics have been adapted for the demonstration of such novel encryption schemes.

Additionally, the visit of Prof. Joseph Fitzsimons allowed to derive a security proof for probabilistic one-time computer programs, which have been recently investigated at the Faculty of Physics by using a quantum photonics setup. Both experiments led to scientific articles that are currently under review.

Scientific Background

One-time programs A unique class of classical computer programs, previously thought to be unachievable in a secure manner, are one-time programs. These programs may be purchased by a client who, in turn, may run them only once. The logic of the problem is impossible for the client to reconstruct while the client's input to the program remains hidden from the program provider. These kinds of programs expose immediate applications within software licensing, computations on sensitive data, negotiation and various other areas of immediate interest. Remarkably, such protocols require only single quantum bits for implementing one-time programs in a secure manner.

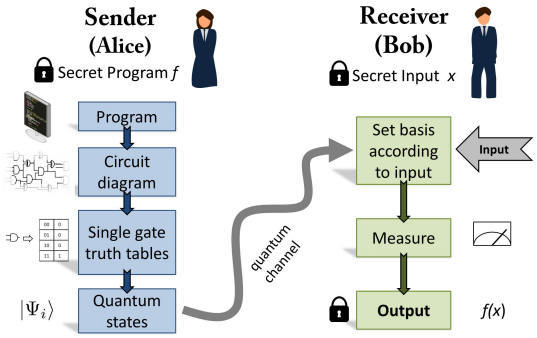

Figure 1: Overview of a probabilistic one-time program scheme. Alice possesses a secret program, f, and Bob a secret input, x. Alice converts f into a logic circuit. Next, Alice encodes the logic gates comprising the circuit as separable quantum states. These states are sent to Bob via a quantum channel. Bob executes the program by sequentially measuring the quantum states. The basis for each measurement is determined by Bob's input to that gate and the measurement result represents the output of the gate, up to some bounded probability of error. The encoding can be chosen such that it suffices for Bob to make only single-qubit measurements. Intuitively, the security of the scheme stems from the fact that the measurements corresponding to different inputs for a given gate do not commute, which prevents Bob from evaluating more than one input.

Homomorphic Encryption Regarding secure data processing using quantum computers a few protocols have been recently developed. Among those is homomorphic encryption, which is one of the most promising schemes for delegated quantum computations. In this case, the client's (Alice's) data is encrypted in such a way that the server (Bob) can process it even though he cannot decrypt it. Moreover, in contrast to other protocols, the client and server do not need to communicate during the computation; because of this feature, the coherence times required for homomorphic-encrypted quantum computation are much shorter than those for, e.g., blind quantum computation, dramatically boosting the protocol's performance and practicality.

Outcomes and achievements

One-time programs This collaborative work has contributed to the first demonstration of probabilistic one-time programs. In fact we could show, both in theory and experiment, that single quantum bits can be used to implement classical one-time programs with a superior level of security to any possible classical technique. The principle behind our implementation is shown in Figure 1 and security is achieved through the exploitation of fundamental features of quantum mechanics including the no-cloning theorem and the fact that measurement of a quantum system is a destructive process. In the experimental implementation at the Faculty of Physics the classical programs are encoded onto photonic single qubits which enables an especially simple exchange of information between two distant parties, although we would like to emphasize that our approach is not limited to any particular physical system. Our achieved experimental demonstration shows a new possibility of quantum-enhanced classical computing: hybrid systems with classical computation supported by feasible quantum technology.

Homomorphic Encryption Supported by the visit of Prof. Fitzsimons we designed and implemented a homomorphically-encrypted quantum random walk. This was achieved by pushing quantum technology beyond state-of-the-art for generating waveguide structures that can implement polarization-independent path unitaries. Using a new annealing technique, we fabricated waveguides with very low birefringence, thus decoupling the result of a quantum random walk from the photon's polarization. Quantum random walks are interesting examples of quantum computation to demonstrate because they are classically computationally hard, while being experimentally undemanding, since feed-forward operations are not required. We demonstrate in the experiment that the security of the encrypted data in our protocol is asymptotic, scaling well with the dimension of the random walk.

Publications and preprints contributed

Marie-Christine Roehsner, Joshua A. Kettlewell, Tiago B. Batalhão, Joseph F. Fitzsimons, Philip Walther, *Quantum advantage for probabilistic one-time programs*, arxiv:1709.09724 [quant-ph]

Jonas Zeuner, Ioannis Pitsios, Si-Hui Tan, Aditya N. Sharma, Joseph F. Fitzsimons, Roberto Osellame, Philip Walther, *paper under review*

Rit Project 4: Renewal Theory and Thermodynamic Formalism for Flows

Collaborators: Henk Bruin (U Vienna), Dalia Terhesiu (Exeter U), and Mike Todd (U of St. Andrews)

Dates: June 19 – July 18, 2017

Budget: ESI € 4 800

Scientific Context

Thermodynamic formalism is concerned with the properties of equilibrium states μ_ϕ for potentials ϕ. Inspired by statistical physics, it was given a rigorous framework in hyperbolic dynamical systems by Sinai and Ruelle in the 1970s. Of specific importance here is the work

of Sarig [S1, S2], who approached this with recurrent/null-recurrent/transient classification of countable state Markov shifts. It is only recently that the theory started to be applied to flows (and semiflows, which are easier to treat but for which many thermodynamic properties are roughly the same). Given a (semi)flow $(f_t)_{t\in\mathbb{R}}$ on a manifold M, one approach is to reduce to the discrete time setting by taking a Poincaré map $F = f^\tau : Y \to Y$ (with good hyperbolicity properties), and induced potential $\bar{\phi}(y) = \int_0^{\tau(y)} \phi(f_s(y))ds$.

Many of the basic notions (e.g. pressure) were formalized (cf. [BI, JKL]) for general flows only recently because if the flow-time (roof function) τ is unbounded and/or not bounded away from zero, there is no simple correspondence between finite/infinite measure and recurrence/transience for the (semi)flow and the induced system. Further work by [BG, BCFT, IJT] extended this basic picture, but for all of the more advanced structures many questions remain, such as (i) nature of phase transitions; (ii) the precise shape of the pressure function and its relation with the tails $\mu_{\bar{\phi}}(\tau > t)$ of τ; (iii) statistical laws.

Progress of research

The paper of Sarig [S3] shows how (in the setting of discrete time phase transitions with a finite equilibrium state), the shape of the pressure function for a perturbed postential $\phi + s\psi$ related to the limit laws of the ergodic average of ψ. The way to obtain these is via induced systems with better (namely Gibbs-Markov) properties, and, simultaneously, via the relation between the shape of the pressure of the induced system and the original system. We planned to generalize these (and further) results to the continuous time setting. Despite some hurdles, this is feasible, and the subject of paper [A] which is still in progress.

During our stay, the situation of infinite equilibrium state appeared to us of increasing interest, also for the discrete time setting. We discovered an aymptotic relation between pressure of the induced system and pressure of the original system, with some important applications to interval maps. Eventually, we solved this problem first, and wrote a paper [B], which is near submission. This paper has the following abstract:

Abstract: Assume that (X, f) is a dynamical system and $\phi : X \to \mathbb{R}$ a potential such that the f-invariant measure μ_ϕ equivalent to ϕ-conformal measure is infinite, but that there is an inducing scheme $F = f^\tau$ with a finite measure $\mu_{\bar{\phi}}$ and polynomial tails $\mu_{\bar{\phi}}(\tau \geq n) = O(n^{-\beta})$, $\beta \in (0,1)$. We give conditions under which the pressure of f for a perturbed potential $\phi + s\psi$ relates to the pressure of the induced system as $P(\phi + s\psi) = (CP(\overline{\phi + s\psi}))^{1/\beta}(1 + o(1))$, together with estimates for the $o(1)$-error term. This extends results from Sarig to the setting of infinite equilibrium states. We give several examples of such systems, thus improving on the results of Lopes [L93] for the Pomeau-Manneville map with potential $\phi_t = t \log f'$, as well as on the results by Bruin & Todd [BT12, BT15] on countably piecewise linear unimodal Fibonacci maps. In addition, limit properties of the measures $\mu_{\phi+s\psi}$ (in particular, correlation coefficients and arcsine laws) are derived.

Further actvities

On June 30, 2017 a Budapest-Vienna Ergodic Theory seminar[3] took place in which Bruin and Todd presented their work.

- Henk Bruin: Regular variation for almost Anosov diffeomorphisms.

[3] http://mat.univie.ac.at/*simz*weimueller/BudWiSer/Budwiser.html

This is joint work with Dalia Terhesiu, and the final version was completed during this research visit.

- Mike Todd: Analysis of a transient interval map.

Publications and preprints contributed

Henk Bruin, Dalia Terhesiu, Mike Todd, *The pressure function for infinite equilibrium measure*, Preprint 2017, arXiv:1711.05069

Henk Bruin, Dalia Terhesiu, Mike Todd, *Thermodynamic formalism and inducing for flows.... (working title)*, in progress.

Henk Bruin, Dalia Terhesiu, *Regular variation and rates of mixing for infinite measure preserving almost Anosov diffeomorphisms,* Preprint 2017, arXiv:1707.09221.

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Rit Project 5: Nonlinear Elliptic Problems in Field Theory and Geometry

Collaborators: Piotr T. Chruściel (U Vienna), Luc Nguyen (Oxford U)

Dates: July 1 – August 31, 2017

Budget: ESI € 4 480

Report on the project

Scientific Background

About half of the literature on mathematical general relativity is concerned with the study of the constraint equations for initial data. The "gluing method", invented by Corvino and Schoen [11, 12], provides a very useful tool for constructing new general relativistic initial data out of old ones [7, 9, 10]. Highlights of the method include the construction of a new class of general relativistic initial data sets with no gravitational field outside of conical regions by Carlotto and Schoen [3], the construction of vacuum space-times with smooth asymptotic structure in lightlike directions [6], the construction of localised "space-time bridges" and "wormholes" [8], and the construction of many-body initial data sets [5].

The gluing methods above have been recently extended [4] to k-Yamabe metrics, i.e. metrics for which the k-th symmetric polynomial of the Schouten curvature tensor is constant. In view of the increased interest in theoretical physics in models with more sophisticated field equations, such as e.g. the Lovelock theories of gravity [13, 14, 15], extended theories of gravity [1, 2] and others, and hence more complicated constraint equations, it is of interest to develop a general scheme of gluing which would apply to large classes of nonlinear geometric theories.

Project aims and scope

The aim of our project, as stated in the original application, was: *To initiate a systematic study of the above set of problems, identify and exhaustively describe the obstructions to gluings, carry out the gluings in nonlinear models relevant for theoretical physics where such constructions have not been attempted so far, obtaining thus new striking classes of physically significant field configurations.* In our application we also pointed out that "the first step of such constructions, which we intend to carry-out during Luc Nguyen's visit in Vienna, is an analysis of the associated charge integrals, arising as obstructions to perform gluings." Typical examples of such integrals are mass, energy, and energy-momentum integrals. Most of our joint research last summer addressed this aspect of the project.

Outcomes and achievements

Indeed, most our efforts, in collaboration with Tim-Torben Paetz from the University of Vienna, concentrated on technical problems with the implementation of a deformation argument designed to control the mass for asymptotically hyperbolic manifolds while preserving an inequality on the scalar curvature. We have managed to overcome those in space-dimensions larger than five. Discussions with Greg Galloway, a participant of the research programme that was taking place at ESI at the time, led to further interesting applications of our deformations results. In the meantime we finilised a paper on the problem, cf. below.

We also had several discussions on possible approaches to the problems pointed-out above, which we plan to further explore in the future.

An inspiring lecture by Paul Tod, another participant of the programme, led us to think again about the following problem, that one of us (PTC) together with Paul Tod unsuccessfully tried to solve years ago: the question of existence of "non-inheriting" asymptotically flat solutions of the Einstein Maxwell equations. The "non-inheriting" solutions are solutions of the Einstein-Maxwell equations with a stationary metric and time-dependent periodic Maxwell fields. Several classes of such solutions are known which do not satisfy any physically relevant boundary conditions. In collaboration with Paul Tod and András Vasy we have been able to prove that no such solutions can be asymptotically flat. We have since made good progress on drafting a paper on this, we expect the draft to be ready by mid December.

Some of the discussions between PTC and LN played a key role in solving a problem that one of us (PTC) encountered when working on a different project, namely the existence of boson stars with negative cosmological constant. This allowed PTC and co-authors to finish the proof of existence of such solutions, cf. a preprint below.

Publications and preprints contributed

Piotr T. Chruściel, Erwann Delay, Paul Klinger, Andreas Kriegl, Peter Michor and Armin Rainer, *Non-singular spacetimes with a negative cosmological constant: V. Boson stars*, arXiv: 1708.02878 [gr-qc].

Piotr T. Chruściel, Greg Galloway, Luc Nguyen and Tim-Torben Paetz, *On the mass aspect function and positive energy theorems for asymptotically hyperbolic manifolds*, arXiv:1801.03442 [gr-qc].

Piotr T. Chruściel, Luc Nguyen, Paul Tod and András Vasy, *Asymptotically flat Einstein-Maxwell fields are inheriting*, arXiv:1802.09915 [math.AP].

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Senior Research Fellows Programme

To stimulate the interaction with the local scientific community the ESI offers regular lecture courses on an advanced graduate level. These courses are taught by Senior Research Fellows of the ESI whose stays in Vienna are financed by the Austrian Ministry of Education, Science and Culture and the U of Vienna. In exceptional cases this programme also includes long-term research stays of small groups or individual distinguished researchers. These lecture courses are highly appreciated by Vienna's students and researchers.

This year's programme was focused on the following Lecture Courses:

Lecture Courses, Summer Term 2017:

Tomáš Roubíček (Charles University and Czech Academy of Sciences, Prague):
Mathematical Methods in Continuum Mechanics of Solids
Lectures 250122 VO: March 3 – June 30, 2017
Friday 11:45 - 13:15
Problem Class 250123 PS: March 3 – June 30, 2017
Friday 13:15 - 14:00

Visitors and Guest Speakers within the Senior Research Fellowship framework:

Marita Thomas (Weierstrass-Institute, Berlin), June 9 - 13, 2017

Tomáš Roubíček: Mathematical Methods in Continuum Mechanics of Solids

Course

The lectures were focused on evolution problems arising in continuum mechanics and thermomechanics of solids at small or large strains. Rigorous formulation of initial-boundary-value problems and existence of their solutions were tackled via some constructive approximation (conceptually leading to implementable computer algorithms) and via proving their stability (a-priori estimates) and convergence. The presented material have provided skills to formulate mathematically various physically consistent models arising in solid mechanics and thermomechanics and to perform their basic mathematical analysis, leading possibly to numerically stable, convergent, and implementable computational algorithms. The classes have been structuralized into five parts:

Part I. Brief introduction and mathematical prerequisites.
Part II. Linear rheological models at small strains.
Part III. Nonlinear materials with internal variables at small strains.
Part IV. Thermodynamics of selected materials and processes.
Part V. Evolution at large strains.

Research

During his stay at the ESI, T. Roubíček worked on various topics related to his classes, which are also reflected in the prepared monograph of the same name with Martin Kružík (Czech Academy of Sciences, Prague).

Simultaneously, he worked with Ulisse Stefanelli (U Vienna) on the thermodynamically consistent model of plasticity or creep at large strains.

Also he pursued his long-lasting initiative of building thermodynamically consistent and mathematically supported geophysical models. More specifically, again in collaboration with Ulisse Stefanelli, he developed a model for tectonic earthquakes arising on lithospheric faults in poroelastic rocks, previously formulated and analyzed at small strains and large displacement, as used in geophysical modelling but without full thermodynamical consistency. This new model is formulated at large strains and its thermodynamics is truly consistent while mathematical analysis being highly nontrivial. Moreover, based largely on consultation with Katharina Brazda (U Vienna), he developed a "monolithical" model that approximates damageable solids coupled with viscoelastic or merely elastic fluids, reflecting the layered structure (i.e. mantle and inner core versus outer core and oceans) of our planet Earth and coupling seismic sources with seismic waves. This model is formulated and analysed at small strains.

Lecture Notes

The provisional text of the above described course was generated as selected parts from a manuscript of the mentioned monograph of the same name being contracted and in current development for Springer Verlag. (This text has been available for attending participants.)

Publications and preprints contributed

T.Roubíček, U.Stefanelli: *Finite thermoelastoplasticity and creep under small elastic strains*. Preprint arXiv no.1804.05742, Math. Mech. of Solids, in print.

T.Roubíček: *Seismic waves and earthquakes in a global monolithic model*. Preprint arXiv: 1703.06267, Cont. Mech. Thermodynam., printed on-line: DOI 10.1007/s00161-018-0636-8.

M.Kružík, T.Roubíček: *Mathematical Methods in Continuum Mechanics of Solids.* Interaction of Mech. and Math. Series, Springer Verlag, Switzerland, to appear 2018.

Erwin Schrödinger Lectures 2017

The Erwin Schrödinger Lectures are directed towards a general audience of mathematicians and physicists. In particular it is an intention of theses lectures to inform non-specialists and graduate students about recent developments and results in some area of mathematics or physics.

Speaker: Mihalis Dafermos (University of Cambridge & Princeton University)

Mihalis Dafermos holds the Lowndean chair of Astronomy and Geometry at the University of Cambridge in the Department of Pure Mathematics and Mathematical Statistic and is Professor at Princeton University in the Department of Mathematics.

Date: February 23, 2017

Mihalis Dafermos: Ramanujan complexes and topological expanders

Abstract
The celebrated "black hole" spacetimes of Schwarzschild and Kerr play a central role in our current understanding of Einstein's general theory of relativity. Are these spacetimes stable, however, as solutions to the Einstein vacuum equations, in their exterior region? And what fate awaits physical observers who enter inside a "generic" black hole? It turns out that these two questions are intimately related and the answer to the second may be more disturbing than previously thought. This talk will try to explain how so.

Speaker: Sascha Husa (Universitat de les Balears)

Sascha Husa, an alumnus of the University of Vienna, is one of the leading experts in the field of numerical relativity. In his research, he solves the Einstein equations with numerical methods to study astrophysical phenomena, such as gravitational waves emitted from black hole mergers. Sascha Husas calculations played an important role in the first detection and analysis of gravitational waves by the LIGO cooperation, a discovery that was awarded the 2017 Nobel Prize in Physics.

Date: December 19, 2017

Sascha Husa: Gravitational Wave Astronomy: Recent Results and Challenges for the Future

Abstract
In this talk I will first summarize recent observations of gravitational wave events that are consistent with mergers of binary systems of black holes and of neutron stars, and discuss what we have learned so far from gravitational wave observations, and what we hope to learn in the future, regarding astrophysics and fundamental physics. I will then discuss the current plans for future ground and space based gravitational wave observatories, and the theoretical and computational challenges that need to be overcome in order to best interpret the data that such detectors will record.

Simons Junior Professor Nils Carqueville

In 2013, following a suggestion of the hiring committee, the Rektor of the University of Vienna offered the Simons Junior Professorship at the ESI to Nils Carqueville (then at the Simons Center for Geometry and Physics, Stony Brook University). He accepted the call. Formally a member of the Faculty of Mathematics at Vienna University, he resumed his position at the ESI on March 1, 2014.

Teaching

Nils Carqueville taught the following courses within the general course programme of the University of Vienna.

Summer Term 2017:

Factorisation algebras
Seminar, 2h, SE: March 1 – June 30, 2017, Tuesday, 16:00–17:30

Course description: continuation of previous seminar; topics: factorisation algebras and higher tensor categories

Lineare Algebra und Geometrie 1
Lecture Course, 2h, 250019 VO: March 1 – June 30, 2017, Tuesday, 9:45–11:15

Course description: second part of a 3-part course on linear algebra

Lineare Algebra und Geometrie 1
Tutorial, 2h, 250020 UE: March 1 – June 30, 2017, Monday, 11:30–13:00

Course description: Tutorial for the homonymous lecture course

Winter Term 2017/18:

Topological Phases of Matter and Topological Quantum Field Theory
Seminar, 2h, 250166 SE: October 4, 2017 – January 31, 2018, Wednesday 11:00 - 12:30

Course description: This seminar aimed to provide an introduction into the recent interactions between the theory of condensed matter and topological quantum field theory. On the mathematical side we covered basic notions and results in TQFT and discuss examples in two and three spacetime dimensions. On the physical side, topological phases of matter, their partial classification, and tensor networks were be among the main topics.

Higher categories in topology and physics
Seminar, 2h, 250109 SE: October 3, 2017 – January 30, 2018, Tuesday, 16:15–17:45

Course description: introduction to $(\infty, 1)$-categories

Lineare Algebra und Geometrie 2
Lecture Course, 2h, 250037 VO: October 3, 2017 – January 30, 2018, Tuesday 11:30 - 13:00

Course description: third part of a 3-part course on linear algebra

Konversatorium zur VO Lineare Algebra und Geometrie 2
Konversatorium, 2h, 250162 KO: October 12, 2017 – January 25, 2018, Thursday 15:00 - 16:30

Course description: Tutorial for the homonymous lecture course

Research

In 2017 the research of Nils Carqueville focused on TQFTs on n-dimensional stratified bordisms as well as fully extended TQFTs in dimensions 2 and 3. In particular, in two papers with I. Runkel and G. Schaumann he introduced the functorial notion of n-dimensional defect TQFT for any positive integer n, developed its basic theory, extended Reshetikhin-Turaev theory to a full 3-dimensional defect TQFT, and constructed invariants of surface embeddings.

Further activities

In March 2017, Nils Carqueville welcomed Manuel Bärenz as the second postdoc into his research group to work on 4-dimensional TQFTs and topological invariants. Together with Anton Mellit and Paul Wedrich, Carqueville successfully applied to organise a 2-week ESI workshop on quantum topology in January 2019. Carqueville also submitted an application for an SFB on "Geometry and Physics" as one of two co-speakers, with Ludmil Katzarkov as speaker, Michael Eichmair as the other co-speaker, as well as six further PIs: Andreas Čap, Piotr T. Chruściel, Stefan Fredenhagen, Tamás Hausel, Johanna Knapp, and Anton Mellit.

Visits from: Ilka Brunner (LMU Munich), Domenico Fiorenza (La Sapienza Rome), Sergey Galkin (NRU Moscow), Anton Mellit (IST Austria), Catherine Meusburger (U Erlangen), Daniel Plencner (ENS, Paris), Claudia Scheimbauer (MPIfM Bonn), Walker Stern (U Bonn), Lorant Szegedy (U Hamburg), Paul Wedrich (Imperial College London), Dominic Williamson (Yale).

Visits to: LMU München, King's College London, Queen Mary, University of London (seminar talk) U Hamburg, U Erlangen (seminar talk), U Bucharest (seminar talk), U Zurich (seminar talk), La Sapienza Rome (seminar talk), Lisbon (speaker at conference "Higher Structures": two talks), Center for Geometry and Physics, Pohang (speaker at conference "String Field Theory of Landau-Ginzburg models" via live video link).

List of talks given by guest scientists:

Catherine Meusburger (U Erlangen)	Kitaev lattice models as a Hopf algebra gauge theory
Claudia Scheimbauer (MPIfM Bonn)	Fully extended twisted field theories
Walker Stern (U Bonn)	Crossed simplicial groups and field theories
Anton Mellit (IST Austria)	Skein algebras
Paul Wedrich (Imperial College London)	On colored link homologies
Domenico Fiorenza (La Sapienza Rome)	T-duality in rational homotopy theory
Sergey Galkin (NRU Moscow)	On Kashaev's simple model of 4d TQFT and realizations of Pachner moves
Daniel Plencner (ENS Paris)	Weyl anomalies and brane charges
Dominic Williamson (Yale)	Fusion categories from tensor networks and topological order
Lorant Szegedy (U Hamburg)	TQFT on r-spin surfaces and the Arf invariant

List of talks given by guest scientists in the course of the Simons Lecture Series:

David Jordan (U Edinburgh)	Quantum character varieties in topology and representation theory, I - IV
Catherine Meusburger (U Erlangen)	Introduction to Poisson Lie-groups, I - IV

Publications and preprints contributed

N. Carqueville, I. Runkel, G. Schaumann, *Line and surface defects in Reshetikhin-Turaev TQFT*, arXiv:1710.10214 [math.QA].

N. Carqueville, I. Runkel, G. Schaumann, *Orbifolds of n-dimensional defect TQFTs*, arXiv:1705.06085 [math.QA].

N. Carqueville, I. Runkel, *Introductory lectures on topological quantum field theory*, with I. Runkel, arXiv:1705.05734 [math.QA].

Junior Research Fellows Programme

The Junior Research Fellowship Programme supports external or local graduate students and recent postdocs (at most 5 years past receiving their PhD) to work on a project of their own in mathematics or physics that is either connected to a research direction carried out at the University of Vienna or to an ESI thematic programme. The ESI provides support for a Junior Research Fellow to work at the ESI for a time period between one and four months.

Madhusudan Manjunath: Topics in Combinatorial Algebraic Geometry

Madhusudan Manjunath (Queen Mary U of London): April 1 – July 21, 2017

Report

A power ideal J_G is an ideal of the polynomial ring generated by a collection of powers of linear forms each associated to a subset of vertices of an undirected connected graph G. This was first studied by Postnikov and Shapiro [4] with motivation from Schubert calculus and is also an interested object to study in its own right. Another ideal associated to G is the G-parking function ideal M_G and this is a monomial ideal. Both J_G and M_G are standard graded modules over the polynomial ring. Postnikov and Shapiro determined the Hilbert series of the ideal J_G showing that it coincides with the Hilbert series of the monomial ideal M_G. Furthermore, based on computer experiments they conjectured the following:

Conjecture: (Postnikov-Shapiro) The graded Betti numbers of J_G and M_G coincide i.e., for every $(i,j) \in \mathbb{Z}^2$, the Betti number $\beta_{i,j}(J_G) = \beta_{i,j}(M_G)$.

At the time of the conjecture, the graded Betti numbers of M_G were not known. Since then, the graded Betti numbers have been explicitly determined [2], [3], [1].

During my visit to the Erwin Schrödinger Institute during April-July 2017, I worked on the conjecture of Postnikov and Shapiro in collaboration with Justin Chen, University of California, Berkeley. We have constructed a candidate minimal free resolution for J_G. We have also constructed a one-parameter family $J_{G,t}$ interpolating between J_G and M_G and have verified in examples that for each value of the parameter t, the resulting ideal has the same graded Betti numbers as M_G. We refer to this conjecture as the generalized Postnikov-Shapiro conjecture. We are currently working towards a proof of this conjecture for generic values of the specialization of the parameter t. In the following, I provide some details of our approach.

Let $\mathbb{K}$ be an algebraically closed field of characteristic zero. Let G be an undirected, connected multigraph with n vertices indexed by $[1,\ldots,n]$. Let R be the polynomial ring $\mathbb{K}[x_1,\ldots,x_{n-1}]$ in $(n-1)$-variables with coefficients in $\mathbb{K}$.

Fix a distinguished vertex of G, n say referred to as the sink. For a pair of subsets S_1 S_2 of $[1,\ldots,n]$ and for $j \in S_1$, let $d(j,S_2)$ be the number of edges that are incident on j and a vertex in S_2.

Let $d(S_1,S_2)$ be $\sum_{j\in S_1} d(j,S_2)$. For each subset S, associate $p_S = (\sum_{j\in S} x_j)^{d(S,\bar{S})}$, where $\bar{S}$ is the complement of S in $[1,\ldots,n]$. The power ideal J_G of G is the ideal generated by p_S over all subsets S of $[1,\ldots,n-1]$. More precisely,

$$J_G = \langle p_S |\ S \subseteq [1,\ldots,n-1] \rangle$$

The ideal M_G is generated by monomials m_S, one associated to each subset S of $[1,\ldots,n-1]$. For a subset S of $[1,\ldots,n-1]$, the monomial m_S is defined as $\prod_{j\in S} x_j^{d(j,\bar{S})}$. The monomial ideal M_G is defined as

$$M_G = \langle m_S |\ S \subseteq [1,\ldots,n-1] \rangle.$$

The G-parking function ideal has been widely studied and its Hilbert series, minimal free resolution have been explicitly determined [4], [2].

In our work, we introduce a one parameter family of ideals $J_{G,t}$, parameterized over $\mathbb{A}^1_{\mathbb{K}}$, that interpolates between J_G and M_G. We are currently working to prove that for a generic parameter, the analogue of the conjecture of Postnikov and Shapiro holds. More precisely, we aim to show the following.

Theorem: Given an undirected connected multigraph G, there is a Zariski open neighbourhood U of $0_{\mathbb{K}} \in \mathbb{A}^1_{\mathbb{K}}$ such that for every element $t_0 \in U$ and for each point $(i,j) \in \mathbb{Z}^2$, the Betti numbers $\beta_{i,j}(J_{G,t_0}) = \beta_{i,j}(M_G)$.

Sketch of the Proof: Our proof is based on the construction of a candidate minimal free resolution for each element of the family $J_{G,t}$. In other words, we are working towards a one parameter family of complexes $\mathcal{F}_t$ of $R[t]$-modules such that for each $t_0 \in \mathbb{A}^1_{\mathbb{K}}$, the element $\mathcal{F}_{t_0}$ is the candidate minimal free resolution of the element J_{G,t_0}. We first verify that for each $t_0 \in \mathbb{K}$, it is indeed a complex and that it is minimal. The remaining step is to prove the exactness of $\mathcal{F}_{t_0}$ for each $t_0 \in \mathbb{K}$. We proceed by showing that at $t = 0_{\mathbb{K}}$, this complex specializes to the minimal free resolution of M_G. We then invoke the open property of exactness to conclude that there is a Zariski open neighbourhood U of $0_{\mathbb{K}} \in \mathbb{A}^1_{\mathbb{K}}$ such that the complex $\mathcal{F}_{t_0}$ is exact for each $t_0 \in U$.

Other Activities during the stay: I worked on the final version of my paper "Syzygies over the Polytope Semiring" [M17]. This paper has now appeared in the Journal of the London Mathematical Society. I attended the Chow Lectures at the Max Planck Institute for Mathematics in the Sciences, Leipzig from May 23 – 24, 2017. During this visit, I also gave a short presentation on my recent work on the commutative algebra of generalised Frobenius numbers. I interacted with Josef Schicho and Pranav Pandit on topics related to tropical geometry.

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Publications and preprints contributed

[M17] Madhusudan Manjunath, *Syzygies over the Polytope Semiring*, arXiv:1606.07395, [math.CO]. See also: Journal of the London Mathematical Society **96 (2)**, 482–500, 2017, https://doi.org/10.1112/jlms.12065, DOI: 10.1112/jlms.12065Journal of the London Mathematical Society **96 (2)**, 482–500, 2017.

Peter Wirnsberger: Thermally Induced Monopoles

Peter Wirnsberger (U of Cambridge): May 8 – June 16, 2017

Report

During my six-week stay at the ESI, I investigated the phenomenon of 'thermally induced monopoles' according to which charge-neutral, heated or cooled particles immersed in a polar solvent can behave as if they carry an effective electric or magnetic charge [1]. To illustrate this effect, let us assume that a radially symmetric metal nanoparticle is immersed in water and heated by a laser. Assuming that the energy in the system is kept constant, the temperature profile in the liquid will reach a steady state after some transient initial behaviour. From computer experiments it is known that a temperature gradient, ∇T, leads to thermo-molecular reorientation of solvent molecules with sufficiently low symmetry [2, 3]. As a result, the water becomes polarised and gives rise to an electrical field $\mathbf{E} \propto \nabla T$. The crucial observation underlying the theory of thermally induced monopoles is that this electrical field can be accurately described by a point charge located at the centre of the heated particle. Multiple heat sources/sinks will therefore interact in the same way as electrical charges would do. Similarly, a heat source/sink immersed in a paramagnetic liquid will act as a magnetic monopole [1].

This intriguing theory was proposed by my PhD supervisor Daan Frenkel [1] and we recently verified the effect numerically in collaboration with Christoph Dellago (U of Vienna) [4]. Although our simulations suggest that the effect is real and robust, little is known about the origin of this complex non-equilibrium phenomenon. The current theoretical description is based on the phenomenological equation $\mathbf{E} = S_{\mathrm{TP}} \nabla T$, where S_{TP} is called the 'thermo-polarisation coefficient' [2,5]. Knowledge of this coefficient would allow us to make *a priori* predictions of the monopole interaction described above. However, since it is unclear why molecules align with a temperature gradient in the first place, the value of S_{TP} is typically inferred from simulation data. This limitation was recently addressed by Alpha Lee, who proposed a theory to quantify the thermally induced orientation of polar dumbbell molecules [6]. Lee's theory is based on a self-consistent mean-field, local equilibrium approach and captures the scaling of the induced alignment with respect to the molecular volume, size anisotropy and dipole moment correctly. Accurate predictions, however, still require knowledge of the relationship between the solvation energy and the size asymmetry of the dumbbell molecule [6]. Moreover, the dipolar theory is not applicable to water for which quadrupolar interactions were shown to play an important role [5, 7]. Given the importance of water as a solvent, it is therefore desirable to address these shortcomings.

At the ESI, I worked on an extension of the theory described above to predict the thermally induced alignment, $\langle \cos\theta \rangle$, of water and off-centre Stockmayer particles [4]. The work has

been carried out in collaboration with Christoph Dellago, Daan Frenkel and Aleks Reinhardt (U of Cambridge). We follow a mean-field approach and assume the system to be in local equilibrium, such that the laws of thermodynamics still apply locally, although the system as a whole is out of equilibrium. We further assume that there are two main contributions to $\langle \cos\theta \rangle$: one due to ∇T itself and the other one due to the induced density gradient, $\nabla\rho$. The main result of our work is a relationship of the form $\langle \cos\theta \rangle = f_1(T,\rho)\nabla T + f_2(T,\rho)\nabla\rho$, where f_1 and f_2 are functions that can be related to equilibrium properties of the liquid. To complement the study, we performed computer simulations of an off-centre Stockmayer system on the Vienna Scientific Cluster (VSC). Although our theory takes dipolar and quadrupolar interactions into account self-consistently, we initially focussed on the case of zero dipole strength, i.e. an off-centre Lennard-Jones liquid. This greatly facilitates the comparison, because we can compute f_1 and f_2 analytically for this system. To disentangle the temperature gradient and density gradient contributions we considered three different scenarios: In the first case, we imposed a temperature gradient and let molecules move freely to allow the formation of a density gradient (local equilibrium). In the second case, we applied a suitable body force to cancel the density gradient, such that only the thermal gradient remains. In the third case, we generated a density gradient in an equilibrium system by applying a body force. Comparison with the simulation data suggests that our theory captures the qualitative behaviour correctly in all three cases and yields reasonably good quantitative agreement. Preliminary simulations for non-zero dipole strength also suggest good agreement with the theory in the isothermal case. A full comparison that also includes water is still work in progress.

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Publications and preprints contributed

A manuscript on this work is currently in preparation.

Annegret Burtscher: Lorentzian curvature revisited

Annegret Burtscher: July 16 – August 19, 2017

Report

During my one-month stay at the ESI I participated in the thematic programme "Geometry and Relativity". In the first two weeks I attended the summer school and the main conference of this programme. In the last week I attended also the conference related to Piotr Chruściel's 60th birthday, with an illuminating and very broad "Panorama of General Relativity". All these conferences provided not only a great opportunity to hear about the many recent breakthroughs in this broad and diverse field, but also to interact with many colleagues and discuss ongoing research. In the remaining two and a half weeks I focused primarily on my own research in the field of mathematical general relativity, but also attended several of the weekly research talks related to the "Geometry and Relativity" programme at the ESI. The continuing presence of experts provided a stimulating environment and the possibility to discuss problems with colleagues greatly benefited my ongoing research.

In what follows I will briefly describe my own research carried out at the ESI. I primarily focused on a particular geometric problem related to static perfect fluids, which I had been working on with Lars Andersson. This research started with the observation that static, spherically symmetric solutions to the Einstein–Euler equations with linear equation of state are not asymptotically flat [1]. The Einstein–Euler equations describe perfect fluids in general relativity and are commonly used to model stellar objects when the fluid has finite extend (and vacuum exterior). The fundamental work of Rendall and Schmidt [7] proved that the static, spherically symmetric Einstein–Euler equations with certain reasonable equations of state yield unique, global and smooth solutions. Some criteria are available to check whether these solutions have finite or infinite extend, which largely depends on the equation of state [2, 3, 5, 8] (much of this work was carried out by researchers attending the ESI thematic programme and researchers in Vienna). Based on numerical observations using a dynamical systems approach the asymptotic behavior of certain solutions has already been investigated [4]. In our work, we use similar reformations of the Einstein–Euler equations with linear and polytropic equation of state as a dynamical system and for the first time analyzed the geometric behavior that emerges. It turns out that solutions with linear equation of state are quasi-asymptotically flat, a geometric notion including a conical angle that has been introduced in the context of global monopoles [6]. Perfect fluids with certain polytropic equation of state are more complicated but can be described by what we call a scaled quasi-asymptotically flat behavior. Since these equations of state are commonly used in mathematical general relativity and astrophysics, we believe that an understanding of the geometric structure of static perfect fluids is invaluable also for the global and time-dependent description of perfect fluids in general relativity.

I already presented some of our findings in my talk entitled "On the asymptotic behavior of static perfect fluids" on August 9, 2017 at ESI. A manuscript with the same title is currently in preparation (see below).

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Publications and preprints contributed

A.Y. Burtscher, L. Andersson, *On the asymptotic behavior of static perfect fluids*, arXiv: 1801.00614 [gr-qe].

Seminars and colloquia outside main programmes and workshops

579 seminar and colloquia talks have taken place at the ESI in 2017.

2017 02 23 , M. Dafermos: Erwin Schrödinger Lecture: “On falling into black holes”
2017 03 27 , C. Meusburger: “Introduction to Poisson Lie-groups I”
2017 03 28 , C. Meusburger: “Introduction to Poisson Lie-groups II”
2017 03 29 , C. Meusburger: “Introduction to Poisson Lie-groups III”
2017 03 30 , C. Meusburger: “Kitaev lattice models as a Hopf algebra gauge theory”
2017 03 31 , C. Meusburger: “Introduction to Poisson Lie-groups IV”
2017 10 11 , D. Mukamel: “Mixed order phase transitions: from DNA denaturation to jamming processes”
2017 11 06 , D. Jordan: “Quantum character varieties in topology and representation theory I”
2017 11 07 , D. Jordan: “Quantum character varieties in topology and representation theory II”
2017 11 08 , D. Jordan: “Quantum character varieties in topology and representation theory III ”
2017 11 09 , D. Jordan: “Quantum character varieties in topology and representation theory IV”
2017 12 19 , S. Husa: Erwin Schrödinger Lecture: “Gravitational Wave Astronomy: Recent Results and Challenges for the Future”

ESI Research Documentation

ESI research in 2017: publications and arXiv preprints

The following codes indicate the association of publications and preprints with specific ESI activities:

ABR = Quantum Physics and Gravity
CBS = Geometry and Relativity
DF = Systematic Approaches to Deep Learning Methods for Audio
JAF = Geometric Transport Equations in General Relativity
JRF = Junior Research Fellow
KSB = Algorithmic and Enumerative Combinatorics
MAB = Geometry and Representation Theory
PDG = Tractability of High Dimensional Problems and Discrepancy
RIT = Research in Teams
SKN = Elliptic Hypergeometric Functions in Combinatorics, Integrable Systems and Physics
SRF = Senior Research Fellows
WHP = Nonlinear Water Waves - an Interdisciplinary Interface

THEMATIC PROGRAMMES

Quantum Physics and Gravity (ABR)

R. Basu, S. Detournay, M. Riegler, *Spectral Flow in 3D Flat Spacetimes*, arXiv:1706.07438 [hep-th].

R. Emparan, A. Fernandez-Pique, R. Luna, *Geometric polarization of plasmas and Love numbers of AdS black branes*, arXiv:1707.02777 [hep-th].

O. Fuentealba, J. Matulich, R. Troncoso, *Asymptotic structure of $N = 2$ supergravity in 3D: extended super-BMS$_3$ and nonlinear energy bounds*, arXiv:1706.07542 [hep-th].

Geometry and Relativity (CBS)

B. Araneda, *Generalized wave operators, weighted Killing fields, and perturbations of higher dimensional spacetimes*, arXiv:1711.09872 [gr-qc].

A. Ashtekar, B. Bonga, *On a basic conceptual confusion in gravitational radiation theory*, arXiv:1707.07729 [gr-qc].

A. Ashtekar, B. Bonga, *On the ambiguity in the notion of transverse traceless modes of gravitational waves*, arXiv:1707.09914 [gr-qc].

V. Branding, K. Kroencke, *Global existence of wave maps and some generalizations on expanding spacetimes*, arXiv:11709.06520 [math.DG].

O. Chodosh, C. Mantoulidis, *Minimal surfaces and the Allen-Cahn equation on 3-manifolds: index, multiplicity, and curvature estimates*, arXiv:1803.02716 [math.DG].

P. T. Chruściel, E. Delay, P. Klinger, *On non-degeneracy of Riemannian Schwarzschild-anti de Sitter metrics*, arXiv:1710.07597 [gr-qc].

P. T. Chruściel, P. Klinger, *The annoying null boundaries*, arXiv:1801.06037 [gr-qc].

P. T. Chruściel, G. J. Galloway, E. Ling, *Weakly trapped surfaces in asymptotically de Sitter spacetimes*, arXiv:1803.02339 [gr-qc].

H. Friedrich, *Peeling or not peeling – is that the question ?*, arXiv:1709.07709 [gr-qc].

M. Graf, J. D. E. Grant, M. Kunzinger, R. Steinbauer, *The Hawking-Penrose singularity theorem for $C^{1,1}$-Lorentzian metrics*, arXiv:1706.08426 [math-ph].

S. Hadar, H. S. Reall, *Is there a breakdown of effective field theory at the horizon of an extremal black hole?*, arXiv:1709.09668 [hep-th].

J. L. Jauregui, *Lower semicontinuity of the ADM mass in dimensions two through seven*, arXiv:1804.04723 [math.DG].

M. Khuri, E. Woolgar, *Nonexistence of extremal de Sitter black rings*, arXiv:1708.03627 [hep-th].

M. Khuri, E. Woolgar, *Nonexistence of degenerate horizons in static vacua and black hole uniqueness*, arXiv:1710.09669 [gr-qc].

M. Khuri, G. Weinstein, S. Yamada, *Stationary vacuum black holes in 5 dimensions*, arXiv:1711.05229 [gr-qc].

T. Makino, *On slowly rotating axisymmetric solutions of the Einstein-Euler equations*, arXiv:1705.07392 [math.AP].

L. B. Szabados, *On gravity's role in the genesis of rest masses of classical fields*, arXiv:1802.04401 [gr-qc].

Tractability of High Dimensional Problems and Discrepancy (PDG)

D. Bilyk, F. Dai, S. Steinerberger, *General and Refined Montgomery Lemmata*, arXiv:1801.07701 [math.CA].

S. Dahlke, C. Schneider, *Besov Regularity of Parabolic and Hyperbolic PDEs*, Bericht Mathematik Nr. 2017-03 des Fachbereichs Mathematik und Informatik, 2017

M. Ddamulira, C. A. Gomez, F. Luca, *On a problem of Pillai with k-generalised Fibonacci numbers and powers of 2*, `https://doi.org/10.1007/s00605-018-1155-1`, DOI: 10.1007/s00605-018-1155-1

E. Hausenblas, T. Randialasolo, M. Thalhammer, *The stochastic Gray Scott model - existence and uniqueness and its numerical modelling*, submitted.

A. Hinrichs, P. Kritzer, F. Pillichshammer, G.W. Wasilkowski, *Truncation Dimension for Linear Problems on Multivariate Function Spaces*, arXiv:1701.06778 [math.NA].

D. Krieg, D. Rudolf *Recovery algorithms for high-dimensional rank one tensors*, arXiv:1711.03986 [math.NA].

P. Kritzer, G. Leobacher, M. Szölgyenyi, S. Thonhauser, *Approximation methods for piecewise deterministic Markov processes and their costs*, arXiv:1712.09201 [math.PR].

R. Kritzinger, *Finding exact formulas for the L2 discrepancy of digital (0,n,2)-nets via Haar functions*, arXiv:1711.06058 [math.NT].

A. Neuenkirch, M. Szölgyenyi, L. Szpruch, *An adaptive Euler-Maruyama scheme for stochastic differential equations with discontinuous drift and its convergence analysis*, arXiv:1802.04521 [math.NA].

F. Pillichshammer, *Tractability properties of the weighted star discrepancy of regular grids*, arXiv:1710.00573 [math.NA].

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L. Spiegelhofer, *Discrepancy results for the Van der Corput sequence*, arXiv:1710.01560 [math.NT].

V. Temlyakov, *Dispersion of the Fibonacci and the Frolov point sets*, arXiv:1709.08158v2 [math.NA].

V. Temlyakov, *Fixed volume discrepancy in the periodic case*, arXiv:1710.11499v1 [math.NA].

M. Ullrich, *A note on the dispersion of admissible lattices*, arXiv:1710.08694 [cs.CG].

Algorithmic and Enumerative Combinatorics (KSB)

S. A. Abramov, M. Petkovšek, H. Zakrajšek, *Convolutions of Liouvillian Sequences*, arXiv:1803.08747 [cs.SC].

B. Adamczewski, T. Rivoal, *Exceptional values of E-functions at algebraic points*, arXiv:1708.00217 [math.NT].

R. M. Adin, S. Elizalde, Y. Roichman, *Cyclic descents for near-hook and two-row shapes*, arXiv:1801.00044 [math.CO].

M. A. Barkatou, M. Jaroschek, *Desingularization of First Order Linear Difference Systems with Rational Function Coefficients*, arXiv:1802.01150 [cs.SC].

D. Betea, J. Bouttier, P. Nejjar, M. Vuletić, *The free boundary Schur process and applications*, arXiv:1704.05809 [math.PR].

P. Biane, M. Josuat-Vergès, *Noncrossing partitions, Bruhat order and the cluster complex*, arXiv:1801.06078 [math.CO].

A. R. Conway, Anthony J. Guttmann, P. Zinn-Justin, *1324-avoiding permutations revisited*, arXiv:1709.01248 [math.CO].

P. Di Francesco, E. Guitter, *Arctic curves for paths with arbitrary starting points: a tangent method approach*, arXiv:1803.11463 [math-ph].

P. Di Francesco, M. F. Lapa, *Arctic Curves in path models from the Tangent Method*, arXiv:1711.03182 [math-ph].

T. Dreyfus, C. Hardouin, J. Roques, M. F. Singer, *Walks in the quarter plane, genus zero case*, arXiv:1710.02848 [math.CO].

A. Garsia, J. Haglund, J. B. Remmel, M. Yoo, *A proof of the Delta Conjecture when* $q = 0$, arXiv:1710.07078 [math.CO].

M. Giesbrecht, J. Haraldson, G. Labahn, *Computing Lower Rank Approximations of Matrix Polynomials*, arXiv:1712.04007 [cs.SC].

J. S. Kim, M. Yoo, *Hook length property of d-complete posets via q-integrals*, arXiv:1708.09109 [math.CO].

C. Koutschan, T. Thanatipanonda, *A Curious Family of Binomial Determinants That Count Rhombus Tilings of a Holey Hexagon*, arXiv:1709.02616 [math.CO].

H. Mühle, P. Nadeau, *A Poset Structure on the Alternating Group Generated by 3-Cycles*, arXiv:1803.00540 [math.CO].

G. Musiker, T. Roby, *Paths to Understanding Birational Rowmotion on Products of Two Chains*, arXiv:1801.03877 [math.CO].

H. Naruse, S. Okada, *Skew hook formula for d-complete posets*, arXiv:1802.09748 [math.CO].

M. Petkovšek, *Definite Sums as Solutions of Linear Recurrences With Polynomial Coefficients*, arXiv:1804.02964 [cs.SC].

WORKSHOPS

Geometry and Representation Theory (MAB)

D. Adamovic, G. Radobolja, *Self-dual and logarithmic representations of the twisted Heisenberg-Virasoro algebra at level zero*, arXiv:1703.00531 [math.QA].

D. Adamovic, V. G. Kac, P. Moseneder Frajria, P. Papi, O. Perse, *On classification of non-equal rank affine conformal embeddings and applications*, arXiv:1702.06089 [math.RT].

T. Arakawa, C. Jiang, *Coset Vertex Operator Algebras and W-Algebras*, arXiv:1701.06880 [math.RT].

T. Arakawa, C. H. Lam, H. Yamada, *Parafermion vertex operator algebras and W-algebras*, arXiv:1701.06229 [math.RT].

A. Javanpeykar, K. Langlois, R. Terpereau, *Horospherical stacks*, arXiv:1703.00488 [math.RT].

V. G. Kac, M. Wakimoto, *Representations of superconformal algebras and mock theta functions*, arXiv:1701.03344 [math.RT].

A. Moreau, *A remark on Mishchenko-Fomenko algebras and regular sequences*, arXiv:1703.00880 [math.RT].

D. Panyushev, O. Yakimova, *On seaweed subalgebras and meander graphs in type D*, arXiv:1702.07879 [math.RT].

N. Ressayre, *On the tensor semigroup of affine Kac-Moody lie algebras*, arXiv:1701.02176 [math.AG].

Geometric Transport Equations in General Relativity (JAF)

D. Fajman, J. Joudioux, J. Smulevici, *The Stability of the Minkowski space for the Einstein-Vlasov system*, arXiv:1707.06141 [gr-qc].

D. Fajman, J. Joudioux, J. Smulevici, *Sharp asymptotics for small data solutions of the Vlasov-Nordström system in three dimensions*, arXiv: 1704.05353 [math.AP].

H. Lee, E. Nungesser, *Late-time behaviour of the Einstein-Boltzmann system with a positive cosmological constant*, arXiv:1709.05223 [gr-qc].

H. Ringström, *Linear systems of wave equations on cosmological backgrounds with convergent asymptotics*, arXiv:1707.02803 [gr-qc].

Elliptic Hypergeometric Functions in Combinatorics, Integrable Systems and Physics (SKN)

H. Baba, M. Katori, *Excursion Processes Associated with Elliptic Combinatorics*, arXiv:1711.00389v1 [math-ph].

G. Bhatnagar, M. J. Schlosser, *Elliptic well-poised Bailey transforms and lemmas on root systems*, arXiv:1704.00020 [math.CA].

M. Katori, *Elliptic Determinantal Processes and Elliptic Dyson Models*, arXiv:1703.03914v2 [math.PR].

A. P. Kels, M. Yamazaki, *Elliptic hypergeometric sum/integral transformations and supersymmetric lens index*, arXiv:1704.03159 [math-ph].

P. Jefferson, H.-C. Kim, C. Vafa, G. Zafir, *Towards classification of 5d SCFTs: Single gauge node*, arXiv:1704.00020 [math.CA].

N. Joshi, N. Nakazono, *Elliptic Painlevé equations from next-nearest-neighbor translations on the $E_8^{(1)}$ lattice*, arXiv:1703.03498 [math-ph].

A. Zabrodin, A. Zotov, *Self-dual form of Ruijsenaars-Schneider models and ILW equation with discrete Laplacian*, arXiv:1711.01036 [math-ph].

Systematic Approaches to Deep Learning Methods for Audio (DF)

M. Dörfler, T. Grill, R. Bammer, A. Flexer, *Basic Filters for Convolutional Neural Networks Applied to Music: Training or Design?*, arXiv: 11709.02291 [cs.LG].

P. Harar, Z. Galaz, J. B. Alonso-Hernandez, J. Mekyska, R. Burget, Z. Smekal, *Towards Robust Voice Pathology Detection*, Neural Comput & Applic (2018), https://doi.org/10.1007/s00521-018-3464-7.

A. Seigal, G. Montufar, *Mixtures and Products in two Graphical Models*, arXiv: 1709.05276 [stat.ML].

Nonlinear Water Waves - an Interdisciplinary Interface (WHP)

K. R. Khusnutdinova, Y. A. Stepanyants, M. R. Tranter, *Soliton solutions to the fifth-order Korteweg-de Vries equation and their applications to surface and internal water waves*, arXiv: 1801.09035 [physics.flu-dyn].

See also: Physics of Fluids, 30, 022104 (2018), https://doi.org/10.1063/1.5009965, DOI: doi.org/10.1063/1.5009965.

RESEARCH IN TEAMS PROGRAMME (RIT)

H. Bruin, D. Terhesiu, M. Todd, *The pressure function for infinite equilibrium measure*, arXiv:1711.05069 [math.DS].

H. Bruin, D. Terhesiu, M. Todd, *Thermodynamic formalism and inducing for flows.... (working title)*, in progress.

H. Bruin, D. Terhesiu,, *Regular variation and rates of mixing for infinite measure preserving almost Anosov diffeomorphisms*, arXiv:1707.09221 [math.DS].

P. T. Chruściel, G. J. Galloway, L. Nguyen, T.-T. Paetz *On the mass aspect function and positive energy theorems for asymptotically hyperbolic manifolds*, arXiv:1801.03442 [gr-qc].

P. T. Chruściel, E. Delay, P. Klinger, A. Kriegl, P. W. Michor, A. Rainer, *Non-singular space-times with a negative cosmological constant: V. Boson stars*, arXiv:1708.02878 [gr-qc].

P. T. Chruściel, Luc Nguyen, P. Tod, A. Vasy, *Asymptotically flat Einstein-Maxwell fields are inheriting*, arXiv:1802.09915 [math.AP].

A. Compelli, R. Ivanov, M. Todorov, *Hamiltonian models for the propagation of irrotational surface gravity waves over a variable bottom*, accepted in Philosophical Transactions of the Royal Society A.,
http://rsta.royalsocietypublishing.org/content/376/2111/20170091,
DOI 10.1098/rsta.2017.0091, arXiv:1708.06791 [physics.u-dyn].

A. Compelli, *Solitary wave solution of Flat Surface Internal Geophysical Waves with Vorticity*, submitted for publication to the American Institute of Physics (AIP)
arXiv:1708.06653 [physics.u-dyn].

L. Frechette, C. Dellago, P. L. Geissler, *Superlattice phases in cation exchange nanocrystals*, in preparation.

C. I. Martin, *On periodic geophysical water ows with discontinuous vorticity in the equatorial f-plane approximation*
accepted in Philosophical Transactions of the Royal Society A.,
http://rsta.royalsocietypublishing.org/content/376/2111/20170096,
DOI: 10.1098/rsta.2017.0096.

C. Moritz, M. Sega, P. L. Geissler, C. Dellago, *Nucleation mechanisms from transition trajectories in periodic systems at coexistence*, in preparation.

G. M. Rotskoff, P. L. Geissler, *Robust nonequilibrium pathways to microcompartment assembly*, arXiv:1709.00321 [cond-mat.soft].

M.-C. Roehsner, J. A. Kettlewell, T. B. Batalhão, J. F. Fitzsimons, P. Walther, *Quantum advantage for probabilistic one-time programs*, arXiv:1709.09724 [quant-ph].

J. Zeuner, Ioannis Pitsios, S.-H. Tan, A. N. Sharma, J. F. Fitzsimons, R. Osellame, P. Walther *paper under review*

SENIOR RESEARCH FELLOWS PROGRAMME (SRF)

T. Roubíček, U. Stefanelli, *Finite thermoelastoplasticity and creep under small elastic strains*, arXiv:1804.05742 [math.AP], Math. Mech. of Solids, in print.

T. Roubíček, *Seismic waves and earthquakes in a global monolithic model*, arXiv:1703.06267 [math-ph], Cont. Mech. Thermodynam., printed on-line: DOI 10.1007/s00161-018-0636-8.

M.Kružík, T.Roubíček: *Mathematical Methods in Continuum Mechanics of Solids.* Interaction of Mech. and Math. Series, Springer Verlag, Switzerland, to appear 2018.

SIMONS JUNIOR PROFESSOR NILS CARQUEVILLE

N. Carqueville, I. Runkel, G. Schaumann, *Line and surface defects in Reshetikhin-Turaev TQFT*, arXiv:1710.10214 [math.QA].

N. Carqueville, I. Runkel, G. Schaumann, *Orbifolds of n-dimensional defect TQFTs*, arXiv:1705.06085 [math.QA] .

N. Carqueville, I. Runkel, *Introductory lectures on topological quantum field theory*, with I. Runkel, arXiv:1705.05734 [math.QA].

JUNIOR RESEARCH FELLOWS PROGRAMME (JRF)

L. Andersson, A. Y. Burtscher, *On the asymptotic behavior of static perfect fluids*. arXiv:1801.06614 [gr-qc].

M. Manjunath, *Syzygies over the Polytope Semiring*, arXiv:1606.07395 [math.CO].
See also: Journal of the London Mathematical Society **96 (2)**, 482–500, 2017.
`https://doi.org/10.1112/jlms.12065`, DOI: 10.1112/jlms.12065

ESI research in previous years: additional publications and arXiv preprints

The following papers and publications complement the ESI preprints already taken into account in the previous years.

AGS = Measured Group Theory, 2016
ASA = Synergies Maths/Computational QMBP, 2016
ATV = Combinatorics, Geometry, and Physics, 2014
BGS = Minimal Energy Point Sets, 2014
FMS = Nonlinear Flows, 2016
GNV = The Interrelation between Mathematical Physics, Number Theory and Noncommutative Geometry
KRS = Arithmetic Geometry and Automorphic Representations
SLE = Qualitative and numerical aspects of water waves and other interface problems, 2011
TSB = Normal Numbers: Arithmetic, Computational and Probabilistic Aspects, 2016

C. Aistleitner, V. Becher, A.-M. Scheerer, T. A. Slaman, *On the construction of absolutely normal numbers*, arXiv:1707.02628 [math.NT].
See also: Acta Arithmetica 180 (4), 333-346, 2017, TSB.

C. Boutillier, J. Boutillier, G. Chapuy, S. Corteel, S. Ramassamy, *Dimers on rail yard graphs*, arXiv:1504.05176 [math-ph].
See also: Ann. Inst. Henri Poincar Comb. Phys. Interact. 4 (2017), 479-539. https://doi.org/10.4171/AIHPD/46, DOI: 10.4171/AIHPD/46, ATV.

J. Brauchart, P. Grabner, W. Kusner, *Hyperuniform point sets on the sphere: deterministic constructions*, arXiv:1709.02613 [math.CA], BGS.

N. Defenu, A. Trombettoni, I. Nándori, T. Enss, *Nonperturbative renormalization group treatment of amplitude fluctuations for $|\phi^4|$ topological phase transitions*, arXiv:1706.00618 [cond-mat.quant-gas], ASA.

F. Fleißner, *Minimal solutions to generalized Lambda-semiflows and gradient flows in metric spaces*, arXiv:1711.07242 [math.AP], FMS.

F. Fleißner, G. Savaré, *Reverse approximation of gradient flows as Minimizing Movements: a conjecture by De Giorgi*, arXiv:1711.07256 [math.CA], FMS.

Y. Petridis, N. Laaksonen, *On the value distribution of two L-functions*, Funct. Approx. Comment. Math., 58, Number 1 (2018), 43 - 68 https://doi.org/doi:10.7169/facm/1640, DOI: doi:10.7169/facm/1640, KRS.

T. Kano, *Tunamis on a deep open sea and on a gentle sloping beach*, in preparation, SLE.

J. Wildeshaus, *On the intersection motive of certain Shimura varieties: the case of Siegel threefolds*, arXiv:1706.02743 [math.AG], GNV.

J.S. Wilson, *Metric ultraproducts of classical groups*, Arch. Math. (2017) 109: 407. https://doi.org/10.1007/s00013-017-1087-3, DOI: 10.1007/s00013-017-1087-3, AGS.

List of all visitors in 2017

887 scientists have visited the ESI in 2017.

The following codes indicate the association of visitors with specific ESI activities:

ABR = Quantum Physics and Gravity
CBS = Geometry and Relativity
CDS = ESI-CECAM Workshop: Challenges across Large-Scale Biomolecular and Polymer Simulations
DF = Systematic Approaches to Deep Learning Methods for Audio
IS = Individual Scientists
JAF = Geometric Transport Equations in General Relativity
JRF = Junior Research Fellow
KKB = Advances in Birational Geometry
KSB = Algorithmic and Enumerative Combinatorics
MAB = Geometry and Representation Theory
PDG = Tractability of High Dimensional Problems and Discrepancy
RIT = Research in Teams
SJ = ESI-CECAM Workshop: Physics and Chemistry at Fluid/Fluid Interfaces
SKN = Elliptic Hypergeometric Functions in Combinatorics, Integrable Systems and Physics
SRF = Senior Research Fellows
WHP = Nonlinear Water Waves - an Interdisciplinary Interface

Aasen Ailo, SINTEF, Trondheim; 08.12.2017 - 13.12.2017, SJ
Abdelaziz Youssef, LPTMC, Paris; 19.03.2017 - 26.03.2017, SKN; 10.11.2017 - 18.11.2017, KSB
Abhiram Mamandur Kidambi, TU Vienna; 29.05.2017 - 07.07.2017, ABR
Achar Pramod, Louisiana State U; 15.01.2017 - 22.01.2017, MAB
Achet Raphaël, U Grenoble Alpes; 15.01.2017 - 28.01.2017, MAB
Adamović Drazen, U of Zagreb; 19.01.2017 - 27.01.2017, MAN
Adzić Natasa, U Vienna; 21.02.2017 - 24.02.2017, CDS
Aichelburg Peter C., U Vienna; 21.02.2017 - 25.02.2017, JAF; 06.06.2017 - 30.06.2017, ABR
Aigner Florian, U Vienna; 16.10.2017 - 24.11.2017, KSB
Aistleitner Christoph, TU Graz; 19.09.2017 - 21.09.2017, PDG; 25.09.2017 - 26.09.2017, PDG
Aizenbud Avraham, Weizman Institute; 21.01.2017 - 28.01.2017, MAB
Akers Benjamin, Air Force Institute of Technology, Wright-Patterson AFB; 26.11.2017 - 02.12.2017, WHP
Alaee Khangha Aghil, U of Alberta; 15.07.2017 - 21.07.2017, CBS
Albenque Marie, CNRS, Palaiseau; 15.10.2017 - 20.10.2017, KSB
Alexeev Valery, U of Georgia, Athens; 12.05.2017 - 20.05.2017, KKB

Allegra Francesco Alberto, U Rome "La Sapienza"; 15.01.2017 - 27.01.2017, MAB
Almakroudi Adam, Imperial College London; 16.07.2017 - 21.07.2017, CBS
Anden Hans Joakim, Flatiron Institute, New York; 09.09.2017 - 17.09.2017, DF
Alqasemi Kayed, U of Amsterdam; 19.03.2017 - 26.03.2017, SKN
Amann Dominic, RICAM Linz; 27.11.2017 - 01.12.2017, WHP
Ames Ellery, KTH Stockholm; 19.02.2017 - 26.02.2017, JAF
Ammann Bernd, U Regensburg; 24.07.2017 - 24.07.2017, CBS; 28.08.2017 - 01.09.2017, CBS
Anderson Michael, Stony Brook U; 16.07.2017 - 22.07.2017, CBS
Andréasson Hakan, U of Gothenburg; 19.02.2017 - 25.02.2017, JAF; 27.08.2017 - 08.09.2017, CBS
Andricioaei Ioan, U of California; 10.12.2017 - 14.12.2017, SJ
Anselmi Fabio, Italian Institute of Tech, Genova & MIT, Cambridge; 10.09.2017 - 15.09.2017, DF
Arakawa Tomoyuki, Kyoto U; 16.01.2017 - 27.01.2017, MAB
Araneda Bernardo, FAMAF, U Nacional de Córdoba; 12.07.2017 - 21.07.2017, CBS
Ashtekar Abhay, Pennsylvania State U; 19.07.2017 - 09.08.2017, CBS
Asinowski Andrei, TU Vienna; 16.10.2017 - 20.10.2017, KSB; 13.11.2017 - 17.11.2017, KSB
Aspelmeyer Markus, U Vienna; 29.05.2017 - 30.06.2017, ABR
Atai Farrokh, KHT, Stockholm; 19.03.2017 - 25.03.2017, SKN
Athanasiou Nikolaos, U of Oxford; 16.07.2017 - 21.07.2017, CBS
Attems Maximilian, U of Barcelona; 10.06.2017 - 17.06.2017, ABR
Avalos Rodrigo, U Federal da Pariba; 16.07.2017 - 26.07.2017, CBS
Ayyer Arvind, Indian Institute of Science, Bangalore; 12.11.2017 - 23.11.2017, KSB
Baaden Marc, CNRS, Paris; 20.02.2017 - 24.02.2017, CDS
Baaker Lambertus, Vrije U Amsterdam; 26.11.2017 - 07.12.2017, WHP
Bäckdahl Thomas, MPI Potsdam-Golm; 27.08.2017 - 02.09.2017, CBS
Baez Carnargo Agvilor Ana Lucia, U Vienna; 17.07.2017 - 21.07.2017, CBS
Bagchi Arjun, Indian Institute of Technology, Kanpur; 04.06.2017 - 09.06.2017, ABR
Balasin Herbert, TU Vienna; 20.02.2017 - 24.02.2017, JAF; 17.08.2017 - 08.09.2017, CBS
Balke Stefan, International Audiolabs, Erlangen; 10.09.2017 - 16.09.2017, DF
Ballesteros Angel, U of Burgos; 07.06.2017 - 11.06.2017, ABR
Bammer Roswitha, U Vienna; 11.09.2017 - 15.09.2017, DF
Banderier Cyril, LIPN, U Paris Nord; 15.10.2017 - 20.10.2017, KSB; 14.11.2017 - 21.11.2017, KSB
Banlaki Andreas, TU Vienna; 29.05.2017 - 07.07.2017, ABR
Barkatou Moulay, CNRS / U de Limoges; 10.11.2017 - 17.11.2017, KSB
Barrett John, U of Nottingham; 07.06.2017 - 10.06.2017, ABR
Basu Biswajit, Trinity College Dublin; 27.11.2017 - 30.11.2017, WHP; 04.12.2017 - 07.12.2017, WHP
Barzegar Hamed, U Vienna; 20.02.2017 - 24.02.2017, JAF; 17.07.2017 - 21.07.2017, CBS
Batyrev Victor, U Tübingen; 15.01.2017 - 20.01.2017, MAB
Baumann Pierre, U de Strasbourg et CNRS; 15.01.2017 - 22.01.2017, MAB
Baur Karin, U Graz; 16.01.2017 - 20.01.2017, MAB
Bavula Vlad, U Sheffield; 23.01.2017 - 27.01.2017, MAB
Beheshti Shabnam, Queen Mary U of London; 20.02.2017 - 24.02.2017, JAF
Behrend Roger, Cardiff U; 13.11.2017 - 24.11.2017, KSB
Beig Robert, U Vienna; 22.02.2017 - 24.02.2017, JAF; 17.07.2017 - 01.09.2017, CBS
Benito Angelica, U Autónoma da Madrid; 27.05.2017 - 04.06.2017, IS
Benjamin Ilan, U of California; 07.12.2017 - 14.12.2017, SJ
Benkel Robert, U of Nottingham; 16.07.2017 - 23.07.2017, CBS
Berger Beverly, Rochester Institute of Technology; 27.08.2017 - 29.08.2017, CBS
Bernardara Marcello, U Paul Sabatier, Toulouse; 14.05.2017 - 19.05.2017, KKB
Bernard Denis, CNRS Paris; 16.06.2017 - 18.06.2017, SAB

Bernuzzi Sebastiano, U Parma & INFN; 28.08.2017 - 01.09.2017, CBS
Bhatnagar Gaurav, U Vienna; 20.03.2017 - 25.03.2017, SKN; 16.10.2017 - 24.11.2017, KSB
Bianco Valentino, U Vienna; 21.02.2017 - 24.02.2017, CDS
Bieri Lydia, U of Michigan; 26.08.2017 - 02.09.2017, CBS
Bilyk Dmitriy, U of Minnesota; 24.09.2017 - 28.09.2017, PDG
Bittmann Léa, U Paris-Diderot; 15.01.2017 - 20.01.2017, MAB
Bizoń Piotr, Jagiellonian U, Krakow ; 19.02.2017 - 25.02.2017, JAF; 16.08.2017 - 31.08.2017, CBS
Bizouard Marie Anne, LAL - CNRS/IN2P3, U Paris Sud; 16.07.2017 - 20.07.2017, CBS
Blanc Anthony, MPI Bonn; 26.04.2017 - 02.05.2017, KKB
Blatt Simon, U Salzburg; 23.07.2017 - 28.07.2017, CBS
Blue Pieter, U of Edinburgh; 19.02.2017 - 23.02.2017, JAF
Böck Sebastian, TU Vienna; 11.09.2017 - 15.09.2017, DF
Boehning Christian, U of Warwick; 29.04.2017 - 07.05.2017, KKB
Bokhove Onno, U of Leeds; 26.11.2017 - 01.12.2017, WHP
Bolhuis Peter, U of Amsterdam; 21.02.2017 - 23.02.2017, CDS
Bombacigno Flavio, U di Roma ”La Sapienza”; 16.07.2017 - 21.07.2017, CBS
Bondal Alexey, Steklov Mathematical Institute, Moscow; 30.04.2017 - 09.04.2017, KKB
Borda Bence, Renyi Institute, Budapest; 25.09.2017 - 29.09.2017, PDG
Boresch Stefan, U Vienna; 21.02.2017 - 24.02.2017, CDS
Stefano Borghini, U di Trento; 16.07.2017 - 28.07.2017, CBS; 27.08.2017 - 01.09.2017, CBS
Borinsky Michael, Humboldt U, Berlin; 15.10.2017 - 03.11.2017, KSB
Bostan Alin, INRIA, Palaiseau; 10.11.2017 - 17.11.2017, KSB
Bouayad Alexandre, U of Cambridge; 23.01.2017 - 30.01.2017, MAB
Bousquet-Mélou Mireille, CNRS, U de Bordeaux ; 15.10.2017 - 22.10.2017, KSB
Bouttier Jérémie, ENS de Lyon; 15.10.2017 - 20.10.2017, KSB; 28.10.2017 - 05.11.2017, KSB
Branding Volker, U Vienna; 17.07.2017 - 08.09.2017, CBS
Brauchart Johann, TU Graz; 11.09.2017 - 11.10.2017, PDG
Bray Hubert, Duke U, Durham; 16.08.2017 - 23.08.2017, CBS
Brenier Yann, CNRS, Palaiseau; 16.02.2017 - 25.02.2017, JAF
Broadhurst David, Open U, Milton Keynes; 15.10.2017 - 24.11.2017, KSB
Brown Morgan, U of Miami; 13.05.2017 - 25.05.2017, KKB
Bruin Henk, U Vienna; 19.06.2017 - 18.07.2017, RiT
Brukner Caslav, Institute for Quantum Optics and Quantum Information, Vienna; 29.05.2017 - 30.05.2017, ABR; 14.06.2017 - 27.06.2017, ABR
Brünner Frederic, TU Vienna; 20.03.2017 - 22.02.2017, SKN
Buchacher Manfred, JKU Linz; 13.11.2017 - 17.11.2017, KSB
Buffoni Boris, EPFL, Lausanne; 03.12.2017 - 08.12.2017, WHP
Bulois Michaël, U Saint-Etienne; 14.01.2017 - 21.01.2017, MAB; Bunao Joseph Raphael R., Ateneo de Manila U, Quezon City; 08.07.2017 - 22.07.2017, CBS
Burde Dietrich, U Vienna; 20.06.2017 - 23.06.2017, ABR
Burić Maja, U of Belgrade; 07.06.2017 - 10.06.2017, ABR
Burkhart Madeleine, U of Washington; 16.07.2017 - 29.07.2017, CBS
Burtscher Annegret, U Bonn; 19.02.2017 - 24.02.2017, JAF; 16.07.2017 - 19.08.2017, JRF
Cabrera Pacheco Armando, U of Connecticut/ U of Tübingen; 16.07.2017 - 30.07.2017, CBS
Calligari Paolo, U Padova; 21.02.2017 - 21.02.2017, CDS
Calogero Simone, Chalmers U of Technology; 19.02.2017 - 25.02.2017, JAF
Campos Lissa, Cidade U; 16.07.2017 - 28.07.2017, CBS
Canepa Giovanni, U of Zurich; 16.07.2017 - 22.07.2017, CBS
Cap Andreas, U Vienna; 08.07.2017 - 08.09.2017, CBS

Capoferri Matteo, U College London; 16.07.2017 - 22.07.2017, CBS
Capone Barbara, U Vienna; 20.02.2017 - 24.02.2017, CDS
Cardenas Marcela, APC CNRS, Paris; 11.06.2017 - 16.06.2017, ABR
Cardelli Chiara, U Vienna; 22.02.2017 - 24.02.2017, CDS
Cardona Jorge Eduordo, U of Miami; 16.07.2017 - 26.07.2017, CBS
Carlotto Alessandro, ETH Zurich; 16.07.2017 - 29.07.2017, CBS; 27.08.2017 - 08.09.2017, CBS
Carpentier Sylvain, MIT; 15.01.2017 - 26.01.2017, MAB
Carr Magda, U of St. Andrews; 27.11.2017 - 02.12.2017, WHP
Carranza Ortiz Diego Antonio, Queen Mary U of London; 16.07.2017 - 23.07.2017, CBS
Casbi Elie, ENS Paris; 15.01.2017 - 28.01.2017, MAB
Cederbaum Clara, U Tübingen; 17.08.2017 - 05.09.2017, CBS
Chakraborty Saikat, Indian Institute of Technology, Kanpur; 14.07.2017 - 21.07.2017, CBS
Chapuy Guillaume, CNRS & IRIF U Paris Diderot; 15.10.2017 - 21.10.2017, KSB
Chau Nguyen, MPI Dresden; 11.06.2017 - 16.06.2017, ABR
Chebaro Yassmine, CNRS, Paris; 20.02.2017 - 26.02.2017, CDS
Cheltsov Ivan, U of Edinburgh; 14.05.2017 - 20.05.2017, KKB
Chen William, Macquarie U; 18.09.2017 - 29.09.2017, PDG
Chhaibi Reda, U Paul Sabatier; 15.01.2017 - 21.01.2017, MAB
Chicherin Dmitri, Johannes Gutenberg U, Mainz; 19.03.2017 - 24.03.2017, SKN
Chihara Masahiro, Kyoto U; 15.01.2017 - 27.01.2017, MAB
Chiu Christopher, U Vienna; 29.05.2017 - 03.06.2017, IS
Chodosh Otis, Princeton U; 26.08.2017 - 08.09.2017, CBS
Choi Wooyoung, New Jersey Inst. of Technology (NJIT) &U Heights; 26.11.2017 - 02.12.2017, WHP
Chowdhury Abhishek, TU Vienna; 29.05.2017 - 07.07.2017, ABR
Chrusciel Piotr, U Vienna; 20.02.2017 - 24.02.2017, JAF; 03.06.2017 - 30.06.2017, ABR
Chyzak Frédéric, INRIA Saclay Île France; 07.11.2017 - 17.11.2017, KSB
Collet Gwendal, TU Vienna; 16.10.2017 - 20.10.2017, KSB
Colliot-Thelene Jean-Louis, U Paris Sud; 23.04.2017 - 30.04.2017, KKB
Coluzza Ivan, U Vienna; 21.02.2017 - 24.02.2017, CDS
Compelli Alan, Dublin Institute of Technology ; 09.04.2017 - 16.06.2017, RIT
Corvino Justin, Lafayette College; 15.07.2017 - 29.07.2017, CBS
Costa Fabio, U Queensland; 12.06.2017 - 16.06.2017, ABR
Costa Joán, Isbon U Institute - ISCRE/CAMGSD; 19.02.2017 - 25.02.2017, JAF
Cox Sonja, U of Amsterdam; 08.10.2017 - 13.10.2017, PDG
Cristea Ligia-Loretta, U Graz; 24.09.2017 - 29.09.2017, PDG
Cvetic Miriam, U of Pennsylvania; 17.06.2017 - 18.06.2017, SAB
Dafermos Mihalis, U of Cambridge/Princeton U; 20.02.2017 - 24.02.2017, IS; 27.08.2017 - 01.09.2017, CBS
Dahl Mattias, KTH Royal Institute of Technology, Stockholm; 23.07.2017 - 05.08.2017, CBS; 14.08.2017 - 08.09.2017, CBS
Dahlke Stephan, Philipps-U, Marburg; 08.10.2017 - 13.10.2017, PDG
Daurenbek Bazarkhanov, Institute of Mathematics and Mathematical Modeling, Almaty; 08.10.2017 - 14.10.2017, PDG
Ddamulira Mahadi, TU Graz; 20.09.2017 - 30.09.2017, PDG;
Deconinck Bernard, U of Washington; 21.11.2017 - 07.12.2017, WHP
de Groot Bert, MPI Göttingen; 21.02.2017 - 24.02.2017, CDS
Dekimpe Karel, KU Leuven; 19.06.2017 - 23.06.2017, IS
Delay Erwann, U of Avignon; 01.09.2017 - 08.09.2017, CBS
Deleforge Antoine, INRIA Rennes; 10.09.2017 - 15.09.2017, DF

De Llano Elisa, Austrian Institute of Technology; 21.02.2017 - 24.02.2017, CDS
Dereich Steffen, Westfälische Wilhelms-U Münster; 08.10.2017 - 13.10.2017, PDG
Derkachev Sergei, Steklov Mathematical Institute, St. Petersburg; 19.03.2017 - 25.03.2017, SKN
Deshpande Tanmay, Tata Institute of Fundamental Research, Mumbai; 15.01.2017 - 27.01.2017, MAB
De Sole Alberto, U of Rome "La Sapienza"; 22.01.2017 - 24.01.2017, MAB
Dharan Nadiv, Ben-Guvion U of the Negev; 20.02.2017 - 24.02.2017, CDS
Díaz Saloana Alberto Isaac, U de Guanajuato; 14.07.2017 - 24.07.2017, CBS
Dias Soeiro Codeiro Maria Natalia, U of Porto; 10.12.2017 - 13.12.2017, SJ
Dick Josef, The U of New South Wales, Sydney; 24.09.2017 - 28.09.2017, PDG
Dieleman Sander, Deepmind, London; 10.09.2017 - 15.09.2017, DF
Diemer Colin, IHES, Bures-sur-Yvette; 12.04.2017 - 16.04.2017, KKB
Di Francesco Philippe, CEA Saclay IPHT; 12.11.2017 - 17.11.2017, KSB
Di Gioia Federico, U of Roma "La Sapienza"; 16.07.2017 - 22.07.2017, CBS
Dimitrov George, International Cebtre for Theoretical Physics, Trieste; 01.05.2017 - 07.05.2017, KKB; 15.05.2017 - 21.05.2017, KKB
Doak Alexander, U College London; 26.11.2017 - 02.12.2017, WHP
Doerr Benjamin, École polytechnique, Palaiseau; 24.09.2017 - 29.09.2017, PDG
Dolbeault Jean, U Paris IX Dauphine, CEREMADE; 20.02.2017 - 24.02.2017, JAF
Dominici Diego, SUNY; 16.10.2017 - 28.10.2017, KSB; 13.11.2017 - 17.11.2017, KSB
Donninger Roland, U Vienna; 01.08.2017 - 31.08.2017, CBS
Dorfer Matthias, JKU Linz; 10.09.2017 - 15.09.2017, DF
Dörfler Monika, U Vienna, NUHAG; 11.09.2017 - 15.09.2017, DF
Doye Jonathan, U of Oxford; 21.02.2017 - 24.02.2017, CDS
Dreyfus Thomas, U Strasbourg; 15.10.2017 - 22.10.2017, KSB
Drmota Michael, TU Vienna; 17.10.2017 - 18.10.2017, KSB; 13.11.2017 - 17.11.2017, KSB
Duboué-Dijon Elise, IOCB & Czech Academy of Science; 10.12.2017 - 13.12.2017, SJ
Dung Dinh, Vietnam National U; 06.10.2017 - 12.10.2017, PDG
Durand Simon, Spotify LTD, London; 10.09.2017 - 15.09.2017, DF
Durhuus Bergfinnur, U of Copenhagen; 08.06.2017 - 10.06.2017, ABR
Eberhardt Jens, Mathematisches Institut Freiburg; 15.01.2017 - 28.01.2017, MAB
Edwards Karen, Harvard U; 18.11.2017 - 25.11.2017, IS
Efimov Alexander, Steklov Mathematical Institute, Moscow; 05.05.2017 - 20.05.2017, KKB
Ehler Martin, U Vienna; 25.09.2017 - 13.10.2017, PDG
Ehrnström Mats, Norwegian U of Science and Tecnology (NTNU); 03.12.2017 - 07.12.2017, WHP
Eichmair Michael, U Vienna; 17.07.2017 - 08.09.2017, CBS
Eigenschink Peter, U Vienna; 20.02.2017 - 24.02.2017, JAF
Elagin Alexey, IITP Ras/Kharkevich Institute, Moscow; 01.05.2017 - 11.05.2017, KKB
Elber Ron, U of Texas at Austin; 20.02.2017 - 26.02.2017, CDS
Elizalde Sergi, Dartmouth College, Hanover, USA; 15.10.2017 - 21.10.2017, KSB
Emparan Roberto, U Barcelona & ICREA; 05.06.2017 - 10.06.2017, ABR
Enders Sabine, KIT, Karlsruhe; 10.12.2017 - 13.12.2017, SJ
Entova-Aizenbud Inna, Ben Gurion U; 15.01.2017 - 28.01.2017, MAB
Escobar Diaz Leon Dario, U of Tübingen; 17.07.2017 - 22.07.2017, CBS
Etingof Pavel, MIT; 15.01.2017 - 18.01.2017, MAB
Fábián Balázs, Budapest U of Technology and Economics & U Bourgogne - Franche-Comté; 08.12.2017 - 14.12.2017, SJ
Faccioli Pietro, U Trento; 21.02.2017 - 24.02.2017, CDS
Fajman David, U Vienna; 20.02.2017 - 24.02.2017, JAF; 17.07.2017 - 08.09.2017, CBS
Fang Wenjie, TU Graz; 16.10.2017 - 20.10.2017, KSB

Favero David, U of Alberta; 11.04.2017 - 27.05.2017, KKB
Fedele Laura, U of Rome “La Sapienza”; 15.01.2017 - 27.01.2017, MAB
Fehrenbach Axel, U of Tübingen; 16.07.2017 - 22.07.2017, CBS
Feichtinger Hans, U Vienna; 25.09.2017 - 13.10.2017, PDG
Feldbauer Roman, OFAI, Vienna; 11.09.2017 - 15.09.2017, DF
Fezenchuk Ivan, Uzhgorod Natrional U; 22.11.2017 - 06.12.2017, IS
Ficek Filip, Jagiellonian U, Kraków; 16.07.2017 - 22.07.2017, CBS
Filion Laura, Utrecht U; 10.12.2017 - 14.12.2017, SJ
Fischer Ilse, U Vienna; 16.10.2017 - 24.11.2017, KSB
Fischer Johann, BOKU Vienna; 11.12.2017 - 13.12.2017, SJ
Fischer Simon-Raphael, LMU Munich; 16.07.2017 - 21.07.2017, CBS
Fitzsimons Joseph, National U of Singapore; 15.06.2017 - 15.07.2017, RiT
Flandera Alés, Charles U; 22.07.2017 - 15.07.2017, CBS
Flexer Arthur, OFAI, Vienna; 11.09.2017 - 15.09.2017, DF
Foda Omar, U of Melbourne; 19.03.2017 - 02.04.2017, SKN
Fogagnolo Mattia, U degli studi di Trento; 16.07.2017 - 22.07.2017, CBS
Fomin Oleksiy, Uzghorod National U; 22.11.2017 - 06.12.2017, IS
Freddolino Peter, U of Michigan, Ann Arbor; 21.02.2017 - 24.02.2017, CDS
Fredenhagen Stefan, U Vienna; 02.06.2017 - 13.07.2017, ABR
Frenkler Joachim, U Bayreuth; 19.02.2017 - 24.02.2017, JAF
Frezza Elisa, U Lyon 1; 20.02.2017 - 25.02.2017, CDS
Friedrich Alexander, U Potsdam; 16.07.2017 - 29.07.2017, CBS
Friedrich Helmut, MPI Potsdam; 19.02.2017 - 24.02.2017, JAF; 23.07.2017 - 29.07.2017, CBS; 16.08.2017 - 05.09.2017, CBS
Fu Shishuo, Chongqing U, China; 15.10.2017 - 21.10.2017, KSB
Fuentealba Oscar, Centro de Estudios Cientiticos, Valdivia; 11.06.2017 - 03.07.2017, ABR
Fuentes Guridi Ivette, U Vienna; 19.06.2017 - 23.06.2017, ABR
Fufa Samuel Asefa, Addis Ababa U; 13.11.2017 - 18.11.2017, KSB
Fujita Ryo, Kyoto U; 15.01.2017 - 28.01.2017, MAB
Fusy Eric, Lix, Ecole Polytechnique, Palaiseau; 15.10.2017 - 20.10.2017, KSB
Gahramanov Ilmar, MPI Potsdam; 19.03.2017 - 25.03.2017, SKN
Gaitsgory Dennis, Harvard U; 15.01.2017 - 29.01.2017, MAB
Galáz Zoltán, Brno U of Technology; 11.09.2017 - 16.09.2017, DF
Galeano Rios Carlos Antonio, U of Bath; 26.11.2017 - 03.12.2017, WHP
Galkin Sergey, National Research U, Moscow; 24.04.2017 - 24.05.2017, KKB
Gallagher Christopher, Queen Mary U of London; 16.07.2017 - 20.07.2017, CBS
Galleas Wellington, ETH Zurich; 19.03.2017 - 25.03.2017, SKN
Galloway Gregory J., U of Miami; 16.07.2017 - 24.07.2017, CBS; 24.07.2017 - 20.08.2017, CBS
Ganev Iordan, IST Austria; 16.01.2017 - 27.01.2017, MAB
Gao Tao, U of Bath; 26.11.2017 - 01.12.2017, WHP
Garcia Angel E., Los Alamos National Laboratory; 20.02.2017 - 25.02.2017, CDS
Garcia-Parrado Gómez-Lobo Alfonso, Basque Country U, Bilbao; 19.02.2017 - 25.02.2017, JAF
Gardini Matteo, U of Rome La Sapienza; 15.01.2017 - 28.01.2017, MAB
Garon Arthur, U Vienna; 21.02.2017 - 24.02.2017, CDS
Gary Mirah, TU Vienna; 29.05.2017 - 23.06.2017, ABR
Gasperin Garcia Edgar, Queen Mary U of London; 19.02.2017 - 25.02.2017, JAF; 17.07.2017 - 21.07.2017, CBS
Gastegger Michael, U Vienna; 11.09.2017 - 15.09.2017, DF
Gaunt James, U of Nottingham; 07.06.2017 - 10.06.2017, ABR

Gaussent Stephane, U Jean Monnet Saint-Etienne; 22.01.2017 - 28.01.2017, MAB
Geiss Christel, U of Jyväskylä, Finland; 08.10.2017 - 15.10.2017, PDG
Geiss Stefan, U of Jyväskylä, Finland; 08.10.2017 - 15.10.2017, PDG
Geissler Phillip, U of California, Berkeley; 01.02.2017 - 10.05.2017, RIT
Genra Naoki, Kyoto U; 15.01.2017 - 29.01.2017, MAB
Geyer Anna, Delft U of Technology; 03.12.2017 - 08.12.2017, WHP
Ghanem Sari, MFO, Oberwolfach; 28.08.2017 - 02.09.2017, CBS
Giddings Steven B., U of California; 11.06.2017 - 15.06.2017, ABR
Giesbrecht Mark, U of Waterloo; 12.11.2017 - 18.11.2017, KSB
Gilbert Alexander, U of New South Wales (UNSW); 01.10.2017 - 15.10.2017, PDG
Giles Michael, Oxford U; 24.09.2017 - 29.09.2017, PDG
Gillessen Stefan, MPE Garching; 21.07.2017 - 21.07.2017, CBS
Giorgi Elena, Columbia U; 16.07.2017 - 21.07.2017, CBS; 27.08.2017 - 02.09.2017, CBS
Giri Amal Kant, U of Porto; 10.12.2017 - 12.12.2017, SJ
Giulini Domenico, Leibniz U of Hannover; 06.06.2017 - 09.06.2017, ABR
Gkiokas Aggelos, RIC Athens; 10.09.2017 - 16.09.2017, DF
Glaser Lisa, Radboud-U Nijmegen; 07.06.2017 - 10.06.2017, ABR
Glöckle Jonatan, U Regensburg; 16.07.2017 - 21.07.2017, CBS
Gnewuch Michael, Christian-Albrechts-U zu Kiel; 02.10.2017 - 13.10.2017, PDG
Goda Takashi, U of Tokyo; 24.09.2017 - 30.09.2017, PDG
Goethe Martin, U of Barcelona; 20.02.2017 - 24.02.2017, CDS
Goodwin Simon, U of Birmingham; 18.01.2017 - 28.01.2017, MAB
Görbe Tamás, U of Szeged; 20.03.2017 - 24.03.2017, SKN
Gorelik Maria, Weizmann Institute of Science; 15.01.2017 - 28.01.2017, MAB
Grabner Peter, TU Graz; 19.09.2017 - 19.09.2017, PDG; 26.09.2017 - 28.09.2017, PDG
Graf Melanie, U of Vienna; 20.02.2017 - 24.02.2017, JAF; 17.07.2017 - 28.07.2017, CBS
Graf Oliver, U Pierre et Marie Curie, Paris; 16.07.2017 - 21.07.2017, CBS
Grant James, U Surrey; 22.02.2017 - 26.02.2017, JAF; 24.07.2017 - 08.09.2017, CBS
Greenberger Daniel, City College of New York; 13.06.2017 - 11.07.2017, ABR
Griffiths Phillip, Institute for Advanced Study, Princeton; 06.05.2017 - 14.05.2017, KKB
Grill Thomas, OFAI, Vienna & U of Music; 11.09.2017 - 15.09.2017, DF
Gröchenig Karlheinz, U Vienna; 25.09.2017 - 05.10.2017, PDG
Grosse Harald, U Vienna; 20.03.2017 - 25.03.2017, SKN; 29.05.2017 - 06.07.2017, ABR
Groves Mark, U des Saarlandes, Saarbrücken; 03.12.2017 - 07.12.2017, WHP
Grubmüller Helmut, MPI Göttingen; 21.02.2017 - 24.02.2017, CDS
Grumiller Daniel, TU Vienna; 30.05.2017 - 23.06.2017, ABR; 10.07.2017 - 14.07.2017, ABR
Grundy Dane, U of East Anglia, Norwich; 25.11.2017 - 02.12.2017, WHP
Guérin Philippe Allard, U Vienna; 17.07.2017 - 21.07.2017, CBS
Gulin Luka, U of Zagreb; 16.07.2017 - 22.07.2017, CBS
Gundlach Carsten, U of Southampton; 19.02.2017 - 25.02.2017, JAF
Guo Ting, Hunan Normal U; 16.10.2017 - 24.11.2017, KSB
Güssregen Stefan, Sanofi; 20.02.2017 - 24.02.2017, CDS
Guttmann Anthony, U of Melbourne; 15.10.2017 - 28.10.2017, KSB
Guyenne Philippe, U of Delaware, Newark; 26.11.2017 - 02.12.2017, WHP
Hadzic Mahir, King's College London; 18.02.2017 - 25.02.2017, JAF
Haglund James, U of Pennsylvenia; 14.10.2017 - 21.10.2017, KSB
Haiden Fabian, Harvard U; 09.05.2017 - 26.05.2017, KKB
Halacheva Iva, Lancaster U; 22.01.2017 - 28.01.2017, MAB
Hallnäs Martin, Chalmers U/ U of Gothenburg; 19.03.2017 - 25.03.2017, SKN

Haragus Larger Mariana, U de Franche-Comté, Besançon; 03.12.2017 - 08.12.2017, WHP
Harar Pavol, Brno U of Technology; 11.09.2017 - 16.09.2017, DF
Harder Andrew, U of Miami; 01.05.2017 - 20.05.2017, KKB
Harvie Brian, U of California, Davis; 15.07.2017 - 30.07.2017, CBS
Hernandez David, U Paris-Diderot; 15.01.2017 - 20.01.2017, MAB
Harris Sarah, Queen Mary U, London; 21.02.2017 - 24.02.2017, CDS
Hatefi Ehsan, TU Vienna; 08.06.2017 - 20.06.2017, ABR
Hausenblas Erika, Montan U Leoben; 09.10.2017 - 13.10.2017, PDG
Hauser Tamás, IST Austria; 05.05.2017 - 05.05.2017, KBB
Haziot Susanna, U Vienna; 27.11.2017 - 07.12.2017, WHP; 20.01.2017 - 23.03.2017, AHM
Hefter Mario, Johan Radon Institute, Linz; 04.10.2017 - 13.10.2017, PDG
Heluani Reimundo, IMPA, Rio de Janeiro; 16.01.2017 - 28.01.2017, MAB
Henao Aristizabal Andres, U Paderborn; 09.12.2017 - 13.12.2017, SJ
Henry David, U College Cork; 30.11.2017 - 10.12.2017, WHP
Hérbert Auguste, U Jean Monnet Saint-Etienne; 15.01.2017 - 27.01.2017, MAB
Herscovich Ramoneda Estanislo, U Grenoble Alpes; 16.01.2017 - 22.01.2017, MAB
Hesse Kerstin, Paderborn U; 16.09.2017 - 24.09.2017, PDG
Hietala Linnea, U of Gothenburg; 17.03.2017 - 24.03.2017, SKN
Hinrichs Aicke, JKU Linz; 13.09.2017 - 20.09.2017, PDG; 24.09.2017 - 14.10.2017, PDG
Holden Helge, Norwegian U of Science and Technology, Trondheim; 16.06.2017 - 18.06.2017, SAB
Holighaus Nicki, Acoustics Research Institute, Vienna; 11.09.2017 - 16.09.2017, DF
Holy Daniel, Czech Academy of Science, Prague; 10.12.2017 - 13.12.2017, SJ
Holzapfel Andre, KTH Stockholm; 06.09.2017 - 17.09.2017, DF
Höngesberg Hans, U Vienna; 16.10.2017 - 24.11.2017, KSB
Hoque SK Jahnur, The Institute of Mathematical Science, Chennai, India; 15.07.2017 - 29.07.2017, CBS
Horinek Dominik, U Regensburg; 10.12.2017 - 13.12.2017, SJ
Horja Richard Paul, U of Miami; 15.05.2017 - 25.05.2017, KKB
Hörzinger Michael, U Vienna; 20.02.2017 - 24.02.2017, JAF
Hörzinger Michael, U Vienna; 17.07.2017 - 08.09.2017, CBS
Hoyt Crystal, Weizmann Institut; 22.01.2017 - 27.01.2017, MAB
Hrechanyk Ivan, National U of “Kyiv-Mokyla Academy”; 01.06.2017 - 14.06.2017, ABR
Huang Lan-Hsuan, U of Connecticut; 30.06.2017 - 31.07.2017, CBS
Huang Ying, U of Surrey, Guildford; 26.11.2017 - 01.12.2017, WHP
Huber Albert, TU Vienna; 17.07.2017 - 21.07.2017, CBS
Huisken Gerhard, U Tübingen; 23.07.2017 - 28.07.2017, CBS
Hummer Gerhard, MPI, Frankfurt; 20.02.2017 - 22.02.2017, CDS
Huneau Cecile, U Grenoble Alpes; 27.08.2017 - 30.08.2017, CBS
Hur Vera Mikyoung, U of Illinois at Urbana-Champaign; 03.12.2017 - 07.12.2017, WHP
Husa Sascha, U of the Balearic Islands, Palma de Mallorca; 18.12.2017 - 20.12.2017, IS
Huybrechts Daniel, U Bonn; 23.04.2017 - 05.05.2017, KKB; 16.06.2017 - 18.06.2017, SAB
Hwang Hsien-Kuei, Academy Sinica; 16.10.2017 - 24.10.2017, KSB
Ikeda Noriaki, Ritsumeikan U, Kusatsu; 08.02.2017 - 18.02.2017, IS
Ilmanen Tom, ETH Zurich; 21.08.2017 - 08.09.2017, CBS
Im Wonpil, Lehigh U, Bethlehem, USA; 20.02.2017 - 26.02.2017, CDS
Ionescu-Kruse Delia, Institute of Mathematics of the Romanian Academy, Bucharest; 03.12.2017 - 08.12.2017, WHP
Isenberg James, U of Oregon; 11.08.2017 - 19.08.2017, CBS
Itkin Igor, Ariel U, Bat Yam; 16.07.2017 - 23.07.2017, CBS

Ito Masahiko, Tokyo Denki U; 20.03.2017 - 24.03.2017, SKN; Ivanov Rossen, Dublin Institute of Technology; 09.04.2017 - 11.06.2017, RIT
Jahns Sophia, U Tübingen; 16.07.2017 - 28.07.2017, CBS; 28.08.2017 - 01.09.2017, CBS
Jalali Anahid, TU Vienna; 11.09.2017 - 15.09.2017, DF
Jang Hyun Chul, U of Connecticut; 16.07.2017 - 29.07.2017, CBS
Jankowiak Gaspard, U Vienna; 11.09.2017 - 11.09.2017, DF
Jaramillo José Luis, IMB, Bourgogne; 27.08.2017 - 01.09.2017, CBS
Jaroschek Maximilian, Tu Vienna; 13.11.2017 - 17.11.2017, KSB
Jauregui Jeffrey, Union College, Schenectady; 16.07.2017 - 21.07.2017, CBS
Jedlovszky Pal, Esterházy Károly U; 10.12.2017 - 13.12.2017, SJ
Jefremov Pavel, ZARM/U Bremen; 16.07.2017 - 23.07.2017, CBS
Jensen Lars Thorge, MPI Bonn; 13.01.2017 - 20.01.2017, MAB
Jentzen Arnulf, ETH Zurich; 12.10.2017 - 13.10.2017, PDG
Jezierski Jacek, U of Warsaw; 29.07.2017 - 19.08.2017, CBS
Johne Florian, Eberhard-Karls U Tübingen; 17.07.2017 - 29.07.2017, CBS
Jonsson Thordur, U. of Iceland; 07.06.2017 - 10.06.2017, ABR
Jordan David, U of Edinburgh; 05.11.2017 - 12.11.2017, IS
Jorge Miguel, U of Strath Clyde; 10.12.2017 - 14.12.2017, SJ
Josuat-Vergès Matthieu, U Paris-est Marne-la-Vallie; 15.10.2017 - 29.10.2017, KSB
Joudioux Jérémie, U Vienna; 20.02.2017 - 24.02.2017, JAF; 17.07.2017 - 31.08.2017, CBS
Jungwirth Pavel, Czech Academy of Science; 10.12.2017 - 12.12.2017, SJ
Juteau Daniel, CNRS/U Paris 7 Diderot; 14.01.2017 - 21.01.2017, MAB
Kac Victor, MIT; 22.01.2017 - 30.01.2017, MAB
Kalmynin Aleksandr, National Research U, Moscow; 19.03.2017 - 25.03.2017, SKN
Kalimeris Konstantinos, U of Cambridge; 26.11.2017 - 08.12.2017, WHP
Kamenova Ljudmila, Stony Brook U; 14.05.2017 - 20.05.2017, KKB
Kang Mihyun, TU Graz; 15.10.2017 - 17.11.2017, KSB
Kanstrup Tina, Hausdorff Center for Mathematics, Bonn; 15.01.2017 - 28.01.2017, MAB
Kapouleas Nicolaos, Brown U; 23.07.2017 - 29.07.2017, CBS
Karzhemanov Ilya, Moscow Institute of Physics and Technology; 15.05.2017 - 25.05.2017, KKB
Kasevich Mark, Stanford U; 29.06.2017 - 01.07.2017, ABR
Katori Makoto, Chuo U, Tokyo; 19.03.2017 - 25.03.2017, SKN
Katzarkov Ludmil, U Vienna; 06.04.2017 - 26.05.2017, KKB
Kauers Manuel, JKU Linz; 12.11.2017 - 15.11.2017, KSB
Kawanoue Hiraku, Kyoto U; 27.05.2017 - 04.06.2017, IS
Kawasetsu Kazuya, Academia Sinica, Taipei; 15.01.2017 - 28.01.2017, MAB
Kehle Christoph, U of Cambridge; 16.07.2017 - 21.07.2017, CBS
Kekic Tadija, Austrian Institut of Technology (AIT); 21.02.2017 - 24.02.2017, CDS
Kels Andrew, U of Tokyo; 19.03.2017 - 27.03.2017, SKN
Kerr Gabriel, Kansas State U, Manhattan; 14.05.2017 - 20.05.2017, KKB
Keum Jong Hae, Korea Institute for Advanced Study, Seoul; 14.05.2017 - 19.05.2017, KKB
Khan Kamran, Aligarh Muslim U; 16.07.2017 - 23.07.2017, CBS
Khedr Abeer, U College London; 09.12.2017 - 13.12.2017, SJ
Khuri Marcus, Stony Brook U; 30.07.2017 - 10.08.2017, CBS
Khusnutdinova Karima, Loughborough U; 26.11.2017 - 02.12.2017, WHP
Kiefer Claus, U Cologne; 11.06.2017 - 17.06.2017, ABR
Kijowski Jerzy, Polish Academy of Sciences, Warszawa; 17.08.2017 - 19.08.2017, IS
Kim Hee Cheol, Harvard U; 21.03.2017 - 26.03.2017, SKN
Kim Jang Soo, Sungkyunkwan U, Korea; 15.10.2017 - 28.10.2017, KSB

Klinger Paul, U Vienna; 20.02.2017 - 24.02.2017, JAF; 17.07.2017 - 08.09.2017, CBS
Kliukin Dmytro, National U of Kyiv-Mohyla Academy; 01.06.2017 - 14.06.2017, ABR
Klozova Eliska, Carles U; 15.07.2017 - 22.07.2017, CBS
Kluczek Mateusz, U College Cork; 03.12.2017 - 09.12.2017, WHP
Knapp Johanna, TU Vienna; 03.04.2017 - 26.05.2017, KKB
Knopik Jerzy, Jagiellonian U; 16.07.2017 - 21.07.2017, CBS; 28.08.2017 - 08.09.2017, CBS
Kohlrus Jan, U of Nottingham; 17.07.2017 - 21.07.2017, CBS
Kolar Ivan, Charles U; 15.07.2017 - 23.07.2017, CBS
Kollár Richard, Comenius U; 27.11.2017 - 07.12.2017, WHP
Konno Hitoshi, Tokyo U of Marine Science and Technology; 19.03.2017 - 25.03.2017, SKN
Kononov Iakov, Columbia U, New York; 18.03.2017 - 25.03.2017, SKN
Koops Hendrik Vincent, Utrecht U; 10.09.2017 - 16.09.2017, DF
Koornwinder Tom, U of Amsterdam; 18.03.2017 - 25.03.2017, SKN
Koroteev Peter, UC Davis; 19.03.2017 - 25.03.2017, SKN
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Kohlrus Jan, U of Nottingham; 20.02.2017 - 24.02.2017, JAF; 14.11.2017 - 17.11.2017, KSB
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Kovácová Hana, U Vienna; 29.05.2017 - 03.06.2017, IS
Kowalski-Glikman Jerry, U Wroclaw; 07.06.2017 - 10.06.2017, ABR
Krattenthaler Christian, U Vienna; 20.03.2017 - 24.03.2017, SKN; 16.10.2017 - 24.11.2017, KSB
Kremsner Stefan, U Graz; 02.10.2017 - 06.10.2017, PDG
Krieg David, Friedrich Schiller U, Jena; 06.10.2017 - 14.10.2017, PDG
Kritzer Peter, Austrian Academy of Science; 11.10.2017 - 13.10.2017, PDG
Kritzinger Ralph, JKU Linz; 19.09.2017 - .09.2017, PDG
Kröncke Klaus, U Hamburg; 24.07.2017 - 04.08.2017, CBS
Kukic Katarina, U of Belgrade; 19.03.2017 - 24.03.2017, SKN
Kulczycka-Mierzejewska Katazyna, U of Warsaw, ICM; 21.02.2017 - 24.02.2017, CDS
Kulczycki Wojciech, Jagiellonian U, Krakow; 20.02.2017 - 25.02.2017, JAF
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Kunzinger Michael, U Vienna; 20.02.2017 - 24.02.2017, JAF; 17.07.2017 - 08.09.2017, CBS
Kusner Robert, U Massachusetts, Amherst; 27.07.2017 - 29.07.2017, CBS
Kusumatuti Nilamsari, U de Poitiers; 15.01.2017 - 21.01.2017, MAB
Kuznetsov Alexander, Steklov Mathematical Institute, Moscow; 30.04.2017 - 19.05.2017, KKB
Labahn George, U of Waterloo; 05.11.2017 - 19.11.2017, KSB
Lahiri Ansuman, U of Calcutta; 19.02.2017 - 24.02.2017, CDS
Lamers Julies, Chalmers U; 19.03.2017 - 24.03.2017, SKN
Lamy Frederic, APC Paris; 17.07.2017 - 21.07.2017, CBS
Landsteiner Karl, U Autonoma de Madrid; 29.05.2017 - 04.06.2017, ABR
Langmann Edwin, Alba Nova U Center, Stockholm; 21.03.2017 - 24.03.2017, SKN
Lannes David, IMB, U Bordeaux & CNRS; 04.12.2017 - 08.12.2017, WHP
Larsson Eric, KTH Royal Institute of Technology ; 23.07.2017 - 06.08.2017, CBS
Lattanzi Gianluca, U Trento; 20.02.2017 - 25.02.2017, CDS
Layne Adam, U of Oregon; 16.08.2017 - 08.09.2017, CBS
Lbadaoui-Darvas Maria, École Polytechnique Federale Lausanne; 10.12.2017 - 14.12.2017, SJ
Lee Dan, Queens College, New York; 26.07.2017 - 02.08.2017, CBS
Lee Ho, Kyung Hee U; 19.02.2017 - 26.02.2017, JAF
Lee Jea Min, City U of New York; 15.07.2017 - 23.07.2017, CBS
Le Floch Philippe, U Pierre et Marie Curie, Paris; 19.02.2017 - 21.02.2017, JAF

Lemou Mohammed, U of Rennes 1; 19.02.2017 - 24.02.2017, JAF
Leobacher Gunther, U Graz; 24.09.2017 - 29.09.2017, PDG; 12.10.2017 - 13.10.2017, PDG
Lepoutre Mathias, Laboratoire d'informatique de l'École Polytechnique, Palaiseau; 16.10.2017 - 20.10.2017, KSB
Letellier Emmanuel, IST Austria, Klosterneuburg; 27.11.2017 - 07.12.2017, WHP
Levin Mordechai, Bar Ilan U, Israel; 24.09.2017 - 28.09.2017, PDG
Li Ka Ki (Carmen), U of Warsaw; 16.07.2017 - 26.07.2017, CBS
Lieb Elliott, Princeton U; 19.03.2017 - 26.03.2017, IS
Ling Eric, U of Miami; 22.07.2017 - 29.07.2017, CBS
Linusson Svante, KTH Stockholm; 15.10.2017 - 25.10.2017, KSB
Linshaw Andrew, U of Denver; 22.01.2017 - 25.01.2017, MAB
Lisal Martin, Institute of chemical Process Fundamentals, Prague; 10.12.2017 - 13.12.2017, SJ
Lishchuk Sergey, Sheffield Hallam U; 10.12.2017 - 14.12.2017, SJ
Liu Chao, Monash U, Victoria; 16.07.2017 - 02.09.2017, CBS
Locatelli Emanuele, U Vienna; 20.02.2017 - 24.02.2017, CDS
Logg Anders, U Chalmers; 20.02.2017 - 22.02.2017, JAF
Lohrasebi Amir, U Isfahan; 21.02.2017 - 24.02.2017, CDS
Lokharu Evgeniy, Lund U; 03.12.2017 - 08.12.2017, WHP
Lopes Barros Ricardo Andre, Loughborough U; 26.11.2017 - 01.12.2017, WHP
Lorgat Raeez, MIT; 15.01.2017 - 30.01.2017, MAB
Valiente Kroon Juan A., Queen Mary U of London; 17.07.2017 - 08.09.2017, CBS
Lostanlen Vincent , Cornell Lab of Ornithology; 10.09.2017 - 16.09.2017, DF
Loudon Tyson, U of Minnesota; 16.07.2017 - 24.07.2017, CBS
Louf Baptiste, IRIF, Paris; 15.10.2017 - 27.10.2017, KSB
Lovrekovic Iva, U Vienna; 29.05.2017 - 23.06.2017, ABR; 24.07.2017 - 07.09.2017, CBS
Lubich Christian, U Tübingen; 16.06.2017 - 18.06.2017, SAB
Luk Jonathan, Stanford U; 20.02.2017 - 24.02.2017, JAF
Lundberg David, U of Lund; 16.07.2017 - 22.07.2017, CBS
Lyons Thomas Anthony, Waterford Institute of Technology; 03.12.2017 - 08.12.2017, WHP
Ma Siyuan, MPI, Potsdam-Golm; 16.07.2017 - 29.07.2017, CBS; 27.08.2017 - 02.09.2017, CBS
MacLaurin Colin, U of Queensland; 17.07.2017 - 28.07.2017, CBS
Magalhaes de Novaes Santos Fabio, Federal U of Rio Grande do Norte; 11.06.2017 - 18.06.2017, ABR
Mahlen Ola, NTNU Trondheim; 03.12.2017 - 07.12.2017, WHP
Makino Tetu, Yamaguchi U; 22.07.2017 - 30.07.2017, CBS
Malfreyt Patrice, Clermont Auvergne U; 10.12.2017 - 13.12.2017, SJ
Maliborski Maciej, U Vienna; 24.07.2017 - 08.09.2017, CBS
Malikov Fedor, U of Southern California; 21.01.2017 - 28.01.2017, MAB
Mellit Anton, IST Austria; 20.03.2017 - 24.03.2017, SKN
Manfredonia Mattia, U di Napoli Federico II; 16.07.2017 - 24.07.2017, CBS
Manivel Laurent, Institute de Mathematiques de Marseille CNRS; 15.01.2017 - 28.01.2017, MAB
Manjunath Madhusudan, Queen Mary U of London; 01.04.2017 - 21.07.2017, JRF
Mantoulidis Christos, MIT Cambridge; 27.08.2017 - 01.09.2017, CBS
Marafioti Andrés, Acoustics Research Institute, Vienna; 11.09.2017 - 15.09.2017, DF
Marini Antonella, Yeshiva U & U of L'Aquila; 06.08.2017 - 11.08.2017, IS
Markovich Ivan, Uzhgorod National U; 22.11.2017 - 06.12.2017, IS
Martin Calin, U Vienna; 10.04.2017 - 30.06.2017, RIT
Martin Daniel, U of Connecticut, Storrs; 16.07.2017 - 29.07.2017, CBS
MArtinjak Ivica, U of Zagreb; 15.10.2017 - 27.10.2017, KSB
Mars Lloret Marc, U de Salamanca; 16.07.2017 - 16.08.2017, CBS

Marushewko Anastasija, National U of Kyiv-Mohyla Academy, Kyiv; 08.06.2017 - 09.06.2017, ABR
Masser David, U Basel; 22.03.2017 - 23.03.2017, SKN
Mathé Peter, Weierstrass Institute, Berlin; 05.10.2017 - 14.10.2017, PDG
Matherne Jacob, U of Massachusetts Amherst; 15.01.2017 - 28.01.2017, MAB
Martin Calin, U College Cork; 27.11.2017 - 28.12.2017, WHP; 04.12.2017 - 07.12.2017, WHP
Matioc Anca-Voichita, Leibniz U, Hannover; 03.12.2017 - 08.12.2017, WHP
Matzke Ryan, U of Minnesota; 16.09.2017 - 29.09.2017, PDG
Mazzeo Rafe, Stanford U; 20.07.2017 - 26.07.2017, CBS
Mazzieri Lorenzo, U of Trento; 27.08.2017 - 01.09.2017, CBS
McComick Stephen, KTH Stockholm; 16.07.2017 - 06.08.2017, CBS
Meer Klaus, BTU Cottbus-Senftenberg; 08.10.2017 - 14.10.2017, PDG
Meinel Joanna, U Stuttgart; 16.01.2017 - 27.01.2017, MAB
Melchionna Simone, U "La Sapienza", Rome ; 23.02.2017 - 27.02.2017, CDS
Melczer Stephen, U of Pennsylvania; 12.11.2017 - 19.11.2017, KSB
Mellit Anton, IST Austria; 03.04.2017 - 26.05.2017, KKB
Mena Filipe, U Minho, Portugal; 20.02.2017 - 24.02.2017, JAF
Merbis Wout, TU Vienna; 30.05.2017 - 07.06.2017, ABR
Mereo Martin, IST Austria; 24.04.2017 - 28.04.2017, KKB
Metzger Jan, U Potsdam; 24.07.2017 - 28.07.2017, CBS
Mezzarobba Marc, CNRS, U Pierre et Marie Curie; 12.11.2017 - 18.11.2017, KSB
Miao Pengzi, U of Miami; 20.07.2017 - 28.07.2017, CBS
Micheletti Cristian, SISSA Trieste; 20.02.2017 - 25.02.2017, CDS
Michor Peter, U Vienna; 17.07.2017 - 08.09.2017, CBS
Middeke Johannes, RISC Linz; 16.10.2017 - 17.10.2017, KSB; 14.11.2017 - 17.11.2017, KSB
Mignemi Salvatore, U di Cagliari; 07.06.2017 - 10.06.2017, ABR
Milewski Paul, U of Bath; 26.11.2017 - 28.11.2017, WHP
Minguzzi Ettore, U degli Studi di Firenze; 28.08.2017 - 01.09.2017, CBS
Mirkovic Ivan, U of Massachusetts, Amherst; 15.01.2017 - 26.01.2017, MAB
Mishra Saumitra, Queen Mary U of London; 10.09.2017 - 16.09.2017, DF
Mokrý Ondrej, Brno U of Technology; 11.09.2017 - 11.09.2017, DF
Möller Sven, TU Darmstadt; 15.01.2017 - 28.01.2017, MAB
Moncrief Vincent, Yale U; 16.07.2017 - 09.09.2017, CBS
Montavon Grégoirer, TU Berlin; 10.09.2017 - 16.09.2017, DF
Montes de Oca Gabriel, U of Oregon; 27.08.2017 - 01.09.2017, CBS
Montufar Guido, MPI Leipzig; 12.09.2017 - 15.09.2017, DF
Moreau Anne, U Lille 1; 14.01.2017 - 29.01.2017, MAB
Moschidis Georgios, Princeton U; 27.08.2017 - 01.09.2017, CBS
Mouhib Halima, U Paris-Est Marne-La-Vallee; 20.02.2017 - 24.02.2017, CDS
Mourier Pierre, U de Lyon; 16.07.2017 - 22.07.2017, CBS
Müllner Clemens, TU Vienna; 25.09.2017 - 29.09.2017, PDG
O'Murchadha Niall, U College Cork; 12.08.2017 - 01.09.2017, CBS
Nachbin André, IMPA, Rio de Janeiro; 26.11.2017 - 03.12.2017, WHP
Nachtmann Otto, U Heidelberg; 27.04.2017 - 30.04.2017, IS
Nadeau Philippe, CNRS U Lyon 1, ICJ; 14.10.2017 - 28.10.2017, KSB
Nagy Gábor, U of Szeged; 15.10.2017 - 20.10.2017, KSB
Nair Radhakrishnan, U of Liverpool; 24.09.2017 - 29.09.2017, PDG
Nakazono Nobutaka, U of Sydney; 18.03.2017 - 25.03.2017, SKN
Nakonieczna Anna, U of Warsaw; 16.07.2017 - 29.07.2017, CBS
Nakonieczny Lukasz, U of Warsaw; 16.07.2017 - 29.07.2017, CBS

Nazarov Maxim, U of York; 15.01.2017 - 29.01.2017, MAB
Nejjar Peter, IST Austria; 16.10.2017 - 20.10.2017, KSB
Nerattini Francesca, U Vienna; 21.02.2017 - 24.02.2017, CDS
Nerz Christopher, KTH Stockholm; 23.07.2017 - 04.08.2017, CBS
Neuenkirch Andreas, U Mannheim; 09.10.2017 - 13.10.2017, PDG
Neumüller Mario, JKU Linz; 09.10.2017 - 13.10.2017, PDG
Neves André, U of Chicago; 23.07.2017 - 28.07.2017, CBS
Nguyen Luc, U of Oxford; 06.07.2017 - 31.08.2017, RiT
Nieri Fabrizio, Uppsala U; 19.03.2017 - 25.03.2017, SKN
Nieto Oriol, Pandora Media, Oakland; 10.09.2017 - 15.09.2017, DF
Nilsson Dag, Lund U; 03.12.2017 - 08.12.2017, WHP
Nilsson Lennart, Karolinska-Institute, Solna, Schweden; 23.02.2017 - 25.02.2017, CDS
Noumi Masatoshi, Kobe U; 19.03.2017 - 25.03.2017, SKN
Novak Erich, FSV Jena; 01.10.2017 - 14.10.2017, PDG
Nunes Ortiz Jose Eduardo, National Autonomous U of Mexico (UNAM); 16.07.2017 - 23.07.2017, CBS
Nungesser Ernesto, ICMAT Madrid; 19.02.2017 - 24.02.2017, JAF
Oancea Marius Adrian, MPI Potsdam; 18.06.2017 - 25.06.2017, ABR
Ocansey Evans Doe, RISC/JKU Linz; 13.11.2017 - 17.11.2017, KSB
Oguiso Keiji, U of Tokyo; 23.04.2017 - 28.04.2017, KKB
Okada Soichi, Nagoya U, Japan; 18.03.2017 - 25.03.2017, SKN; 15.10.2017 - 04.11.2017, KSB
Okounkov Andrei, Columbia U, New York; 14.03.2017 - 24.03.2017, SKN
Oliveras Katie, Seattle U; 22.11.2017 - 03.12.2017, WHP
Ollila Samuli, Czech Academy of Science; 10.12.2017 - 13.12.2017, SJ
Omar Yasser, Instituto de Telecomunicacoes, Lisbon; 04.06.2017 - 27.06.2017, ABR
Oostenbrink Chris, U of Natural Resources and Life Sciences, Vienna; 23.02.2017 - 23.02.2017, CDS
Oprzesua-Zingrebe Ewa Anna, U Stuttgart; 18.02.2017 - 26.02.2017, CDS
Orozco Modesto, IRB, Barcelona; 21.02.2017 - 24.02.2017, CDS
Otoba Nobuhiko, U Regensburg; 16.07.2017 - 29.07.2017, CBS
Ottolini Andrea, Stanford U; 16.07.2017 - 22.07.2017, CBS
Paetz Tim-Torben, U Vienna; 22.02.2017 - 24.02.2017, JAF; 17.07.2017 - 08.09.2017, CBS
Paganini Claudio, AEI Potsdam; 16.07.2017 - 29.07.2017, CBS; 27.08.2017 - 01.09.2017, CBS
Palenta Stefan, Theoretisch-physikalisches Institut Jena; 16.08.2017 - 19.08.2017, IS
Panazzolo Daniel, U de Haute-Alsace; 29.05.2017 - 03.06.2017, IS
Pandit Pranav, U Vienna; 16.01.2017 - 20.01.2017, MAB; 03.04.2017 - 28.05.2017, KKB
Panova Greta, Institute for advanced Study, Princeton; 14.10.2017 - 29.10.2017, KSB
Pantone Jay, Dartmouth College, Hannover; 15.10.2017 - 29.10.2017, KSB
Panyushev Dmitri, Institute for Information Transmission Problems of the R.A.S.; 15.01.2017 - 24.01.2017, MAB
Papalexiou Nikolaos, U of the Aegean, Neo Karlovassi; 22.01.2017 - 28.01.2017, MAB
Papi Paolo, U of Rome “La Sapienza”; 20.01.2017 - 29.01.2017, MAB
Parau Ionica Emilian, U of East Anglia; 26.11.2017 - 05.12.2017, WHP
Parekh Pulastya, Indian Institute of Technology, Kanpur; 12.06.2017 - 19.06.2017, ABR
Park Jihun, IBS/Postech, Pohang, Korea; 02.05.2017 - 19.05.2017, KKB
Pasquali Samuela, U Paris Descartes; 20.02.2017 - 24.02.2017, CDS
Passenbrunner Markus, JKU Linz; 25.09.2017 - 29.09.2017, PDG
Patimo Loenardo, MPI Bonn; 15.01.2017 - 20.01.2017, MAB
Paule Peter, RISC/JKU Linz ; 15.10.2017 - 20.10.2017, KSB; 12.11.2017 - 17.11.2017, KSB
Paunkovic Nikola, Instituto de Telecomunicações Lisbon; 19.06.2017 - 23.06.2017, ABR
Pech Clelia, U of Kent; 22.01.2017 - 27.01.2017, MAB

Pemantle Robin, U of Pennsylvania; 12.11.2017 - 17.11.2017, KSB
Penrose Roger, U of Oxford; 19.06.2017 - 25.06.2017, ABR; 27.08.2017 - 30.08.2017, CBS
Pereverzyev Sergiy, RICAM, Linz; 08.10.2017 - 13.10.2017, PDG
Perez Donoso Alfredo Hector, Centro de Estudios Cientificos, Valdivia; 11.06.2017 - 25.06.2017, ABR
Perlega Stefan, U Vienna; 29.05.2017 - 03.06.2017, IS
Perry Alexander, Columbia U; 07.05.2017 - 20.05.2017, KKB
Perse Ozren, U of Zagreb; 21.01.2017 - 27.01.2017, MAB
Petkov Aleksandar, Sofia U; 24.04.2017 - 26.04.2017, KKB
Petkovšek Marko, U of Lubljana; 15.10.2017 - 20.10.2017, KSB; 12.11.2017 - 24.11.2017, KSB
Pezzini Guido, U of Rome "La Sapienza"; 14.01.2017 - 22.01.2017, MAB
Pflug Georg, U Vienna; 10.10.2017 - 13.10.2017, PDG
Pillwein Veronika, RISC/JKU Linz; 15.10.2017 - 28.10.2017, KSB; 12.11.2017 - 18.11.2017, KSB
Pino Miguel, U de Santiago de Chile; 09.06.2017 - 24.06.2017, ABR
Pillichshammer Friedrich, JKU Linz; 13.09.2017 - 14.09.2017, PDG; 19.09.2017 - 21.09.2017, PDG; 25.09.2017 - 29.09.2017, PDG; 09.10.2017 - 06.10.2017, PDG; 10.10.2017 - 13.10.2017, PDG
Piotto Stefano, U Salerno, Fisciano; 20.02.2017 - 24.02.2017, CDS
Pirog Michal, Jagiellonian U, Krakow; 20.02.2017 - 25.02.2017, JAF; 16.07.2017 - 22.07.2017, CBS
Pirutka Alena, New York U; 23.04.2017 - 28.04.2017, KKB
Piubello Annachiara, U Tübingen; 16.07.2017 - 22.07.2017, CBS
Plantania Alessia, U of Catania, INAF & INFN; 15.07.2017 - 24.07.2017, CBS
Plaskota Leszek, U of Warsaw; 07.10.2017 - 14.10.2017, PDG
Pollack Daniel, U of Washington; 23.07.2017 - 30.07.2017, CBS
Poole Aaron, U of Southampton; 16.07.2017 - 22.07.2017, CBS
Potestio Raffaello, MPI, Mainz; 19.02.2017 - 25.02.2017, CDS
Potka Samu, KTH Stockholm; 15.10.2017 - 20.10.2017, KSB
Pradler Josef, HEPHY, Vienna; 29.05.2017 - 30.06.2017, ABR
Premet Alexander, U of Manchester; 15.01.2017 - 22.01.2017, MAB
Premoselli Bruno, U libre de Bruxelles; 16.07.2017 - 29.07.2017, CBS
Prochno Joscha, U of Hull; 09.10.2017 - 13.10.2017, PDG
Prvanović Slobodan, Institute of Physics Belgrade; 26.06.2017 - 30.06.2017, ABR
Przezdziecki Tomasz, U of Glasgow; 15.01.2017 - 28.01.2017, MAB
Przybytowicz Pawel, AGM U of Science & Technology, Krakow; 08.10.2017 - 14.10.2017, PDG
Przyjalkowski Victor, Steklov Mathematical Institute, Moskow & International laboratory for Mirror Symmetry and Automorphic Forms; 03.04.2017 - 30.04.2017, KKB
Puhm Andrea, CPhT, Ecole Polytechnique, Palaiseau & U Harvard; 11.06.2017 - 21.06.2017, ABR
Quinta Queimada Leonel, U de Lisboa; 16.07.2017 - 22.07.2017, CBS
Quirchmayr Ronald, KTH, Royal Institute of Technology; 04.12.2017 - 07.12.2017, WHP
Raab Clemens, JKU Linz; 12.11.2017 - 17.11.2017, KSB
Rácz István, Wigner RCP, Budapest; 23.07.2017 - 12.08.2017, CBS
Radermacher Katharina, KTH Stockholm; 30.07.2017 - 04.08.2017, CBS
Radovanović Voja, U of Belgrade; 07.06.2017 - 10.06.2017, ABR
Rahman Jillur, LMU Munich; 16.07.2017 - 22.07.2017, CBS
Rains Eric, California Institute of Technology, Pasadena; 19.03.2017 - 25.03.2017, SKN
Remonato Filippo, Norwegian U of Science and Technology (NTNU); 03.12.2017 - 07.12.2017, WHP
Rasamat Shlomo-Sergei, Technion, Haifa; 19.03.2017 - 24.03.2017, SKN
Rasel Ernst, Leibniz U Hannover; 07.06.2017 - 09.06.2017, ABR
Rashkov Radoslav, TU Vienna; 13.06.2017 - 30.06.2017, ABR
Rätzel Dennis, U Vienna; 20.02.2017 - 24.02.2017, JAF
Reall Harvey, DAMTP, U of Cambridge; 27.08.2017 - 01.09.2017, CBS

Rebhan Anton, ITP, TU Vienna; 29.05.2017 - 07.07.2017, ABR
Rechnitzer Andrew, U of British Columbia; 28.10.2017 - 11.11.2017, KSB
Regensburger Georg, JKU Linz; 14.11.2017 - 16.11.2017, KSB
Reichelt Nikita, U of Graz; 17.07.2017 - 21.07.2017, CBS
Reif Shifra, Bar Ilan U; 22.01.2017 - 25.01.2017, MAB
Rein Gerhard, U Bayreuth; 19.02.2017 - 26.02.2017, JAF
Reiris Martin, U de la República, Montevideo; 23.07.2017 - 31.07.2017, CBS
Reis Tomás, Perimeter Institute for Theoretical Physics, Waterloo; 16.07.2017 - 22.07.2017, CBS
Requilé Clément, JKU Linz; 12.11.2017 - 17.11.2017, KSB
Ressayre Nicolas, U of Lyon; 22.01.2017 - 27.01.2017, MAB
Rey Soo-Jong, Seoul National U; 10.06.2017 - 14.06.2017, ABR; 07.07.2017 - 17.07.2017, ABR
Richter Benedikt, Instituto Superior Technico & LMU Munich; 05.06.2017 - 16.06.2017, ABR
Ringström Hans, KTH, Stockholm; 19.02.2017 - 25.02.2017, JAF; 16.08.2017 - 19.08.2017, CBS
Ritter Klaus, TU Kaiserslautern; 30.09.2017 - 13.10.2017, PDG
Riegler Max, U libre de Bruxelles; 29.05.2017 - 29.06.2017, ABR
Rinne Oliver, HTW Berlin & Albert-Einstein-Institut Potsdam; 19.05.2017 - 25.02.2017, JAF
Rioseco Yanez Paola Carolina, U Michoacana de San Nicolas de Hidalgo; 19.02.2017 - 25.02.2017, JAF
Ripley Justin, Princeton U; 16.07.2017 - 29.07.2017, CBS
Riquelme Osses Miguel Angel, CECS, Valdivia; 11.06.2017 - 02.07.2017, ABR
Rivoal Tanguy, Institute Fourier, Saint Mairtin d'Heres; 12.11.2017 - 18.11.2017, KSB
Robertson Calum, Monash U; 17.02.2017 - 25.02.2017, JAF
Roby Thomas, U of Connecticut; 11.11.2017 - 25.11.2017, KSB
Roche-Newton Oliver, JKU Linz; 25.09.2017 - 29.09.2017, PDG
Rodríguez Sanjurjo Adrian, U College Cork; 03.12.2017 - 09.12.2017, WHP
Roesch Henri, U of California, Irvine; 17.07.2017 - 28.07.2017, CBS
Romatschke Paul, U of Colorado, Boulder ; 19.06.2017 - 21.06.2017, ABR
Romik Dan, U of California, Davis; 08.11.2017 - 17.11.2017, KSB
Rosa Angelo, SISSA, Trieste; 20.02.2017 - 25.02.2017, CDS
Rosengren Hjalmar, Calmers U, Göteborg; 19.03.2017 - 25.03.2017, SKN
Roubícek Tomás, Charles U, Prague; 27.02.2017 - 01.07.2017, SRF
Rudolf Daniel, Georg-August U Göttingen; 24.09.2017 - 30.09.2017, PDG
Rudzinski Joseph, MPI Mainz; 21.02.2017 - 24.02.2017, CDS
Ruffo Stefano, SISSA, Trieste; 16.06.2017 - 18.06.2017, SAB
Ruijsenaars Simon, U of Leeds; 20.03.2017 - 25.03.2017, SKN
Rutkowski Mieszko, U Jagiellonian, Krakow; 16.07.2017 - 22.07.2017, CBS
Ruzziconi Romain, U Libre de Bruxelles; 15.07.2017 - 22.07.2017, CBS
Sachdev Rohit, Fergusson College Pune, India; 15.07.2017 - 22.07.2017, CBS
Saikia Manjil Pratim, U Vienna; 20.03.2017 - 24.03.2017, SKN; 16.10.2017 - 24.11.2017, KSB
Saito Yoshihisa, U of Tokyo; 15.01.2017 - 27.01.2017, MAB
Sakovich Anna, Uppsala U; 13.08.2017 - 31.08.2017, CBS
Salvy Bruno, INRIA, Le Chesnay; 09.11.2017 - 18.11.2017, KSB
Sämann Clemens, U Vienna; 20.02.2017 - 24.02.2017, JAF; 24.07.2017 - 28.07.2017, CBS; 28.08.2017 - 01.09.2017, CBS
Samuel Preena, IIT-Kanpur; 15.01.2017 - 27.01.2017, MAB
Sanbonmatsu Karissa, Los Alamos National Laboratory; 20.02.2017 - 28.02.2017, CDS
Sánchez Pedro, U Nacional Autónoma de México; 12.07.2017 - 02.08.2017, CBS
Sanchez Sanchez Yafet, Leibniz U, Hannover; 16.07.2017 - 22.07.2017, CBS
Santiago Silva Jessica, Victoria U of Wellington; 16.07.2017 - 22.07.2017, CBS
Sarbach Olivier, U Michoacana de San Nicolas de Hidalgo, Morelia; 19.02.2017 - 25.02.2017, JAF

Sbierski Jan, U of Cambridge; 28.08.2017 - 02.09.2017, CBS
Schabus Dietmar, OFAI, Vienna; 11.09.2017 - 15.09.2017, DF
Schaman Christoph, U Vienna; 20.02.2017 - 24.02.2017, JAF
Scheidegger Emanuel, Albert-Ludwig-U Freiburg; 03.04.2017 - 20.04.2017, KKB
Schicho Josef, JKU Linz; 29.05.2017 - 03.06.2017, IS
Schimpf Maria, TU Vienna; 29.05.2017 - 07.07.2017, ABR
Schindler Alexander, TU Vienna; 11.09.2017 - 15.09.2017, DF
Schlick Tamar, New York U; 18.02.2017 - 25.02.2017, CDS
Schlosser Michael, U Vienna; 20.03.2017 - 24.03.2017, SKN; 16.10.2017 - 19.10.2017, KSB; 13.11.2017 - 17.11.2017, KSB
Schlüter Jan, OFAI, Vienna; 11.09.2017 - 15.09.2017, DF
Schmid Wolfgang, U of Salzburg; 23.09.2017 - 28.09.2017, PDG
Schneider Carsten, RISC/JKU Linz; 15.10.2017 - 17.10.2017, KSB; 12.11.2017 - 17.11.2017, KSB
Schneider Guido, IADM, U Stuttgart; 03.12.2017 - 07.12.2017, WHP
Schoen Richard M., U of California, Irvine; 15.07.2017 - 30.07.2017, CBS
Schön Oliver, U of Tübingen; 17.07.2017 - 22.07.2017, CBS
Schöttl Sebastian, U Regensburg; 10.12.2017 - 13.12.2017, SJ
Schurko Roman, Kiev National U; 22.11.2017 - 06.12.2017, IS
Schuster Sebastian, Victoria U of Wellington; 16.07.2017 - 23.07.2017, CBS
Schwab Christoph, ETH Zurich; 26.09.2017 - 29.09.2017, PDG; 09.10.2017 - 12.10.2017, PDG
Schwermer Joachim, U Vienna; 03.04.2017 - 26.05.2017, KKB
Sega Marcello, U of Vienna; 11.12.2017 - 13.12.2017, SJ
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Seipel Julian, U Regensburg; 16.07.2017 - 21.07.2017, CBS
Senapati Koushik, U Vienna; 20.03.2017 - 22.03.2017, SKN
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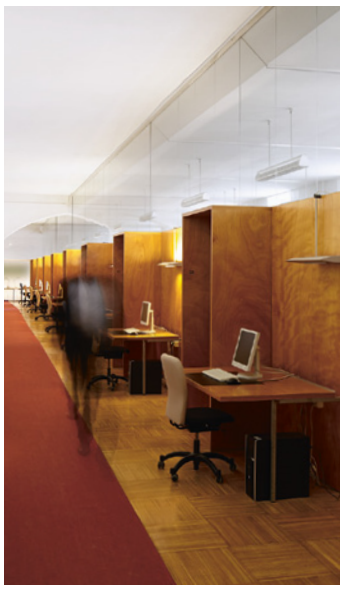


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