



ANNUAL 2024 REPORT

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

ESI Annual Report 2024

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Preface

Message of the Director

I am pleased to share the Annual Report 2024 of the Erwin Schrödinger Institute for Mathematics and Physics. For the first time since the onset of the COVID-19 pandemic, our visitor numbers have not only returned to but even surpassed their pre-pandemic levels: 959 researchers from around the globe came to Vienna to participate in four Thematic Programmes, eleven Workshops and Schools, and a variety of other scientific events. Please explore the following pages to learn more about the rich programme of activities at the ESI in 2024.

In a world where conflict too often overshadows our collective pursuit of knowledge, face-to-face interaction is more essential than ever. Founded to build bridges between East and West, the ESI remains true to that legacy: by bringing together researchers across political, geographical, and social divides, we enable the collaborations and insights that drive real breakthroughs.

Digital outreach complements our on-site excellence: more than 1,500 recorded lectures and hundreds of thousands of views on our YouTube channel extend the impact of the ESI to regions where travel remains challenging. Yet while virtual platforms play an important role, nothing replaces the energy of scholars meeting face-to-face. That blend of cutting-edge online access and in-person exchange defines the ESI's unique contribution to the global research ecosystem in mathematics, physics and adjacent disciplines.

The Scientific Advisory Board of the ESI plays a vital role in guiding its mission, offering expert advice on research strategy, programme development, and the evaluation of activities at the ESI. Their insights help shape our scientific direction, uphold the highest standards, and foster knowledge exchange between disciplines. We are particularly grateful to Alberto Bressan (Penn State University) and Gerhard Huisken (University of Tübingen), who have completed their terms on the SAB in 2024; their counsel and commitment have been invaluable. We also extend our thanks to Stefan Fredenhagen for his contributions on the Kollegium and as Deputy Director — he stepped down in autumn 2024 to become Dean of the Faculty of Physics.

October 2024 marked another key moment as the ESI was renewed for six more years within the University of Vienna. Having been part of the University for over fourteen years, we greatly appreciate the ongoing support of the University administration and the Faculties of Mathematics and Physics. Thanks are also due to the Austrian taxpayer, whose commitment makes work at the institute possible. Looking ahead, this renewed mandate gives the stability to plan ambitious future activities that expand the frontiers of knowledge and nurture the personal connections essential for scientific progress.

Christoph Dellago
Director of the ESI

August 2025

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.

It is the Institute's foremost objective to advance scientific knowledge in all areas of mathematics and physics and to create an environment where scientists can exchange ideas and fruitful collaborations can unfold. The Institute provides a place for focused collaborative research and interweaves leading international scholars, both in mathematics and physics, with 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.

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 several 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 organizing 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;
- (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;
- (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 2024

The list of research areas in mathematics and physics covered by the scientific activities of the Erwin Schrödinger Institute in 2024 shows a wide variety. In 2024, the following thematic programmes took place at the ESI:

- *Carrollian Physics and Holography*
April 1 – 26, 2024

Organizers: Andrea Campoleoni (U of Mons), Laura Donnay (SISSA, Trieste), Stefan Fredenhagen (U of Vienna), Daniel Grumiller (TU Vienna)

– *Nonlinear Waves and Relativity*

April 29 – June 21, 2024

Organizers: Roland Donniger (U of Vienna), David Fajman (U of Vienna), Birgit Schörkhuber (U of Innsbruck)

– *The Landscape vs. the Swampland*

July 1 – August 9, 2024

Organizers: Gary Shiu (U of Wisconsin-Madison), Washington Taylor (MIT), Irene Valenzuela (CERN), Timm Wrase (Lehigh U)

– *Linking Microscopic Processes to the Macroscopic Rheological Properties in Inert and Living Soft Materials*

August 19 – October 11, 2024

Organizers: Roberto Cerbino (U of Vienna), Emanuela Del Gado (Georgetown U), Giuseppe Foffi (Paris-Sud U)

A detailed account of the thematic programmes that took place is given in subsequent sections of this report.

In addition to this thematic programmes, eleven workshops the ESI Medal Award Ceremony 2024 and the IMO and MEMO trainings took place on-site at the ESI in 2024, complemented by visits of some individual scholars who collaborated with scientists of the University of Vienna and the local community. Here is a list of these activities:

– *Workshop: Stochastic Partial Differential Equations*

February 12 – 26, 2024

Organizers: Sandra Cerrai (U of Maryland), Martin Hairer (Imperial College London), Carlo Marinelli (University College London), Eulalia Nualart (U of Barcelona), Luca Scarpa (Politecnico Milano), Ulisse Stefanelli (U of Vienna)

– *Workshop: Chromatin Modeling: Integrating Mathematics, Physics, and Computation for Advances in Biology and Medicine*

March 4 – 15, 2024

Organizers: Anton Goloborodko (Institute of Molecular Biotechnology of the Austrian Academy of Sciences), Tamar Schlick (NYU), Jan Smrek (U of Vienna)

– *Workshop: Rare Events in Dynamical Systems*

March 18 – 22, 2024

Organizers: Françoise Pène (U of Western Brittany), Tanja Schindler (U of Vienna), Roland Zweimüller (U of Vienna)

– *Workshop: Transport Properties in Soft Matter Systems*

April 2 – 5, 2024

Organizers: Laura Alvarez (U of Bordeaux), Olekandr Chepizhko (U of Vienna), Vittoria Sposini (U of Vienna)

– *Workshop: Synthetic Curvature Bounds for Non-Smooth Spaces: Beyond Finite Dimension*

May 21 – 24, 2024

Organizers: Lorenzo Dello Schiavo (IST Austria), Christian Ketterer (Albert Ludwigs U Freiburg), Chiara Rigoni (U of Vienna)

- *Workshop: One World Optimization Seminar in Vienna*
June 3 – 7, 2024
Organizers: Radu Ioan Bot (U of Vienna), Yurii Malitskyi (U of Göttingen)
- *Training: IMO and MEMO Training 2024*
June 19 – 22, 2024 & October 28 – November 1, 2024
Organizer: Theresia Eisenkölbl (U of Vienna)
- *Workshop: Determinacy, Inner Models and Forcing Axioms*
June 24 – 28, 2024
Organizers: Sandra Müller (TU of Vienna), Grigor Sargsyan (Polish Academy of Sciences), Ralf Schindler (Westfälische Wilhelms-U Münster), John Steel (U of California, Berkeley)
- *Workshop: Exactly Solvable Models*
July 24 – 26, 2024
Organizers: Maja Buric (U of Belgrade), Edwin Langmann (KTH Stockholm), Harold Steinacker (U of Vienna), Raimar Wulkenhaar (U of Münster)
- *Workshop: Spin-Orbit Entangled Quantum Magnetism*
September 23 – 27, 2024
Organizers: Cesare Franchini (U of Vienna), Vesna Mitrovic (Brown U), Leonid Pourovskii (Ecole Polytechnique, Palaiseau)
- *Workshop: Algebraicity and Transcendence for Singular Differential Equations*
October 7 – 19, 2024
Organizers: Alin Bostan (INRIA Paris), Francis Brown (U of Oxford), Herwig Hauser (U of Vienna), Shihoko Ishii (Tokyo U of Science), Hiraku Kawanoue (Chubu U), Michael Singer (North Carolina State U)
- *ESI Medal Award Ceremony 2024*
December 6, 2024
Organizer: Christoph Dellago (U of Vienna, ESI Director)
- *Workshop: Lensing and Wave Optics in Strong Gravity*
December 9 – 13, 2024
Organizers: Pedro Cunha (U of Aveiro), Marius A. Oancea (U of Vienna), Miguel Zumalacárregui (MPI MiS Leipzig)

Senior Research Fellows

As in previous years, within the *Senior Research Fellows* programme, the ESI offered lecture courses on an advanced graduate level. In 2024 the ESI offered three of them.

In Spring 2024 Martina Krämer (U of Mainz) gave a course on *A guided tour through the cirrus clouds*. In the summer term 2024 Irene Fonseca (Carnegie Mellon U) gave a course on *Γ -Convergence and Phase Transitions of Heterogeneous Materials* and in Autumn 2024 Thomas Strobl (U Claude Bernard Lyon 1) gave a course on *Geometry of Gauge Theories: Old and New*.

Research in Teams Programme

Established in 2012, the *Research in Teams 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 research teams worked at the ESI in 2024.

- MurphyKate Montee (Carleton College, Northfield) and Markus Steenbock (U of Vienna), *Dynamical, geometric and analytic properties of random groups*, May 20 – June 19, 2024
- Thomas Krajewski (Aix-Marseille U), Carlos I. Pérez Sánchez (U of Heidelberg) and Roberta A. Iseppi (Göttingen U), *Towards a noncommutative Geometrical Approach to BV Quantization*, July 27 – August 10, August 19 – 31 and December 16 – 20, 2024
- Nihat Sakik Deger (Bogazici U) and Jan Rosseel (Rudjer Boskovic Institute), *Supersymmetric Solutions of 3D Minimal Massive Supergravity*, August 10 – September 29, 2024
- Eduard Feireisl (Czech Academy of Sciences), Ansgar Jüngel (TU of Vienna) and Mária Lukáčová (Johannes Gutenberg-U Mainz), *Entropy methods for evolutionary systems: Analysis and Numerics*, October 3 – 10, 2024 and December 6 – 20, 2024

In the year 2024 the following Junior Research Fellows visited the ESI to work on their research projects:

- Tanushree Shah (Alfréd Rényi Institute Budapest), *Low-dimensional Topology Specifically contact Topology*, February 2 – April 30, 2024.
- Abhiram Mamadur Kidambi (MPI MiS, Leipzig), *Novel mathematical structures in 3d quantum gravity*, April 1 – May 4, 2024.
- Mariem Magdy Ali Mohamed (Queen Mary U of London), *The asymptotic structure of spacetimes*, May 1 – June 30, 2024.
- Victoria Sánchez Muñoz (U of Galway), *The Bell-like inequalities for interference into quantum games*, May 1 – June 30, 2024.
- Eduard Schesler (FernU Hagen), *Grothendieck pairs and Grigorchuk's group*, May 1 – June 30, 2024.
- Kaushlendra Kumar (U of Hannover), *KKT model & Gravity*, March 5 – June 15, 2023 & June 7 – 25, 2024.

Other activities

On October 23, 2024 an Erwin Schrödinger Lecture by Martina Krämer (U of Mainz) on the very interesting topic “Ice clouds over the Asian monsoon and their role in the global climate” was held.

Furthermore, a series of lectures was given by the ESI Junior Research Fellow Abhiram M Kidambi (MPI MiSc, Leipzig) on “Automorphic forms and L-functions” in April 2024.

The ESI also offered space for the following external activities:

- *Award Ceremony of the regional students competition of the Physics Olympiade* organized by Marianne Korner of the Faculty of Physics, U of Vienna, on March 6, 2024
- Opening of the *DATCH Meeting*, an international meeting for pupils from Austria, Germany and Switzerland, organized by Michael Eichmair and Dmytro Rzhemovskyi of the project MmF (Mathematik macht Freude) at the Faculty of Mathematics, U of Vienna, June 19, 2024
- *Vienna-Budapest Probability Seminar* organized jointly by M. Beiglböck, N. Berestycki, L. Erdős, J. Maas, M. Rasonyi, G. Pete, F. Toninelli, B. Toth, on October 4, 2024
- The ESI also hosted parts of the *Simons International Science School in Mathematics* and the *Simons Science School in Physics and Chemistry* for Ukrainian high-school students, organized by Michael Eichmair and Dmytro Rzhemovskyi of the project MmF (Mathematik macht Freude) at the Faculty of Mathematics, U of Vienna, September 9 – 18, 2024. This activity was also partly financed by the ESI, not only by the Simons Foundation, New York.
- *2024 INAQT network meeting* organized by Philip Walther and Lee Rozema, Faculty of Physics, U of Vienna, November 4 - 6, 2024
- *Nábor Junior*, an international team competition for highschool students, organized by Michael Eichmair and Dmytro Rzhemovskyi of the project MmF (Mathematik macht Freude) at the Faculty of Mathematics, U of Vienna, November 22, 2024
- *Components, systems and other stuff for quantum satellites*, VCQ Colloquium Talk by Alexander Ling (Singapore), organized by Philip Walther and Borivoje Dakic, Faculty of Physics, U of Vienna, November 27, 2024
- *Meeting of the Ukrainian Science Diaspora*, organized by Andrii Chumak, Faculty of Physics, U of Vienna, December 5, 2024

As already in the years before, the ESI hosted also in 2024 the MCMP Seminars of the Master Class Mathematical Physics, a joint activity of the Faculties of Mathematics and Physics, organized by David M. Fajman and Roland Donniger:

- *Marcus Sperling*, Faculty of Physics, U of Vienna on “Algebra Meets Physics: Symmetries, Polynomials, and Hilbert Series”, January 15, 2024
- *Luigi Roberti*, Faculty of Mathematics, U of Vienna on “Geophysical Fluid Dynamics: An overview and some recent advancements”, June 10, 2024
- *Clemens Sämann*, Faculty of Mathematics, U of Vienna on “On curvature in General Relativity and geometry, particularly in a non-regular setting”, October 21, 2024
- *Willi Kepplinger*, Faculty of Mathematics, U of Vienna on “Some aspects of topological fluid dynamics”, December 2, 2024

The Institute's Management

Kollegium

The ESI is governed at the organizational and scientific level by a board ('Kollegium') of six scholars, all faculty members of the University of Vienna. Their term of office is three years. The members of this board are appointed by the Rector of the University after consultations with the Deans of the Faculties of Physics and Mathematics. Our Deputy Director Stephan Fredenhagen left the Kollegium of the ESI on October 1, 2024, since he was appointed as Dean of the Faculty of Physics. Thus, he also had to step down as Deputy Director of the ESI. The Institute is very grateful to him for many years of valuable contributions, support and work. We congratulate him on his new position. On October 1, 2024 Norbert Schuch was newly appointed to the Kollegium to replace his position there. In the period January 1 - December 31, 2024, the Kollegium consisted of A. Constantin (Mathematics), C. Dellago (Physics), M. Eichmair (Mathematics), S. Fredenhagen (Physics) (until September 2024), I. Perugia (Mathematics), N. Schuch (Physics) (from October 2024 on) and B. Weinzierl (Physics). All members of the Kollegium act as professors at the University of Vienna.

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

Scientific Advisory Board

The scientific activities of the ESI are supervised by the Scientific Advisory Board (SAB), composed of eminent scholars in mathematics and physics. The SAB also reflects the international ties which are essential for the ESI. In 2024, the SAB consisted of: Douglas N. Arnold (U Minnesota), Alberto Bressan (Penn State U), Sandra Di Rocco (KTH, Stockholm) [chair], Domenico Giulini (U Hannover), Mariana Graña (CEA Paris-Saclay), Gerhard Huisken (U Tübingen), Julia Kempe (NYU), and Francesco Sciortino (U of Rome).

The composition of the SAB of the ESI changed by the end of 2024. After two terms of office Alberto Bressan (Penn State U) and Gerhard Huisken (U Tübingen) have retired from the Board. The Institute is very grateful to them for many years of valuable advice and support. Anton Alekseev (U of Geneva) and Maria Chudnovsky (Princeton U) joined the Board as new members on January 1, 2025.

Administration

There was no change in the composition of the ESI administration in 2024. The administration team continued its work with customary efficiency for our visitors, research fellows and board.

Christoph Dellago
ESI Director

September 1, 2025

The ESI in 2024: facts and figures

Management and Administration:

Director: Christoph Dellago

Kollegium: Christoph Dellago (Director), Stefan Fredenhagen (Deputy Director) (until September 2024), Ilaria Perugia (Deputy Director), Adrian Constantin, Michael Eichmair, Norbert Schuch (from October 2024 on), Bernadett Weinzierl

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

Computing and networking support: Marion Praschl, Thomas Leitner

Video recording and publishing: Sophie Kurzmann

International Scientific Advisory Board in 2024:

Douglas N. Arnold (U Minnesota)

Alberto Bressan (Penn State U)

Sandra Di Rocco (KTH, Stockholm) [chair]

Domenico Giulini (U Hannover)

Mariana Graña (CEA Paris-Saclay)

Gerhard Huisken (U Tübingen)

Julia Kempe (NYU)

Francesco Sciortino (U of Rome)

Budget and visitors: In 2024 the support of ESI received from the University of Vienna amounted to **€ 790 000**. Furthermore, ESI obtained a total of € 81 091 in third-party funds from external sources to support the various activities.

The total amount spent in 2024 on scientific activities was € 480 574 while the expenditures for administration (mainly salaries) and infrastructure (mainly rent) were € 562 492.

The total number of scientists visiting the Erwin Schrödinger Institute in 2024 was 959, see pages [107](#) – [127](#). Gender ratio: male: 703 (73,3 %), female: 193 (20,2 %), non-binary: 1 (0.1 %), prefer not to disclose or unspecified 62 (6,5 %). Moreover, 24 registered people participated online in various activities of the ESI.

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 that appeared in 2024 but are related to past ESI activities, starting from 2011, have been tracked as well to provide long-term evidence of the ESI research outcome success.

The total number of preprints and publications contributed to the ESI research documentation database in 2024 is 100 [related to the activities in 2024: 91, related to the activities in previous years: 9], see pages [99](#) – [105](#) for details.

Since the summer of 2019, lectures given at the ESI are routinely recorded and the videos are published on the ESI Youtube-Channel. In total 316 videos were recorded in 2024 amounting to more than 240 hours of video material. These videos have been accessed 102.700 times in

2024 alone. Currently, the number of views is growing quickly indicating the strong interest for recorded ESI lectures in the community.

Scientific Reports

Main Research Programmes

Carrollian Physics and Holography

Organizers: Andrea Campoleoni (U of Mons), Laura Donnay (SISSA, Trieste), Stefan Fredenhagen (U of Vienna), Daniel Grumiller (TU Vienna)

Dates: April 2 – 26, 2024

Budget: ESI € 39 991
FWF € 2 000 (Vassilevich)

Report on the thematic programme

The ESI programme “Carrollian Physics and Holography” fostered further progress on the rapidly developing research fields of Carrollian physics and flat space holography, in particular, on Carrollian fluids, Carrollian gravity theories, lower-dimensional models, fracton physics, as well as Celestial and Carrollian holography. Including the organizers and local participants, 114 researchers participated in this programme. Two younger participants, Adrien Fiorucci and Stefan Prohazka, took over local organization duties, like the organization of welcome receptions, conference dinners, and taking care of scheduling issues.

Activities

The first week (April 2 – 5) had 10 talks, several of which were introductory/review talks suitable for younger participants. Half of the talks were given by younger researchers (Daniel Kapec, Prahar Mitra, Gerben Oling, Ana-Maria Raclariu, Jakob Salzer). There was a focus on Celestial and Carrollian symmetries in the first week.

The second week (April 8 – 12) was a workshop with 15 talks on a variety of Carrollian topics and null infinity, 5 of which were given by younger researchers (Shreyansh Agrawal, Jack Borthwick, Florian Ecker, Lea Mele, Matthieu Vilatte).

The third week (April 15 – 19) continued with a workshop with 18 talks, now with more focus on Carrollian fluids and fractons, and overall a wider spread of topics, 6 of which were given by younger researchers (Erica Bertolini, Alessio Caddeo, Federico Capone, Aleksander Głódkowski, Leonhard Kehrberger, Raphaela Wutte).

The final week (April 22 – 26) had 13 talks, with more focus on holographic aspects but overall a spread of topics, 7 of which were given by younger researchers (Abhiram Kidambi, Federica Muscolino, Sabrina Pasterski, Simon Pekar, Romain Ruzziconi, Amartya Saha, Céline Zwikel).

In every week, we also organized a welcome reception on the first day and a social dinner in the middle of the week.

Talk videos and slides are available at the ESI website <https://www.esi.ac.at/events/e518/>.

Specific information on the thematic programme

Younger researchers delivered 23 talks (out of 56 in total) at our ESI programme, see above for their names. Over 11% of the participants and over 14% of the speakers were female.

Outcomes and achievements

Numerous discussions between the 114 participants from different communities, stretched over 4 weeks, led to several new research projects and collaborations. The best evidence for this is the list of publications emerging from our programme, see the references below.

List of talks

Week 1, April 2 - 5, 2024

Ana-Maria Raclariu (U Amsterdam)	Infinity of higher-spin asymptotic charges and celestial symmetries
Stefan Vandoren (Utrecht U)	Carrollian and BMS-invariant field theories
Jakob Salzer (ULB, Brussels)	Carrollian fields at timelike infinity
Prahar Mitra (U Amsterdam)	Celestial Conformal Primaries in Effective Field Theories
Eric Bergshoeff (U Groningen)	Matter Coupled Carroll Gravity through a Compensating Mechanism
Gerben Oling (U of Edinburgh)	Carroll Gravity, BKL Dynamics and Holography
Daniel Kapec (Harvard U, Cambridge)	The Geometry of the Space of Celestial CFTs
Jelle Hartong (U of Edinburgh)	Carroll Strings and Black Holes
Peter West (Oxford U)	Dual gravity

Week 2, April 8 - 12, 2024

Marios Petropoulos (École Polytechnique, Palaiseau)	Carroll and Applications - Selected Topics
Marc Henneaux (Collège de France, Paris)	Carroll Swiftons
Florian Ecker (TU Vienna)	Carroll Hawking effect
Arjun Bagchi (IITK, Kanpur)	Carrollian Holography: Yesterday, today, tomorrow.
Maxim Grigoriev (U of Mons)	BV-AKSZ approach to asymptotic symmetries of gravity
Sudipta Dutta (IITK, Kanpur)	Carroll correlators from Witten diagrams
José Figueroa-O'Farrill (U of Edinburgh)	CFT explorations of BMS-like algebras
Xavier Bekaert (U Tours)	Holographic realisation of Carrollian conformal scalars
Lea Mele (U of Mons)	Carroll Fermions
Jack Borthwick (McGill U)	Asymptotic structures at timelike infinity from projective geometry
Yannick Herfray (U Tours)	An introduction to twistor theory, as seen from null infinity.
Shreyansh Agrawal (SISSA, Trieste)	Logarithmic soft graviton theorems from superrotation Ward identities
Konstantinos Siampos (Aristotle U of Thessaloniki)	The geometric origin of the energy-momentum tensor improvement terms
Patricio Salgado-Rebolledo (TU Vienna)	A first-order action for electric Carroll gravity

Matthieu Vilatte (CNRS &
École Polytechnique, Palaiseau)

Carrollian perspective on gravitational charges

Week 3, April 15 - 19, 2024

Jay Armas (U of Amsterdam)

Aleksander Głodkowski (UST Wrocław)

Laurent Freidel (Perimeter Institute,
Waterloo)

Raphaela Wutte (ASU, Phoenix)

Kristan Jensen (U of Victoria)

Alfredo Perez (CECS, Valdivia)

Erica Bertolini (DIAS, Dublin)

Alessio Caddeo (U de Oviedo)

Marc Geiller (ENS Lyon)

Leonhard Kehrberger (U of Cambridge)

Joaquim Gomis (U of Barcelona)

Nicolas Boulanger (U of Mons)

Stephan Stieberger (MPP, Munich)

Massimo Porrati (NYU, New York)

Dima Vassilevich (UFABC,
Santo André)

Peter Horvathy (U of Tours)

Federico Capone (U of Jena)

Daniele Pranzetti (U of Udine)

Carrollian Fluids and Spontaneously Broken Boosts

Hydrodynamics with dipole conservation

Null Raychaudhuri: Canonical structure, Dressing time and
Quantum geometry

Hyperbolic Mass in 2+1 Dimensions

Fractons and quantum theories with exotic symmetry

Fracton infrared triangle

A covariant approach to fractons: Maxwell theory of
fractons

Fracton gravity from spacetime dipole symmetry

Subleading structure of asymptotically-flat spacetimes

The Case Against Smooth Null Infinity and the Persistence
of Polyhomogeneity

Interacting Conformal Carroll Particles and Tachyonic
Carroll strings

Conformal boundaries of Minkowski superspace and their
super cuts

Celestial and Carrollian Amplitudes and Celestial
Liouville Theory

Supertranslation invariance and covariance of Lorentz
charges

PSM diffeos and holography

Memory Effect and Carroll Symmetry for gravitational
waves

Asymptotic Structure and BMS Symmetries in Any
Dimension

On the definition of the spin charge in asymptotically
-flat spacetimes

Week 4, April 22 - 26, 2024

Claudio Dappiaggi (U Pavia)

Javier Matulich (UAM-CSIC, Madrid)

Sabrina Pasterski (Perimeter Institute,
Waterloo)

Simon Pekar (Ecole Polytechnique)

Juan A. Valiente Kroon (QMU London)

Piotr Chrusciel (U of Vienna)

Romain Ruzziconi (U Oxford)

Federica Muscolino (San Sebastian U)

Glenn Barnich (ULB, Brussels)

Amartya Saha (IITK, Kanpur)

Abhiram Kidambi

Quantum field theory on asymptotically flat spacetimes
and the BMS group

Superrotations at Spacelike Infinity

Radiation in Holography

From Carrollian conformal scalars to flat-space higher-spin
gravity

BMS-supertranslation charges at the critical sets of null
infinity

Characteristic initial data and smoothness of scri

Carrollian Amplitudes, Celestial Symmetries and Twistor
Space

The Carroll particles in Two Times

BMS representations

Soft Theorems from Carrollian Physics

Non-holomorphic Eisenstein Series and Quadratic Forms for
Ensemble Averages in Holography Enthusiasts

Céline Zwikel (Perimeter Institute, Waterloo) New developments on asymptotically leaky boundaries
 Giandomenico Palumbo (DIAS, Dublin) Boundary states of covariant fracton models

Publications and preprints contributed

S. Agrawal, P. Charalambous, L. Donnay, *Celestial $sw1 + \infty$ algebra in Einstein-Yang-Mills theory*, [arXiv:2412.01647](#)[hep-th].

M. Ammon, J. Hollweck, T. Hössel, K. Wölfl, *Conformal Blocks in Two and Four Dimensions from Oscillator Representations*, [arXiv:2406.19436](#)[hep-th].

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P. Bieliavsky, P. Spindel, R. Wutte, *Aspects of Warped AdS3 geometries*, [arXiv:2410.09688](#)[gr-qc].

A. Bissi, L. Donnay, B. Valsesia, *Logarithmic doublets in CCFT*, [arXiv:2407.17123](#)[hep-th].

J. Borthwick, Y. Herfray, *Projective and Carrollian geometry at time/space-like infinity on projectively compact Ricci flat Einstein manifolds*, [arXiv:2406.01800](#)[math.DG].

J. Cotler, K. Jensen, S. Prohazka, A. Raz, M. Riegler, J. Salzer, *Quantizing Carrollian field theories*, [arXiv:2407.11971](#)[hep-th].

L. P. de Gioia, A. M. Raclariu, *Celestial amplitudes from conformal correlators with bulk-point kinematics*, [arXiv:2405.07972](#)[hep-th].

F. Ecker, D. Grumiller, P. Salgado-Rebolledo, *Postcarrollian gravity*, [arXiv:2504.16162](#)[hep-th].

J. M. Figueroa-O'Farrill, G. S. Vishwa, *The BRST quantisation of chiral BMS-like field theories*, [arXiv:2407.12778](#)[hep-th].

S. Fredenhagen, F. Lausch, K. Mkrtchyan, *Interactions of massless fermionic fields in three dimensions*, [arXiv:2404.00497](#)[hep-th].

- O. Fuentealba, I. Lovrekovic, D. Tempo, R. Troncoso, *Enhanced conformal BMS3 symmetries*, [arXiv:2501.00439](#) [hep-th].
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- J. Hartong, G. Palumbo, S. Pekar, A. Pérez, S. Prohazka, *Fractons on curved spacetime in $2 + 1$ dimensions*, [arXiv:2409.04525](#) [hep-th].
- E. Have, K. Nguyen, St. Prohazka, J. Salzer, *Massive carrollian fields at timelike infinity*, [arXiv:2402.05190](#) [hep-th].
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- S. Majumdar, *On the Carrollian nature of the light front*, [arXiv:22406.10353](#) [hep-th].
- R. McNees, C. Zwickel, *The symplectic potential for leaky boundaries*, [arXiv:2408.13203](#) [hep-th].
- J. A. O'Connor, S. Pekar, *A note on non-Lorentzian duality symmetries*, [arXiv:2409.12279](#) [hep-th].
- G. Oling, J. F. Pedraza, *Mixmasters in Wonderland: Chaotic dynamics from Carroll limits of gravity*, [arXiv:2409.05836](#) [hep-th].
- S. Pekar, A. Pérez, P. Salgado-Rebolledo, *Cartan-like formulation of electric Carrollian gravity*, [arXiv:2406.01665](#) [hep-th].
- A. Pérez, St. Prohazka, A. Seraj, *Fracton Infrared Triangle*, [arXiv:2310.16683](#) [hep-th].
- R. Ruzziconi, S. Stieberger, T. R. Taylor, B. Zhu, *Differential equations for Carrollian amplitudes*, [arXiv:2407.04789](#) [hep-th].
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- P. M. Zhang, Q. L. Zhao, M. Elbistan, P. A. Horvathy, *Gravitational wave memory: further examples*, [arXiv:2412.02705](#) [gr-qc].
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- P.-M. Zhang, P. A. Horvathy, *Displacement within velocity effect in gravitational wave memory*, [arXiv:2405.12928](#) [gr-qc].

Invited scientists

Evangelos Afxonidis, Ankit Aggarwal, Shreyansh Agrawal, Peter C. Aichelburg, Martin Ammon, Jay Armas, Arjun Bagchi, Sourish Banerjee, Glenn Barnich, Mathieu Beauvillain, Robert Beig, Xavier Bekaert, Jibril Ben-Achour, Eric Bergshoeff, Erica Bertolini, Samuel Blitz, Jack Borthwick, Nicolas Boulanger, Alessio Caddeo, Andrea Campoleoni, Andreas Cap, Federico Capone, Panagiotis Charalambous, Piotr T. Chruściel, Luca Ciambelli, Wan Cong, Claudio Dappiaggi, Arnaud Delfante, Gianfranco De Simone, Stephane Detournay, Prateksh Dhivakar, Laura Donnay, Sudipta Dutta, Florian Ecker, David Fajman, José Figueroa-O'Farrill, Adrien Fiorucci, Stefan Fredenhagen, Laurent Freidel, Oscar Fuentealba, Marc Geiller, Aleksander Głodkowski, Joaquim Gomis, Maxim Grigoriev, Daniel Grumiller, Jelle Hartong, Emil Have, Marc Henneaux, Yannick Herfray, Jakob Hollweck, Peter Horvathy, Tobias Hössel, Kristan Jensen, Daniel Kapec, Xavier Kervyn, Vinayak Mallikarjun Kulkarni, Johannes Lahnsteiner, Rob Leigh, Iva Lovrekovic, Sucheta Majumdar, Mikhail Markov, Javier Matulich, Lea Mele, Prahar Mitra, Saikat Mondal, Luciano Montecchio, Ashwin Murali, Federica Muscolino, Kevin Nguyen, Niels Obers, Josh O'Connor, Gerben Oling, Giandomenico Palumbo, Michel Pannier, Yorgo Pano, Noémie Parrini, Sabrina Pasterski, Simon Pekar, Alfredo Perez, Anastasios Petkou, Marios Petropoulos, Massimo Porrati, Daniele Pranzetti, Stefan Prohazka, Andrea Puhm, Ana-Maria Raclariu, Ronnie Rodgers, Jan Rosseel,

Romain Ruzziconi, Amartya Saha, Patricio Salgado-Rebolledo, Domenico Giuseppe Salluce, Jakob Salzer, Ali Seraj, Konstantinos Siampos, Christoph Sieling, Amartya Harsh Singh, Stephan Stieberger, Poula Tadros, Wen-Di Tan, Greg Taujanskas, Tung Tran, Ricardo Troncoso, Lazaros Tsaloukidis, Juan A. Valiente Kroon, Beniamino Valsesia, Stefan Vandoren, Dmitri Vassilevich, Matthieu Vilatte, Peter West, Katharina Wölfl, Raphaela Wutte, Céline Zwickel.

Nonlinear Waves and Relativity

Organizers: Roland Donn timer (U of Vienna), David Fajman (U of Vienna), Birgit Schörkhuber (U of Innsbruck)

Dates: April 29 – June 21, 2024

Budget: ESI € 55 200

Report on the thematic programme

The programme brought together researchers from the areas of dispersive partial differential equations (PDEs) and mathematical relativity to present cutting-edge advancements, discuss future challenges, and foster interaction between these closely related yet distinct disciplines.

General relativity, a classical but highly dynamic area of mathematical physics, has a rich tradition in Vienna. The field of dispersive PDEs, though relatively new, has become a cornerstone of modern analysis. Both fields have experienced remarkable progress over the past two decades. Relativity constitutes an invaluable source for interesting problems in PDEs that create new directions of research, while techniques developed for simpler PDE models can significantly impact relativity. The programme facilitated intensive collaboration between researchers in both areas, encouraging new developments and opening up new research directions.

Activities

The programme spanned eight weeks and was highly regarded by the international community. A total of 96 researchers participated, ranging from world-renowned experts to young scientists and PhD students in the fields of Dispersive PDEs and Mathematical Relativity.

Two major workshops were held from May 13 – 17 and June 17 – 21, respectively. In line with the programme's core objective, presentations from both fields were scheduled during each workshop to foster greater interaction between the two communities.

The intensity of discussions and presentations naturally peaked during the workshops, yet the programme maintained a steady flow of activity throughout its duration. Up to six lectures per week granted a continuous exchange of ideas, highlighted by two colloquia presented by P. Gerard and J. Krieger at the Faculty of Mathematics. Additionally, many participants deliberately scheduled their visits during the quieter periods surrounding the workshops, taking full advantage of the ESI venue's excellent facilities for scientific collaboration.

Specific information on the thematic programme

During the time of the programme 58 lectures and presentations were contributed on dynamical aspects of relativity, wave-type geometric equations, dispersive models and fluids. Given the

interdisciplinary nature of the workshop, speakers typically began with a general introduction to key concepts, ensuring that non-experts and younger participants could benefit from the presentations and actively engage in the discussions.

A particular highlight during the two workshops were lightning talks by PhD students - local and international - who presented their work in concise 15-minutes sessions to an audience of internationally renowned experts. Among them were Allison Byars (U of Wisconsin), Maximilian Ofner (U of Vienna), Matthias Ostermann (U of Vienna), Ovidiu-Neculai Avadanei (UC, Berkeley), Matthew Kowalski (UCLA), Liam Urban (U of Vienna), Ambre Chabert (ENS Paris), Ryan Martinez (UC, Berkeley), Alexander Wittenstein (KIT, Karlsruhe), Mahdi Haghshenas (Imperial College London), Warren Li (Princeton U) and Istvan Kadar (U of Cambridge).

In addition, several postdoctoral researchers gave talks during the programme: Maciej Mali-borski (U of Vienna), Irfan Glogić (U of Vienna), Tobias Schmid (EPFL), Filip Ficek (U of Vienna), David Wallauch-Hajdin (U of Vienna), Michael McNulty (Michigan State U) and Marko Sobak (U of Vienna).

Putting young mathematicians in the spotlight fostered an inclusive atmosphere for interactions between different generations of researchers and created opportunities for young people to establish valuable connections which might lead to future collaborations.

Scientific content

The scientific results presented throughout the programme encompassed a wide array of models, ranging from classical dispersive PDEs like the nonlinear Schrödinger equation, to nonlinear wave equations and hyperbolic models on both flat and curved backgrounds, as well as equations from general relativity, including cosmological models and black holes. Despite the diversity of topics, common overarching themes emerged, sparking lively discussions and facilitating the exchange of ideas across the two communities.

Special solutions, stability and interaction. The nonlinear characteristics of many models allow for the existence of non-trivial, special solutions, e.g static configurations, time-dependent solitary waves, or self-similar solutions. Since such special solutions can (or do indeed) represent physical phenomena, a deep understanding of their properties is of particular importance. Several talks focused on the stability of special solutions across various models, which often involves intricate spectral analysis. Another hot topic that was addressed during the programme is the construction and the analysis of dynamically interacting nonlinear entities, such as multi-solitary waves.

Singularity formation. A particular feature of nonlinear models is the potential formation of singularities in finite time. A prototypical physical example is the formation of black holes during gravitational collapse. However, blowup can be found in many other models and the detailed understanding of if and how singularities are formed is one of the big challenges in current PDE analysis. In several talks, special solutions and self-similarity were identified to play a decisive role in this context, which again links to stability problems. Also, critical phenomena in gravitational collapse and the analysis of thresholds for blowup were discussed intensively throughout the programme.

Global existence and long-time behavior. Establishing global existence of solutions and determining the long-term asymptotics in nonlinear evolution problems for arbitrary initial data is a highly challenging task that cannot be addressed solely through perturbative methods. Many talks and discussions in the programme concentrated on these issues, with a particular focus on scattering, dispersive estimates, and the characterization of late-time tails.

Outcomes and achievements

Many participants took the opportunity to meet with their collaborators at the ESI to discuss and continue ongoing work. Some preprints have already emerged and are listed below. Additionally, new collaborations were formed, with several involving young researchers (e.g. T. Schmid and M. McNulty jointly worked on blowup for the critical Skyrme model; D. Wallauch, A. Sanwal and B. Schörkhuber started a project on self-similar solutions in nonlinear wave equations, C. Klein and B. Schörkhuber discussed blowup in higher order dispersive models, . . .). The open and inclusive atmosphere at the ESI was highly appreciated, as it fostered an environment conducive to learning and collaboration, ultimately enhancing the overall impact of the event.

List of talks

Workshop 1, May 13 - 17, 2024

Daniel Tataru (UC, Berkeley)	Global solutions for quasilinear Schrödinger flows
Sebastian Herr (U Bielefeld)	Strichartz estimates and global well-posedness of the cubic NLS on the 2d torus
Mihaela Ifrim (U of Wisconsin-Madison)	Modified scattering for the three dimensional Maxwell-Dirac system
Didier Pilod (U of Bergen)	Finite point blowup for the critical generalized Korteweg-de Vries equation
Herbert Koch (U Bonn)	The Korteweg-de Vries hierarchy in rough function spaces
Raphaël Côte (IRMA, Strasbourg)	Perturbation at blow up of self similar solution for mKdV
Pierre Germain (Imperial College London)	Nonlinear waves and turbulence
Allison Byars (U of Wisconsin)	Global Dynamics of the small data solutions to the Derivative Nonlinear Schrödinger Equation
Maximilian Ofner (U of Vienna)	Expansion thresholds for the stability of cosmological fluids
Matthias Ostermann (U of Vienna)	Stable self-similar blowup for nonlinear wave equations beyond light cones
Ovidiu-Neculai Avadanei (UC, Berkeley)	Low regularity well-posedness for the generalized surface quasi-geostrophic front equation
Matthew Kowalski (UCLA)	Dispersive decay for the energy-critical nonlinear Schrödinger equation
Liam Urban (U of Vienna)	On the past maximal development of near-FLRW data for the Einstein scalar-field Vlasov system
Michał Kowalczyk (U de Chile, Santiago)	Asymptotic stability of kinks in the odd energy space
Kenji Nakanishi (Kyoto U)	Initial classification of global behavior around multi-solitons for the nonlinear Klein-Gordon equation
Sung-Jin Oh (UC, Berkeley)	Late time tail of waves on dynamic asymptotically flat spacetimes of odd space dimensions
Arthur Touati	Initial data for stability theorems in general relativity
Sohrab Shahshahani (UMass Amherst)	Codimension one stability of the catenoid for the hyperbolic vanishing mean curvature equation
Hans Lindblad (Johns Hopkins U, Baltimore)	Scattering for wave equations with sources and slowly decaying data
Hans Ringström (KTH Stockholm)	Formation of quiescent big bang singularities
Christoph Kehle (ETH Zurich)	Extremal Critical Collapse
Philippe G. LeFloch (Sorbonne U, Paris)	Optimal shielding for Einstein gravity
Maciej Maliborski (U of Vienna)	Periodic solutions for 1d nonlinear wave equation

Workshop 2, June 17 - 21, 2024

Piero D’Ancona (U Roma 1, Sapienza)	Dispersion estimates for Dirac equations with Aharonov–Bohm magnetic fields
Jonas Lührmann (TAMU, College Station)	Asymptotic stability of solitary waves for the 1D focusing cubic NLS under even perturbations
Claudio Munoz (U de Chile, Santiago)	Kink dynamics for the Yang-Mills field in an extremal Reissner-Nordström black hole
Tadahiro Oh (U of Edinburgh)	Fourier restriction norm method adapted to controlled paths
Avy Soffer (Rutgers U)	Scattering Theory of Linear and Nonlinear Waves: A Unified New Paradigm
Klaus Widmayer (U Zurich)	Landau damping around the Poisson equilibrium for the Vlasov-Poisson system
Ambre Chabert (ENS Paris)	Weakly turbulent solution to the Schrödinger equation on the 2D torus with potential
Ryan Martinez (UC, Berkeley)	The Modified Energy Method for a Nonlocal Quasilinear Wave Equation
Alexander Wittenstein (KIT, Karlsruhe)	Existence and stability of corotational wave maps into perturbed spheres
Jérémie Szeftel (Sorbonne U, Paris)	The nonlinear stability of Kerr for small angular momentum
Alexandru Ionescu (Princeton U)	On the stability of homogeneous equilibria of the Vlasov-Poisson system
Benjamin Dodson (Johns Hopkins U, Baltimore)	Global well-posedness and scattering for the conformal nonlinear wave equation
Volker Schlue (U Melbourne)	Scattering problems with homogeneous asymptotics
Andras Vasy (Stanford U)	Waves on Kerr-de Sitter space
Jonathan Luk (Stanford U)	High frequency spacetimes in general relativity
Michał Wrochna (Utrecht U)	Feynman problems for the Klein-Gordon and wave equation
Mahdi Haghshenas (Imperial College London)	The effect of expansion and dispersion on waves in FLRW spacetimes with decelerated expansion
Warren Li (Princeton U)	Scattering towards the spacelike singularity in Kasner spacetimes
Istvan Kadar (U of Cambridge)	Construction of multi-soliton solutions for semilinear equations in dimension 3
Susanna Haziot (Brown U)	Desingularization and long-term dynamics of solutions to fluid models
Klaus Kröncke (KTH Stockholm)	A volume-renormalized mass for asymptotically hyperbolic manifolds
Benoit Pausader (Brown U, Providence)	Landau damping/Surfing ducklings

Individual talks

Håkan Andréasson (Chalmers U of Technology, Gothenburg)	Oppenheimer-Snyder type collapse for the Einstein-Vlasov system
Gong Chen (GATECH, Atlanta)	Dynamics of multi-soliton solutions to Klein-Gordon equations
Sven Hirsch (IAS, Princeton)	Initial data sets with vanishing mass are contained in pp-waves
Patrick Gerard (U Paris-Saclay)	An explicit formula for the Benjamin-Ono equation and applications
Irfan Glogić (U of Vienna)	Stable self-similar blowup for the Keller-Segel model in three dimensions
Tobias Schmid (EPFL, Lausanne)	Blow up dynamics for the 3D energy-critical nonlinear Schrödinger equation

Luis Vega (BCAM & UPV/EHU, Bilbao)	The binormal flow and the desingularization of the Biot-Savart integral
Filip Ficek (U of Vienna)	Dynamics of conformal scalar field in asymptotically-AdS black hole spacetimes
Christian Klein (U Bourgogne, Dijon)	Numerical study of blow-up for solutions to nonlinear dispersive PDES
David Wallauch-Hajdin (U of Vienna)	Optimal blowup stability for wave maps
Michael McNulty (Michigan State U, East Lansing)	Stable blowup for the higher-dimensional Skyrme model
Joachim Krieger (EPFL, Lausanne)	Singularity formation for a geometric wave equation
Marko Sobak (U Vienna)	Haunted Einstein-Yang-Mills wormholes

Publications and preprints contributed

F. Cacciafesta, P. D’Ancona, Z. Yin, J. Zhang, *Dispersive estimates for Dirac equations in Aharonov-Bohm magnetic fields: massless case*, [arXiv:22407.12369](#)[math.AP].

G. Chen, J. Luhrmann, *Asymptotic stability of the sine-Gordon kink*, [arXiv:2411.07004](#)[math.AP].

R. Donn timer, B. Schörkhuber, *Self-similar blowup for the cubic Schrödinger equation*, [arXiv:2406.16597](#)[math.AP].

D. Fajman, M. Ofner, T. Oliynyk, Z. Wyatt *Stability of fluids in spacetimes with decelerated expansion*, [arXiv:2501.12798](#)[gr-qc].

S. Haque, R. Killip, M. Visan, Y. Zhang, *Global well-posedness and equicontinuity for mKdV in modulation spaces*, [arXiv:2411.05300](#)[math.AP].

S. Herr, M. Ifrim, M. Spitz, *Modified scattering for the three dimensional Maxwell-Dirac system*, [arXiv:2406.02460](#)[math.AP].

M. Kowalski, *Dispersive decay for the energy-critical nonlinear Schrödinger equation*, [arXiv:2411.01466](#)[math.AP].

Y. Li, J. Luhrmann, *Asymptotic stability of solitary waves for the 1D focusing cubic Schrödinger equation under even perturbations*, [arXiv:2408.15427](#)[math.AP].

Invited scientists

Patricia Alonso Ruiz, Selim Amar, Lars Andersson, Håkan Andréasson, Ovidiu-Neculai Avadanei, Valeria Banica, Louie Bernhardt, Piotr Bizón, Adam Black, Andras Bonk, Volker Branding, Allison Byars, Ambre Chabert, Gong Chen, Piotr T. Chruściel, Charles Collot, Raphaël Côte, Piero D’Ancona, Benjamin Dodson, Roland Donn timer, Thomas Duyckaerts, Florian Ecker, David Fajman, Filip Ficek, Patrick Gerard, Pierre Germain, Irfan Glogić, Carsten Gundlach, Susana Gutierrez, Mahdi Haghshenas, Susanna Haziot, Sebastian Herr, James Hogan, Mihaela Ifrim, Alexandru Ionescu, Oana Ivanovici, Istvan Kadar, Christoph Kehle, Rowan Killip, Christian Klein, Herbert Koch, Michal Kowalczyk, Matthew Kowalski, Joachim Krieger, Klaus Kröncke, Michael Kunzinger, Antoine Lardot, Kiyeon Lee, Philippe G. LeFloch, Enno Lenzmann, Warren Li, Hans Lindblad, Ethan Lu, Jonas Lührmann, Jonathan Luk, Driss Maitrejean, Cyril Maléze, Maciej Maliborski, Ryan Martinez, Michael McNulty, Jakob Möller, Vincent Moncrief, Frederick Moscatelli, Claudio Munoz, Kenji Nakanishi, Maximilian Ofner, Sung-Jin Oh, Tadahiro Oh, Matthias Ostermann, Benoit Pausader, Didier Pilod, Hans Ringström, Paola Rioseco, Clemens Sämann, Akansha Sanwal, Wilhelm Schlag, Volker Schlue, Tobias Schmid, Birgit Schörkhuber, Sohrab Shahshahani, Marko Sobak, Avy Soffer, Martin Spitz, Jérémie Szeftel, Mónica Tapia del Moral, Daniel Tataru, Liam Urban, Juan A. Valiente Kroon, Andras Vasy, Luis Vega, Monica Visan, David Wallauch-Hajdin, Klaus Widmayer, Alexander Wittenstein, Michał Wrochna, Bowen Zhao.

The Landscape vs. the Swampland

Organizers: Gary Shiu (U of Wisconsin-Madison), Washington Taylor (MIT, Cambridge), Irene Valenzuela (CERN, Geneva), Timm Wrase (Lehigh U, Bethlehem)

Dates: July 1 – August 9, 2024

Budget: ESI € 49 756

Report on the thematic programme

In the last two decades it has become apparent that string theory has a gigantic number of consistent solutions, the so-called string ‘landscape’. This has raised an interesting and important question: Can all *consistent* low energy effective field theories that include gravity actually arise in string theory or not? While this is a very difficult question to answer, it seems clear that not every *consistent looking* low energy effective theory can arise from string theory. This has led to the term ‘swampland’ to describe low energy effective field theories, which look consistent but ultimately are not when coupled to gravity.

The aim of this programme was to bring together people working on these two aspects of string theory: the landscape and the swampland. The goal was to provide complementary viewpoints that would, during a six-week programme with ample interactions, lead to mutually beneficial insights that will help guide the future research directions of this very active line of research.

Activities

This six-week programme started out on Monday July 1st, 2024 with a meet and greet during which the participants got to know each other. The first week continued with four introductory keynote lectures. Two of which were on Tuesday and two were on Thursday. Additionally, on Wednesday we had a two-hour long discussion session on the general theme of the workshop. This was in line with the ESI guidelines and provided a service to the local scientific community and helped the young participants to get a broader overview. These events as well as the other weeks of the programme were attended by local scientist from the University of Vienna as well as the TU Vienna.

The second, fourth, fifth and sixth week were all non-workshop weeks and we kept a light schedule to allow for ample interactions and collaborations. We started out each week with a Meet & Greet on Monday so that all the participants of that weeks could get to know each other. This also allowed each participant to mention their current research interests, which led to ample discussions during our joint lunches. We encouraged everyone to get take out and come back to the ESI coffee room to eat. On Tuesdays, Wednesdays and Thursdays we scheduled two-hour discussion sessions on topics that were of interest to participants of that particular week. On Wednesdays we also organized a joint dinner so that the participants could mingle and socialize outside the work environment at the ESI. This all worked out very well and hopefully seeded many future collaborations on topics and questions that were discussed.

Lastly, week 3 of the programme was our workshop week. We had a total of 26 talks during that week and a workshop dinner on Tuesday night. We left the Wednesday and Friday afternoon free for collaborations and discussions between the participants since many could only come during that particular week. We also encouraged speakers to give shorter talks and allow for ample questions. Additionally, five slots were slightly longer and filled entirely with discussions that were very interactive.

Specific information on the thematic programme

We had a total of 37 younger research (prae- and post-docs) participating in our six-week programme. Many of them were supported via funds from the ESI. An alphabetical list is given here: Fien Apers, Sukṛti Bansal, Jose Calderon-Infante, Matilda Delgado, Markus Dierigl, Muldrow Etheredge, Mir Faruk, Bjoern Friedrich, Alessandra Grieco, Kai Hall, Alvaro Herraiez, Ludwig Horer, Steven Weilong Hsia, Patrick Jefferson, Daniel Junghans, Ahmed Rakin Kamal, Yixuan Li, Guglielmo Lockhart, Gregory Loges, Andriana Makridou, Alessandro Manta, Zheng Miao, Georges Obied, Hector Parra de Freitas, Stefan Prohazka, Muthusamy Rajaguru, Thomas Raml, Nicole Righi, Ignacio Ruiz, Marco Scalisi, Andreas Schachner, Maria Schimpf, Flavio Tonioni, Ethan Torres, Georgios Tringas, Vincent Van Hemelryck, Max Wiesner.

Since it is very important for these younger researchers to give talks about their work we tried to offer all of them the possibility to speak during the programme. However, not all of them wanted to do that. The following 18 younger research gave a research seminar or even lead a discussion session during our programme: Jose Calderon-Infante, Markus Dierigl, Muldrow Etheredge, Alvaro Herraiez, Yixuan Li, Guglielmo Lockhart, Gregory Loges, Andriana Makridou, Georges Obied, Muthusamy Rajaguru, Thomas Raml, Ignacio Ruiz, Marco Scalisi, Andreas Schachner, Ethan Torres, Georgios Tringas, Vincent Van Hemelryck, Max Wiesner.

Outcomes and achievements

This programme brought together researchers from Europe, America and Asia. We managed to attract the leaders in the field of the landscape of string theory as well as the swampland. Additionally, as detailed above, we invited many younger researchers, which allowed for a transfer of knowledge and the seeding of new research projects. While many of these project and research ideas will develop in the next weeks and months, we list here a few examples of collaborations that have already resulted in publications:

- Magdalena Larfors used her first few days at the ESI to finish a paper on using machine learning to find particular Calabi-Yau metrics.
- Muthusamy Rajaguru and Timm Wrase used their time together at the ESI to write a paper that discusses Minkowski vacua in non-geometric Landau-Ginzburg models. They performed most of their work for this paper during the programme.
- During their time at the ESI, Jose Calderon-Infante, Miguel Montero and Irene Valenzuela made significant progress on a project focused on testing the Distance conjecture in two dimensional CFTs. This progress was made possible by bringing the three of them together at the ESI, allowing for in-person discussions.
- The programme brought together Muldrow Etheredge and Ben Heidenreich from Amherst University, USA and Tom Rudelius from Durham, UK. They finished together a paper on the distance conjecture for branes that was also presented by the junior collaborator, Muldrow Etheredge, during our workshop.
- Harald Skarke met with Gary Shiu and Magdalena Larfors during the programme to discuss their shared interest in toric geometry. They are now in the process of applying for a different ESI programme in 2026 on "Toric Geometry in String Theory".
- Fien Apers, Miguel Montero and Irene Valenzuela used the opportunity of being at the ESI to work on a project about AdS scale separation.

List of talks

Workshop, July 15 – 19, 2024

Sera Cremonini (Lehigh U, Bethlehem)	Causality constraints on EFTs.
Yuta Hamada (KEK, Tsukuba)	Exploring the Landscape/Swampland of 6d supergravity
Georges Obied (U of Oxford)	Festina Lente and branes
Marco Scalisi (MPP, Munich)	Species Cosmology
Max Wiesner (Harvard U, Cambridge)	Non-perturbative Resolution of Strong Coupling Singularities in 4d $N=1$
Thomas Raml (MPP, Munich)	Infinite distances, the scalar potential and non-geometry
Ralph Blumenhagen (MPP, Munich)	Discussion on “Lessons from the swampland programme for the formulation of theories of quantum gravity”
Tom Rudelius (Durham U)	Taxonomy of Infinite Distance Limits
Ignacio Ruiz (UAM-CSIC, Madrid)	On the uses of towers in 4d $N=1$
Muldraw Etheredge (UMass Amherst)	A Distance Conjecture for Branes
David Andriot (LAPTh Annecy)	Quintessence: from string theory to observations, and back
Alvaro Herrera (MPP, Munich)	On the Origin of Species Thermodynamics and the Black Hole - Tower Correspondence
Dieter Lüst (LMU Munich)	Discussion on “Species Scale and UV/IR Mixing”
Seung-Joo Lee (Inst. for Basic Science, Daejeon)	On 7-Brane Moduli Limits
Ben Heidenreich (UMass, Amherst)	Discussion on “Infinite Distance Limits”
Savdeep Sethi (U of Chicago)	Discussion on “Non-Supersymmetric Strings”
Sonia Paban (Harvard U, Cambridge)	Primordial Stochastic Gravitational Wave
Ana Achúcarro (Leiden U)	Backgrounds in Multi-field Inflation
Muthusamy Rajaguru (Lehigh U, Bethlehem)	Rethinking multifield inflation
Daniel Junghans (TU Vienna)	Stabilizing Massless Fields in the 2 ⁶ Landau-Ginzburg Model
Keshaw Dasgupta (McGill U)	Problems of O8 de Sitter models
Kim Hee-Cheol (Postech, Pohang)	What if string theory has a de Sitter excited state?
Anamaria Font (Central U of Venezuela, Caracas)	Constraints on Kahler moduli space of 6d $N=1$ Supergravity
Pablo Soler (U de Oviedo)	Discussion on “Applications of Asymmetric Orbifolds”
Yixuan Li (MPP, Munich)	On non-SUSY deformations of AdS S-folds
Georgios Tringas (LAPTh Annecy)	Holography for KKLT: Anatomy of a Flow
Jose Calderon-Infante (CERN, Geneva)	Anisotropic scale-separated AdS flux vacua
	Tensionless Strings Limits in 4d Conformal Manifolds

Individual talks

Mirjam Cvetič (U of Pennsylvania, Philadelphia)	F-theory: Landscape of Particle Physics Models
Lara Anderson (Virginia Tech, Blacksburg)	Geometry of string comparative actions
James Gray (Virginia Tech, Blacksburg) & Irene Valenzuela (CERN, Geneva)	Discussion session on the landscape and swampland, 1 - 2
Miguel Montero (IFT Madrid)	Introduction to the Swampland - Part I: no global symmetries
Ben Heidenreich (Amherst U)	Introduction to the Swampland - Part II: The Weak Gravity Conjecture and the Distance Conjecture
Severin Lüst (LMU Munich) & Vincent Van Hemelryck (Uppsala U)	Discussion session on scale separation

Andriana Makridou (ITP UAM-CSIC Madrid) & Ethan Torres (CERN, Geneva)	Discussion session on cobordism and generalized symmetries.
Gary Shiu (U of Wisconsin-Madison) & Jan Pieter van der Schaar (U of Amsterdam)	Discussion session on cosmology, 1 - 2
Gregory Loges (KEK, Tsukuba) & Washington Taylor (MIT, Boston)	Discussion session on the 6d landscape and swampland
Severin Lust (LMU Munich) & Vincent Van Hemelryck (Uppsala U)	Discussion session on scale separation
Andriana Makridou (ITP UAM-CSIC Madrid) & Ethan Torres (CERN, Geneva)	Discussion session on cobordism and generalized symmetries.
Gary Shiu (U of Wisconsin-Madison) & Jan Pieter van der Schaar (U of Amsterdam)	Discussion session on cosmology, 1 - 2
Gregory Loges (KEK, Tsukuba) & Washington Taylor (MIT, Boston)	Discussion session on the 6d landscape and swampland
Susha Parameswaran (Liverpool) & Ivonne Zavala (Swansea U)	Discussion session on “Dark Energy in String Theory”, 1 - 2
Arthur Hebecker (Heidelberg U) & Andreas Schachner (LMU, Munich)	Discussion session on “de Sitter constructions in String Theory”, 1 - 2
Luca Martucci (Padova U)	Wormholes in the Axiverse, and the Species Scale
Fernando Marchesano (IFT Madrid) & Luca Martucci (Padova U)	Discussion session on “So what about the Standard Model?”
Jakob Moritz, CERN, Geneva	Discussion session, 1 - 2
Markus Dierigl (LMU, Munich)	Discussion session on Global Symmetries and How to Avoid Them, 1 - 2
Guglielmo Lockhart (U of Bonn)	Discussion session on String Probes in Quantum Gravity, 1 - 2
Ruben Minasian, Saclay, SPhT	Discussion session on No spin structure, no orientation. . . no problem, 1 - 2
Joe Conlon, Oxford U	Discussion session on Holography and the Swampland, 1 - 2

Publications and preprints contributed

V. Aragam, S. Paban & R. Rosati, *Primordial Stochastic Gravitational Wave Backgrounds from a Sharp Feature in Three-field Inflation II: The Inflationary Era*, [arXiv:2409.09023](#)[astro-ph.CO].

G. Aldazabal, E. Andrés, A. Font, K. Narain & I. G. Zadeh *Asymmetric orbifolds, rank reduction and heterotic islands*, [arXiv:2501.17228](#)[hep-th].

J. Calderón-Infante, M. Delgado, Y. Li, D. Lust & A. M. Uranga, *Classical black hole probes of UV scales*, [arXiv:2502.03514](#)[hep-th].

G. F. Casas & I. Ruiz, *Cosmology of light towers and swampland constraints*, [arXiv:2409.08317](#)[hep-th].

M. Dierigl & D. Novičić, *The Axion is Going Dark*, [arXiv:2409.02180](#)[hep-th].

M. Etheredge, B. Heidenreich & T. Rudelius, *A Distance Conjecture for Branes*, [arXiv:2407.20316](#)[hep-th].

Y. Hendi, M. Larfors & M. Walden, *Learning Group Invariant Calabi-Yau Metrics by Fundamental Domain Projections*, [arXiv:2407.06914](#)[hep-th].

P. Lin & G. Shiu, *Schwinger Effect of Extremal Reissner-Nordström Black Holes*, [arXiv:2409.02197](#)[hep-th].

M. Rajaguru, A. Sengupta & T. Wrase, *Fully stabilized Minkowski vacua in the 2^6 Landau-Ginzburg model*, [arXiv:2407.16756](#)[hep-th].

F. Tonioni, *Curvature-induced moduli stabilization* [arXiv:2407.21104](#)[hep-th].

V. Van Hemelryck, *Weak G_2 -manifolds and scale separation in M-theory from type IIA backgrounds*, [arXiv:2408.16609](#)[hep-th].

Invited scientists

Ana Achúcarro, Lara Anderson, David Andriot, Fien Apers, Sukṛti Bansal, Ralph Blumenhagen, Jose Calderon-Infante, Joseph Conlon, Sera Cremonini, Mirjam Cvetič, Arnav Das, Keshav Dasgupta, Matilda Delgado, Markus Dierigl, Muldrow Etheredge, Anamaria Font, Stefan Fredenhagen, Bjoern Friedrich, James Gray, Alessandra Grieco, Kai Hall, Yuta Hamada, Arthur Hebecker, Kim Hee-Cheol, Ben Heidenreich, Alvaro Herrera, Francis Atta Howard, Steven Weilong Hsia, Daniel Junghans, Ahmed Rakin Kamal, Magdalena Larfors, Seung-Joo Lee, Yixuan Li, Guglielmo Lockhart, Gregory Loges, Dieter Lüst, Severin Lüst, Andriana Makridou, Abhiram Mamandur Kidambi, Alessandro Manta, Fernando Marchesano, Luca Martucci, Zheng Miao, Ruben Minasian, Miguel Montero, Jakob Moritz, Georges Obied, Sonia Paban, Susha Parameswaran, Hector Parra de Freitas, Stefan Prohazka, Muthusamy Rajaguru, Thomas Raml, Nicole Righi, Tom Rudelius, Ignacio Ruiz, Marco Scalisi, Andreas Schachner, Maria Schimpf, Savdeep Sethi, Gary Shiu, Harald Skarke, Pablo Soler, Radu Tatar, Washington Taylor, Stefan Theisen, Flavio Tonioni, Ethan Torres, Georgios Tringas, Irene Valenzuela, Jan Pieter van der Schaar, Vincent Van Hemelryck, Max Wiesner, Timm Wrase, Ivonne Zavala.

Linking Microscopic Processes to the Macroscopic Rheological Properties in Inert and Living Soft Materials

Organizers: Roberto Cerbino (U of Vienna), Emanuela Del Gado (Georgetown U), Giuseppe Foffi (Paris-Saclay U)

Dates: August 19 – October 11, 2024

Budget: ESI € 56 431

In addition to the ESI funding we obtained funding as follows:

€ 7 000 from CECAM (Centre Européen de Calcul Atomique et Moléculaire) for the co-organization of the ESI-CECAM joint workshop: “Failure in soft materials: from yielding to fracture”, as a part of this thematic programme.

€ 5 000 from VDSP (Vienna Doctoral School in Physics) to support the organization of the Summer School "Non-equilibrium Processes in Physics and Biology", as a part of this thematic programme.

€ 3 000 from the Faculty of Physics of the U of Vienna, to support the organization of the travel expenses of speakers from abroad.

Report on the thematic programme

The thematic programme focused on the rheological properties of amorphous soft systems — such as gels, glasses, foams, and granular materials — as well as living tissues. Both classes of materials exhibit transitions under mechanical stress, notably yielding, jamming, and fracture. While inert soft materials transition from elastic to plastic response as external driving increases, living tissues experience similar phenomena driven by both external forces and internal

physiological activity, with implications for developmental and pathological processes. Despite these analogies, the amorphous nature of these systems challenges traditional theoretical frameworks, prompting the need for novel approaches. The programme aimed to connect researchers working on inert and living soft materials by identifying common underlying mechanisms — such as failure, rigidity transitions, percolation, topological defects, and active matter dynamics — and by fostering dialogue across experimental, theoretical, and computational perspectives. Through lectures, talks, posters, and collaborative sessions, the programme provided a platform for exchanging ideas, synthesizing viewpoints, and initiating new research directions, with the broader goal of advancing both fundamental understanding and practical applications in soft and biological matter.

Activities

The thematic programme spanned from August 19 to October 11, 2024, with two scheduled breaks from August 31 to September 8 and from September 21 to 29. The following specific activities were successfully concluded:

Weeks 1 and 2 (August 19 – 30): The thematic programme began with the two-week Summer School "Non-equilibrium Processes in Physics and Biology" designed to provide basic and advanced training to early-career researchers — particularly PhD students and postdocs — working in soft matter and biological physics. Supported by the Vienna Doctoral School in Physics (VDSP), the school promoted interdisciplinary learning by addressing both inert and living soft materials from theoretical, experimental, and computational perspectives.

The morning sessions featured formal lectures by leading international experts. Topics included rheology and yielding transitions (Simon Rogers, Luca Cipelletti), bio-inspired and out-of-equilibrium material design (Zorana Zeravcic, Julia Yeomans), viscoelasticity and plasticity (Alessandra Bonfanti, Anael Lemaitre), active matter and tissue dynamics (Edouard Hannezo, Rastko Sknepnek), and biophysical systems such as bacterial biofilms and embryonic morphogenesis (Eleonora Secchi, Diana Pinheiro).

Afternoon activities were structured to maximize participant engagement and peer learning. These included:

- Two poster sessions, where participants presented and discussed their ongoing research
- Twelve hands-on tutorials, which offered parallel tracks in computational (e.g. vertex models, simulation of active matter) and experimental techniques (e.g. rheology of soft matter, microfluidics)
- Two journal club sessions, encouraging critical reading and collaborative discussion of landmark papers

The Summer School also included informal networking opportunities such as a welcome reception and a social dinner at a traditional Viennese *Heuriger*, which contributed to a stimulating and collegial atmosphere. The diversity of participants — from several institutions in ~ 20 countries — ensured rich interdisciplinary dialogue and the establishment of several collaborative links that extended beyond the programme.

Week 3 (September 9 – 13): ESI–CECAM Joint Workshop "Failure in Soft Materials: From Yielding to Fracture". This workshop, jointly organized by the Erwin Schrödinger Institute (ESI) and CECAM, brought together researchers from a broad spectrum of disciplines to address mechanical failure in soft and biological materials. The central aim was to bridge

traditional gaps between atomistic, mesoscopic, and continuum descriptions of soft matter and to explore universal features governing failure, yielding, and fracture across diverse systems — ranging from colloidal gels and emulsions to biological tissues and active matter.

Particular emphasis was placed on integrating different modeling and experimental approaches. The programme featured sessions on elastoplastic modeling, continuum theories of active and passive materials, simulations of fracture in soft gels, and emerging machine learning tools for identifying failure precursors. Contributions also explored analogies between biological morphogenesis and mechanical failure, uniting perspectives from physics, biology, and engineering. The workshop enabled productive interdisciplinary exchanges by grouping talks thematically — rather than by field — and pairing speakers from different backgrounds. Several sessions included paired talks by theorists and experimentalists on the same material system, and all sessions encouraged open discussion. A significant outcome of the workshop was the identification of key challenges in the multiscale modeling of failure and the definition of preliminary frameworks for collaborative research.

The workshop benefited from funding by both CECAM and ESI and played a central role in the thematic programme by catalyzing interactions among participants with overlapping but traditionally siloed interests in rheology, mechanics, and biological physics.

Week 4 (September 16 – 20): During this week we had a softer programme, with four long-format talks — three of them delivered by the programme organizers — each followed by extended discussions. The aim was to stimulate informal yet in-depth exchanges on emerging topics in the field, with a focus on bridging concepts between inert and living soft materials.

The talks covered a wide range of perspectives. We discussed the transition from thermal to athermal systems and highlighted universal features underlying self-assembly and absorbing phase transitions. We also covered the dynamics of active particles at high densities, shedding light on the collective behaviour and emergent dynamics near glassy and jammed states. Novel experimental approaches to cell tissue dynamics using differential dynamic microscopy in reciprocal space were also discussed, offering insights into the interplay of fluctuations, structure, and collective motion. Finally, the role of rigidity and hierarchical organization in soft particulate networks was also extensively covered, by emphasizing the role of architecture and multiscale connectivity in determining mechanical response.

These sessions were intentionally designed to be interactive and discursive, allowing participants to raise cross-cutting questions and to initiate small-group collaborations. The atmosphere was conducive to creative thinking and strategic planning for the final phase of the programme.

Weeks 5 and 6 (September 30 – October 11): During these two weeks, the concomitant start of the teaching semester in Vienna and many other countries made it impossible to maintain in-person activities at ESI, but many participants were involved in online activities (meetings, questionnaires,...) to continue the discussion and plan future activities on the theme.

Specific information on the thematic programme

The Summer School was designed around the needs of prae-docs at the intersection of soft and biological physics. We had a total of 41 participants from 12 countries. The participants were involved in many hands-on activities including tutorials, journal clubs, and poster sessions resulting in engaging discussions among students and between students and teachers.

The ESI-CECAM workshop has seen the attendance of 47 participants, from European (34), North American (9), and Asian (4) institutions, with a very diverse ethnicity. Among them, we counted 34 male participants, and 13 female participants. Restricting the analysis to the

39 workshop invite and contributed speakers, the ratio of female speakers was 31%. Among the contributed talks, 60% was reserved to early career stage researchers, and the invited talks ensured a balanced contribution from tenure-track and tenured researchers at various career stages.

Another measure to promote inclusivity was to make use of the audiovisual facilities provided by ESI to professional record all the presentations, which have been made available (for the speakers who agreed), publicly on the ESI's Youtube channel.

Outcomes and achievements

The whole thematic programme facilitated several tangible and intangible outcomes. Feedback from participants (collected through an anonymous form) highlighted both scientific advancements and the initiation of promising collaborations.

Participants emphasized that the programme contributed to advancing the state of the art in understanding mechanical response, yielding, and fracture in soft and biological materials. Discussions on topics such as brittleness, shear banding, glassiness, and the rheological behavior of complex systems proved especially impactful. Several responses noted the relevance of mechanical concepts across both biological and inert systems, reinforcing the programme's interdisciplinary goals.

One key outcome was the initiation of new collaborations, including the drafting of at least two joint publications (see list below) stemming directly from discussions held during the workshop. Some participants identified new research directions, including collaborative modeling efforts and potential grant proposals. Others noted that the workshop clarified outstanding theoretical challenges and helped shape their understanding of open questions in the field.

The take-home messages included the importance of precise and quantitative definitions in soft matter mechanics, the need for interdisciplinary cooperation between theorists and experimentalists, and the relevance of unifying frameworks to describe yielding and fracture phenomena across diverse systems.

Regarding societal impact, several attendees pointed out the potential applications of the presented work in materials science and medicine — for example, in understanding pathological transitions in biological tissues or designing better-performing, failure-resistant soft materials.

Apart from the collaborations that originated the two articles mentioned below in the list of publications and preprints, we also mention the following collaborations initiated or fostered by the event (the list is not exhaustive):

- Foffi, Cipelletti, Ramos and Jamali (joint research proposal)
- Bonfanti, Rogers (joint research activities)
- Del Gado, Jamali (joint proposal for a KITP workshop)
- Cerbino, Aime (joint research activities)
- Cerbino, Hannezo, Pinheiro (joint research activities)

List of talks

School, August 19 - 30, 2024

Simon Rogers (U of Illinois at Urbana-Champaign)	Yielding from a rheological perspective
Zorana Zeravcic (ESPCI, Paris)	Pattern formation out of equilibrium
Mehdi Bouzid (CNRS - U Grenoble Alpes)	Computational rheology in soft matter
Luca Cipelletti (U de Montpellier)	A microscopic, experiment-based view of the yielding transition - part I: scattering methods under a mechanical drive
Alessandra Bonfanti (Politecnico di Milano)	Fractional viscoelastic models for power-law materials
Laurence Ramos (CNRS, Montpellier)	Drying colloidal systems
Luca Cipelletti (U de Montpellier)	A microscopic, experiment-based view of the yielding transition - part II: the yielding transition of soft colloids
Anael Lemaitre (U Gustave Eiffel, Paris)	Stress correlations in glasses
Zorana Zeravcic (ESPCI, Paris)	Bio-inspired design in soft-matter systems
Sebastian Fürthauer (TU Vienna)	The physics of highly crosslinked cytoskeletal networks
Rastko Sknepnek (U of Dundee)	Vertex mode for tissue mechanics - part I
Andreas Zöttl (U of Vienna)	Theoretical modeling of passive and active particle dynamics in shear flow
Eleonora Secchi (ETH Zurich)	Bacterial Biofilms: Linking Microscopic Processes to Their Material properties and Ecological Function - part I - II
Anael Lemaitre (U Gustave Eiffel, Paris)	The contact aging scenario in adhesive colloidal suspensions
Julia Yeomans (U of Oxford)	Active Nematics and Mechanobiology
Edouard Hannezo (IST Austria)	Active matter model of multicellular tissue dynamics
Thomas Voigtmann (DLR, Köln)	Nonequilibrium Response Theory for Soft and Active Matter
Rastko Sknepnek (U of Dundee)	Numerical approaches to modelling curved surfaces
Diana Pinheiro (Vienna Biocenter)	How developing embryos take shape

ESI-CECAM joint Workshop: "Failure in soft materials: from yielding to fracture", September 9 - 13, 2024

Edouard Hannezo (ISTA, Klosterneuburg)	Mechanochemical models of tissue shape changes
Helene Delanoe-Ayari (U Lyon)	Stoke's flow experiment in biological tissues: comparison with an active abiotic system
Saroj Kumar Nandi (TIFR)	The cell shape variability and its implications in epithelial monolayers
Diogo Pinto (U Roma 1)	Cell motility in confluent tissues induced by substrate disorder
James Harden (U of Ottawa)	Rheo-XPCS studies of yielding, recovery and memory in soft colloidal glasses
Safa Jamali (Northeastern)	Topological origins of yielding in soft glassy materials
Simon Rogers (U Illinois)	Brittle and ductile yielding in soft materials
Giorgio Scita (IFOM)	Tissue Fluidification in pathophysiology: contact percolation sets phase transition and genetic rewiring in heterogeneous breast cancers
Dapeng "Max" Bi (Northeastern)	Shear-Induced Dynamics and Mechanical Responses in Biological Tissues
Paddy Royall (ESPCI, Paris)	Yielding in Colloidal Systems Far-From-Equilibrium: from Gels to Active Matter

Francesco Puosi (U Gustave Eiffel, Paris)	Plastic ridge formation in a compressed thin amorphous film
Diana Pinheiro (Vienna Biocenter)	Shaping developing tissues via dynamic signaling gradients
Suzanne Fielding (Durham U)	Strain localisation during yielding of amorphous materials
Kirsten Martens (CNRS -UGA)	How activity changes the rheological properties of dense disordered soft matter systems
Magali LeGoff (U of Innsbruck)	A coarse-grained molecular dynamics study of damage localization during the fracture of double polymer networks
Guillaume Charras (U College London)	Rupture strength of living cell monolayers
Alessandra Bonfanti (Politecnico Milano)	Disentangling the role of rheology and intercellular bond rupture in predicting tissue rupture strength
Mathieu Leocmach (CNRS)	Direct Confocal Imaging of Fracture Precursors in Casein Gel
Irmgard Bischofberger (MIT, Cambridge)	Under Pressure: Suspensions Pushed Too Far
Tanja Denise Singewald (JKU, Linz)	Coiled coils as mechanoresponsive material building blocks: towards molecular control of smart biomimetic hydrogels
Xavier Trepas (IBEC)	Epithelial mechanics from the bottom up
Bulbul Chakraborty (Brandeis U)	Emergent Elasticity in Non-Thermal Solids
Laurence Ramos (CNRS, Montpellier)	Compression of beads of colloidal gel
Alberto Rosso (Paris-Saclay U)	The fate of shear-oscillated amorphous solids
Peter Sollich (Georg-August-U, Göttingen)	Towards a complete mean-field theory for the ductile and brittle yielding of amorphous solids: beyond the paradigm of the Ising model in a random field
Matthieu Wyart (EPFL, Lausanne)	Thermal avalanches in liquids, amorphous solids and crumpled paper
Frederick C. MacKintosh (Rice)	Critical phenomena in biopolymer rheology
Nicoletta Petridou (EMBL, Heidelberg)	Passive vs active tissue material phase transitions instruct different morphogenetic trajectories
Stefano Aime (ESPCI, Paris)	Microscopic plasticity and dynamic heterogeneities in yielding soft glasses
Fabio Giavazzi (U Milan)	Intermittent, cooperative plastic events associated with homogeneous and heterogeneous deformations in yield stress fluids under oscillatory shear
Raffaele Pastore (Naples U)	Yielding and rheology of charged vesicle gels
Mazi Jalaal (U of Amsterdam)	Light Production and Adaptive Morphodynamics in an Active Biological System
Zvonimir Dogic (UC, Santa Barbara)	Encoding Shape, Structure, Mechanics, and Dynamics of a Soft Network with an Active Fluid
Srikanth Sastry (JNCASR)	Computer simulations of fatigue failure in glasses
Veronique Trappe (U of Fribourg)	Memory of shear flow in soft jammed materials
Pinaki Chaudhuri (IMSC)	Creep response of amorphous materials
Anael Lemaitre (U Gustave Eiffel, Paris)	Non-structural aging in adhesive colloidal suspensions
Giuliano Zanchetta (U Milan)	Of microgels and particles: trapping, yielding, sliding and swelling in water and non-aqueous solvents
Thomas Gibaud (ENS Lyon)	Early stage of cheese making: a two step aging process in milk gels

Individual talks

Giuseppe Foffi (Paris-Saclay U)	From thermal to athermal systems: self-assembly and absorbing phase transitions
Thomas Voigtmann (DLR, Köln)	Dynamics of active particles at high densities
Emanuela Del Gado (Georgetown U)	Rigidity and hierarchical organization in soft particulate networks
Roberto Cerbino (U of Vienna)	Exploring Cell Tissue Dynamics in Reciprocal Space: A Differential Dynamic Microscopy Approach

Publications and preprints contributed

M. Brizioli, M. A. Escobedo-Sánchez, P. M. McCall, Y. Roichman, V. Trappe, M. L. Gardel, S. U. Egelhaaf, F. Giavazzi, R. Cerbino, *One- and two-particle microrheology of soft materials based on optical-flow image analysis*, <https://doi.org/10.1039/D4SM01390E>.

T. Ghosh, P. Sollich & S. Kumar Nandi, *An elastoplastic model approach for the relaxation dynamics of active glasses*, [arXiv:2411.10793](https://arxiv.org/abs/2411.10793) [cond-mat.soft].

Invited scientists

Thematic programme

Stefano Aime, Dapeng "Max" Bi, Irmgard Bischofberger, Alessandra Bonfanti, Roberto Cerbino, Bulbul Chakraborty, Guillaume Charras, Pinaki Chaudhuri, Helene Delanoe-Ayari, Emanuela Del Gado, Giovanni Del Monte, Zvonimir Dogic, Suzanne Fielding, Giuseppe Foffi, Sebastian Fürthauer, Fabio Giavazzi, Thomas Gibaud, Edouard Hannezo, James Harden, Mazi Jalaal, Safa Jamali, Magali LeGoff, Anael Lemaitre, Mathieu Leocmach, Frederick C. MacKintosh, Swarnendu Maity, Kirsten Martens, Saroj Kumar Nandi, Jeremie Palacci, Raffaele Pastore, Nicoletta Petridou, Diana Pinheiro, Diogo Pinto, Francesco Puosi, Laurence Ramos, Simon Rogers, Alberto Rosso, Paddy Royall, Srikanth Sastry, Giorgio Scita, Tanja Denise Singewald, Peter Sollich, Veronique Trappe, Xavier Treppe, Thomas Voigtmann, Matthieu Wyart, Giuliano Zanchetta.

Summer school

Faisal Ahmad, Tanmay Biswas, Alessandra Bonfanti, Mehdi Bouzid, Dario Buonomo, Stefano Castellini, Roberto Cerbino, Tristan Cerdin, Miguel Àngel Chamorro Burgos, Monika Choudhary, Luca Cipelletti, Nora Deiringer, Francesca Dessi, Jasmin Di Franco, Stephan Domann, Eavan Fitzgerald, Giuseppe Foffi, Paul Fruton, Sebastian Fürthauer, Astik Halder, Edouard Hannezo, Magdalena Häupl, Debayan Jana, Pratikshya Jena, Nikolaos Kalafatakis, Anael Lemaitre, Jose Lòpez, Clara Luque-Rioja, Euan Mackay, Raphaël Maire, Manuel Mayo, Valeriia Muraveva, Laureano Ortellado, Sourav Pal, Alexander Petrunin, Diana Pinheiro, Martin Pinto, Laurence Ramos, Arun Ravi, Clare Rees-Zimmerman, Simon Rogers, Jan Rozman, Pablo Sanchez-Moreno Royer, Lisa Sappl, Florian Sauer, Jakob Schindewolf, Marketa Schmidt Cernohorska, Eleonora Secchi, Suganthan Senthilkumar, Amir Sheikh Shoaie, Rastko Sknepnek, Roman Staño, Alptug Ulugol, Devendra Kumar Verma, Thomas Voigtmann, Radost Waszkiewicz, Julia Yeomans, Zorana Zeravcic, Andreas Zöttl.

Workshops organized independently of the main programmes

Stochastic Partial Differential Equations

Organizers: Sandra Cerrai (U of Maryland), Martin Hairer (Imperial College London), Carlo Marinelli (University College London), Eulalia Nualart (U Barcelona), Luca Scarpa (Politecnico Milano), Ulisse Stefanelli (U of Vienna)

Dates: February 12 – 16, 2024

Budget: ESI € 12 112

Report on the Workshop

Stochastic partial differential equations arise naturally in several models of random phenomena, in such fields as biology, physics, and engineering. In particular, while deterministic models represent an efficient tool to describe time-evolution of real-world systems, they fail in rendering the presence of possible microscopic uncertainty of the model. Such randomness components may be related to several factors (such as temperature oscillations or magnetic/configurational perturbations) and are usually tracked through the introduction of a stochastic source of randomness in the equations involved.

One of the most challenging goals of the mathematics of stochastic partial differential equations is the understanding of quantitative and qualitative properties of solutions and their dependence on the coefficients. The complexity of such topic requires a wide variety of mathematical techniques, bridging from functional analysis to probability, from monotone and convex analysis to optimisation theory, from stochastic modelling to numerics. Such diversity attracts researchers from different areas of expertise.

The great relevance for applications and the enormous range of theoretical tools involved have contributed to an amazing development of this field in the last years. However, several aspects are still open in many directions. The main goal of this workshop is to bring together the international community on SPDEs in order to discuss the most recent advances of the theory and create an environment for cross-fertilisation of ideas.

Activities

The structure of the workshop has been quite classical: Participants have delivered scientific talks and have engaged in scientific exchange. The schedule has provided sufficient time for interaction and discussions.

Specific information on the workshop

The group of participants included researchers of all academic age. In particular, pre- and postdocs took part, in some cases even delivering talks. Some local pre- and postdocs did participate without being officially invited.

Participating predocs: Marco Bagnara (SNS Pisa, delivered a talk), Timo Bertolini (U of Vienna), Stefan Schrott (U of Vienna), Eduard Stefanescu (TU Graz), Riccardo Voso (U of Vienna), Andrea Chiesa (U of Vienna), Manuel Seitz (U of Vienna).

Participating postdocs: Federico Cornalba (U Bath, delivered a talk), Antonio Agresti (TU Delft, delivered a talk), Lukas Anzeletti (TU Vienna), Helena Kremp (TU Vienna), Tijana Levajkovic (TU Vienna), Katerina Nik (U of Vienna), Benjamin Robinson (U of Vienna), Katharina Schuh (TU Vienna), Immanuel Zachhuber (FU Berlin), Anastasia Molchanova (U of Vienna), Giacomo Sodini (U of Vienna).

Outcomes and achievements

Several scientific collaborations were started during this workshop. For example, a group in Vienna started a collaboration with an international group of participants on cross-diffusion systems with noise. At the same time, many existing scientific collaborations have been further developed, also including groups at the University of Vienna. An example in this direction is the running collaboration between Vienna and Pavia on uniqueness-by-noise techniques for nonlinear parabolic SPDEs. Furthermore, important new connections have been established, strengthening the link of people at the University of Vienna to the international community.

Direct output of the workshop are some joint papers, which are currently submitted or in the final stage of preparation. A joint proposal for further activities has been also prepared and submitted.

List of talks

Viorel Barbu (U A.I.I.Cuza, Iasi)	Probabilistic representation of solutions to 2-D Navier-Stokes equations and weak uniqueness for the solutions to corresponding McKean-Vlasov SDEs
Mohammud Foondun (U Strathclyde, Glasgow)	Recent results on global existence and stochastic partial differential equations.
Carlo Orrieri (U Pavia)	Weak uniqueness by noise for some singular SPDEs
Erika Hausenblas (Montanuniversität Leoben)	A stochastic Schauder Theorem and biochemical nonlinear systems of SPDEs
Margherita Zanella (Politecnico Milano)	Ergodic results for the stochastic nonlinear Schrödinger equation with large damping.
Marco Bagnara (SNS Pisa)	A suitable nonlinear Stratonovich noise prevents blow-up in the Euler equations and other SPDEs.
István Gyöngy (U Edinburgh)	On parabolic SPDEs with singular coefficients
Benedetta Ferrario (U Pavia)	Invariant measures for a nonlinear Schrödinger equation
Kostantinos Dareiotis (U Leeds)	Regularisation of reaction-diffusion equations by multiplicative noise
Federica Masiero (U Milano-Bicocca)	Partial smoothing of the stochastic wave equation and regularization by noise phenomena
Giuseppina Guatteri (Politecnico Milano)	Nonlinear Random Perturbations of PDEs and Quasi-Linear Kolmogorov Equations in Hilbert Spaces
Paul Gassiat (Dauphine U, Paris)	Gradient flow on control space with rough initial condition
Ivan Yaroslavtsev (U Hamburg)	Weak L^p inequalities for stochastic integrals with respect to random measures
Annie Millet (U Paris Sorbonnes)	Rate of convergence of a time Euler scheme for a stochastic 2D Boussinesq equation
Ansgar Jüngel (TU Vienna)	Martingale solutions to stochastic cross-diffusion systems: A new regularization procedure
Martin Ondreját (Czech Academy of Sciences, Prague)	Numerical approximation of the stochastic total variation flow
Aleksandra Zimmermann (TU Clausthal)	Well-posedness and Lewy-Stampaccia inequalities for nonlinear stochastic evolution equations

Arnaud Debussche (ENS de Rennes)	Non linear Schrödinger equation with a spatial white noise potential.
Tusheng Zhang (U Manchester)	Irreducibility and accessibility of SPDEs driven by pure jump noise
Hendrik Weber (U Münster)	A priori bounds for subcritical fractional ϕ^4 on T^3
Federico Cornalba (U Bath)	Multilevel Monte Carlo methods for the Dean–Kawasaki equation from Fluctuating Hydrodynamics
Benjamin Gess (U of Bielefeld)	Large deviations from porous media and gradient flow structures
Antonio Agresti (TU Delft)	Regularization by noise for systems of reaction-diffusion equations
Peter K. Friz (TU Berlin)	Analyzing classes of SPDEs via RSDEs
Yuri Bakhtin (NYU, New York)	Differentiability of shape functions and effective Lagrangians
Ajay Chandra (Imperial College London)	A priori bounds for the generalised parabolic Anderson model
Michael Röckner (U of Bielefeld)	Nonlinear Fokker-Planck-Kolmogorov equations and nonlinear Markov processes

Invited scientists

Antonio Agresti, Lukas Anzeletti, Marco Bagnara, Yuri Bakhtin, Viorel Barbu, Timo Bertolini, Ajay Chandra, Federico Cornalba, Sonja Cox, Kostantinos Dareiotis, Arnaud Debussche, Benedetta Ferrario, Mohammad Foondun, Peter K. Friz, Paul Gassiat, Benjamin Gess, Giuseppina Guatteri, István Gyöngy, Martin Hairer, Erika Hausenblas, Ansgar Jüngel, Tijana Levajkovic, Chengcheng Ling, Jan Maas, Federica Masiero, Annie Millet, Eulalia Nualart, Martin Ondreját, Carlo Orrieri, Chiara Rigoni, Michael Röckner, Luca Scarpa, Christian Schmeiser, Stefan Schrott, Katharina Schuh, Ulisse Stefanelli, Eduard Stefanescu, Jan van Neerven, Hendrik Weber, Ivan Yaroslavtsev, Immanuel Zächhuber, Margherita Zanella, Tusheng Zhang, Aleksandra Zimmermann.

Chromatin Modeling: Integrating Mathematics, Physics, and Computation for Advances in Biology and Medicine

Organizers: Anton Goloborodko (IMBA, Vienna), Tamar Schlick (NYU, New York), Jan Smrek (U of Vienna)

Dates: March 4 – 15, 2024

Budget: ESI € 16 160

Journal of Chemical Physics \$ 500

Report on the Workshop

Advances in computer technology and innovative algorithms are opening opportunities for modeling in biology as never before. In turn, these advances are driving biology and medicine forward, as clearly seen during the Covid-19 pandemic, where basic science of RNA and RNA viruses has helped develop the mRNA-based vaccines. While there are many general methods that can be applied widely like linear algebra routines and fast summation algorithms, the most successful approaches are tailored and tightly connected with both the application at hand and the computing platform.

Genome organization is a prominent area where a variety of models and methods — from atomistic to polymer levels — is critically needed to bridge experimental data to solve important medical questions. Genome organization refers to the folding of the genome material, or the chromatin fiber that makes up chromosomes, in the cell nucleus of higher organisms.

In eukaryotes, this multiscale nucleoprotein complex of tightly packed nucleosomes connected by linker DNAs and associated with many regulatory proteins and RNAs, folds like yarn around many spools. The regulation of life's essential processes like gene expression, DNA repair, and cell differentiation is determined by the structure and interactions associated this packaged genome material. Yet chromatin structure and epigenetic mechanisms remain elusive despite decades of research.

Importantly, profound mathematical, physics, and biological questions regarding DNA geometry, topology, and function arise that span from the DNA base-pair level to condensed chromosomal arrangements on the mega-basepair level in the metaphase cell cycle. These questions involve both the structure of the chromatin fiber as well as its associated transformations.

Because these structures and transitions also impact human disease, and disruption of epigenetic mechanisms plays a key role in driving initiation and progression of most human cancers, a better understanding of these processes also has strong translational ramifications on human health via epigenome-based therapeutics.

Exciting recent advances in instrumentation are providing important information into these puzzles from X-ray crystallography, Cryo-electron microscopy, in-vitro biochemistry, single-nucleosome resolution nanoscopy, single-nucleosome fluorescence, electron tomography, and genome-wide contact data. In tandem, in silico modeling from atomic nucleosomes to coarse-grained chromatin fibers to polymer models of chromosomes underscore the polymorphic nature of chromatin in vivo.

Activities

Our workshop was organized by three scientists of diverse backgrounds and expertise that assembled an extraordinary group of scientists.

The three organizers are active researchers in the chromatin and polymer physics fields who approach problems on a broad range of modeling tools and some experimentation.

The organizers brought together a leading group of highly collaborative and broad minded mathematical biologists and physicists, computational biophysicists, and experimental biologists to help share the state-of-the-art in genome modeling and develop new integrative approaches from the base-pair level to chromosome and genome wide scales and address these fundamental questions. In addition to addressing these multiscale challenges, we created a highly open atmosphere where new ideas from different fields were generated to advance studies of the hierarchical structure of chromatin and the functional implication of these levels and rearrangements on human disease.

The relaxed programme style and ample free time stimulated personal and scientific interactions and established several new collaborations as well as continued fruitful interactions that were already formed by two former Les Houches meetings.

We also invited young scientists to learn and meet established researchers, and included a large number of women and minorities.

Our programme featured structured workshop on the first four weekdays (March 4-7, 2024), with lectures and extensive discussions. Long breaks allowed scientists to discuss ongoing and develop new collaborations. A reception on March 7 sponsored by the Journal of Chemical Physics also opened opportunities for participant contributions to a special publication issue of the journal devoted to chromatin structure and dynamics.

During the second week, a couple formal lectures and many informal discussions were held among the participants who were able to remain for the second week.

Specific information on the workshop

The list of young researchers: Mariana Kozłowska, Bharti Bharti, Hossein Salari Oliver Gittus, Jakob Schindelig, Hatice Döşeme, Mattia Alberto Ubertini, Cleis Battaglia, Cleis Battaglia, Valerio Sorichetti, Matthew Thomas, Rakesh Das, Serhan Turunç, Hatice Döşeme, Dario Dasaro, Edoardo Marchi, Manuel Fernandez Merino.

The young researchers contributed posters and took active part in discussions.

Outcomes and achievements

The ESI workshop on chromatin modelling brought together an expert group of broad minded scientists and facilitated the open discussion of key challenges and approaches that are best to pursue in the near future. Many existing collaborations were strengthened and new ones have been created. This was highlighted in responses by about 60% of the participants to our follow-up questionnaire which we sent before gathering this report.

Other outcomes and achievements mentioned by participants include: learning more about modeling at the DNA-nucleosome level, computational tools, and other areas; opportunities to discuss one's own works and findings; plans to formulate a collaborative proposal; plans to organize a follow-up workshop to this community; and excellent way to learn about the most recent exciting developments on the field.

The young scientist group we brought to the workshop will also undoubtedly enjoy and pursue directions they learned about in Vienna.

We thus expect many publications to result from the collaborations we triggered, notably not only among mathematical/chemical physicists but also between experimental biologists and theoreticians.

Compliments also were shared by all respondents on the venue, scientific programme, workshop atmosphere, helpful staff, and overall excellence of the facilities. They liked the size ("not too small, not too large") to maximize interactions, the excellent caliber of talks and interactions fostered, and all wanted to come again should a follow-up workshop at ESI be organized (we plan to apply). Suggestions were made on adding a tutorial for novices at the beginning of the week and maybe a round table discussion session.

We invited participants to join the Biophysical Society and join the Multiscale Genome Organization subgroup for yearly minisymposia at annual meetings, bimonthly webinars, and much more. Many participants have done it, as the MGO subgroup has substantially increased

critically since our workshop, ensuring its viability for the near future. This is an impressive outcome.

Besides active and new collaborations, participants were invited to contribute articles to a special issue in the Journal of Chemical Physics guest edited by Bin Zhang and Tamar Schlick on “Chromatin Structure and Dynamics: Recent Advancements”, in collaboration with Editor in Chief John Straub. Articles are due on August 31, 2024. Topics covered include, but are not limited to:

- Equilibrium chromosome folding mechanisms
- Non-equilibrium chromosome folding mechanisms
- Coupling between nuclear landmarks and genome organization
- Phase separation in genome organization

We would like to apply for a workshop continuation of this excellent programme in two years.

List of talks

Alexander Grosberg (NYU, New York)	Scaling, Topology, and Hydrodynamics in Polymer Models of Chromatin
Wilma Olson (Rutgers U)	Contributions of nucleosomal DNA architecture to higher-order chromatin organization
Anna Panchenko (Queen's U)	High-resolution exploration of chromatin dynamics using integrative approaches
Modesto Orozco (IRB, Barcelona)	Exploring chromatin structure and dynamics through experiments and simulations.
Stephen Levene (U Texas, Dallas)	DNA Dynamics and Chromatin Landscapes in the Circulome
Ivet Bahar (Stony Brook U, New York)	Insights into 4D Genome from Leveraging Hi-C technology with Elastic Network Models
Kerstin Bystricky (U Toulouse Capitole)	Real time in situ chromatin dynamics tracking at nanoscale resolution during transcription activation in human cells
Lars Nordenskiöld (NTU Singapore)	Columnar Nucleosome Stacking Dictates NCP and (Telomeric) Chromatin Condensation
Maria Pia Cosma (Center for Genomic Regulation, Barcelona)	Integrating imaging and genomic approaches to model 3D genome structure
Sergei Grigoryev (Penn State U)	Cryo-electron tomography reveals the nanoscale anatomy of condensed native chromatin
Ariel Kaplan (Technion Haifa)	Force spectroscopy sheds light on the structure and dynamics of nucleosomes
Sarah Swygert (CSU, Fort Collins)	Quiescent yeast: a cellular model of chromatin architecture across scales
Yuval Garini (Technion Haifa)	The multi-scale organization of chromatin in the nucleus
Alexey Onufriev (Virginia Tech)	The nucleosome as the “hydrogen atom” of epigenetics.
Vlad Cojocaru (Utrecht U)	Transcription factors pioneering genomic DNA under the computational nanoscope
Daniel Jost (ENS Lyon)	On the role of polymerases in shaping the 4D Genome
Vladimir Teif (U of Essex)	Nucleosome repositioning in cancer
Helmut Schiessel (TU Dresden)	A physical mechanism for the maintenance of epigenetic information
Peter Virnau (U Mainz)	A polymer-based approach to reconstruct 3d chromatin structures from single cell HiC and implications for knotting
Ludvig Lizana (Umeå U)	Modelling mechanisms of chromatin folding, gene regulation, and aging

John van Noort (Leiden U)	Unfolding chromatin fibers: how linker DNA organizes chromatin
Angelo Rosa (SISSA, Trieste)	Bottom-up data integration in polymer models of chromatin organization
Anton Goloborodko (IMBA, Vienna)	Sister chromatid cohesion is asymmetric
Buddhapriya Chakrabarti (U of Sheffield)	Physics of Surface Segregation: from Industrial Formulations to Chromatin Organization and Biology
David Brueckner (ISTA, Klosterneuburg)	Stochastic motion and transcriptional dynamics of pairs of distal DNA loci on a compacted chromosome
Mikhail Tamm (Tallinn U)	Non-ideal Gaussian polymers: a possible reference model for chromatin?
Alexandre Morozov (Rugers U)	Statistical mechanics of chromatin structure and dynamics
Geoff Fudenberg (U of Southern California, LA)	Physical chemistry of interphase loop extrusion

Publications and preprints contributed

See above (Outcomes section) on collaborations initiated at ESI and the scheduled issue in the Journal of Chemical Physics on Chromatin Structure and Dynamics.

Invited scientists

Ivet Bahar, Cleis Battaglia, David Brueckner, Kerstin Bystricky, Buddhapriya Chakrabarti, Vlad Cojocaru, Flavia Corsi, Maria Pia Cosma, Dario Dasaro, Vladimir Dmitriev, Hatice Döşeme, Manuel Fernandez Merino, Geoff Fudenberg, Sebastian Fürthauer, Yuval Garini, Oliver Gittus, Anton Goloborodko, Sergei Grigoryev, Alexander Grosberg, Daniel Jost, Ariel Kaplan, Mariana Kozłowska, Stephen Levene, Ludvig Lizana, Alexandre Morozov, Lars Nordenskiöld, Wilma Olson, Alexey Onufriev, Modesto Orozco, Anna Panchenko, Angelo Rosa, Helmut Schiessel, Jakob Schindlwig, Tamar Schlick, Jan Smrek, Valerio Sorichetti, Sarah Swygert, Mikhail Tamm, Vladimir Teif, Matthew Thomas, Gasper Tkacik, Serhan Turunç, Mattia Alberto Ubertini, John van Noort, Peter Virnau.

Rare Events in Dynamical Systems

Organizers: Françoise Pène (UBO, Brest), Tanja Schindler (Jagiellonian U, Krakow), Roland Zweimüller (U of Vienna)

Dates: March 18 – 22, 2024

Budget: ESI € 8 110

Report on the Workshop

The study of return-times and hitting-times of small sets (rare events) in ergodic dynamical systems has undergone some intense research in the past 20 years. It is part of the wider field of probabilistic properties of (deterministic) dynamical systems. One general motivation from the sciences is that the times at which various extreme events (possibly modeling catastrophes in real-world systems) occur, often cannot be predicted over a reasonably long period. It is therefore

important to at least understand the statistical laws governing these occurrences. Accordingly, there are well-developed stochastic models describing such rare events and enabling further theoretical analysis. These stochastic descriptions, however, necessarily start from simplifying assumptions and sometimes disregard additional detailed knowledge about the mechanisms driving the system. In contrast, there is a branch of ergodic theory which aims at analysing dynamical system models which incorporate this extra information, and rigorously derives statistical properties from the underlying deterministic dynamics.

The central goal of this workshop was to bring together a group of researchers working on core themes of the theory, plus selected experts on neighbouring areas. It was meant to enable efficient work on current projects pursued by several overlapping groups of participants, and to explore connections to and potential collaborations with experts from adjacent fields, including more applied topics.

Activities

At the center of this workshop were a limited number of presentations each day, with a focus topic for each day or session. (Most talks were recorded and are thus available via the ESI website.) Equally important, we allocated comparatively long time intervals between the morning and afternoon talks for discussions and collaborative work.

We also mention a hike up Kahlenberg on Tuesday March 19th, and the Conference Dinner on Thursday, March 21st, at Heuriger Feuerwehr Wagner, both of which helped, through a change of scenery, to maintain momentum in an intense week of scientific exchange. We are very grateful to ESI for giving us the opportunity to hold this workshop and for their generous hospitality and excellent administrative service throughout.

Specific information on the workshop

Limiting the number of presentations allowed us to reserve ample time for extensive discussions and efficient work on concrete questions. We have received very positive feedback from the participants indicating that this was widely appreciated and used to productively pursue current joint projects (see below). Nonetheless, younger participants (PhD students and postdocs) were encouraged to present their work, and most of them (Auer, Bansard-Tresse, Phalempin, Yassine) did use this opportunity to introduce themselves to a larger group of experts. This has led to many exchanges which we expect to be especially helpful for our young colleagues.

Outcomes and achievements

As stated above, a number of concrete collaborations was initiated or continued during this workshop, including, in particular: Auer & Zweimüller (Local limit theorems for hitting times and return times); Bansard-Tresse & Chazottes & Zweimüller (Rare events in infinite measure systems); Balint & Terhesiu (Law of iterated logarithm for the Lorentz gas with infinite horizon); Bruin & Terhesiu; Chazottes & Zhang (Computer-assisted proofs, proof assistants and visualization in dynamical systems); Carney & Nicol (Rare Viral Mutation Modeling); Carney & Zhang (Deep Learning for Chaotic Systems); Freitas & Todd (Functional limit theorems related to extreme value processes); Freitas & Nicol & Pene & Vaienti (Stable laws and convergence to Levy Processes); Kumhera & Schindler & Zweimüller (Rare events in Borel-Cantelli sequences); Pene & Phalempin; Pene & Nicol & Vaienti (Convergences for random quenched dynamical systems); Pene & Saussol & Zweimüller (Rare events in Poisson suspensions);

Schindler & Terhesiu (Effective (stable) large deviation for the Gauss map); Terhesiu & Pene (CLT for random perturbation of the Lorentz gas with infinite horizon)

List of talks

Mike Todd (U of St Andrews)	Extremes and self-recurrence
Jorge Freitas (U Porto)	Convergence to decorated Lévy processes for dynamical systems
Max Auer (U of Maryland)	Poisson Limit Theorems for Systems with Product Structure
Maxence Phalempin (U degli Studi di Firenze)	Averaging result for differential equations perturbed by a Z-periodic Lorentz gas.
Sandro Vaienti (U of Toulon)	Extreme Value theory and Poisson statistics for stochastic differential equations.
Meagan Carney (U of Queensland, Brisbane)	Runs of Extremes of Observables and Applications
Peter Balint (BME, Budapest)	Generalized law of iterated logarithm in the infinite horizon Lorentz gas
Nasab Yassine (UBS, Vannes)	Quantitative recurrence for Z-extension of three-dimensional Axiom A flows
Dylan Bansard-Tresse (CNRS, École Polytechnique, Palaiseau)	Quantitative recurrence for infinite measure dynamical systems
Philipp Kunde (Jagiellonian U, Krakow)	Dichotomy results for eventually always hitting time statistics
Henna Koivusalo (U Bristol)	Dynamical subsets in iterated function systems
Tomas Persson (Lund U)	Fractional response and a parameter almost sure invariance principle for the quadratic family
Hong-Kun Zhang (UMass Amherst)	Advancing learning in Chaotic Systems with Novel Neural Network Techniques
Matthew Nicol (U of Houston)	Convergence of Birkhoff sums of heavy-tailed observables on Gibbs-Markov systems to stable laws and applications (joint talk with An Chen & Andrew Torok)

Publications and preprints contributed

The list of contributed papers below does not yet reflect the outcome of the workshop adequately since most of the projects mentioned above are still ongoing and will lead to publications only in the future. Acknowledgement of ESI support will be added to these preprints/ papers during the next revision of the respective works.

Max Auer, Roland Zweimüller, *Local limit theorems for hitting times and return times of small sets* [arXiv:2312.14581](#)[math.DS].

Peter Balint, Dalia Terhesiu, *Generalized law of iterated logarithm for the Lorentz gas with infinite horizon*, [arXiv:2403.19582](#)[math.PR].

Invited scientists

Seyyed Alireza Ahmadi, Max Auer, Peter Balint, Dylan Bansard-Tresse, Henk Bruin, Meagan Carney, Jean-Rene Chazottes, Jorge Freitas, Henna Koivusalo, Bernd Kumhera, Philipp Kunde, Nooshin Darban Maghami, Matthew Nicol, Françoise Pène, Tomas Persson, Maxence Phalempin, Benoit Saussol, Tanja Schindler, Domokos Szasz, Dalia Terhesiu, Mike Todd, Imre Péter Tóth, Sandro Vaienti, Nasab Yassine, Hong-Kun Zhang, Roland Zweimüller.

Transport Properties in Soft Matter Systems

Organizers: Laura Alvarez (U Bordeaux), Oleksandr Chepizhko (U of Vienna), Vittoria Sposini (U of Vienna)

Dates: April 2 – 5, 2024

Budget: ESI € 6 080

CECAM € 4 000

REWIRE (personal fellowship of one of the organizers) € 4 000

Report on the Workshop

The complex dynamics of soft matter systems have been a focus of study for decades. The importance of dynamic and transport processes is reflected in the many layers of complexity at different scales and areas, spanning from transport inside cells, anomalous diffusion in glasses, cell migration, and information flow in society. Continuous progress in the field of transport properties has been achieved by studying experimental model systems that allow us to break the intrinsic complexity and tackle crucial fundamental physics and engineering challenges. The use of numerical models to study systems at different levels of description continuously allows us to gather new information and support theoretical and analytical approaches often based on a coarse-grained picture.

This workshop aimed at covering the state of the art in various systems and approaches focused on the design, engineering, modelling and study of active and passive Brownian dynamics. Specifically, we focused on connecting the theoretical and mathematical framework to the current experimental development, leading to insightful discussions, and tackling open challenges in the field.

Activities

The talks from the invited speakers represented the core activity of the workshop which was carried out in the time range 9:00 – 17:00, taking place at the Boltzmann Lecture Hall on the Erwin Schrödinger Institute (ESI) in Vienna. In addition, we organized extra activities to foster networking, interactions and discussions among the participants.

Poster Session, Wednesday, April 3, 2024

At the registration stage we collected poster applications from the participants. Eventually we selected the following 13 posters to be presented at the workshop:

1. Yihong Shi (Max Planck Institute for Dynamics and Self-Organization)
Mutual information as a measure of mixing efficiency in viscous fluids
2. Abhimanyu Nowbagh (Heinrich-Heine U, Düsseldorf)
Effect of increasing active particle concentration in passive crowds
3. Regina Rusch (Institute for theoretical physics, U Innsbruck)
Transport properties of Brownian particles analyzed using the noise suppression algorithm
4. Galor Geva (U Autonoma de Madrid)
Rolling backwards: Counteractive locomotion of a microroller in an obstacle lattice

5. Boyi Wang (Max Planck Institute for the Physics of Complex Systems)
Chiral Dynamics and Edge Current Flow in Active Ising Lattice Models
6. Javier Crist  n (CNR-Institute of Complex Systems)
The Inertial Spin model in presence of a conservation law
7. Ilian Pihlajamaa (Eindhoven U of Technology)
Mode-coupling theory under the microscope: Dissecting the theory's underlying approximations
8. Michal Balcerek (Wroclaw U of Science and Technology)
Vector fractional Brownian motion with random Hurst exponents
9. Andrey A. Kuznetsov (U of Vienna)
Field-guided self-propulsion of Brownian swimmers with superparamagnetic inclusions
10. Juraj M  jek (ISTA)
Treadmilling filaments: a new kind of active matter
11. Pece Trajanovski (Research centre for Computer Sciences and Information Technologies, Macedonian Academy of Sciences and Arts)
Anomalous diffusion in comb-like structures: particle's dynamics under Ornstein-Uhlenbeck process
12. Paula Magrinya (U Autonoma de Madrid)
Rolling vesicles: From confined rotational flows to surface-enabled motion
13. C. Heath Turner (The U of Alabama)
Predicting Solute Diffusion in Viscous Liquid Solvents

The main poster session lasted two hours and took place on the second day, April 3, 2024. We encouraged the presenters to leave the posters visible and accessible during the whole duration of the workshop to facilitate further discussions. We noticed interest and involvement from all participants.

Round Table, Thursday, April 4, 2024

On the third day of the workshop, we planned an informal round table discussion to address topic of interests to the scientific community. We collected topics during the first two days, based on the questions raised during the talks, and discussions that participants had after the official Workshop time. All the participants engaged in this activity, either contributing by suggesting possible topics, or during discussion. In particular, the following topics were proposed:

- mathematical origin and physical relevance of Fractional Brownian motion
- microgravity
- active or driven systems?
- issues related to Open Access and publication
- AI in research
- AnDi challenge and challenges as a new tool for the scientific community

We presented the topics and organized small group of discussions. The participation to this activity has been higher than expected, especially from the more early-career stage participants. However, we believe there is still room for improvement to make this kind of events more

attractive for established professors as well.

Social activities, Tuesday, April 2 and Thursday, April 4, 2024

We organized a couple of recreational activities to encourage networking in a less formal context. The first activity was Welcome drinks on the first day (April 2, 2024), where participants enjoyed a few drinks and snacks on the arrival day. Then on April 4 we organized a social dinner in a local restaurants recommended by ESI. We noticed high participation in both activities, with very positive feedback from the participants.

Specific information on the workshop

During the whole organization we committed to address and promote inclusivity with respect to gender, geographical provenance, career stage, etc... Our effort in this direction was well perceived by the participants who provided very nice feedback on the topic. This shows without a doubt that taking into consideration diversity and inclusivity at different levels is a key factor for a successful scientific activity. We quantified 38% of the speakers as female, with slightly fewer female participants overall. We highlight the importance of increasing the community efforts to encourage the participation of early career researchers from minority groups in such events.

In addition, all the participants acknowledged and appreciated the diverse speaker list, where we not only considered established scientists, but also early career principal investigators and experienced postdocs. This showcases the importance of keeping an open possibility of participation not only based on career stage, but also on the quality of the research performed by the scientists.

All the participants showed interest and involvement during the core activity (talks from invited speakers). Indeed, at least two of the topics suggested for the round table came up during the Q&A and discussion sessions included in the talks.

In general, we believe that the extra activities organized within the workshop were effective in fostering discussions among the participants. In particular, we witnessed good networking among the group of young researchers (around 10 between pre-doctoral students and early post-docs) who did not know each other beforehand. Their participation during the talks, mainly asking questions, was also very satisfactory, due to the great environment of the community during the Workshop.

Outcomes and achievements

Interdisciplinarity. From a more scientific point of view, this workshop brought together communities that are usually focused on different approaches. Indeed, there were participants from a strongly mathematical background and others more focused on very applied (often experimental) systems. Fostering discussions and interactions between the two communities surely represents one of the main outcomes of the workshop.

Future challenges. During the invited talks, the poster session and the open discussion, data analysis emerged as a key topic across different disciplines (in both mathematical and experimental approaches). In line with this, one of the talks presented "the AnDI challenge", scientific challenges for testing and developing data analysis techniques for various models of diffusion in complex environments. This led to interesting discussions on whether scientific challenges can

be beneficial to the scientific community and what can be learnt from them. Such discussions represent another great achievement of the workshop, as they go beyond the specific research topics and help in shaping the general direction and interests of our scientific community.

List of talks

Thomas Salez (CNRS, Bordeaux)	Brownian motion at interfaces
Sophie Marbach (CNRS, Paris)	The Countoscope: Measuring Dynamics by Counting Particles in Boxes
Ralf Metzler (U of Potsdam)	Heterogeneity, long-range dependence, and ageing in stochastic motion
Agnes Wylomanska (UST Wroclaw)	How to distinguish fractional Brownian motion with random and constant Hurst exponent – quadratic form statistics-based approach
Gianni Pagnini (BCAM, Bilbao)	First-passage time densities for non-Markovian uncoupled continuous-time random walks and the universality of the Sparre Andersen theorem
Roberto Cerbino (U of Vienna)	Reciprocal space analysis unveils Brownian yet non-Gaussian diffusion in hard-sphere glasses
Sarah Loos (U Cambridge)	Emergence of collective currents and irreversible fluctuations in nonreciprocal binary mixtures
Diego Krapf (CSU, Fort Collins)	Measuring and modeling heterogeneous diffusion in living cells
Giovanni Volpe (U Gothenburg)	The 2nd Anomalous Diffusion Challenge
Daniela Kraft (Leiden U)	Active particles with anisotropic shape and flexibility
Andela Saric (ISTA, Klosterneuburg)	Non-equilibrium processes that split and merge cells across evolution
Christina Kurzthaler (PKS-MPG)	Characterizing the swimming gait of bacteria
Sujit Datta (Princeton U)	Sticking together: How bacterial collectives (re)shape themselves
Chantal Valeriani (Complutense U Madrid)	Discovering dynamic laws from observations: the case of self-propelled, interacting colloids
Jae-Hyung Jeon (Postech, Pohang)	Active trapped-and-hopping diffusion in polymer complexes
Lucio Isa (ETH Zurich)	Designing Active Particles: From Optical Control to Shape Adaptation
Nina Kravets (LOMA, CNRS, Bordeaux)	Topological structuring of thermotropic liquid crystals using structured magnetic field
Holger Stark (TU Berlin)	Controlling and designing active flow
Alfredo Sciortino (CEA, ESPCI, Paris)	Microtubules as Maxwell's demons: transport-based phase-separation of a binary motor mixture and microtubules.
Laura Scalfi (FU Berlin)	Generalized Langevin Equations to analyze MD simulations
Andreas Zöttl (U of Vienna)	Active transport of squirmers in explicitly modeled polymeric and filamentous solutions
Hamid Kellay (LOMA, CNRS, Paris)	Activity induced rigidity of liquid droplets.
Hartmut Löwen (U Düsseldorf)	Transport and dynamics of active polymers and microgels
Stefania Melillo (ICS, CNR)	Are field data really crucial for the study of collective behavior?
Nicolas Bain (UCB Lyon)	Dynamic response and hydrodynamics of polarized crowds
Demian Levis (U Barcelona)	Driven and self-driven transport in model active systems
Liesbeth Janssen (TU Eindhoven)	Glassy dynamics of active matter
Fernando Peruani (U of Cergy-Pontoise)	Transport properties in intermittent active matter

Invited scientists

Laura Alvarez, Nicolas Bain, Michal Balcerek, Matan Yah Ben Zion, Matteo Bessega, Roberto Cerbino, Debayan Chakraborty, Alexander Chervanyov, Jonathan Coldstream, Javier Cristin, Sujit Datta, Thomas Franosch, Rafael Gervasone, Galor Geva, Lucio Isa, Liesbeth Janssen, Jae-Hyung Jeon, Gerhard Kahl, Sofia Kantorovich, Hamid Kellay, Daniela Kraft, Diego Krapf, Nina Kravets, Christina Kurzthaler, Andrey Kuznetsov, Demian Levis, Diego Liberati, Sarah Loos, Hartmut Löwen, Paula Magrinya, Juraj Májek, Sophie Marbach, Stefania Melillo, Ralf Metzler, Antti Niemi, Abhimanyu Nowbagh, Gianni Pagnini, Fernando Peruani, Ilian Pihlajamaa, Regina Rusch, Thomas Salez, Laura Scalfi, Alfredo Sciortino, Yihong Shi, Vittoria Sposini, Holger Stark, Pece Trajanovski, C. Heath Turner, Chantal Valeriani, Giovanni Volpe, Boyi Wang, Agnes Wylomanska, Andreas Zöttl.

Synthetic Curvature Bounds for Non-Smooth Spaces: Beyond Finite Dimension

Organizers: Lorenzo Dello Schiavo (ISTA, Klosterneuburg, currently: U degli Studi di Roma “Tor Vergata”), Christian Ketterer (ALU Freiburg, currently: U Ireland), Chiara Rigoni (U of Vienna)

Dates: May 21 – 24, 2024

Budget: ESI € 11 360

€ 1 300 FWF ESPRIT Grant 224-N *Rigidity results in $CD(K, N)$ spaces with negative N* awarded to Dr. C. Rigoni

€ 1 500 FWF ESPRIT Grant 208 *Configuration Spaces of Nonsmooth Spaces* awarded to Dr. L. Dello Schiavo

Report on the Workshop

The theory of curvature-dimension bounds for nonsmooth spaces is motivated by several factors, including: *i*) the study of functional and geometric inequalities in structures far from being Euclidean (using new non-Riemannian tools), *ii*) the description of the closure, with respect to an appropriate topology, of classes of Riemannian manifolds under geometric constraints, and *iii*) the stability of the analytic and geometric properties of different types of spaces.

The problem of finding synthetic notions of lower Ricci curvature bounds has been a central focus for many years. It became clear that the correct class of spaces where such a synthetic notion can be defined is that of *metric measure spaces*. The goal is to find a notion that is consistent with the smooth Riemannian case such that interesting consequences like geometric inequalities and rigidity theorems can be derived, yet weak enough to remain stable under measured Gromov-Hausdorff convergence. However, stability competes with the need for a condition that is as restrictive as possible to efficiently describe the closure of the class of Riemannian manifolds with Ricci curvature uniformly bounded from below.

In their seminal papers J. Lott and C. Villani [1] and K.-T. Sturm [2] independently attacked these questions with tools based on the theory of *Optimal Transport*: a metric measure space is said to have Ricci curvature bounded from below by $K \in \mathbb{R}$ (in short, it is a $CD(K, \infty)$ space) if the *relative Boltzmann-Shannon entropy functional*, defined on the *Wasserstein space of probability measures*, is K -geodesically convex.

On the other hand, following an approach based on the theory of diffusion operators (Dirichlet forms), Bakry and émer, in their paper [3], describe synthetic lower Ricci bounds $K \in \mathbb{R}$ for a diffusion operator acting on a function algebra (strongly local Dirichlet space) in terms of a generalized Bochner inequality.

For the so-called *infinitesimally Hilbertian spaces* [4], it was shown by L. Ambrosio, N. Gigli, and G. Savaré [5,6] that the Cheeger energy is quadratic and defines a Dirichlet form and an associated diffusion operator. In this class the two approaches to synthetic Ricci bounds have been shown to be equivalent in work by L. Ambrosio, N. Gigli, and G. Savaré [7] and in the work by M. Erbar, K. Kuwada, and K.-T. Sturm [8], providing in particular a Bochner inequality for metric measure spaces.

The workshop brought together experts in analysis and geometry on metric measure spaces, to discuss the current state of the art of the general theory together with its recent developments and some major open problems. These included in particular the study of

- *extended metric non-Radon* measure spaces (i.e. for which the distance can attain the value $+\infty$ and/or the measure is not Radon);
- *sub-Riemannian, Lorentzian, Finslerian* and other *geometries*, for which some of the standard definitions of the curvature-dimension condition do not hold and new ones have recently been proposed;
- *discrete* and *semi-discrete geometry* for which several, possibly inequivalent, theories are available.

Activities

The workshop consisted of sessions about different topics:

General theory of metric measure spaces and applications

During this session, a series of introductory talks were presented to refresh the standard definitions in the field, particularly for younger participants. Additionally, recent results in the “standard theory” of synthetic Ricci-curvature lower bounds for metric measure spaces were explored.

- D. Lučić and G. Savaré reported on structural properties of differentiation on general metric measure spaces.
- N. Shanmugalingam reported on linking certain nonlocal energies on compact doubling metric measure spaces to local energies on their hyperbolic fillings.
- P. Alonso Ruiz reported on the construction of p -energies in Cheeger metric measure spaces via the doubling property and the local Poincaré inequality.
- R. Perales reported on properties of Lipschitz maps on integral current spaces with values in Euclidean spaces.
- F. Galaz-García reported on a distance on the space of persistence diagrams and its geometric properties.

Ricci- and sectional-curvature bounds for metric measure spaces

The aim of this session is to report on the current state of the art in the theory of metric and metric measure spaces with lower sectional curvature bounds and lower Ricci curvature bounds, respectively.

- K.-T. Sturm reported on new and sharp spectral inequalities on manifolds with conical singularities.
- K. Kuwae reported on recent results for the theory of Dirichlet spaces with measure-valued lower curvature bounds
- D. Tewodrose reported on improved results for Gromov-Hausdorff limits of Riemannian manifolds satisfying a Kato condition.
- D. Semola spoke about recent results and open questions on the concavity of the isoperimetric profile in RCD spaces.
- Q. Deng reported on a collaboration with V. Kapovitch. They show quantitative estimates for the boundary measure of Alexandrov spaces.

Configuration spaces and extended metric measure spaces

The aim of this session is to focus on the general treatment of synthetic Ricci lower bounds for extended metric-measure spaces, arising from concrete examples. This requires a thorough understanding of first-order calculus on extended metric-topological measure spaces, as introduced by L. Ambrosio, M. Erbar, and G. Savaré in [9] and further investigated by L. Dello Schiavo and K. Suzuki in [10,11].

- K. Suzuki reported on the synthetic curvature properties of Dyson Brownian motion.

Non-smooth sub-Riemannian, Lorentzian, and Finslerian geometry

- D. Barilari, M. Gordina, G. Stefani, and A. Pinamonti reported on general approaches, recent results, and open problems in sub-Riemannian geometry.
- N. Gigli reported on some recent geometric results related to the ellipticity of the p -D'Alembertian on a Lorentzian manifold.
- A. Mondino reported on a sharp and rigid isoperimetric inequality for metric measure spacetimes with synthetic timelike lower Ricci bounds.
- C. Sämann reported on the theory of Lorentzian length spaces that allows to study various lower Lorentzian curvature bounds independent of a smooth structure.
- M. Magnabosco, reported on the validity or failure of curvature-dimension conditions for sub-Finslerian spaces including the sub-Finsler Heisenberg group.
- S. Ohta reported on the integral Varadhan short-time formula for the nonlinear heat flow on measured Finsler manifolds.

Discrete and semi-discrete geometry, applications

In this section, leading experts in the field discussed various discrete models and techniques related to the discrete-to-continuum approximation and the stability of curvature bounds.

- E. Kopfer reported on homogenization results for discrete optimal transportation in the discrete-to-continuum limit.
- F. Münch reported on a general approach to curvature for Markov chains.

Specific information on the workshop

Pre-docs (15): Mohammad Alattar, Matteo Calisti, Mauricio Che, Nicolò Cont, Marco Flaim, Valerie Freund, Luca Gennaioli, Trí Minh Lê, Ruowei Li, Argam Ohanyan, Filippo Quattrocchi, Renata Possobon, Alessio Vardabasso, Simone Vincini, Matteo Zanardini.

Post-docs (15): Samuël Borza, Giovanni Brigati, Qin Deng, Wojciech Gorny, Danka Lučić, Mattia Magnabosco, Davide Manini, Felix Rott, Daniele Semola, Giacomo Enrico Sodini, Giorgio Stefani, Melchior Wirth, Sergio Zamora Barrera, Xin Zhang, Xingyu Zhu.

List of talks

Karl-Theodor Sturm (U Bonn)	Bakry-émery, Hardy, and Spectral Gap Estimates on Manifolds with Conical Singularities
Nageswari Shanmugalingam (U of Cincinnati)	Discrete approximations of metric measure spaces and nonlocal energies
Nicola Gigli (SISSA, Trieste)	Trading linearity for ellipticity - a novel approach to global Lorentzian geometry
Shouhei Honda (Tohoku U)	Gromov-Hausdorff stability of tori under Ricci and integral scalar curvature bounds
Eva Kopfer (HCM, Bonn) & Raquel Perales (CIMAT, Guanajuato)	Homogenisation of discrete dynamical optimal transport Rigidity of mass-preserving 1-Lipschitz maps from integral & current spaces into Euclidean space
Andrea Pinamonti (U of Trento)	The Bernstein problem in Sub-Riemannian
Davide Barilari (U of Padova)	Heisenberg groups: Origins and new developments
Maria (Masha) Gordina (U of Connecticut)	Unified synthetic Ricci curvature lower bounds for Riemannian and sub-Riemannian structures
Shin-ichi Ohta (U Osaka)	Dimension-independent functional inequalities on sub-Riemannian manifolds
Andrea Mondino (U of Oxford)	Integral Varadhan formula for nonlinear heat flow
Clemens Sämann (U of Oxford)	A sharp isoperimetric-type inequality for Lorentzian spaces satisfying time-like Ricci lower bounds
Giuseppe Savaré (U Bocconi, Milano)	Non-regular spacetime geometry via metric (measure) geometry
Giorgio Stefani (SISSA, Trieste)	Sobolev spaces in extended metric-topological measure spaces
Kazuhiro Kuwae (Fukuoka U)	Sub-Riemannian manifolds are not CD
Fernando Galaz-García (Durham U)	Riesz transforms for Dirichlet spaces tamed by distributional curvature lower bounds
David Tewodrose (Vrije U Brussels)	Metric geometry of spaces of persistence diagrams
Kohei Suzuki (Durham U)	Kato meets Bakry-émery
Patricia Alonso Ruiz (TAMU, College Station)	Dyson Brownian Motion as a Wasserstein Gradient Flow
Florentin Münch (MPI MPS Leipzig)	Looking for p-energy forms in Cheeger spaces.
Daniele Semola (ETH Zurich)	Markov chain curvature and mixing
Qin Deng (MIT, Cambridge)	Sharp concavity of the isoperimetric profile under lower Ricci bounds: recent results and open questions
Danka Lučić (JYU, Jyväskylä)	Maximal boundary volume rigidity for Alexandrov spaces
Mattia Magnabosco (U of Oxford)	Plans, derivations, and currents in metric measure spaces
	Failure of the curvature-dimension condition in sub-Finsler manifolds

Publications and preprints contributed

S. Honda, A. Mondino, *Poincaré inequality for one forms on four manifolds with bounded Ricci curvature*, [arXiv:2405.19168](#) [math.DG].

L. Dello Schiavo, M. Magnabosco, C. Rigoni, *Gradient flows of (K, N) -convex functions with negative N* , [arXiv:2412.04574](#) [math.FA].

Invited scientists

Mohammad Alattar, Patricia Alonso Ruiz, Davide Barilari, Samuel Borza, Giovanni Brigati, Matteo Calisti, Mauricio Che, Nicolò Cont, Lorenzo Dello Schiavo, Qin Deng, Marco Flaim, Valerie Freund, Fernando Galaz-García, Luca Gennaioli, Nicola Gigli, Maria (Masha) Gordina, Wojciech Gorny, Shouhei Honda, Christian Ketterer, Eva Kopfer, Kazuhiro Kuwae, Tri Minh Le, Ruowei Li, Danka Lučić, Jan Maas, Mattia Magnabosco, Davide Manini, Andrea Mondino, Florentin Münch, Argam Ohanyan, Shin-ichi Ohta, Raquel Perales, Andrea Pinamonti, Renata Possobon, Filippo Quattrocchi, Chiara Rigoni, Felix Rott, Clemens Sämann, Giuseppe Savaré, Daniele Semola, Nageswari Shanmugalingam, Giacomo Enrico Sodini, Ulisse Stefanelli, Giorgio Stefani, Karl-Theodor Sturm, Kohei Suzuki, David Tewodrose, Alessio Vardabasso, Simone Vincini, Melchior Wirth, Sergio Zamora Barrera, Matteo Zanardini, Xin Zhang, Xingyu Zhu.

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- [2] Karl-Theodor Sturm, On the geometry of metric measure spaces, *Acta Math.* 196 (2006), 65–131.
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- [4] Nicola Gigli, On the differential structure of metric measure spaces and applications, *Mem. Amer. Math. Soc.* 236 (2015), no. 1113, vi+91. MR 3381131.
- [5] Luigi Ambrosio, Nicola Gigli, and Giuseppe Savaré, Density of Lipschitz functions and equivalence of weak gradients in metric measure spaces, *Rev. Mat. Iberoam.* 29 (2013), 969–996.
- [6] Heat flow and calculus on metric measure spaces with Ricci curvature bounded below – the compact case, *Analysis and Numerics of Partial Differential Equations* (Franco Brezzi, Piero Colli Franzone, Ugo Gianazza, and Gianni Gilardi, eds.), *Springer INdAM Series*, vol. 4, Springer, 2013, pp. 63–115.
- [7] Bakry–Emery Curvature-Dimension Condition and Riemannian Ricci Curvature Bounds, *Ann. Probab.* 43 (2015), no. 1, 339–404.
- [8] Matthias Erbar, Kazumasa Kuwada, and Karl-Theodor Sturm, On the equivalence of the entropic curvature-dimension condition and Bochner’s inequality on metric measure spaces, *Invent. Math.* 201 (2015), 993–1071.
- [9] Luigi Ambrosio, Matthias Erbar, and Giuseppe Savaré, Optimal transport, Cheeger energies and contractivity of dynamic transport distances in extended spaces, *Nonlinear Anal.* 137 (2016), 77–134.
- [10] Lorenzo Dello Schiavo and Kohei Suzuki, Rademacher-type theorems and Sobolev-to-Lipschitz properties for strongly local Dirichlet spaces, *J. Funct. Anal.* 281 (2021), no. 11, 109234, 63 pp.
- [11] L. Dello Schiavo, K. Suzuki, *Persistence of Rademacher and Sobolev-to-Lipschitz Properties*, [arXiv:2309.10733](#) [math.MG].

One World Optimization Seminar in Vienna

Organizers: Radu Ioan Boţ (U of Vienna) and Yurii Malitskyi (U of Vienna)

Dates: June 3 – 7, 2024

Budget: ESI € 10 640

Vienna Graduate School on Computational Optimization: € 6 000

Faculty of Mathematics, U of Vienna: € 2 000

Report on the Workshop

The primary aim of the ESI workshop was to convene speakers from the [One World Optimization Seminar](#) to discuss recent advancements in continuous optimization, machine learning, and variational analysis. The *One World Optimization Seminar* (OWOS) was a series of online seminars in optimization that ran from April 2020 to April 2022. Despite the challenges posed by the pandemic, OWOS emerged as a vital platform, significantly contributing to the cohesion of the optimization community by offering valuable insights and fostering collaboration among its participants.

During the workshop, invited OWOS speakers and additional experts presented their latest research and shared new insights, thereby promoting new scientific collaborations.

The primary research focus of the workshop included the following topics.

Variational and nonsmooth analysis. Nonsmooth and nonconvex optimization problems continue to be in the focus of the optimization community due to their omnipresence in real-life applications and the fact that many related theoretical aspects still have to be investigated and understood. To the questions of immediate concern belong: which notions of optimality are most suitable for nonconvex problems, especially for those that appear in practice, how to characterize these via first-order optimality systems formulated in terms of classical (e.g. limiting/Mordukhovich and Clarke) subgradient notions or rather in terms of recently introduced conservative subgradients, that possess significantly better calculus rules, which second-order subdifferential/generalized Hessian notions for nonsmooth functions are helpful when characterizing optimality, and how to derive via sensitivity analysis estimates for optimal value and solution dependence on various perturbations of the optimization problems based on regularity properties of the objects involved in their description.

Numerical methods in optimization. Numerical methods have always played a pivotal role in the field of optimization. The workshop dedicated special attention to the following areas: (a) worst-case analyses of optimization methods, (b) continuous dynamics, (c) monotone inclusions, and (d) stochastic optimization.

Applications to other fields. The field of continuous optimization is currently experiencing a captivating phase characterized by its extensive and ever-growing relevance to various disciplines, particularly machine learning and artificial intelligence. On one hand, the application of optimization techniques has yielded notable successes in machine learning algorithms. However, on the other hand, there remains a need to deepen our understanding of the mathematical foundations underlying these algorithms and the factors contributing to their exceptional effectiveness in solving complex optimization problems. Optimization and minimax algorithms play a pivotal role in several applications, such as support vector machines for classification and regression, training deep learning neural networks, clustering methods, robust learning approaches, and training generative adversarial networks.

Activities

The workshop featured a high caliber of speakers and presentations. Participants shared the latest research results, some of which were not yet published, fostering robust interactions both during talks and breaks. Between workshop sessions, ESI served as a hub for discussions and paper writing. These activities significantly advanced collaborations among attendees and initiated new research projects.

Specific Information on the Workshop

The workshop was attended by 61 participants, with 44 individuals invited to present their work. Among the attendees were 7 PhD students and 5 postdoctoral researchers. These junior scientists particularly valued the opportunity to interact with eminent figures in the field, such as R.T. Rockafellar.

The daily schedule comprised 8 to 9 talks. On Monday, a welcome reception was held, and on Wednesday, attendees enjoyed a conference dinner at Schübel-Auer Heuriger. Thanks to the ESI recording facilities, 32 talks were recorded and made publicly available, accumulating over 2500 views to date.

Outcomes and Achievements

The workshop facilitated the exchange of recent findings and the initiation of new projects and collaborations. Informal interactions during coffee breaks, lunches, and the conference dinner provided a conducive atmosphere for networking, particularly benefiting junior scientists who had the opportunity to engage with renowned researchers. These interactions have already resulted in the commencement of several collaborative and individual research articles.

List of talks

Terry Ralph Rockafellar (U of Washington, Seattle)	Progressive Decoupling of Dynamics in Convex Optimal Control
Ewa Bednarczuk (Polish Academy of Science, Warsaw)	Constraint qualification and the existence of multipliers for nonconvex infinite-constrained optimization problems in Banach spaces
Jong-Shi Pang (U of Southern California, Los Angeles)	Heaviside composite optimization and complementarity constraints by a progressive integer programming method
Panayotis Mertikopoulos (CNRS, Grenoble)	The Long-Run Distribution of Stochastic Gradient Descent: A Large Deviations Analysis
Roberto Cominetti (U Adolfo Ibanez, Santiago de Chile)	Error bounds for mean-payoff Markov decision processes
Alp Yurtsever (Umeå U)	CCCP is Frank-Wolfe in disguise
Adrien Taylor (INRIA Paris)	Computer-aided Lyapunov analyses & counter-examples to the convergence of first-order optimization algorithms
Ya-Ping Hsieh (ETH Zurich)	How to Optimize a Schrödinger Bridge?
Mert Gürbüzbalaban (Rutgers U)	High probability and risk-averse guarantees for stochastic saddle point problems
Marc Teboulle (Tel Aviv U)	Proximal Gradient Methods for Nonsmooth Nonconvex Minimax: A Unified Convergence Analysis
Russell Luke (U Göttingen)	Nonconvex Optimization and the Curse of Local Minima: Lessons Learned from Orbital Tomography
Jalal Fadili (CNRS-ENSICAEN, Caen)	Iterative Regularization of the Deep Inverse Prior via (Inertial) Gradient Flow

Ya-xiang Yuan (Chinese Academy of Sciences, Beijing)	A new derivative-free method using an improved under-determined quadratic interpolation model
Frank Curtis (Lehigh U, Bethlehem)	Stochastic Algorithms for Constrained Continuous Optimization
Michael Hintermüller (WIAS, Berlin)	Quasi-Variational Inequalities: Semismooth Newton Methods, Optimal Control, and Uncertainties
Michael Ulbrich (TU Munich)	Sample Size Estimates for Risk-Neutral Semilinear PDE-Constrained Optimization
Behzad Azmi (U Konstanz)	Nonmonotone Forward-Backward Splitting Method for a Class of Infinite-Dimensional Nonsmooth Nonconvex Problems
Tom Luo (CUHK Shenzhen)	Finite Horizon Optimization
Edouard Pauwels (TSE, Toulouse)	Inexact subgradient algorithm with errors for semialgebraic functions
Niao He (ETH Zurich)	A Hessian-Aware Stochastic Differential Equation Modelling of SGD
Shoham Sabach (Technion Haifa)	Bilevel Optimization Problems: Algorithms and Theory
Adriana Nicolae (Babes-Bolyai U, Cluj-Napoca)	Weighted means in geodesic metric spaces
Stephen Wright (U Wisconsin Madison)	Revisiting Inexact Fixed-Point Iterations for Min-Max Problems: Stochasticity and Structured Nonconvexity
Benjamin Grimmer (Johns Hopkins U, Baltimore)	Some Better Theory for Gradient Descent
Anthony Man-Cho So (CU Hong Kong)	Spurious Stationarity and Hardness Results for Bregman-Type Algorithms
Pontus Giselsson (Lund U)	Automated tight Lyapunov analysis for first-order methods
Osman Güler (U of Maryland)	On the Kantorovich theory of Newton's method
Coralia Cartîş (U Oxford)	Optimization of functions with low effective dimensionality
Guoyin Li (UNSW Sydney)	Generalized Metric Subregularity and Superlinear Convergence Analysis for High-order Regularized Newton's Method with Momentum
Peter Richtarik (KAUST, Thuwal)	The First Optimal Distributed SGD in the Presence of Data, Compute and Communication Heterogeneity
Mustafa Pinar (Bilkent U, Ankara)	Sparsity Regularized Mean-Variance Portfolio Optimization
Amir Beck (Tel Aviv U)	Exact Lipschitz Regularization of Convex Optimization Problems
Szilard Csaba Laszlo (U Cluj-Napoca)	On strong convergence of inertial algorithms via Tikhonov regularization
Patrick Combettes (North Carolina State U)	The geometry of monotone operator splitting
Mathias Staudigl (U Mannheim)	A conditional gradient homotopy method with applications to Semidefinite Programming
Boris Mordukhovich (Wayne State U, Detroit)	Semi-Newton Method in Difference Programming
Ernest Ryu (Seoul National U)	Toward a grand unified theory of accelerations in optimization and machine learning
Ting Kei Pong (PolyU, Hong Kong)	Kurdyka-Łojasiewicz exponent for a class of Hadamard-difference-parameterized models
Wotao Yin (Alibaba Group, Bellevue)	Sum-of-Minimum Model: Joint Optimization of Specialized Models for Heterogeneous Data
Ion Necoara (U Politehnica Bucharest)	Coordinate descent methods beyond separability and smoothness
Jonathan Eckstein (Rutgers U)	“DEFBAL” – a Connection between the ADMM and Forward-Backward methods

Pierre-Cyril Aubin-Frankowski (TU Vienna)	Alternating minimization and gradient descent with $c(x,y)$ cost
Sorin-Mihai Grad (ENSTA Paris)	A fresh look at algorithms for solving smooth multiobjective optimization problems
Masoud Ahookhosh (U Antwerpen)	High-order Moreau envelope in the nonconvex setting: Framework and algorithms

Invited scientists

Masoud Ahookhosh, Pierre-Cyril Aubin-Frankowski, Behzad Azmi, Amir Beck, Ewa Bednarczuk, Matúš Benko, Immanuel Bomze, Radu Ioan Boț, Coralia Cartîș, Enis Chenchene, Patrick Combettes, Roberto Cominetti, Robert Csetnek, Frank Curtis, Daniel De Vicente, Jonathan Eckstein, Jalal Fadili, Markus Gabl, Pontus Giselsson, Sorin-Mihai Grad, Benjamin Grimmer, Osman Güler, Mert Gürbüzbalaban, Niao He, Michael Hintermüller, Ya-Ping Hsieh, David Alexander Hulett, Mikhail Karapetyants, Szilard Csaba Laszlo, Guoyin Li, Russell Luke, Tom Luo, Yurii Malitskyi, Panayotis Mertikopoulos, Boris Mordukhovich, Ion Necoara, Rossen Nenov, Adriana Nicolae, Jong-Shi Pang, Edouard Pauwels, Bo Peng, Mustafa Pinar, Ting Kei Pong, Alexander Posch, Peter Richtarik, Terry Ralph Rockafellar, Ernest Ryu, Shoham Sabach Hermann Schichl, Chiara Schindler, Michael Sedlmayer, Anthony Man-Cho So, Mathias Staudigl, Adrien Taylor, Marc Teboulle, Buris Tongnoi, Michael Ulbrich, Stephen Wright, Wotao Yin, Ya-xiang Yuan, Alp Yurtsever.

IMO and MEMO Training 2024

Organizers: Theresia Eisenkölbl (U of Vienna)

Dates: June 19 – June 22, 2024 and October 27 – November 1, 2024

Budget: ESI € 4 000

Federal Ministry of Education, Science and Research for travel costs € 280

Faculty of Mathematics € 459

Report on the training

The goal of the event was to prepare the Austrian team for IMO (International Mathematical Olympiad) and MEMO (Middle European Mathematical Olympiad). The more general aim is to enable the best high school students to become proficient at many mathematical subjects and problem-solving early on and prepare them for a mathematics career.

Activities

The event included talks on all the main topics of international mathematics competitions for high school students (algebra, combinatorics, geometry, number theory), discussion and interactive problem solving, participation in the problem solving seminar of the department of mathematics, a training competition that consists of problems that the students pose each other and participation in the Iranian Combinatorics Olympiad, a challenging international competition organized by young Iranian mathematicians and taking place in many countries at once.

Specific information on the training

Due to the nature of the event, the young participants had the chance to increase their mathematical knowledge significantly. The presenters included prae-docs and post-docs.

Outcomes and achievements

We are happy to report that this year, the Austrian team at the MEMO received a silver medal and an honourable mention. The Austrian team at IMO received 5 silver medals and one honourable mention at the International Mathematical Olympiad in Bath UK in July 2024, putting Austria at place 25 among 108 participating countries which is Austria's best result since 1981.

List of talks

June 2024

Moritz Hiebler	Geometry, Mixed problems
Ivan Izmetstiev	Farey fractions, Ford circles, porisms
Morteza Saghafian	Combinatorics

October 2024

Theresia Eisenkölbl	Marriage theorem and Max-Flow Min-Cut theorem, Gemischte Aufgaben
Moritz Hiebler	Potenzreste
Michael Hollnbuchner	Ungleichungen, Funktionalgleichungen
Ivan Izmetstiev	Drehstreckung
Dominik Pultar	Kombinatorik/Zahlentheorie
Georg Weisbier	Kombinatorische Geometrie

Participants

June 2024

Theresia Eisenkölbl, Valentin Glatz, Raphael Heuchl, Moritz Hiebler, Ivan Izmetstiev, Philipp Kreuzer, Valentina Kubicek, Rafael Lubert, Dominik Pultar, Morteza Saghafian, William Shi, Jan Strehn, André Tremetsberger, Yelyzaveta Yevtushenko.

October 2024

Cassandra Boş, Letizia Bräuer, Philipp Bui, Valentin Glatz, Moritz Hiebler, Michael Hollnbuchner, Ivan Izmetstiev, Valentina Kubicek, Rafael Lubert, Dominik Pultar, André Tremetsberger, Georg Weisbier, Dinmukhamed Yezhubayev, Yelyzaveta Yevtushenko, Jakob Zellinger.

Determinacy, Inner Models and Forcing Axioms

Organizers: Sandra Müller (TU Vienna), Grigor Sargsyan (Polish Academy of Science, Warsaw) Ralf Schindler (WWU Münster), John Steel (UC, Berkeley)

Dates: June 24 – 28, 2024

Budget: ESI € 11 120

FWF START Project Y1498: € 9 300

WPI: € 3 330

Report on the Workshop

Set theory is the mathematical study of infinity. Its main goal is to develop mathematical ways of thinking about infinity that both explain our mathematical intuitions about infinity and also make the concept of infinity useful for other areas of mathematics. Regardless of its relative young age, set theory has been very successful both in answering its own deep fundamental questions and in being applied elsewhere.

Gödel's Programme is a major set theoretic programme addressing the most fundamental set theoretic issue, *independence*: the inability of the basic axioms of set theory (Zermelo-Fraenkel set theory with Choice, ZFC) or any (consistent) extension thereof to decide natural questions about infinite sets, including the Continuum Hypothesis (CH). Gödel's Programme aims at removing undecidability from foundations by studying natural extensions of ZFC. The goal of the programme is to remove incompleteness in the natural foundational theory T by passing to a stronger theory that is as natural as T itself and decides all or some of the undecidable questions of T . Gödel's idea was that iterating this process would resolve all undecidable questions of ZFC, and that they would all be resolved within the **Large Cardinal Hierarchy**. While, as demonstrated by the celebrated Levy-Solovay theorem, the Large Cardinal Hierarchy cannot achieve Gödel's dream, other set theoretic hierarchies, such as **forcing axioms** or **determinacy axioms**, that are grounded in the Large Cardinal Hierarchy can go incredibly far in deciding natural questions, including CH, that are undecidable within ZFC.

The workshop brought together leading researches in determinacy, inner model theory and forcing axioms with promising students and postdoctoral researchers to exchange recent progress in this area and develop ideas for attacking central open problems in the field.

Activities

The workshop started with an introductory talk by John Steel (UC Berkeley) on *The comparison lemma*. This talk was intended for non-experts and gave an overview of the inner model theoretic background needed to follow more specialized talks. Other talks during the week were given by experts in inner model theory as well as by experts in related areas and junior participants. This allowed talks at different levels of technicality and increased the interaction between the participants. While this workshop stands in the tradition of other two-weeks long meetings in inner model theory that have taken place in Münster, Germany (2010, 2011, 2015, 2017, 2022), Berkeley, USA (2014, 2019), Irvine, USA (2016, 2023), and Girona, Spain (2018), it was organized differently from previous meetings. Its focus was on the interaction with researchers from neighbouring fields. This attracted many participants, that did not attend any of the previous inner model theory conferences, for example, David Aspero, James Cummings, Juliette Kennedy, Philipp Lücke, Dima Sinapova, Jouko Väänänen, Matteo Viale, and their students.

Specific information on the workshop

There was a large number of students and postdocs who attended the workshop. Several of them gave talks, including Dominik Adolf, William Chan, Monroe Eskew, Takehiko Gappo, Jan Kruschewski, Derek Levinson, Andreas Lietz, Farmer Schlutzenberg, Benjamin Siskind, Juan Santiago Suárez, Shervin Sorouri, and Taichi Yasuda.

Outcomes and achievements

Specific collaborations that participants had begun or continued at the Institute during the workshop:

- Daisuke Ikegami and Matteo Viale started a new collaboration on universally Baire sets in 2^κ that will result in a preprint (see in the list of preprints below).
- Lukas Koschat and Sebastiano Thei proved a new factorization theorem for weak projections of forcings that will result in a preprint (see in the list of preprints below). They introduce the notion of forcing bundle, which is inspired by the topological notion of a fiber bundle.
- Benjamin Siskind and John Steel continued their collaboration on strategy comparisons.
- Takehiko Gappo and Nam Trang started a collaboration on relating determinacy and inner models at levels right after the projective hierarchy.
- Juan Aguilera and Philipp Lücke initiated a collaboration that they are planning to continue with another research visit by Philipp Lücke to Vienna in the fall semester.

List of talks

John Steel (UC, Berkeley)	The comparison lemma
Jouko Väänänen (U Helsinki)	Inner models constructed from generalized logics and their relationship with the standard inner models
Bartosz Wcislo (U of Gdańsk)	Separating levels of DC on reals from levels of PD.
William Chan (TU Vienna)	Cardinality of the Set of Bounded Subsets of a Cardinal
Menachem Magidor (HU of Jerusalem)	Inner Models constructed from generalized logics and their relationship with the standard models.
Dima Sinapova (Rutgers U)	Stationary reflection for $\aleph_{\omega_1+1}$
Benjamin Siskind (TU Vienna)	Order-preserving Martin's Conjecture and Inner Model Theory
Martin Zeman (UC Irvine)	On the failure of two successive squares
Dominik Adolf (–)	Chang's Conjecture and Mouse Reflection
Andreas Lietz (TU Vienna)	On Mathias Characterizations for Generics for Variants of Namba Forcing
Takehiko Gappo (TU Vienna)	Determinacy of long games just beyond fixed countable length
Trevor Wilson (Miami U, Oxford)	Characterizing large cardinals in terms of Löwenheim-Skolem and weak compactness properties of strong logics
Hugh Woodin (Harvard U)	Exotic models - part I & II
Juan M Santiago Suárez (U Paris Cité)	Forcing and consistency properties
Jan Kruschewski (TU Vienna)	Analysis of HOD for Admissible Structures
Derek Levinson (UCLA)	Unreachability in the Second Projective-Like Hierarchy
James Cummings (Carnegie Mellon U, Pittsburgh)	Squares, scales and lines
Grigor Sargsyan (Polish Academy of Science, Warsaw)	Hod mice as a bridge between determinacy, forcing axioms and infinitary combinatorics - part I & II
Gabriel Goldberg (UC, Berkeley)	The HOD conjecture and its failure
Taichi Yasuda (U Münster)	Martin's Maximum $^{*,++}_c$ in P_{max} extensions of strong models of determinacy
Farmer Schlutzenberg (TU Vienna)	Ladder mice
Monroe Eskew (U of Vienna)	Transferring ideals
Nam Trang (UNT, Denton)	Almost disjoint families in natural models of AD^+
Shervin Sorouri (U of Münster)	Longer privacy sequences

Publications and preprints contributed

- J. Aguilera, *Boolean completeness of infinitary logic with arbitrary signatures*, preprint.
- J. Aguilera, *Local Hanf-Tarski numbers*, preprint.
- F. Barrera, V. Dimonte, S. Müller, *The λ -PSP at λ -coanalytic sets*, preprint.
- D. Ikegami, M. Viale, *Universally Baire sets in 2^κ* , preprint.
- L. Koschat, S. Thei, *A factorization theorem for weak projections*, preprint.
- S. Müller, B. Wcisło, *A model with fragments of projective determinacy and failures of DC*, preprint.

Invited scientists

Dominik Adolf, Claudio Agostini, Alessandro Andretta, David Aspero, Fernando Barrera, William Chan, Sean Cody, James Cummings, Ben De Bondt, Monroe Eskew, Azul Fatalini, Vera Fischer, Gunter Fuchs, Takehiko Gappo, Gabriel Goldberg, Zakkai Goriely, Christopher Henney-Turner, Stefan Hoffelner, Peter Holy, Martina Iannella, Daisuke Ikegami, Daniel Iosub, Jakob Kellner, Juliette Kennedy, Siiri Kivimäki, Lukas Koschat, Jan Kostrzon, Jan Kruschewski, Derek Levinson, Andreas Lietz, Philipp Lücke, Toby Meadows, Miguel Moreno, Elena Pozzan, Otto Rajala, Tapio Saarinen, Juan M Santiago Suárez, Ralf Schindler, Farmer Schlutzenberg, David Schritterser, Robert Schütz, Xianghui Shi, Dima Sinapova, Benjamin Siskind, Shervin Sorouri, John Steel, Grigori Stepanov, Cesare Straffelini, Corey Switzer, Sebastiano Thei, Nam Trang, Andrés Felipe Uribe-Zapata, Jouko Väänänen, Matteo Viale, Lena Wallner, Bartosz Wcisło, Thilo Weinert, Philip Welch, Trevor Wilson, Wolfgang Wohofsky, Hugh Woodin, Taichi Yasuda, Lyubomyr Zdomskyy, Martin Zeman, Jiaming Zhang.

Exactly Solvable Models

Organizers: Maja Burić (U of Belgrade), Edwin Langmann (KTH Stockholm), Harold Steinacker (U of Vienna), Raimar Wulkenhaar (U of Münster)

Dates: July 24 – 26, 2024

Budget: ESI € 5 119

Report on the Workshop

Exactly Solvable Models play a central role in mathematical physics. They also receive considerable interest by mathematicians with different specializations such as combinatorics, representation theory, differential geometry, or the modern theory of special functions. There is a large spectrum of exactly solvable models and techniques to solve them, but often the techniques are specific to some particular field of theoretical physics or mathematics.

The aim of this workshop was to bring together experts working on exactly solvable models of different types to present their results, aiming to an exchange of ideas and share of mathematical tools that would boost up research in the field. In particular, this workshop is dedicated to Harald Grosse, who has contributed significantly to exactly solvable models. Although the range of the topics covered at the workshop was scaled down in comparison with the initial proposal, the basic idea was unchanged.

A unifying topic of the workshop was the quantization of special (i.e. exactly solvable) field theories. This includes advances in established theories, properties of new models, and discussion of the used mathematical techniques. Some specific topics included

- axiomatic field theory (interacting fields, curved backgrounds, twisted Fock space)
- combinatorial quantization of Chern-Simons and super Chern-Simons theory
- Calogero models
- quantum field theory models from noncommutative geometry (Moyal deformation, spectral geometry)
- braided and twisted gauge theories
- some pertinent infinite-dimensional algebras and their representations, such as W_N , W_∞ , L_∞ .

Activities

The workshop consisted of 15 talks, 45 minutes each. The workshop was attended by 38 participating scientists.

The talks covered the following topics:

Day one: included two talks in the setting of axiomatic field theory by Gandalf Lechner (FAU Erlangen-Nürnberg) and Kasia Rejzner (U of York), focusing on particular constructions (twists) and general structures. Patrizia Vitale (U of Naples) reported on progress towards the construction of noncommutative $U(1)$ gauge theory on generic noncommutative spaces, in the semi-classical limit. Ludwik Dabrowski (SISSA, Trieste) discussed how geometric tensors (such as the metric or the Ricci tensor) can be obtained from the spectral functionals in noncommutative geometry based on spectral triples. Olaf Lechtenfeld (Leibniz U Hannover) gave a detailed account of intertwiners and W algebras in the Calogero Model. Finally, Akifumi Sako (Tokyo U of Sciences) explained a relation of the Calogero model to the Grosse-Wulkenhaar model.

Day two: Two talks by Anton Alekseev (U Geneva) and Volker Schomerus (DESY Hamburg) discussed the combinatorial quantization of Chern-Simons theory, explaining recent developments such as factorization homology, BV structures and generalizations to supergroups. Alexander Strohmaier (U Hannover) discussed recent work on analytic singularities in axiomatic QFT on curved space-time. In the context of one-dimensional integrable systems, Pavel Wiegmann (Chicago U) explained recent work on a quantum version of the Peierls phenomenon in terms of the Thermodynamic Bethe Ansatz. The Bethe ansatz also played a crucial role in the talk of Tomasz Prohaska (Czech Academy of Sciences) on 2d CFT, emphasizing the role of W algebras and integrable hierarchies.

Day three: The last day was started by Thomas Krajewski (U Aix-Marseille), who discussed Twisted Drinfeld doubles in the context of the Kitaev model. Sylvie Paycha (U of Potsdam) explained recent work on meromorphic germs in several variables, in the context of Feynman integrals and renormalisation of QFT. Richard Szabo (Heriot-Watt U, Edinburgh) reported on a recent paper on braided quantum field theory, which is a new approach to noncommutative field theory based on Drinfeld twists. Finally, Raimar Wulkenhaar (U Münster) provided an exposition of the joint work with Harald Grosse and others on a solvable 4-dimensional noncommutative field theory known as Grosse-Wulkenhaar model.

There were ample opportunities for informal discussions between the participants during the

coffee breaks (30 min in the morning & afternoon), common lunches, and during a social event (Heuriger) on the evening of the second day.

We would like to thank the secretaries for the friendly atmosphere and perfect organization. The participants enjoyed their stay and made the workshop a successful event which stays in memory.

Outcomes and achievements

- Discussion between Wiegmann and Langmann on a possible common project (spin Benjamin-Ono equation and CFT)
- Discussion between Szabo and Langmann on a possible common project (higher brackets in QFT)
- Discussion between Schomerus and Langmann on taking up an unfinished project from several years ago (spin Calogero-Moser system arising in higher dimensional CFT)
- Discussions between Grosse, Sako and Wulkenhaar on the relationship between the ϕ^4 -matrix model and N -body harmonic oscillator, in particular the zero-energy solution.

Specific information on the workshop

Five local participants attended, as did several unregistered local students and postdocs who joined the talks.

We would like to thank the secretaries for the friendly atmosphere and perfect organization. The participants enjoyed their stay and made the workshop a successful event which stays in memory.

Maja Burić, Edwin Langmann, Harold Steinacker and Raimar Wulkenhaar

List of talks

Gandalf Lechner (FAU Erlangen-Nürnberg)	Twists and Localization Structures: Local and Non-Local Models in Quantum Field Theory
Patrizia Vitale (Naples U)	Noncommutative U(1) gauge theory in the semiclassical limit
Ludwik Dabrowski (SISSA, Trieste)	Geometric tensors via spectral functionals
Kasia Rejzner (U of York)	From perturbative to non-perturbative AQFT
Olaf Lechtenfeld (Leibniz U)	Infinite algebras and intertwining networks for Calogero models
Akifumi Sako (Tokyo U of Science)	Relationship between Grosse-Wulkenhaar model and N -body harmonic oscillators or Calogero model
Anton Alekseev (U Genève)	Combinatorial Quantization: old and new
Volker Schomerus (DESY Hamburg)	Supergroup Chern-Simons Theory
Alexander Strohmaier (U Hannover)	The timelike tube theorem in quantum field theory on curved spacetimes
Pavel Wiegmann (U of Chicago)	Peierls instability in integrable models (classical and quantum)
Tomas Prochazka (LMU Munich)	Bethe ansatz in 2d conformal field theory
Thomas Krajewski (U Aix-Marseille)	Twisted Drinfeld double : from strings to the Kitaev model
Sylvie Paycha (U of Potsdam)	Locality Galois group of meromorphic germs in several variables
Richard Szabo (Heriot-Watt U, Edinburgh)	Braided quantum field theory

Raimar Wulkenhaar (U Münster) Scalar quantum fields on 4-dimensional noncommutative geometry

Invited scientists

Anton Alekseev, Maja Burić, Nathan Cohen, Ludwik Dabrowski, Stefan Fredenhagen, Harald Grosse, Thomas Krajewski, Edwin Langmann, Gandalf Lechner, Olaf Lechtenfeld, Albert Much, Sylvie Paycha, Tomas Prochazka, Anton Rebhan, Kasia Rejzner, Akifumi Sako, Volker Schomerus, Harold Steinacker, Thomas Strobl, Alexander Strohmaier, Richard Szabo, Patrizia Vitale, Pavel Wiegmann, Raimar Wulkenhaar, Jakob Yngvason.

Spin-Orbit Entangled Quantum Magnetism

Organizers: Cesare Franchini (U of Vienna), Vesna Mitrovic (Brown U, Providence), Leonid Pourovskii (École Polytechnique, Palaiseau)

Dates: September 23 – 27, 2024

Budget: ESI € 6 793

Psi-K € 4 800

VASP Software GmbH € 2 000

Report on the Workshop

The workshop *Spin-Orbit Entangled Quantum Magnetism*, held at the Erwin Schrödinger Institute, brought together approximately 60 participants from across the globe, including Europe, the USA, Canada, Japan, India, and Singapore.

The primary objective of the workshop was to assemble both leading experts and early-career researchers working on spin-orbit entangled magnetism from diverse domains — including density functional theory (DFT), many-body effective Hamiltonians (MBEH), and experiments — with the goal of reviewing recent advances and, crucially, fostering synergy between theoretical and experimental approaches. A central focus was the rich and complex physics arising from spin-orbit entanglement, which underpins a wide array of emergent phenomena such as multipolar orders, quantum spin and dimer-bond liquids, spin-orbit excitons, topological phases, and fractional excitations. The workshop facilitated in-depth discussions on how these phenomena are driven by intersite couplings between entangled spin-orbit states, their interactions with lattice degrees of freedom, applied fields, and external perturbations.

The workshop was a unique platform for reporting scientific progress, identifying key challenges, and initiating collaborative efforts.

Activities

The scientific programme spanned five full days and included 40 oral presentations and 10 poster contributions, structured into thematic sessions covering:

- Electron-Lattice Coupling (2 sessions)
- Two-Dimensional Magnetism (3 sessions)

- Spin Liquids and Spin Dynamics (3 sessions)
- Magnetoelectrics and Multiferroics
- Light-Matter Interaction
- Ab Initio Methods for Spin-Orbit Magnetism (2 sessions)
- Double Perovskites and Pyrochlores (3 sessions)
- Magnetic, Orbital, and Multipolar Orders in Correlated Insulators (3 sessions)

A dedicated poster session provided early-career researchers with the opportunity to showcase their work and engage in discussions with peers and experts. To promote informal interactions and strengthen the workshop community, a social dinner was also organized.

Specific information on the workshop

The attendees represented a wide range of career stages, from PhD students and postdoctoral researchers to senior scientists and industry representatives (including VASP) — highlighting the vibrant and interdisciplinary nature of the field. More specifically:

Six postdoctoral researchers and two PhD students delivered oral presentations, while several other early-career participants contributed through poster sessions. All young researchers had the opportunity to attend the talks, actively engage in the Q&A sessions, and continue discussions with peers and senior scientists during coffee breaks and at the social dinner, fostering a dynamic and interactive scientific environment.

Category	Number of Participants
Total Participants	57
PhD Students	10
Postdoctoral Researchers	6
Professors and Senior Scientists	40
Company	2
Female Scientists (across all categories)	13

Table: Breakdown of participants at the ESI workshop Spin-Orbit Entangled Quantum Magnetism.

Outcomes and achievements

The workshop provided a fertile ground for initiating and strengthening collaborations, many of which have continued beyond the event and led to new scientific activities. For example, Samuele Sanna and Marco Moretti have organized a topical symposium for the upcoming FISMAT 2025 conference — the largest materials physics meeting in Italy — to be held in Venice in July 2025. Leonid Pourovskii, Silke Biermann, Johanna Carbone, and Cesare Franchini have co-developed a joint France–Austria research proposal, which has been submitted to the ANR and FWF funding agencies. Dario Fiore Mosca has been invited by Claude Ederer to ETH Zurich for an in-depth discussion and potential collaboration. Bongjae Kim, Naoya Iwahara, Cesare Franchini, and Leonid Pourovskii have agreed to co-author a joint article. Additionally, Marie-Therese Hübsch has initiated a collaboration with Stefano Pittalis, while Sergii Khmelevskiy and Leonid Pourovskii have started a new project with Liviu Chibotaru.

As a direct outcome of the discussions and the high level of participation, C. Franchini, L. Pourovskii, A. Paramekanti, L. Celiberti and D. Fiore Mosca have been invited to author a comprehensive review article for *Nature Reviews Materials*, to appear in Summer 2025 — an

acknowledgment of the relevance and impact of this event in shaping future research directions in quantum magnetism.

List of talks

Giniyat Khaliullin (MPI Stuttgart)	Lattice effects in spin-orbit Mott insulators
Liviu Chibotaru (KU Leuven)	Vibronic vs. orbital order in magnetic insulators
Arun Paramakanti (U Toronto)	Probing and controlling multipolar orders via strain and phonons
Mikhail Katsnelson (Radboud U)	Selected problems of two-dimensional magnetism
Johanna Paulina Carbone (TU Vienna)	Magnetocrystalline anisotropy of heavy rare-earth atoms on graphene: From DFT to crystal field theory
Alberto Morpurgo (UNIGE, Geneva)	Probing 2D magnetic materials with magnetotransport
Branislav Nikolic (U Delaware)	What can spintronics do for quantum magnetism and vice versa?
Nandini Trivedi (Ohio State U, Columbus)	Signatures of fractionalization in quantum spin liquids and predictions for experiments
Yong Baek Kim (U Toronto)	Dynamical signatures of fractionalization in dipolar-octupolar quantum spin ice
Sergey Streltsov	Possible spin-liquid and cluster Mott states on a breathing Kagome lattice
Hae-Young Kee (U Toronto)	Transforming from Kitaev to Disguised Ising Chain
Jungho Kim (Argonne National Laboratory)	RIXS Study of Excitations in Kitaev Honeycomb Iridates
Jeffrey Quilliam (U of Sherbrooke)	Non-trivial spin dynamics in quantum spin liquid candidates with and without applied pressure
Olle Eriksson (Uppsala U)	Relativistic effects for exchange interactions and spin-dynamics simulation
Marco Gibertini (U Modena)	Expanding the portfolio of two-dimensional magnetic materials and their applications from first principles
Ellen Fogh (EPFL, Lausanne)	Tuning magnetoelectricity in a mixed-anisotropy antiferromagnet
Nicola Spaldin (ETH Zurich)	Hidden magnetic order with and without spin-orbit coupling
Thomas Olsen (Technical U Denmark, Kongens Lyngby)	Helical ground state and magnetoelectric properties of two-dimensional Nb ₃ Cl ₈
Silvia Picozzi (CNR-SPIN, Chieti)	Multiferroicity and magnetoelectricity in the flatland
Maria Daghofer (U Stuttgart)	Light- induced couplings and spin-orbit coupling
Xinwei Li (NUS, Singapore)	Light induced metastable spin-orbital order in Ca ₂ RuO ₄
Stefan Bluegel (FZ Jülich)	Spin-orbit related phenomena in magnets from density functional theory
Stefano Pittalis (CNRNANO, Modena)	Density functionals for spin-orbit entangled systems: from theory to practice
Marie Therese Huebsch (VASP, Vienna)	Predicting the magnetic ground state with VASP
Diana Csontosova (Masaryk U, Brno)	Hidden covalent insulator and spin excitations in SrRu ₂ O ₆
Bruce Gaulin (McMaster U, Hamilton)	Multipolar Order and Fluctuations in 5d Double Perovskites
Daigorou Hirai (Nagoya U)	Multipole orders in 5d transition metal double perovskites and pyrochlores
Claude Ederer (ETH Zurich)	Multipolar order in the 5d double perovskite Ba ₂ MgReO ₆ from DFT+DMFT
Dario Fiore Mosca (École Polytechnique, Palaiseau & U of Vienna)	Interplay of superexchange and vibronic effects in the from first hidden order of Ba ₂ MgReO ₆ unravelled principles

Marco Moretti (Politecnico Milano)	The origin of magnetism in a supposedly nonmagnetic osmium oxide
Samuele Sanna (U Bologna)	Effect of electron-doping in $\text{Ba}_2\text{Na}_{1-x}\text{Ca}_x\text{OsO}_6$
Lorenzo Celiberti (U of Vienna)	Mott insulator with strong spin orbit coupling
Naoya Iwahara (U Chiba)	Jahn-Teller spin-orbital bipolarons in doped magnetic oxides
Eva Pavarini (FZ Jülich)	Ordering of spin-orbit-lattice entangled states in 5d1 double perovskites
Marjana Lezaic (FZ Jülich)	Finding true Kugel-Khomskii materials
Silke Biermann (École Polytechnique, Palaiseau)	CaIrO_3 : a nonmagnetic semimetal, a magnetic insulator, or something in-between?
Sergey Artyukhin (IIT, Genova)	Hund's exchange in electrochemistry: Electronic properties of cathode materials for battery applications
Sergii Khmelevskiy (TU Vienna)	Towards modelling of VBS states in IrTe_2
Kemp Plumb (Brown U, Providence)	Exotic Phenomena Due to Multipolar Superexchange Interactions in f-Electron Systems
Bongjae Kim (KNU, Daegu)	Pulling order from the brink of disorder: Observation of a nodal line spin liquid and fluctuation stabilized order in the FCC lattice K_2IrCl_6
	Competing magnetisms and onset of the static magnetic order in Sr_2RuO_4

Publications and preprints contributed

L. Pourovskii, D. Fiore Mosca, L. Celiberti, S. Khmelevskiy, A. Paramakanti, C. Franchini, *Hidden multipolar phases in spin-orbit entangled correlated insulators*, in: Nature Review Materials, 2025.

N. Iwahara, L. Pourovskii, C. Franchini, B. Kim, *Physics of Osmates: A Theoretical Perspective*, in: Topical Review to Journal of Physics: Condensed Matter, 2025.

Invited scientists

Sergey Artyukhin, Jakob Baumsteiger, Srishti Bhardwaj, Silke Biermann, Piotr Błoński, Stefan Bluegel, Johanna Paulina Carbone, Lorenzo Celiberti, Liviu Chibotaru, Matteo Costa, Diana Csontosova, Maria Daghofer, Claude Ederer, Olle Eriksson, Dario Fiore Mosca, Ellen Fogh, Cesare Franchini, Bruce Gaulin, Marco Gibertini, Ahmed Halool, Daigorou Hirai, Marie Therese Huebsch, Naoya Iwahara, Darin Joseph, Mikhail Katsnelson, Hae-Young Kee, Giniyat Khaliullin, Sergii Khmelevskiy, Bongjae Kim, Jungho Kim, Yong Baek Kim, Marjana Lezaic, Xinwei Li, Francesco Martinelli, Vesna Mitrovic, Marco Moretti, Alberto Morpurgo, Toshihiko Muroi, Branislav Nikolic, Thomas Olsen, Federico Orlando, Arun Paramakanti, Eva Pavarini, Silvia Picozzi, Stefano Pittalis, Kemp Plumb, Leonid Pourovskii, Jeffrey Quilliam, Rashmi Ranjan Routaray, Samuele Sanna, Sergey Streltsov, Nandini Trivedi, Ilja Turek, Payal Wadhwa, Ivica Zivkovic.

Algebraicity and Transcendence for Singular Differential Equations

Organizers: Alin Bostan (INRIA Paris), Francis Brown (U Oxford), Herwig Hauser (U of Vienna), Shihoko Ishii (U Tokyo), Hiraku Kawanoue (Chubu U, Kasugai City), Michael Singer (NC State U, Raleigh)

Dates: October 7 – 18, 2024

Budget: ESI € 8 632

U of Vienna, Faculty of Mathematics, Workshop Dinner: € 900

Report on the Workshop

The study of Fuchsian Differential Equations and, more particularly, of the quality of their solutions – algebraicity, transcendence, integrality – has been a subject of intensive research for the last two hundred years. Whereas univariate algebraic functions are known to satisfy a linear differential equation with polynomial coefficients, it is, conversely, largely unknown which differential equations admit a basis of algebraic solutions. Explicit criteria are given in the hypergeometric case and for order one equations, but the general case remains open. Most prominent is the conjecture of Grothendieck-Katz about the vanishing of the p -curvatures for almost all primes p .

In the workshop, the state of the art and recent advances in this context were presented and discussed at length. The selection of speakers was made so as to cover all aspects of the problem and to enable fruitful dialogues between people from different backgrounds.

Activities

The first week was devoted to a Summer School like format. Four five-hour mini-courses by expert speakers presented theoretical material and practical implementations. The courses were split into three 90 minutes lectures and two 60 minutes problem sessions, favouring communication and joint solution findings.

Mini-Courses

- Julien Roques, Lyon: The p -Curvature Conjecture
- Michael Singer, Raleigh: Differential Galois Theory and the Algebraicity of Solutions
- Duco van Straten, Mainz: Differential Equations, Geometry and Arithmetic.
- Daniel Vargas-Montoya, Toulouse, Masha Vlasenko, Kyiv: A p -adic Approach to Differential Equations.

The second week was composed by 18 individual lectures between 60 and 90 minutes. Again, emphasis was laid on the accessibility of the material to non-experts and young researchers. Very competent and prominent speakers presented a fascinating and enriching panorama about Fuchsian Differential Equations.

The organizers are very grateful to the Institute, its director and the staff of the Institute for having hosted and financed the workshop. The service was perfect, the venue is exceptional, and the financial support was essential and very helpful. Thank you very much!

Specific information on the workshop

A number of Prae-Docs and Post-Docs attended the workshop, among them Christopher Chiu, Gregor Böhm, Sebastian Eterovic, Florian Fürnsinn, Francisco García Cortés, Nutsa Gegelia, Luisa Gietl, Anna Goncharuk, Sebastian Gontarek, Zhiqiang He, Abhiram Mamandur Kidambi, Hadrien Notarantonio, Feliks Raczka, Adele Padgett, Nigel Pynn-Coates.

Outcomes and achievements

It is too early to determine the specific collaborations between participants which may have started during the workshop.

List of talks

Julien Roques (U of Lyon)	The p-Curvature Conjecture, I - III
Michael Singer (North Carolina State U, Raleigh)	Differential Galois Theory and the Algebraicity of Solutions, I - III
Duco van Straten (U of Mainz)	Differential Equations, Geometry and Arithmetic, I - III
Daniel Vargas-Montoya (IMT, Toulouse) & Masha Vlasenko (KSE, Kyiv)	A p-adic Approach to Differential Equations, I - III
Javier Fresán (Sorbonne U)	On G-functions of differential order 2
Frits Beukers (Utrecht U)	Picard-Fuchs equations and modular forms - with some applications
Yoshishige Haraoka (Josai U)	Higher dimensional Katz theory
Andrea Pulita (U Grenoble Alpes)	p-adic differential equations over Berkovich curves
Marius van der Put (U Groningen)	First order differential equations in characteristic zero and characteristic p.
Hiraku Kawanoue (Chubu U)	The exponential function in characteristic p
Francis Brown (U Oxford)	Mellin transforms and P-recurrences, point counts over finite fields and invariants of graphs
Masaaki Yoshida (Fukuoka U)	Fuchsian differential equations of order 3 and 6 with three singular points and with one accessory parameter
Jean-Benoît Bost (U Paris Sud)	Arithmetic algebraization theorems and the analogy between number fields and function fields
Maxim Kontsevich (IHES, Bures-sur-Yvette) and	On Katz' nilpotent conjecture, p-determinants, q-generalization
Vesselin Dimitrov (Caltech U)	Arithmetic holonomy bounds
Yunqing Tang (California Inst. of Technology)	The arithmetic of power series and applications to periods
Éric Delaygue (I Camille Jordan)	On Abel's problem and Gauss congruences
Masahiko Yoshinaga (Osaka U)	Towards a Kontsevich-Zagier type conjecture for holonomic series
Vasily Golyshev (Abdus Salam ICTP)	Beyond Complex Multiplication
Alin Bostan (INRIA Paris)	How to decide in practice if a D-finite power series is algebraic?
Charlotte Hardouin (IMT, Toulouse)	Extending Hölder's result on the differential transcendence of the Gamma function

Publications and preprints contributed

S. Yokura, *A naive co-operational bivariant theory derived from cohomology operations*, unpublished.

Invited scientists

Hiroki Aoki, Matthias Aschenbrenner, Vincent Bagayoko, Frits Beukers, Gregor Böhm, Jean-Benoît Bost, Alin Bostan, Francis Brown, Manfred Buchacher, Francisco Castro, Christopher Chiu, Gilles Christol, Éric Delaygue, Vesselin Dimitrov, Roland Donninger, Sebastian Eterovic, Eleonore Faber, Javier Fresán, Florian Fürsinn, Francisco García Cortés, Nutsa Gegelia, Vasily Golyshev, Anna Goncharuk, Sebastian Gontarek, Davide Guzzetti, Yoshishige Haraoka, Charlotte Hardouin, Herwig Hauser, Zhiqiang

He, Martin Kalck, Manuel Kauers, Hiraku Kawanoue, Maxim Kontsevich, Christoph Koutschan, Christian Krattenthaler, Abhiram Mamandur Kidambi, Anton Mellit, Luis Narváez Macarro, Adele Padgett, Eric Pichon, Andrea Pulita, Nigel Pynn-Coates, Feliks Raczka, Armin Rainer, Harald Rindler, Julien Roques, Bruno Salvy, Josef Schicho, Michael Schlosser, Michael Singer Szilárd Szabó, Yunqing Tang, Gerald Teschl, Marius van der Put, Duco van Straten, Daniel Vargas-Montoya, Masha Vlasenko, Shoji Yokura, Masaaki Yoshida, Masahiko Yoshinaga, Sergey Yurkevich, Wadim Zudilin.

Symposium: ESI Medal Award Ceremony 2024

Organizer: Christoph Dellago, ESI Director (U Vienna)

Dates: December 6, 2024

ESI Medal

The *Medal of the Erwin Schrödinger Institute for Mathematics and Physics*, in short ESI-Medal, has been created to recognize outstanding achievements in any area of mathematics or physics, including contributions at the interface of the two fields.

The ESI-Medal is awarded annually and emphasis is generally given to recent achievements not older than ten years. There is no age limitation for the recipient and ordinarily the ESI-Medal is awarded to one person only.

The recipient of the ESI-Medal receives a medal, a certificate and a monetary award of € 4 000. Nominations for the ESI Medal can be made by organizers of current and previous ESI Thematic Programmes, current and former ESI Senior Research Fellows, former members of the Scientific Advisory Board (SAB) of the ESI, former recipients of the ESI Medal, former Directors of the ESI and the President of the ESI Association. The recipient is selected by the Scientific Advisory Board of the ESI.

Winner of the ESI Medal 2024

The winner of the the *Medal of the Erwin Schrödinger Institute for Mathematics and Physics* for the year 2024 is Piotr T. Chruściel, Professor at the Faculty of Physics of the U of Vienna.

Professor Chruściel is honoured for his original and influential contributions to many areas in the field of Mathematical Relativity, including the mathematical description of black holes, the initial value problem for the Einstein equations, and aspects of current physical interest, like the influence of weak gravitational fields on the propagation of photonic states in dielectric wave-guides. He and his co-authors obtained deep new insights by combining sophisticated methods from differential geometry, topology and partial differential equations. Outstanding examples are Chruściel's work on the concept of mass, on the structure of initial data sets, as well as his seminal contributions to Lorentzian geometry of non-differentiable metrics.

Award Ceremony

The award ceremony took place on December 6, 2024 at the ESI Boltzmann Lecture Hall.

Schedule of the Ceremony

Christoph Dellago, ESI Director (U of Vienna)	Welcome
Hans Ringström (KTH Stockholm)	Initial data on big bang singularities
Zoe Wyatt (U of Cambridge)	A new phase transition in cosmological fluid dynamics
Helmut Friedrich (MPIGP, Potsdam)	Laudatio
Christoph Dellago, ESI Director (U of Vienna)	Award of the ESI Medal
Piotr T. Chruściel (U of Vienna)	Award Lecture
Christoph Dellago, ESI Director (U of Vienna)	Closing

Lensing and Wave Optics in Strong Gravity

Organizers: Pedro Cunha (U of Aveiro), Marius A. Oancea (U of Vienna), Miguel Zumalacárregui (MPIGP, Potsdam)

Dates: December 9 – 13, 2024

Budget: ESI € 11 064

Report on the Workshop

Gravitational lensing represents a characteristic feature of astrophysical systems in strong gravitational fields, such as the supermassive black holes recently observed by the Event Horizon Telescope (EHT). On the other hand, strong gravitational fields are also being probed by the LIGO-Virgo-KAGRA (LVK) observations of gravitational waves. With the rapidly increasing number of observed gravitational waves, it is expected that a small portion of these events will be gravitationally lensed.

The workshop “*Lensing and Wave Optics in Strong Gravity*” organized at the ESI, brought together members of the astrophysical community working on lensing and wave effects in strong gravitational field, in order to discuss physics relevant for both EHT and LVK observations. Our main goal was to discuss the theoretical, numerical, and observational aspects of lensed electromagnetic and gravitational waves as astrophysical probes of the regime of strong gravitational fields. This is motivated by recent experimental observations: The EHT is currently able to observe microwave radiation originating from the vicinity of supermassive black holes, whereas LVK (as well as future gravitational wave detectors, such as the Einstein telescope and LISA) are expected to be able to detect lensed gravitational waves originating from mergers in high-curvature environments. Current open problems and perspectives in the field were discussed, namely how to transfer techniques from the mature field of lensing of electromagnetic waves towards novel studies in the lensing of gravitational waves. The goal is to pave the road towards multi-messenger astrophysics in the strong-gravity regime.

Activities

The detailed schedule of the workshop can be found at <https://www.esi.ac.at/events/e546/>.

The workshop included 28 seminars distributed in 10 sessions. The first session consisted of two overview seminars of one hour each, covering the state of the art, current open problems, and

research directions in two complementary fields: lensing of electromagnetic waves, black hole shadows, and EHT observations, and lensing of gravitational waves, wave optics effects and the prospect of future observations by gravitational wave detectors. These overview seminars were provided by Luciano Rezzolla and Jose Maria Ezquiaga, who are leading experts in these fields. The remaining 26 seminars of 30 minutes each (+10 minutes for questions and discussions) were provided by young experts, as well as senior researchers, covering observational, numerical, theoretical, and mathematical aspects of gravitational lensing and wave optics phenomena.

On Wednesday evening, 43 participants took part in the conference dinner organized at the *Heuriger Feuerwehr Wagner, Grinzinger Straße 53, 1190 Wien*.

Specific information on the workshop

We aimed to promote young scientists and female scientists by providing a suitable framework for discussions and interactions with senior scientists. Furthermore, the wide diversity of participants from different research fields (such as lensing of electromagnetic waves and lensing of gravitational waves, covering theoretical, numerical, and observational aspects) created a prolific environment for exchange of ideas and techniques.

Several PhD students and early career Postdoc researchers contributed with seminar talks: *Nezihe Uzun, Felix Willenborg, Héctor Villarrubia-Rojo, Dylan Jow, João Novo, Han Gil Choi, Srashti Goyal, Helena Ubach*.

Outcomes and achievements

The workshop was highly appreciated by many participants, as it provided an important bridge between researchers in different communities who are working on relatively similar problems. Furthermore, while there are many scientific events dedicated to the lensing of electromagnetic waves, this workshop was one of the first to address gravitational wave lensing.

During the workshop, the diversity of scientists with complementary research expertise, as well as the excellent working environment at ESI, led to important scientific exchanges. The participants continued their work with previous collaborators, and many new collaborations were established. We give here some examples:

- J. Samsing, J. M. Ezquiaga, R. K. Lo, and L. Vujeva continued their work on the transverse velocity of strongly lensed gravitational wave sources, resulting in a paper.
- J. Samsing, J. M. Ezquiaga, R. K. Lo, and L. Vujeva continued their work on strongly lensed eccentric binary mergers, resulting in a paper.
- M. Garcia, J. Redondo-Yuste, and L. Vujeva continued their work on lensing and wave optics in the strong gravitational field of a black hole, resulting in a paper.
- J. M. Ezquiaga, H. Villarrubia-Rojo, and M. Zumalacarregui started working on the effects of higher-order caustics in gravitational wave lensing.
- G. P. Smith, H. Wang, and M. Zumalacarregui started working on synergies between the Vera C. Rubin Observatory and binary supermassive black holes.
- P. Ajith, A. Barsode, S. Goyal, and M. Zumalacarregui began working on the incorporation of microlensing in strong lensing searches.

List of talks

Luciano Rezzolla (Goethe U Frankfurt)	M87* and Sgr A*: Imaging supermassive black holes
Jose M. Ezquiaga (NBI, Copenhagen)	Gravitational Wave Lensing: Current Searches and Future Prospects
Nezihe Uzun (CFT PAN)	Gaussian beams and caustic avoidance
Felix Willenborg (ZARM, Bremen)	Exact wave-optical imaging of black hole spacetimes
Richard Brito (IST Lisboa)	Black holes as laboratories: searching for ultralight fields
Mikołaj Korzyński (CFT PAN)	Bi-local approach to geometrical optics in GR
Giulia Cusin (IAP, Paris)	Gravitational wave lensing in the deep wave-optics regime: results and future directions
Alex Lupsasca (Vanderbilt U, Nashville)	The Black Hole Photon Ring
Graham Smith (U of Birmingham)	Multi-messenger gravitational lensing and the Vera C. Rubin Observatory
Oleg Tsupko (ZARM, Bremen)	Analytical Studies of Higher-Order Photon Rings in the Images of Spherically Symmetric Black Holes
Héctor Raúl Olivares Sánchez (UAVR)	A simulation pipeline for nearly circular supermassive black hole binaries
Xian Chen (Peking U)	Why are LIGO/Virgo Black Holes So Massive?
Hector Villarrubia-Rojo (U Complutense de Madrid)	Efficient methods for wave-optics lensing
João Novo (U of Aveiro)	Null and Timelike Circular Orbits: Insights from Effective 2D Metrics
Abraham Harte (Dublin City U)	What is high-frequency approximation?
Johan Samsing (NBI, Copenhagen)	Measuring Proper Motion of GW Sources with Strong Lensing Events
Volker Perlick (U Bremen)	Gravitational lensing in the presence of a plasma
Hayato Motohashi (Kogakuin U)	Spin wave optics of gravitational waves
Dylan Jow (Stanford U)	Measuring cosmic expansion with diffractive gravitational scintillation of nanoHertz gravitational waves
Otto Hannuksela (CU Hong Kong)	Gravitational-wave lensing challenges and opportunities
Han Gil Choi (IBS, Daejeon)	Distinguishing the dressed black holes with gravitational wave diffraction
Tjonnje Li (KU Leuven)	Using time series to identify strongly-lensed gravitational waves with deep learning
Carlos A. R. Herdeiro (U of Aveiro)	Light ring topological theorems
Galin Gyulchev (Sofia U)	Images of a thin accretion disk around Kerr black holes with time dependent multiscalar hair
Pierre Fleury (CNRS, Montpellier)	Line-of-sight effects in strong gravitational lensing
Srashti Goyal (MPIGP, Potsdam)	Prospects of probing dark & baryonic structures with gravitational-wave lensing
Parameswaran Ajith (ICTS, Bordeaux)	Cosmology using gravitationally lensed gravitational waves
Helena Ubach (U of Barcelona)	Interference signatures from gravitational lensing on gravitational waves

Publications and preprints contributed

J. C. L. Chan, C. Dyson, M. Garcia, J. Redondo-Yuste & L. Vujeva, *Lensing and wave optics in the strong field of a black hole*, [arXiv:2502.14073](https://arxiv.org/abs/2502.14073)[gr-qc].

J. Samsing, L. Zwick, P. Saini, D. D’Orazio, K. Hendriks, J. M. Ezquiaga, R. K. Lo, L. Vujeva, G. D. Radev, & Y. Yu, *Measuring the Transverse Velocity of Strongly Lensed Gravitational Wave Sources with Ground Based Detectors*, [arXiv:2412.14159](https://arxiv.org/abs/2412.14159)[astro-ph.HE].

J. Samsing, L. Zwick, P. Saini, K. Hendriks, R. K. L. Lo, L. Vujeva, G. D. Radev & Y. Yu, *Constraining Proper Motion of Strongly Lensed Eccentric Binary Mergers using Doppler Triangulation*, [arXiv:2501.12494](#)[astro-ph.HE].

L. Zwick & J. Samsing, *The Proper Motion of Strongly Lensed Binary Neutron Star Mergers in LIGO/Virgo/Kagra can be Constrained by Measuring Doppler Induced Gravitational Wave Dephasing*, [arXiv:2502.03547](#)[astro-ph.CO].

Invited scientists

Peter C. Aichelburg, Parameswaran Ajith, Drew Backhouse, Ankur Barsode, Ginevra Braga, Richard Brito, Xian Chen, Han Gil Choi, Wan Cong, Pedro Cunha, Giulia Cusin, Uddeeta Deka, Alejandro Estrada, Jose M. Ezquiaga, David Fajman, Filip Ficek, Pierre Fleury, Matilde Garcia, Serena Giardino, Srashti Goyal, Finnian Gray, Galin Gylchev, Otto Hannuksela, Sreekanth Harikumar, Abraham Harte, Carlos A. R. Herdeiro, Justin Janquart, Dylan Jow, Vladimir Karas, Mikołaj Korzyński, Tjonnie Li, Xinyi Lin, Rico Lo, Alex Lupsasca, Maciej Maliborski, Nicola Menadeo, Thomas Mieling, Hayato Motohashi, Petya Nedkova, João Novo, Marius A. Oancea, Maximilian Ofner, Héctor Raúl Olivares Sánchez, Volker Perlick, Dennis Philipp, Martin Pijnenburg, Luciano Rezzolla, Claire Rigouzzo, Johan Samsing, Ivo Sengo, Xikai Shan, Walter Simon, Graham Smith, Sudhagar Suyamprakasam, Oleg Tsupko, Helena Ubach, Juan Urrutia, Nezihe Uzun, Hector Villarrubia-Rojo, Luka Vujeva, Hanxi Wang, Felix Willenborg, Man Chun Yeung, Jaime Redondo Yuste, Iman Zabett, Lorena Zertuche, Miguel Zumalacárregui.

Research in Teams

Research in Teams Project 1: Entropy methods for evolutionary systems: Analysis and Numerics

Collaborators: Eduard Feireisl (Czech Academy of Sciences, Prague), Ansgar Jüngel (TU Vienna) and Mária Lukáčová-Medvid'ová (Johannes Gutenberg U Mainz)

Dates: October 2 – 14, 2024 and December 8 – 20, 2024

Budget: ESI € 3 440
DFG € 2 000

Report on the project

Scientific Background

The main aim of the proposed collaboration was to combine the expertise of all three team members and to identify general principles with the aim to exploit synergies in entropy methods for some well-chosen classes of evolutionary differential equations, in particular compressible fluid dynamical models. Examples, studied in this project, are the compressible Euler equations of gas dynamics and multicomponent quasi-incompressible Maxwell–Stefan–Navier–Stokes systems.

Project aims and scope

The main goal of the project was to exploit synergies of available entropy methods for several well-chosen physically relevant models. Our plan was to develop a general framework for entropy methods both in analysis and numerics that will allow us to extend and generalize partial results already existing for particular models to a general class of models with the common feature of being thermodynamically consistent.

The analytical investigations will help us to design efficient numerical methods for a large class of models, that will lead to consistent and stable approximations. Note that due to low regularity estimates that are in general available, possible oscillations give rise only to the weak convergence of the approximate sequences that cannot be captured directly by a single computation. Instead, several iterations and statistical averaging are necessary to represent the observable quantities. The problem is complex with many basic issues that are completely open. From this point of view, new results in the analysis and numerics of the proposed models are expected.

Outcomes and achievements

The development of a general framework for entropy methods turned out to be very demanding during the short duration of the project. On the other hand, the concept of low-regularity solutions has led to some important results. More specifically, we focused on two directions: analysis of (dissipative) solutions to the compressible Euler equations of gas dynamics and structure-preserving numerical schemes for Maxwell–Stefan–Navier–Stokes systems. We achieved the following results.

We have shown that any dissipative (measure-valued) solution to the compressible Euler system that complies with Dafermos' criterion of maximal dissipation is necessarily an admissible weak solution. In addition, we proposed a simple, at most two step, selection procedure to identify a unique semigroup solution in the class of dissipative solutions to the Euler system. Finally, we introduced a refined version of Dafermos' criterion yielding a unique solution of the problem for any finite energy initial data. The results have been summarized in the research article [1].

Furthermore, we proposed a new structure-preserving numerical method for numerical solutions of the quasi-incompressible Maxwell–Stefan–Navier–Stokes system. Our numerical method employs conforming finite elements and a mixed explicit–implicit time discretization. We proved that the numerical method preserves important physical properties, such as the mass conservation, discrete energy stability, and preservation of the quasi-incompressibility constraint. Numerical experiments illustrate structure-preserving properties and convergence of the numerical scheme. The results have been summarized in the draft [2].

In future research, we want to continue in our collaboration and plan mutual visits in Vienna, Prague or Mainz. We want to investigate connections between vanishing viscosity-based numerical methods and Dafermos' criterion on maximal entropy production. Further fluid dynamical and multi-component systems will be investigated with respect to their thermodynamic stability and interactions between generalized solution concepts and their numerical approximations.

Publications and preprints contributed

- [1] E. Feireisl, A. Jüngel, and M. Lukáčová-Medvid'ová. *Regularity and well-posedness of the Euler system in gas dynamics for dissipative solutions*. Submitted for publication, [arXiv:2501.05134](https://arxiv.org/abs/2501.05134)[math.AP].
- [2] A. Brunk, A. Jüngel, M. Lukáčová-Medvid'ová. , *A structure-preserving numerical method for quasi-incompressible Navier–Stokes–Maxwell–Stefan systems*, [arXiv:2504.11892](https://arxiv.org/abs/2504.11892)[math.NA].

Research in Teams Project 2: Supersymmetric Solutions of 3D Minimal Massive Supergravity

Collaborators: Nihat Sadik Deger (Bogazici U, Istanbul), Jan Rosseel (Rudjer Boskovic Institute, Zagreb)

Dates: August 10 – September 29, 2024

Budget: ESI € 6 720

Report on the project

Scientific Background

Three-dimensional (3D) gravity has long been established as a useful laboratory in order to understand, solve and test fundamental questions of quantum gravity, black hole physics, and holography. The pure 3D Einstein gravity is locally trivial but one can add higher curvature terms to the theory to generate local dynamics which results in massive spin-2 excitations around

Minkowski and Anti-de Sitter (AdS) spacetimes. Over the years, several such 3D gravitational theories have been developed including topologically massive gravity (TMG) [4], new and general massive gravities [5, 6], minimal massive gravity (MMG) [7], and exotic massive gravities [8, 9].

The MMG model propagates a single massive spin-2 mode around an AdS background (that is why it is called *minimal*), and is distinguished by the fact that its parameter space allows for a region in which the massive spin-2 mode is neither ghost nor tachyonic, while maintaining both boundary central charges positive. Therefore, remarkably, MMG evades the bulk-boundary unitarity clash from which most other 3D massive gravity models suffer, elevating the model to a potentially useful toy model for a quantum gravity theory dual to a putative unitary 2D conformal field theory [10, 11]. However, MMG also has a rather unusual property; its field equation, which contains an extra curvature squared term compared to TMG, does not come from the variation of a local action of the metric alone. Consequently, the Bianchi identity on its own does not guarantee the consistency of this equation. Nevertheless, this equation still makes sense on-shell since its divergence vanishes if one uses the field equation again. This novel mechanism is called the “third way consistency”, see [12, 13] for a review. Further such 3D gravity models were constructed in [8, 9], and a 3D Yang-Mills example was found in [14]. Interacting p -form theories with this property in arbitrary dimensions were constructed in [15].

Until recently it was not known whether supersymmetry and third way consistency were compatible, but in [16] we showed that this is possible by explicitly constructing the $N = 1$ supersymmetric version of the massive Yang-Mills theory of [11]. Later, it was found that the model of [14] possesses a natural action as a Chern-Simons coupled gauged sigma model after Hodge dualization of the three-dimensional gauge fields to scalars [17]. In this dual formulation, coupling of [11] to the $N = 1$ supergravity became straightforward. Decoupling the gravity sector one obtains the supersymmetric system of [16]. After supersymmetrization of the Yang-Mills model [14], trying to do the same for gravity was a natural next step. The construction of the $N = 1$ supersymmetric extension of MMG was achieved in [18, 19] which is the first example of a supersymmetric third way consistent gravity theory.

Project aims and scope

The aim of this project is to study supersymmetric solutions of the minimal massive supergravity (MMSG) which was constructed recently [18, 19]. Such solutions are pivotal in the study of supergravity theories since they enjoy stability properties that survive quantum deformations and have various important applications. It will be interesting to compare supersymmetric solutions of MMSG with those of the topologically massive supergravity (TMSG) [20, 21, 22] and with bosonic solutions of MMG. Especially, finding those which exist in the region of the parameter space with well-defined bulk and boundary unitarity is desirable.

Outcomes and achievements

Together with our collaborator Henning Samtleben at ENS de Lyon, we achieved the main goal of our project, namely the construction of the most general supersymmetric solution of the MMSG and presented our results in [1]. The analysis of Killing spinor equations of MMSG closely follows the lines of [22] for TMSG [20, 21] and interestingly reduces to the same type of differential equation. Accordingly, the supersymmetric solutions of MMSG are in correspondence with the supersymmetric solutions of TMSG and given by plane waves with

a null Killing vector field. Wave solutions of the same form were found in bosonic MMG in [23] and the main difference with ours is that supersymmetry requires a specific orientation. Therefore, any such solution is supersymmetric in only one of the four possible supersymmetric extensions of MMG. In general, they are half-supersymmetric (except AdS_3 which preserves full supersymmetry) and in the unitary region of the MMSG except those that appear at some special points of the parameter space. A particular subclass of our solutions corresponds to null warped AdS_3 spaces and one can obtain black holes from them by performing periodic identifications [24, 25]. We showed that these identifications are compatible with supersymmetry but the unitary region becomes more restricted to have physically well-defined black holes. Moreover, supersymmetry is enhanced at the near horizon limit.

After completing [1] we started to work on [2]. The construction of MMSG [18, 19] is based on a new first order action principle which can also be used to construct an infinite family of third way consistent gravity models that contains previous examples [8,9]. In [19] this was used to obtain such deformations of New and General Massive gravities [5, 6]. Our goal in [2] is to study unitarity properties of these models. Our preliminary results indicate that the no tachyon, no ghost and positive central charges requirements cannot all be satisfied simultaneously for them. However, the situation at chiral points requires a more detailed analysis which is currently under investigation.

During this collaboration at ESI one of us also made significant progress on the preprint [3] which was completed shortly after the visit. In this paper, timelike supersymmetric solutions of a particular 3D, $N = 4$ gauged supergravity [26, 27], that comes from 6D via a consistent 3-sphere reduction [28], are studied. It is found that AdS_3 is the only solution within this class. Meanwhile, for such solutions, the ungauged theory reduces to a supergravity coupled to a sigma model with a 2-dimensional hyperbolic target space $\mathbb{H}^2$ and admits infinitely many of them that can be expressed in terms of two arbitrary holomorphic functions. It is shown that, the spacetime metric can be written as a warped product of the time direction with the metric on the sigma model target manifold and the warp factor is given in terms of the Kähler potential of $\mathbb{H}^2$.

Publications and preprints contributed

- [1] N.S. Deger, J. Rosseel & H. Samtleben, *The General Supersymmetric Solution of Minimal Massive Supergravity*, [arXiv:2410.07964](#) [hep-th].
- [2] N.S. Deger & J. Rosseel, *Third Way Deformation of New and General Massive Gravities*, in preparation.
- [3] N.S. Deger & C.A. Deral, *Timelike Supersymmetric Solutions of $D=3$, $N=4$ Supergravity*, [arXiv:2411.04437](#) [hep-th].

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- [5] E.A. Bergshoeff, O. Hohm and P.K. Townsend, *Massive Gravity in Three Dimensions*, [arXiv:0901.1766](#) [hep-th].
- [6] E.A. Bergshoeff, O. Hohm and P.K. Townsend, *More on Massive 3D Gravity*, [arXiv:0905.1259](#) [hep-th].
- [7] E. Bergshoeff, O. Hohm, W. Merbis, A.J. Routh and P.K. Townsend, *Minimal Massive 3D Gravity*, [arXiv:1404.2867](#) [hep-th].

- [8] M. Özkan, Y. Pang and P.K. Townsend, *Exotic Massive 3D Gravity*, [arXiv:1806.04179](#) [hep-th].
- [9] H. R. Afshar and N.S. Deger, *Exotic massive 3D gravities from truncation*, [arXiv:1909.06305](#) [hep-th].
- [10] E. A. Bergshoeff, W. Merbis and P.K. Townsend, *On-shell versus Off-shell Equivalence in 3D Gravity*, [arXiv:1812.09205](#) [hep-th].
- [11] E.A. Bergshoeff, W. Merbis and P.K. Townsend, *On asymptotic charges in 3D gravity*, [arXiv:1909.11743](#) [hep-th].
- [12] E. Bergshoeff, W. Merbis, A.J. Routh and P.K. Townsend, *The Third Way to 3D Gravity*, [arXiv:1506.05949](#) [gr-qc].
- [13] N. S. Deger, *A Review of Third Way Consistent Theories*, [arXiv:2109.04339](#) [hep-th].
- [14] A.S. Arvanitakis, A. Sevrin and P.K. Townsend, *Yang-Mills as massive Chern-Simons theory: a third way to three-dimensional gauge theories*, [arXiv:1501.07548](#) [hep-th].
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- [16] N. S. Deger and J. Rosseel, *Novel 3D supersymmetric massive Yang-Mills theory*, [arXiv:2105.13300](#) [hep-th].
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- [18] N. S. Deger, M. Geiller, J. Rosseel and H. Samtleben, *Minimal Massive Supergravity*, [arXiv:2206.00675](#) [hep-th].
- [19] N. S. Deger, M. Geiller, J. Rosseel and H. Samtleben, *Minimal massive supergravity and new theories of massive gravity*, [arXiv:2312.12387](#) [hep-th].
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- [22] G.W. Gibbons, C.N. Pope and E. Sezgin, *The General Supersymmetric Solution of Topologically Massive Supergravity*, [arXiv:0807.2613](#) [hep-th].
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- [24] D. Anninos, W. Li, M. Padi and A. Strominger, *Warped AdS₃ Black Holes*, [arXiv:0807.3040](#) [hep-th].
- [25] D. Anninos, G. Compere, S. de Buyl, S. Detournay and M. Guica, *The Curious Case of Null Warped Space*, [arXiv:1005.4072](#) [hep-th].
- [26] N.S. Deger, N. Petri and D. Van den Bleeken, *Supersymmetric Dyonic Strings in 6-Dimensions from 3-Dimensions*, [arXiv:1902.05325](#) [hep-th].
- [27] N.S. Deger, C.A. Deral, A. Saha and Ö. Sarioğlu, *Rotating AdS₃ x S³ and dyonic strings from 3-dimensions*, [arXiv:2408.03197](#) [hep-th].
- [28] N.S. Deger, H. Samtleben, Ö. Sarioğlu and D. Van den Bleeken, *A supersymmetric reduction on the three-sphere*, [arXiv:1410.7168](#) [hep-th].

Research in Teams Project 3: Dynamical, geometric and analytic properties of random groups

Collaborators: MurphyKate Montee (Carleton College, Northfield), Markus Steenbock (U of Vienna)

Dates: May 23 – June 19, 2024

Budget: ESI € 2 400

This project was supported in parts by NSF grant number DMS-2317001 and the Austrian Science Fund (FWF) project 10.55776/P35079.

Report on the project

Scientific Background

Randomness has been used extensively to explore properties of ‘typical’ mathematical objects, such as random graphs, random matrices, and random groups. This now is a fruitful topic in group theory, as it allows us to test conjectures and helps to understand what properties are to be expected from a group given by a ‘typical’ group presentation. Over time the theory of random groups has been developed into a rich theory with many challenging open questions of its own.

A frequently studied model of random groups is the Gromov density model. In this paradigm, a group is chosen by a random group presentation. Let $n, \ell \in \mathbb{N}$, $d \in (0, 1)$ be fixed parameters and pick a group presentation $G = \langle S | R \rangle$ so that $|S| = n$, $|R| = (2n - 1)^{d\ell}$, and every word $r \in R$ is a cyclically reduced word of length ℓ chosen uniformly at random from all such words. A random group satisfies a property P if the probability of satisfying P approaches 1 when $\ell \rightarrow \infty$.

For example, a random group is hyperbolic when $d < 1/2$, and when $d > 1/2$ a random group is finite. For many other properties the corresponding threshold density is not known. For example, we only know that the threshold density for Property (T) in random groups is between $1/4$ and $1/3$ [11,7,2]. On the other hand, for $d < 1/6$ random groups are cubulated [10], and for $d < 3/14$ they admit a cocompact action on a CAT(0) cube complex [9,8]. The latter properties are mutually exclusive with Property (T).

Question 1. *What is the behavior of random groups when $1/4 < d < 1/3$? Can cubulation be promoted to densities $d < 1/4$?*

An affirmative answer to the latter question would have powerful corollaries; in particular, residual finiteness at density $d < 1/4$. It is currently unknown if random groups at $1/6 < d < 1/2$ are residually finite.

Project aims and scope

The ultimate goal of this project is to better understand Question 1. To achieve this, we studied related questions, including the following:

Question 2. *How ‘should’ one model random quotients of free products of groups? How are different models related? Can we prove cubulation and/or Property (T)?*

Question 3. *What properties of small cancellation groups can be promoted to random groups? What are sharp density bounds for these properties?*

The immediate goal with studying Question 2 is to develop a tool to study ‘typical’ examples of relatively hyperbolic groups. Ultimately, we hope that tools developed in both questions will help us answer Question 1.

Outcomes and achievements

Random quotients of free products (Question 2). Let A, B be groups and consider a random quotient of $A * B$. We define two possible models to select a random collection of words R defining $G = A * B / \langle\langle R \rangle\rangle$.

Fix presentations $A = \langle S_A | R_A \rangle, B = \langle S_B | R_B \rangle$. In Model 1, we choose a random set of relators R of density d sampled over the cyclically reduced words of length l in $S_A \cup S_B$. In Model 2, we choose relators of free-product length ℓ so that each syllable is a word in A or B of word length $\leq m$ for some fixed m .

Model 2 has several benefits for studying relative hyperbolicity and cubulation: preliminary results with Einstein, Krishna, and Ng indicate that in Model 2, factor groups embed in a random quotient G and G is hyperbolic relative to $\{A, B\}$ when $d < 1/2$; when $d > 1/2$ G is finite. When $d < 1/6$ G admits a relatively geometric action on a CAT(0) cube complex; if furthermore A, B are cubulated then so is G . These properties do not necessarily hold in Model 1; indeed, in the case that $A = \mathbb{F}_m, B = \mathbb{Z}$, as m grows, with high probability A will fail to embed in G at any $d > 0$. On the other hand, Property (T) is more easily understood in Model 1: by [11, 7] $\langle S_A, S_B \mid R \rangle$ has Property (T), and since Property (T) is preserved by quotients so does G .

In the context of Model 1, we explored the free product of r non-abelian free groups as a motivating example. Computation shows that the expected value for the free product length is roughly $(1 - 1/r)\ell$, while the variation is roughly about $(1 - 1/r)\ell/r$. This explains the difficulty in Model 1 to capture the relative geometry of the free product.

We also started to explore Property (T) in Model 2, by first analysing spectral properties of random quotients of free products of free groups. Following [3], the idea is to split the relators into three parts respecting the syllables and to define graphs whose spectral properties encode Property (T) for the group. This leads to two new open questions. Firstly, whether the corresponding graphs have the spectral gap property. Secondly, whether this does indeed imply Property (T) for the random quotient. If true, we obtain Property (T) for the random quotients of a free product in Model 2.

We also studied relative cubulation in density $< 1/6$ in Model 2. We discussed a direct proof of cubulation relative to the free factors by analysing the Sageev construction.

Cubulation in the Gromov model (Question 1). Our study of relative cubulation in density $< 1/6$ motivated us to study an approach towards a positive answer to Question 1. That is, to prove that random groups in the Gromov model act properly and cocompactly on a CAT(0) cube complex at density $d < 1/5$. Ollivier-Wise proved a cocompact action on a CAT(0) cube complex [10]. Groves-Manning [6] reduced Question 1 to showing that vertex stabilisers of this cube complex are virtually special. This strategy has been implemented in a related model for random groups [5]. In the Gromov density model, at density $< 3/14$ our preliminary results include that stabilisers of principal vertices are finitely generated free groups. This follows essentially from the fact that, in this case, hypergraphs are quasi-isometrically embedded trees. Thus the question reduces further to the analysis of non-principal vertices. We have developed an approach to deal with these vertices that we plan to further investigate in the near future.

Small-cancellation-type properties (Question 3). We investigated an approach to show that random groups at density $< 1/5$ are at least CAT(-1), using ideas of Brown [4] for uniformly $C'(1/6)$ -small cancellation groups.

The Cohen-Lyndon property states that the normal subgroup generated by the relator set of the group in the free group is freely generated by certain conjugates of the relator words. It is open whether the Cohen-Lyndon property holds for densities $d > 1/5$. We discussed an idea of extending the recent work of Arenas [1] on the Cohen-Lyndon for $C(6)$ -small cancellation groups to random groups at densities $d < 1/4$.

Publications and preprints

E. Einstein, S. Krishna M S, M. Montee, T. Ng, M. Steenbock, *Random quotients of free products*, [arXiv:2502.08630](#)[math.GR]. We anticipate that this project will lead to other publications.

References

- [1] M. Arenas, *The Cohen-Lyndon property in non-metric small-cancellation*, [arXiv:2310.20288](#) [math.GR].
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- [3] C. J. Ashcroft, *Property (T) in random quotients of hyperbolic groups at densities above 1/3.*, [arXiv:2202.12318](#)[math.GR].
- [4] S. Brown, *CAT(-1) metrics on small cancellation groups.*, [arXiv:1607.02580](#) [math.GR].
- [5] Y. Duong, *On Random Groups: The Square Model at Density $d < 1/3$ and as Quotients of Free Nilpotent Groups.*, Thesis (Ph.D.), U of Illinois at Chicago. ProQuest LLC, Ann Arbor, MI, 2017.
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- [7] M. Kotowski, M. Kotowski, *Random groups and Property (T): Żuk's theorem revisited.*, Journal of the London Mathematical Society, 88.2 (Aug. 2013), pp. 396-416.
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- [10] Y. Ollivier, D. T. Wise, *Cubulating random groups at density less than 1/6.*, Transactions of the AMS, 363.9 (2011), pp.4701-4733.
- [11] Andrzej Żuk, *Property (T) and Kazhdan constants for discrete groups.*, Geometric and Functional Analysis, 13.3 (June 2003), pp. 643-670.

Research in Teams Project 4: Towards a noncommutative Geometrical Approach to BV Quantization

Collaborators: Roberta A. Iseppi (U of Göttingen), Thomas Krajewski (U Aix-Marseille), Carlos I. Pérez Sánchez (U of Heidelberg)

Dates: July 27 – August 10, August 19 – 31 and December 16 – 20, 2024

Budget: ESI € 7 200

Report on the project

Scientific Background

Yang-Mills and *Chern-Simons* are cornerstone theories in mathematical physics. Connes-Chamseddine [1] showed, using their spectral action, how these two theories can be studied from the noncommutative geometric viewpoint. The final theory of BV-quantization – a formalism that is auxiliary in the quantisation of gauge theories – is nevertheless still missing in the noncommutative geometric formalism.

Project aims and scope

The core of this project are two gauge theories: Yang-Mills and Chern-Simons, which arise from the physical action dictated by noncommutative geometry (NCG).

As a toy model for the quantum theory of NCG (quantum gravity and quantum gauge theory from the physics viewpoint), we aim at developing BV-quantization. The novelty of our approach is its application to a random matrix model, aiming at understanding quantization in NCG as a whole. Part of this proposal is carried out in a finite-dimensional setting that allows us to address conceptual questions, rather than investing effort in the technically more challenging infinite-dimensional one.

Outcomes and achievements

- We partially inspired the construction of our model in a splitting of the spectral action appearing in [2] into Yang-Mills and Chern-Simons actions. We understood part of that theory in terms of matrix models when the spectral action is polynomial. This theory breaks unitary invariance in each monomial, which turned out being too complicated to employ matrix model tools. Another model that was hard to address was [3], since a preliminary BV-quantization analysis indicated that it would not be treatable, at least not so during a short research stay. Instead of multi-matrix models and unitary-breaking matrix models, the models

$$\begin{aligned} W_{\text{YM}}(D) &= \frac{1}{4} \text{Tr}[(D^2 - v^2)^2] & (v \in \mathbb{R}, v \neq 0) \\ W_{\text{CS}}(D) &= \lambda \text{Tr}(-D + \frac{1}{3}D^3) & (\lambda \in \mathbb{R}) \end{aligned}$$

were proposed as finite-dimensional realizations of Yang-Mills and Chern-Simons.

- Initially these two were only educated guesses based on [4]. Later, the identification of W_{CS} with a finite-dimensional version of Chern-Simons and of W_{YM} with Yang-Mills was justified formally with a graded differential calculus.
- Mainly with the tools of [5], we set up the basis for the BV-formalism for the models W_{CS} and W_{YM} .
- Our focus was first the eigenvalue-integral that W_{CS} yields. Subtracting from D its pure gauge part, the partition function became a matrix integral that required a contour change; the new contour is described by cycles that come from and go to infinity in the directions

$\{1, \exp(2\pi i/3), \exp(4\pi i/3)\}$ that correspond to the roots of unity that the cubic model dictates. This is one of the problems we focus on now.

- When the whole team was not at ESI (e.g. because the three of us had duties from our institutions), one of the fellows, C.P.S., wrote the preprint listed below (this project started in his institution). Based on these results, a talk during the visit period in December 2024 was given in the framework of the (Not So) Informal Probability Seminar at the Institute for Mathematics, U Vienna.

Publications and preprints contributed

Carlos Perez-Sanchez, *The loop equations for noncommutative geometries on quivers*, <https://arxiv.org/abs/2409.03705> [math-phys]

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- [2] C. I. Pérez-Sánchez, *On Multimatrix Models Motivated by Random Noncommutative Geometry II: A Yang-Mills-Higgs Matrix Model*, Annales Henri Poincaré, 23(6):1979–2023, 2022.
- [3] T. D. H. van Nuland and W. D. van Suijlekom, *Cyclic cocycles and one-loop corrections in the spectral action*, 9 2022.
- [4] T. Krajewski, *Gauge invariance of the Chern-Simons action in noncommutative geometry*, pages 21–35, 10 1998.
- [5] R. A. Iseppi, *The BV formalism: theory and application to a matrix model*, Rev. Math. Phys. 31(10):1950035, 2019.

Senior Research Fellows Programme

To stimulate the interaction with the local scientific community the ESI offers regular lecture courses on an advanced graduate level taught by Senior Research Fellows of the ESI. 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 covered the following Lecture Courses:

Lecture Courses, Summer Term 2024:

Martina Krämer (U of Mainz):

A guided tour through cirrus clouds

Lecture Course 260088 VU: March 20 – May 22, 2024

Start: Wednesday, March 20, 2024

Further dates: Friday, March 22, 2024, Wednesday, April 10, 2024, Wednesday, May 8 and May 15, 2024, 11:00 - 13:15, Thursday, May 16, 15:30 - 17:00, Wednesday, May 22, 2024, 11:00 - 13:15.

Irene Fonseca (Carnegie Mellon U):

Γ -Convergence and Phase Transitions of Heterogeneous Materials

Lecture Course 250088 VU: April 11 – 25, 2024

Start: Thursday, April 11, 2024

Further dates: Friday, April 12, 2024, Tuesday, April 16, 2024, Wednesday, April 17, 2024, Thursday, April 25, 2024

All days 11:00 - 13:15

Lecture Courses, Winter Term 2024/25:

Thomas Strobl (U of Lyon):

Geometry of Gauge Theories: old and new

Lecture Course 520036 VU: October 16 – November 27, 2024

Start: October 16, 2024

Further dates: October 23, 2024, October 30, 2024, November 6, 2024, November 13, 2024, November 13, 2024, November 20, 2024, November 27, 2024. Every Wednesday 11:00 - 12:45 (with 15 minutes break)

Visitors associated with Senior Research Fellowships:

Rita Ferreira (King Abdullah U of Science and Technology), April 20 – 27, 2024

José Iglesias (U of Twente), April 21 – 26, 2024

Riccardo Cristoferi (Radboud University, The Netherlands), April 22 – 26, 2024

Alexei Kotov (U of Hradec Králové), October 18 – 27, 2024

Zohreh Ravanpak (West U of Timisoara), October 14 – December 20, 2024

Rafal R. Suszek (U of Warsaw), November 1 – 12, 2024

Martina Krämer: A guided tour through cirrus clouds

Prof. Martina Krämer (U of Mainz): March 20 – May 22, 2024

Course

Cirrus clouds, which consist entirely of ice crystals and are found between 5 to 19 km in the atmosphere, represent one of the largest uncertainties in predicting the Earth's climate. Cirrus are still not fully understood due to the complexity of the processes that control their formation and evolution. This lecture aims to first provide an overview of the role of cirrus clouds in the climate system and then to present a guide to cirrus microphysics. To this end, the theory of ice formation and development as well as airborne instrumentation used to measure cirrus clouds will be introduced. The microphysical properties of cirrus clouds are then presented and discussed through the synergy of extensive model simulations, covering the broad range of atmospheric conditions, and comprehensive aircraft observations from the Arctic to the tropics.

Aim of the course:

The aim of this course was to introduce and explain cirrus clouds which appear in an environment in which only ice can exist. An impression of the global distribution of these clouds and their properties has been provided and the feedback to the Earth's climate was be discussed.

Contents and method of the course:

Cirrus & climate system; Cirrus measurements; Cirrus life cycles from simulations; Cirrus properties, climatologies and global views

Research

In collaboration with Dr. Blaž Gasparini and Dr. Aiko Voigt from the Institute for Meteorology and Geophysics at the University of Vienna, I organized an international workshop on the topic of 'Ice Clouds', which took place before to the EGU conference (1). The workshop was attended by around 40 participants; five central topics were introduced in keynote lectures and then discussed in depth in working groups.

I also worked with Dr. Blaž Gasparini in Vienna on a scientific project, which aimed to improve the simulation of the life cycle of tropical cirrus clouds. My contribution included evaluating the simulations on the basis of airborne measurement data that I had collected in a database in earlier work. The results of this study are presented at an international cloud physics conference (2) and are currently in review for publication (3).

During my stay at the University of Vienna, I also had the opportunity to give a lecture in the seminar of the Institute Aerosol and Environmental Physics (4) and finally an invited lecture at the ESI (5).

As a result of intensive scientific discussions on airborne measurement technology of aerosol and cloud particles with Dr. Manuel Schöberl from the Institute of Aerosol and Environmental Physics at the U of Vienna, I was invited to act as reviewer and member of the examination committee of his dissertation (6).

During my stay, it was also planned to analyze airborne ice cloud measurements at the U of Vienna. This project was started, but has not yet been completed. Delays were caused by health impairments - both on my side during my stay at Vienna and due to longer-term problems of my cooperation partner at the Institute of Aerosol and Environmental Physics.

I would like to express my thanks once again for the opportunity to spend time at the University of Vienna as an “ESI senior research fellow”. The collaborations with different scientists from two institutes were very exciting and helped me to advance my research. I really enjoyed the lectures and I hope that some of the students felt the same way.

Lectures, Workshop, Conferences, Publications, Reports

1. Gasparini, Blaž, Aiko Voigt, Martina Krämer, Odran Sourdeval, Peter Spichtinger (2024): Pre-EGU Ice Cloud Workshop 2024, Institut für Meteorologie und Geophysik, 11 - 12 April 2024, <https://ucrisportal.univie.ac.at/de/activities/pre-egu-ice-cloud-workshop-2024> (*Workshop*)
2. Gasparini, Blaž, Peter N. Blossey, Rachel Atlas, Martina Krämer, Aiko Voigt: The journey of ice crystals from deep convection to thin cirrus: a modeling perspective, International Commission on Cloud and Precipitation (ICCP) Conference 2024, 14 - 19 July 2024, Jeju, South Korea. (*Conference contribution*)
3. Gasparini, B., Atlas, R., Voigt, A., Krämer, M., and Blossey, Tropical cirrus evolution in a km-scale model with improved ice microphysics, EGU sphere [preprint], 2025, <https://doi.org/10.5194/egusphere-2025-203>. (*Publication*)
4. Krämer, Martina: Occurrence patterns of cloud particles sizes in cirrus and mixed-phase clouds, Aerosol seminar, U of Vienna, April 4, 2024. (*Seminar lecture*)
5. Krämer, Martina: Ice clouds over the Asian monsoon and their role in the global climate, ESI Lecture, October 28, 2024. (*ESI Lecture*)
6. Schöberl, Manuel: 'Coarse-mode and giant aerosol particles in biomass burning layers and aerosol mixtures: characterization, occurrence and transport', U of Vienna, November 28, 2024. (*Dissertation report & member of the examination committee*)

Irene Fonseca: Γ -Convergence and Phase Transitions of Heterogeneous Material

Prof. Irene Fonseca (Carnegie Mellon U): April 11 – 25, 2024

Visitors within the Senior Research Fellowship framework:

Riccardo Cristoferi (Radboud University, The Netherlands), April 22 – 26, 2024

Rita Ferreira (King Abdullah University (KAUST), Saudi Arabia), April 20 – 27, 2024

José Iglesias (University of Twente, Enschede, The Netherlands), April 21 – 26, 2024

Course

In this series of lectures, using the notion of Γ -convergence as introduced by De Giorgi in 1975, we derived the variational model for phase transitions between two fluids as an asymptotic limit of a family of Cahn-Hilliard energies (also known as the Modica-Mortola functional in the mathematical community). We then considered a variational model for the interaction between homogenization and phase separation when small scale heterogeneities are present in the fluids.

Aim, contents and method of the course:

The course was intended to provide an introduction to some recent research directions in the calculus of variations, especially in relation with the mathematical analysis of problems issuing from materials science. Variational models and methods for the description of phase change, homogenization, and high-contrast materials were presented. Variational approximation by Γ -convergence was the overarching technical setting.

Research

During this visit, we worked mainly on two research projects involving collaborations with the visitors listed above.

Project 1. Jointly with Riccardo Cristoferi, José Iglesias and Rita Ferreira, we are attempting to extend a previous result by Riccardo Cristoferi on “Exact Solutions for the Total Variation Denoising Problem of Piecewise Constant Images in Dimension One”, *Journal of Applied Analysis*, **27**, 13–33, (2021), to images other than piecewise constant. In particular, using the total variation (TV) model for image denoising, we are trying to prove monotonicity of the jump sets depending on the choice of the tuning parameters.

Project 2. Jointly with Elisa Davoli, José Iglesias and Rita Ferreira, we are extending our paper on “Dyadic Partition-Based Training Schemes for TV/TGV Denoising”, under revision in *Journal of Mathematical Imaging and Vision*.

As in the previous project, we use total variation (TV) and total generalized variation (TGV) in image denoising. Their performance crucially depend on the choice of their tuning parameters. Here, in an Mumford-Shah context, we consider space-dependent parameters which are piecewise constant on dyadic grids, with the grid itself being part of the minimization. Using multi-level training schemes, the goal is to prove existence of minimizers for fixed discontinuous parameters under mild assumptions on the data, which ideally will lead to the existence of finite optimal partitions.

Lecture Notes

The course was based on scientific papers, whose list was provided at the beginning of the course, together with an extensive description of the course contents. General references on the subject included the classical monographs:

- 1) Dal Maso, Gianni. An introduction to Gamma-convergence. Progress in Nonlinear Differential Equations and their Applications, Birkhäuser Boston, Inc., Boston, MA, 1993.
- 2) Dacorogna, Bernard. Introduction to the calculus of variations. Third edition. Imperial College Press, London, 2015.
- 3) Fonseca, Irene; Leoni, Giovanni. Modern methods in the calculus of variations: L^p spaces. Springer Monographs in Mathematics. Springer, New York, 2007.

Thomas Strobl: Geometry of Gauge Theories: Old and New

Thomas Strobl (U of Lyon): October 16 – November 27, 2024

Visitors within the Senior Research Fellowship framework:

Alexei Kotov (U of Hradec Králové), October 10 – 27, 2024

Zohreh Ravanpak (WU of Timisoara), October 14 – December 20, 2024

Rafał R. Suszek (U of Warsaw), November 1 – 12, 2024

Course

Principal and associated bundles play an important role in differential geometry and govern the geometrical setting of the Standard Model of particle physics: Interaction forces or particles

correspond to connections in principal bundles, matter fields or particles to sections in bundles associated to the principal ones. Starting from the 90's other type of gauge theories made their appearance, which are no more governed simply by Lie groups and Lie algebras. In particular, the generalization of the latter to Lie groupoids, algebroids, and higher Lie algebras become central. We first introduce or recall the notions mentioned above. We then present some of the more general geometric setting needed to define topological and non-topological gauge theories such as the AKSZ sigma models, Curved Yang-Mills-Higgs theories, and higher gauge theories. At least some of those theories will be defined and studied on the way.

Aim of the course:

This course aimed at introducing to some of the geometry of modern gauge theories. I provided a short overview of the standard, traditional setting of principal bundles, introduce mathematical notions such as Lie algebroids and Lie groupoids, and presented some of the more recent gauge theories as they appeared in mathematical physics in the last two or three decades.

Contents and method of the course:

1. Lie algebroids and groupoids, higher Lie algebras/oids and their super geometric description.
2. Overview: Principal and associated bundles, connections, covariant derivatives and curvature. The geometrical setting underlying the standard model of particle physics and GR.
3. The Chern-Simons theory and the Poisson sigma model, and (time permitting) their joint generalization to AKSZ sigma models.
4. Q-bundles and gauge theories and characteristic classes.
5. Yang-Mills gauge theories and their generalization to Curved-Yang-Mills-Higgs gauge theories.
6. (Time permitting) Principaloid Bundles.

Résumé:

In the end we focused on a restricted program so as to not loose students whose background in differential geometry was somewhat weak. We introduced Lie algebroids and their geometry (Lie algebroid connections, their curvatures and torsion etc). We also introduced $\mathbb{Z}$ - and $\mathbb{Z}_2$ -graded geometry as well as Q-manifolds and bundles. On the level of gauge theories related to ordinary principal bundles we focused on the topological Chern-Simons theory and standard Yang-Mills theories. Similarly, concerning gauge theories governed by Q-bundles and Lie algebroid geometries (and ultimately by principaloid bundles which we did not have time to introduce), we studied the (also topological) Poisson sigma model in detail and introduced Curved Yang-Mills-Higgs gauge theories with their involved Lie-algebroid and super-geometry. In addition to master students, there was a constant participation of postdocs and permanent stuff (from the university but also the TU Vienna) and a vivid interaction.

Research

I first want to thank the director and the ESI staff for the excellent working conditions that I found at the institute.

I progressed on several projects during this period and also had many useful discussions. The main ones in chronological order:

1. With Alexei Kotov we proceeded on a joint article about Leibniz algebras and their induced L_∞ -algebras, in continuation of a previous one of us on the subject in Commun. Math. Phys from

2020.

2. Zohreh Ravanpak stayed for more than two months. She mainly worked on her own papers (cf. also below). But we had also fruitful interactions. In particular, I had a proposal for a supergeometric reformulation for her integrable hierarchy related to deformations of Lie bialgebras. We also involved Alexei Kotov then, who proposed that this can be used to describe (ordinary and generalized) complex structures. We intend to pick up this project again when together on another occasion.

3. With Rafal Suszek we had very intensive interactions to develop our principaloid bundles $\mathcal{P}$ (cf. article below) during his stay further. These bundles are a new generalization of principal bundles when replacing the structure group by a structure groupoid $\mathcal{G}$. In contrast to principal groupoid bundles, it is an honest fiber bundle, with typical fiber $\mathcal{G}$. As limiting cases for the choice of particular Lie groupoids for $\mathcal{G}$, one obtains ordinary principal bundles P without or together with associated bundles (for $\mathcal{G}$ a Lie group or an action Lie groupoid, respectively) as well as general, unrestricted fiber bundles (when $\mathcal{G}$ is the pair groupoid). Connections on $\mathcal{P}$ and their gauge transformations were studied in detail. We expect this new species of bundles to be the adequate framework for the novel gauge theories introduced in the master course; the details of this are work in progress now.

4. I also used the time at the ESI for finishing our paper with Hadi Nahari (cf. below). In this work we present and study a Lie groupoid of minimal dimension that generates the famous singular octonionic Hopf foliation.

5. I also had discussions with Stefan Fredenhagen about a potential project on higher spin gauge theories.

Lecture Notes

Some hand-written notes about part of the material were distributed.

Publications and preprints contributed

H. Nahari and T. Strobl, *The minimal Lie groupoid and infinity algebroid of the singular octonionic Hopf foliation*, [arXiv:2412.21135](#) [math.DG].

Z. Ravanpak, *NL Bialgebras*, accepted for publication in Advances in Theoretical and Mathematical Physics.

Z. Ravanpak and C. Vizman, *Metric degeneracies and gradient flows on symplectic leaves*, [arXiv:2505.08948](#) [math.DG].

T. Strobl and R. Suszek, *Principaloid bundles*, [arXiv:2503.09886](#) [math.DG].

Erwin Schrödinger Lectures 2024

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

Martina Krämer: Ice clouds over the Asian monsoon and their role in the global climate

Speaker: Martina Krämer (U of Mainz)

Martina Krämer is a leading scientist in the field of cloud and aerosol physics focusing on observations and simulations of ice clouds.

Prof. Dr. Martina Krämer headed the working group "Water Vapour and Clouds" at the Research Centre Jülich (FZJ) at the Institute for Energy and Climate Research: Stratosphere (IEK-7) for more than twenty years. She has been a member of the Gutenberg Research College at the Johannes Gutenberg University Mainz since 2019, and is a honorary professor at their Institute of Atmospheric Physics since 2022.

Date: October 23, 2024

Abstract: The Asian Summer Monsoon is the most pronounced atmospheric weather system during boreal summer, consisting of a large-scale anticyclone extending from Asia to the Middle East. Moist air masses are transported via strong convection or general tropical upwelling to altitudes where the coldest temperatures in the atmosphere are found. Thin cirrus clouds that consist only of ice crystals form at these cold temperatures. In addition, thick ice clouds are carried into the upper troposphere in deep convective thunderstorms.

The ice clouds over the Asian monsoon can have either a warming or a cooling effect. Also, they affect the amount of water vapour in the tropical upper troposphere, from where the water vapour is further transported into the stratosphere as far as the Arctic Circle. Because water vapour is a strong greenhouse gas, it causes a warming directly in the tropics up to the Arctic stratosphere.

Understanding the overall effect of ice clouds on this chain of processes is a focus of recent research. Here, unique aircraft-based observations of ice clouds and water vapour over the Asian monsoon are presented. In particular, ice cloud properties, formation and evolution will be shown and investigated based on simulations.

Junior Research Fellows Programme

Tanushree Shah: Low-dimensional Topology Specifically contact Topology

Tanushree Shah (U of Glasgow): February 1 – April 30, 2024

Report

A plane field ξ on a 3-manifold M is called a *contact structure* if there exists a 1-form α such that $\xi = \ker(\alpha)$ and $\alpha \wedge d\alpha \neq 0$. Two contact structures ξ_0 and ξ_1 on M are *contactomorphic* if there exists a diffeomorphism $f : M \rightarrow M$ such that $f_*(\xi_0) = \xi_1$. Jean Martinet showed that any oriented closed 3-manifold admits a contact structure. A contact manifold is *overtwisted* if it contains an embedded disk where the contact structure is tangent to the disk on the boundary [JM]. A contact structure that is not overtwisted is called *tight*.

A knot in a contact manifold is called *Legendrian* if it is tangent to the contact plane at each point. Vera Vértési (U of Vienna), Rima Chatterjee (U of Cologne) and I look at a special class of Legendrian knots called non-loose knots in overtwisted contact structures. A knot in overtwisted contact structures is called non-loose if it intersects all the overtwisted disks transversely. Therefore, the complement of a non-loose knot is tight. We worked on understanding tight complements behaviour under the operations of connect sum in overtwisted contact structures. Legendrian knots in 3-sphere are completely determined by the contact structure on the knot complement. So, to study Legendrian knots in overtwisted contact structures we study 3-manifolds with boundary. If the boundary is torus then it can be viewed as a knot complement. The annulus sum of two such manifolds corresponds to the connected sum of the knots. We give a structure theorem to understand the knot complement of the composite knot using the knot complements of the prime knots.

While I was an ESI fellow, I delivered a lecture at U of Vienna on knots in contact 3-manifolds. I also gave a talk at Winter Braids in France.

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Abhiram Mamadur Kidambi: Novel mathematical structures in 3d quantum gravity

Dates of stay: September 14 – December 14, 2023 and April 1 – April 30, 2024:

Report

Scientific achievements

The key aim of the fellowship was to address and apply novel number theoretic and lattice

theoretic concepts to the study of low dimensional quantum gravity, particularly for the case of the AdS_3/CFT_2 correspondence. This correspondence conjectures a duality of a large set of observables between gravity on a d -dimensional AdS spacetime and a $d - 1$ dimensional conformal field theory. The statement of this duality lacks mathematical rigor and the aim of the proposal was to attempt to formulate and calculate in a mathematical rigorous manner a particular proposed aspect of the duality viz. ensemble averages.

Ensemble averages of CFT have been discussed in the context of wormholes in gravity. However, in the context of this research stay, I considered ensemble averages of arbitrary conformal field theories whose moduli spaces are well defined orthogonal varieties (the so called *Narain* moduli spaces, which are isomorphic to the space of lattices of the same rank as the orthogonal varieties quotient out by discrete and rotational symmetries of lattice vectors.).

Conformal field theories (which in this context are lattice valued vertex operator algebras) can be defined using the theory of binary quadratic forms and theta functions on lattices. To construct the ensemble average, one needs to take additional care of many additional contributions (such as theta functions on smaller congruence subgroups, additional cusps, additional multiplicative characters etc.) and therefore prove the Siegel Weil theorem for a large class of spaces of conformal field theories. Part of this research was carried out in 2021 by M. Ashwinkumar, M. Dodelson, A. Kidambi, J. Leedom and M. Yamazaki.

In the preprint listed below, we extended the proof of the theorem and ensemble averages to the case of orbifolded conformal field theories and made progress towards a topological interpretation of the average partition function, which is given by a non-holomorphic Eisenstein series.

In addition to work on the above projects, I was also able to form three novel collaboration on various projects related to computational number theory and applications to physics, particularly string theory and scattering amplitudes. These projects are promising but are not at a stage where I can report on their progress yet. This progress has been possible due to the facilities and support of the ESI and I am extremely grateful to them, the staff, the directors and the scientific visitors for making my stay there productive and fruitful.

Courses Taught

Automorphic forms and L-functions (Erwin Schrödinger Institute, U of Vienna, April 2024)

Invited Talks

1. Cambridge: $g = 2$ Hyperelliptic curves and Siegel Modular Functions (October 2023)
2. Cambridge: Introduction to the Birch and Swinnerton-Dyer Conjecture (October 2023)
3. TU Vienna: Applications of non-holomorphic Eisenstein series in $3d$ gravity (April 2024)
4. U of Vienna: Hodge theoretic characterizations of rational CFTs (April 2024)

Publications and preprints contributed

M. Ashwinkumar, A. Kidambi, J. Leedom, M. Yamazaki, *Generalized Narain Theories Decoded: Discussions on Eisenstein series, Characteristics, Orbifolds, Discriminants and Ensembles in any Dimension*, <https://arxiv.org/abs/2311.00699>[hep-th].

Mariam Magdy Ali Mohamed: The asymptotic structure of spacetimes

Dates of stay: May 1 – June 30, 2024

Report

Motivated by my previous PhD research, my plan for this research fellowship was to explore the asymptotic structure of spacetimes. Specifically, I aimed to investigate the relationship between gravitational memory and the properties of initial data on a Cauchy hypersurface. Gravitational memory, simply put, refers to a permanent shift experienced by a gravitational wave detector following the passage of gravitational waves. Since its emergence in linearized gravity in [1], gravitational memory has become an increasingly popular research topic, with interest further amplified by the proposed connections to soft theorems and asymptotic symmetries [2].

During my stay at ESI, I collaborated with Dr. Juan Valiente-Kroon and began my analysis of gravitational memory using techniques similar to those employed in my previous work [3]. In that work, Friedrich's conformal field equations and the cylinder at spatial infinity [4] were used to demonstrate that, for a generic class of asymptotically Euclidean and regular initial data, the asymptotic charges associated with BMS-supertranslation symmetries at null infinity are generally not well-defined in the limits of spatial infinity unless additional regularity conditions are imposed. That previous work relied on the zero-order solutions of Friedrich's conformal field equations and, to some extent, is simpler than the analysis of gravitational memory, which relies on higher-order solutions (particularly first and second order solutions). This work is still in progress, and the results are expected to be published in an article in the near future.

The complexity of analysing gravitational memory in the nonlinear setting prompted me to consider a similar analysis in the linear case. The simplest example is the scalar memory associated with the spin-0 field on a Minkowski background—see, for instance, [5]. However, spin-0 asymptotic charges had yet to be investigated in the context of Friedrich's construction of the cylinder at spatial infinity and an initial value problem formulation of the field equations. In collaboration with Dr. Edgar Gasperín and Prof. Filipe C. Mena, we studied the asymptotic charges associated with the spin-0 field on an n -dimensional Minkowski spacetime, with the results now appearing in a preprint [6].

In summary, we examined the evolution of the spin-0 field on an n -dimensional Minkowski spacetime given generic initial data on a Cauchy hypersurface. The solutions to the spin-0 equations are used to study the asymptotic charges, which relate to the leading order of the solution. We find that the regularity of the solutions and the asymptotic charges at the critical sets—where null infinity meets spatial infinity—depends crucially on the dimension of the space. In four-dimensional spacetimes, there is an infinite number of asymptotic charges that are well-defined at the critical sets, provided the initial data satisfy extra regularity conditions. In higher dimensions, however, there is only a finite number of non-trivial asymptotic charges that remain regular at the critical sets. This result sets the stage for a future study of the scalar memory associated with the spin-0 field.

Overall, my stay at the Erwin Schrödinger Institute (ESI) of the University of Vienna was exceptionally productive. The Junior Research Fellowship came at a pivotal point in my academic career and offered an ideal environment to concentrate on advancing my research post-PhD. Additionally, as it was my first time visiting Vienna, the city's rich history and culture contributed positively to my overall experience.

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Publications and preprints contributed

E. Gasperín, M. Magdy and F. C. Mena, *Asymptotics of spin-0 fields and conserved charges on n -dimensional Minkowski spaces*, [arXiv:2408.03389](https://arxiv.org/abs/2408.03389) [gr-qc].

Victoria Sánchez Muñoz: The Bell- like inequalities for interference into quantum games

Victoria Sánchez Muñoz (U of Galway): May 1 – June 30, 2024

Report

I collaborated with Prof. Borivoje Dakić and his group at the University of Vienna, who are working on a large project aimed at **understanding quantum interference from an information-theoretic point of view**.

I participated in an ongoing small project led by Prof. Borivoje Dakić, his PhD student Fatemeh Bibak, and Dr. Flavio del Santo. The setup of this research project is a triangle network/graph, in which each node represents one player and each edge a source of particles between each node/player. These three sources, assumed to be independent of each other, will produce either classical or quantum particles, which will be distributed to the players. When each player receives one single particle (from any source) a game is defined. The game forbids any communication between players, and requires the players to output a binary bit $a, b, c \in \{0, 1\}$, that can be obtained by performing local operations, e.g. measurements, on their own particle. The players win jointly if the parity of all the outputs is even, i.e. $a + b + c = 0 \bmod 2$. The other researchers involved have shown that this game cannot be won perfectly when the players use well-localised particles produced by classical sources, whereas exploiting the interference of quantum particles leads to a perfect win.

In the same way as Bell inequalities distinguish classical and quantum correlations, the other researchers involved proposed a **(non-linear) inequality whose bound separates what can be achieved using classical and quantum resources for interference** in this triangle scenario with 3 parties, and also its generalisation to N parties distributed in a circular graph, i.e. each player is only connected to the closest two neighbours. The quantum bound for these

inequalities had already been obtained, so **my work focused on characterising the classical correlations to find the classical bound of such N -party non-linear inequality in the context of interference**. I could not finish my work during my time there, so I continued working on that afterwards.

My two months in Vienna also gave me the opportunity to meet some of the most important researchers and their groups working on foundations of quantum mechanics – my field of interest –, based at the University of Vienna and at the Institute for Quantum Optics and Quantum Information (IQOQI) - Vienna. I also attended several seminars, such as the colloquium talks organized by the Vienna Center for Quantum Science and Technologies (VCQ), and some of the talks organized by IQOQI Vienna. These events allowed me to broaden my research network and connect with many other researchers, which could lead to collaborations in the future.

Not everything was about research, I really enjoyed the lovely city of Vienna. I would like to come back, maybe a research position in the future. In any case, I will probably come back to visit all the amazing people I met during my time in Vienna.

References

S. Horvat, B. Dakić, *Interference as an information-theoretic game*, [arXiv:2003.12114](https://arxiv.org/abs/2003.12114)[quant-ph].

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Eduard Schesler: Grothendieck pairs and Grigorchuk's group

Eduard Schesler (FernU Hagen): May 1 – June 30, 2024

Report

It is one of the most classical problems in group theory to determine the maximal subgroups of a given group G . A particularly interesting class of groups for which this task was completed is the class of finite p -groups, i.e. groups in which the order of every element is a power of a prime p . In this case, the maximal subgroups of G are precisely the subgroups of index p in G . Since the appearance of finitely generated infinite simple p -groups, such as Olshanskii's Tarski monsters [8], it became clear that this result cannot be generalized to all finitely generated p -groups. However, it is an intriguing open problem whether the finiteness assumption on G can be replaced by the much weaker assumption that the finitely generated p -group G is *residually finite*, where the latter means that for every $g \in G \setminus \{1\}$ there is a finite group Q and a homomorphism $\pi: G \rightarrow Q$ with $\pi(g) \neq 1$. A slightly different formulation of this problem was provided by Passman [6, Question 18.81]:

Question (Passman): Let G be a finitely generated p -group that is residually finite. Are all maximal subgroups of G necessarily normal?

Let C_p denote the class of finitely generated p -groups that are residually finite. We say that a group $G \in C_p$ has property (P) if all of its maximal subgroups are normal. As Passman's question is well-known to have an affirmative answer in the class of finite p -groups, we may restrict our attention to the infinite groups in C_p , the first of which were found in 1964 by Golod and Shafarevich [3].

Meanwhile many techniques are known to produce infinite groups in C_p with a variety of interesting further properties, see e.g. [1, 4, 7, 10].

However, there is still a lack of groups in C_p for which the status of Passman's question is known. In fact, the only classes of infinite groups in C_p that are known satisfy (P) are the so-called locally 0 – 1 groups of Ershov and Jaikin-Zapirain [2] and some families of branch groups, see e.g. [11].

To the best of my knowledge, all examples of branch groups in C_p that are known to satisfy (P) are rather 'small' in the sense that they are slight variations of *bounded automata groups*, which consist of automorphisms of the p -adic tree T_p whose action on the tree is determined by a finite set of particularly simple rules. The first result that established property (P) for a family of bounded automata groups was obtained in 2005 by Pervova [11]. The aim of my Junior Research Fellowship was to gain progress on Passman's question in the following ways:

1. Verifying Passman's question for new families of p -groups that are defined via their action on T_p .
2. Providing a negative answer to Passman's question by constructing a so-called *Grothendieck pair* of groups in C_p .

Both approaches turned out to be fruitful. Regarding the first point, I was able to provide a short and easy proof of Pervova's result that aims to be extendable to the class of *polynomial automata groups* in C_p , which generalizes the class of bounded automata groups in the same way as polynomial functions generalize constant functions. Although I am convinced that my proof can be extended to the class of polynomial automata groups, there is still a long way to go and I expect that the resulting paper will appear at the end of this year on the arXiv.

Regarding the second point, it turned out that the Grothendieck pair in C_p that I had in mind implies the existence of a group $G \in C_p$ and an element $\gamma \in \widehat{G}$, where $\widehat{G}$ denotes the profinite completion of G , such that $(G, \langle G \cup \{\gamma\} \rangle)$ is a Grothendieck pair. Since the latter seemed to me easier than my initial approach, I shifted my attention to search for groups $G \in C_p$ that contain an element $\gamma \in \widehat{G}$ as above. So far I have not been able to find such a group G . However, it was a very pleasant surprise to me that the techniques that I developed during this search, could be used to solve another problem in group theory, stated in 2008 by Olshanskii and Osin [9], that I was working on since more than one year. To formulate it, let us write $\mathcal{FC}$ to denote the class of groups G such that for every $g \in G \setminus \{1\}$ there is a finite simple group Q and an epimorphism $\pi: G \rightarrow Q$ with $\pi(g) \neq 1$.

Problem (Olshanskii, Osin): Does the class $\mathcal{FS}$ contain a finitely generated infinite torsion group?

The motivation behind this problem is that it is related to the existence of hyperbolic groups that are not residually finite, which was asked in 1987 by Gromov [5] and is currently one of the biggest open questions in group theory. More precisely, it was shown by Olshanskii and Osin that a negative answer to their problem would imply the existence of a hyperbolic group that is not residually finite. The following result, which I obtained during my stay at the ESI, shows in particular that the question of Olshanskii and Osin has a positive solution.

Theorem: Every finitely generated residually finite torsion group embeds into a finitely generated torsion group in $\mathcal{FS}$.

Meanwhile the above result is available on the arXiv, see below.

All of the above has benefited greatly from the scientific discussions I have had with Prof. Goulmira Arzhantseva and the members of her research group from the Faculty of Mathematics. With Prof. Arzhantseva we discussed a variety of different problems and approaches to them including Passman's question, the solvability of Thompson's groups F , and the question of whether branch groups may admit property (T). Together with Markus Steenbock we developed a new idea on how to construct groups in C_p without property (P) that is based on theory of CAT(0)-groups. The latter approach seems to me to be the most promising one that I have encountered so far. With Merlin Incerti-Medici we observed that a recent paper of him gives rise to a generalization of Thompson's group V , which seems very interesting and which we will continue to think about. Apart from scientific discussions, I participated in the activities of the group around Prof. Arzhantseva, e.g. by giving a talk in their research seminar.

References

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Publications and preprints contributed

Schesler, E., *Finitely generated infinite torsion groups that are residually finite simple*, [arXiv:2407.05533](https://arxiv.org/abs/2407.05533)[math.GR].

Kaushlendra Kumar (U of Hannover): IKKT model & Gravity

Dates of stay: March 5 – June 15, 2023 & June 7 – 25, 2024

Report

The emergent geometry. The IKKT matrix model is given by the following action (with bosonic T , fermionic Ψ and $so(1, 9)$ Clifford Γ_A matrices),

$$S[T, \Psi] = \text{Tr} \left([T^A, T^B][T_A, T_B] + \bar{\Psi} \Gamma_A [T^A, \Psi] \right), \quad (1)$$

that admits gauge invariance, a global $SO(1, 9)$ symmetry as well as maximal supersymmetry. The solution of the bosonic part of this classical action yields 10 Hermitian matrix configurations $T^A \in \text{End}(\mathcal{H})$ with $A = 0, \dots, 9$. Of special interest are backgrounds $\bar{T}^a$ with $a = 0, \dots, 3$ producing (3+1)-dimensional embedding branes $\mathcal{M}^{1,3} \hookrightarrow \mathbb{R}^{1,9}$. The backbone of such a semiclassical ($n \rightarrow \infty$) analysis is the equivalence between the algebra of functions $t^a \in C^\infty(\mathcal{M})$ and a quantum algebra $T^a \in \text{End}(\mathcal{H}_n)$, denoted by $t^a \sim T^a$, such that $[\cdot, \cdot] \sim i\{\cdot, \cdot\}$. This Poisson bracket comes from a symplectic structure $\theta^{\mu\nu} = \{x^\mu, x^\nu\}$ for the spacetime coordinates $x^\mu \in \mathcal{M}^{1,3}$. A special class of solutions are $T^a = R^{-1} \mathcal{M}^{a4}$, $a = 0, \dots, 3$ ($\mathcal{M}^{a4}$ are $\mathfrak{so}(2, 4)$ generators) that leads to an emergent manifold, viewed as S^2 -bundle $\mathbb{C}P^{1,2}$ over the spacetime $\mathcal{M}^{1,3}$. Another useful solution is the Kaluza-Klein (KK) embedding, $T^a \sim x^a : \mathcal{M}^{1,3} \hookrightarrow \mathbb{R}^{1,3}$ and $T^i \sim z^i : \mathcal{K} \hookrightarrow \mathbb{R}^6$ with $i = 4, \dots, 6$, for some compact manifold $\mathcal{K}$. The fluctuations around these backgrounds, $T^A = \bar{T}^A + \mathcal{A}^A$, can be expanded in terms of S^2 -harmonics and KK-modes respectively. Moreover, these fluctuations determine an effective metric $G^{\mu\nu}$ obtained from the kinetic term of the action (1). It turns out that this metric is conformally related to an auxiliary metric $\gamma^{\mu\nu} = \eta^{ab} E_a^\mu E_b^\nu$ constructed from the frames $E_a^\mu = \{\bar{T}_a, x^\mu\}$; this yields an extra Dilaton field ρ , also related to the frame. Furthermore, E_a^μ obeys a divergence constraint (arising from the Jacobi identity) which breaks the local Lorentz invariance. As a consequence, this emergent theory has more physical content than in usual GR and is interpreted as a torsion tensor, $T^a = dE^a = (1/2)T_{\mu\nu}^a dx^\mu \wedge dx^\nu$, constructed from the frame field $E^a = E_\mu^a dx^\mu$.

Previous 1loop result. The following 1loop expression with $\mathcal{M}_{AB}$ being $\mathfrak{so}(1, 9)$ generators in vector (V) and spinor (ψ) representations,

$$\Gamma_{1\text{loop}} \sim \text{Tr} \left(\log(\square + \mathcal{M}_{AB}^{(V)} [\Theta^{AB}, \cdot]) - \frac{1}{2} \log(\square + \mathcal{M}_{AB}^{(\psi)} [\Theta^{AB}, \cdot]) - 2 \log(\square) \right), \quad (2)$$

arises from a ‘partition function’ around the free action $S_0[T] = \text{Tr}([T^A, T^B][T_A, T_B])$. The first three terms in the log expansion vanishes due to supersymmetry and it, furthermore, splits into three parts with individual/mixed contributions coming from $\mathcal{M}$ and $\mathcal{K}$. The result was computed in [S22-S23] for the above-mentioned backgrounds using the so called *string modes*; the $\mathcal{M}$ contribution turns out to be negligible in the long wavelength regime while the $\mathcal{K}$ -(vacuum energy) and mixed-part yields,

$$\begin{aligned} \Gamma_{1\text{loop}}^{\mathcal{K}} &\equiv S_{\text{vac}} = \int_{\mathcal{M}} \Omega \rho^{-2} \left(C_1 m_{\mathcal{K}}^4 + C_2 \frac{1}{R^4} + C_3 \frac{1}{R^8 m_{\mathcal{K}}^4} \right), \\ \Gamma_{1\text{loop}}^{\mathcal{M}-\mathcal{K}} &= \int_{\mathcal{M}} d^4 x \frac{\sqrt{|G|}}{16\pi G_N} \left(\mathcal{R} + \frac{1}{2} T \cdot T - 2\rho^{-2} \partial \rho \cdot \partial \rho + 2\rho^{-1} G_N^{-1} \partial \rho \cdot \partial G_N \right). \end{aligned} \quad (3)$$

Here C_i are some large constants and the Newton’s constant $G_N = \frac{\pi^3 \rho^2}{2c_{\mathcal{K}}^2 m_{\mathcal{K}}^2}$ is made from parameters on the compact manifold: a constant $c_{\mathcal{K}}$ and the KK mass $m_{\mathcal{K}}$.

Outcome. During this fellowship I worked with Harold Steinacker to understand the equation of motion arising from an effective action consisting of the free (Yang–Mills), matter and 1loop actions,

$$S_{\text{eff}} \sim - \int \Omega \left(\{T^a, T^b\} \{T_a, T_b\} + m_{\mathcal{K}}^4 F_{\mathcal{K}}^2 \right) + \int d^4x \sqrt{|G_{\mu\nu}|} \mathcal{L}_{\text{matter}} + \Gamma_{1\text{loop}}, \quad (4)$$

where Ω is the symplectic volume form and the extra term proportional to $m_{\mathcal{K}}^4$ comes from transversal $\mathcal{K}$ direction with some discrete $F_{\mathcal{K}}$. We computed the variations, by first considering $G^{\mu\nu}$, $m_{\mathcal{K}}$ and ρ as independent dynamical quantities to get (a) a mass-constraint that can in principle be solved for $m_{\mathcal{K}}$ and (b) fix it to then express the result in term of frame variation using the following results,

$$\delta\sigma = -\frac{1}{2}E^{a\sigma}\delta E_{a\sigma}, \quad \delta G^{\mu\nu} = 2\rho^{-2}E_a^\mu\delta E^{a\nu} + G^{\mu\nu}E^{a\sigma}\delta E_{a\sigma}. \quad (5)$$

A key challenge was to handle the Yang–Mills-term, which we did by using $\square_G T_a = \{C_{a\mu}, x^\mu\}$, for some “anharmonicity” tensor $C_{\mu\nu} = C_{a\mu}E_\nu^a$, to obtain (torsion-free) *modified Einstein equations* (dilaton field is re-parametrized as $\sigma = \log(\rho)$)

$$\boxed{\mathcal{R}_{\mu\lambda} - \frac{1}{2}G_{\mu\lambda}\mathcal{R} = 8\pi G_N \left[T_{\mu\lambda}^{(m)} - \frac{1}{\rho^4}G_{\mu\lambda}(2\rho^2 F_{\mathcal{K}}^2 m_{\mathcal{K}}^4 - C_1 m_{\mathcal{K}}^4 + \frac{C_2}{R^4} + \frac{3C_3}{R^8 m_{\mathcal{K}}^4}) + 4(C_{\mu\lambda} - \frac{1}{2}G_{\mu\lambda}C) \right] + 2(\partial_\mu\sigma\partial_\lambda\sigma - \partial_\mu\partial_\lambda\sigma + G_{\mu\lambda}(\square_G\sigma - \frac{3}{2}\partial\sigma \cdot \partial\sigma))}. \quad (6)$$

Our analysis shows that this emergent gravity theory is close to general relativity (up to a modifications due to extra fields) at shorter scales, but deviates significantly from GR on cosmic scales. During this stay I also made contacts with other visitors (especially useful were contacts with John Barrett, whom I met again in Berlin last September, and Sumati Surya; these may develop into future collaborations) and my previous work at ESI seminar on May 4, 2023 that was titled “Exact gauge fields from anti-de Sitter space”. During the second short visit at ESI, I had fruitful discussions with Harold and we talked about the meaning of the anharmonicity tensor (noted above) as well as his recent works and future directions of collaboration. At the time of writing this report, I am working at the Queen Mary University of London as a DFG Walter-Benjamin research fellow.

References

[S22] H.C. Steinacker, *Gravity as a quantum effect on quantum space-time*, Phys. Lett. B 827 (2022) 136946.

[S23] H.C. Steinacker, *One-loop effective action and emergent gravity on quantum spaces in the IKKT matrix model*, JHEP 05 (2023) 129.

Publications and preprints contributed

K. Kumar & H.C. Steinacker, *Modified Einstein equations from the 1-loop effective action of the IKKT model*, Class.Quant.Grav. 41 (2024) 18, 185007.

Seminars and colloquia outside main programmes and workshops

545 seminar and colloquia talks have taken place at the ESI in 2024 including the following individual talks.

The Erwin Schrödinger Lecture by Martina Krämer (U of Mainz): “Ice clouds over the Asian monsoon and their role in the global climate”, October 23, 2024.

A series of lectures was given by the ESI Junior Research Fellow Abhiram M Kidambi (MPI MiSc, Leipzig) on “Automorphic forms and L-functions” in April 2024. This lecture series was offered to students of the University of Vienna with 250098 VU beneath our Senior Reserach Fellow lecture courses.

ESI Research Documentation

ESI research in 2024: publications and arXiv preprints

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

CDFG = Carrollian Physics and Holography
FSD = Nonlinear Waves and Relativity
WTV = The Landscape vs. the Swampland
DFC = Linking Microscopic Processes to the Macroscopic Rheological Properties in Inert and Living Soft Materials
CHS = Partial Differential Equations
SSG = Chromatin Modeling: Integrating Mathematics, Physics, and Computation for Advances in Biology and Medicine
ZPS = Rare events in Dynamical Systems
SCA = Transport Properties in Soft Matter Systems
JRF = Junior Research Fellow
KDR = Synthetic Curvature Bounds for Non-Smooth Spaces: Beyond Finite Dimension
MB = One World Optimization Seminar in Vienna
SSM = Determinacy, Inner Models and Forcing Axioms
WBS = Exactly Solvable Models
FPM = Spin-Orbit Entangled Quantum Magnetism
HBI = Algebraicity and Transcendence for Singular Differential Equations
COZ = Lensing and Wave Optics in Strong Gravity
RIT = Research in Teams
SRF = Senior Research Fellows

THEMATIC PROGRAMMES

Carrollian Physics and Holography (CDFG)

S. Agrawal, P. Charalambous, L. Donnay, *Celestial $sw1 + \infty$ algebra in Einstein-Yang-Mills theory*, [arXiv:2412.01647](#)[hep-th].

M. Ammon, J. Hollweck, T. Hössel, K. Wölfl, *Conformal Blocks in Two and Four Dimensions from Oscillator Representations*, [arXiv:2406.19436](#)[hep-th].

- L. Avilés, J. Gomis, D. Hidalgo, O. Valdivia, *AdS Carroll Structures from Poincaré Isomorphism: Asymptotic Symmetry Analysis*, [arXiv:2407.14457](#) [hep-th].
- L. Avilés, O. Fuentealba, D. Hidalgo, P. Rodríguez, *AdS3 Carroll gravity: asymptotic symmetries and C-thermal configurations*, [arXiv:2503.18818](#) [hep-th].
- A. Bagchi, P. Chakraborty, S. Chakraborty, S. Fredenhagen, D. Grumiller, P. Pandit, *Boundary Carrollian Conformal Field Theories and Open Null Strings*, [arXiv:2409.01094](#) [hep-th].
- A. Bagchi, P. Dhivakar, S. Dutta, *3D Stress Tensor for Gravity in 4D Flat Spacetime*, [arXiv:2408.05494](#) [hep-th].
- A. Bagchi, A. Lipstein, M. Mandlik, A. Mehra, *3d Carrollian Chern-Simons theory & 2d Yang-Mills*, [arXiv:2407.13574](#) [hep-th].
- A. Bagchi, A. Banerjee, J. Hartong, E. Have, K. S. Kolekar, *Strings near black holes are Carrollian. Part II*, [arXiv:2407.12911](#) [hep-th].
- A. Bagchi, M. Nachiketh, P. Soni, *Anatomy of null contractions*, [arXiv:2406.15061](#) [hep-th].
- X. Bekaert, A. Campoleoni, S. Pekar, *Holographic Carrollian conformal scalars*, [arXiv:2404.02533](#) [hep-th].
- E. A. Bergshoeff, P. Concha, O. Fierro, E. Rodríguez, J. Rosseel, *A Conformal Approach to Carroll Gravity*, [arXiv:22412.17752](#) [hep-th].
- E. A. Bergshoeff, C. D. A. Blair, J. Lahnsteiner, J. Rosseel, *The surprising structure of non-relativistic 11-dimensional supergravity*, [arXiv:2407.21648](#) [hep-th].
- E. Bergshoeff, A. Campoleoni, G. Palumbo, P. Salgado-Rebolledo, *Massive higher-spin fields in the fractional quantum Hall effect*, [arXiv:2404.16013](#) [cond-mat.str-el].
- P. Bieliavsky, P. Spindel, R. Wutte, *Aspects of Warped AdS3 geometries*, [arXiv:2410.09688](#) [gr-qc].
- A. Bissi, L. Donnay, B. Valsesia, *Logarithmic doublets in CCFT*, [arXiv:2407.17123](#) [hep-th].
- J. Borthwick, Y. Herfray, *Projective and Carrollian geometry at time/space-like infinity on projectively compact Ricci flat Einstein manifolds*, [arXiv:2406.01800](#) [math.DG].
- J. Cotler, K. Jensen, S. Prohazka, A. Raz, M. Riegler, J. Salzer, *Quantizing Carrollian field theories*, [arXiv:2407.11971](#) [hep-th].
- L. P. de Gioia, A. M. Raclariu, *Celestial amplitudes from conformal correlators with bulk-point kinematics*, [arXiv:2405.07972](#) [hep-th].
- F. Ecker, D. Grumiller, P. Salgado-Rebolledo, *Postcarrollian gravity*, [arXiv:2504.16162](#) [hep-th].
- J. M. Figueroa-O'Farrill, G. S. Vishwa, *The BRST quantisation of chiral BMS-like field theories*, [arXiv:2407.12778](#) [hep-th].
- S. Fredenhagen, F. Lausch, K. Mkrtchyan, *Interactions of massless fermionic fields in three dimensions*, [arXiv:2404.00497](#) [hep-th].
- O. Fuentealba, I. Lovrekovic, D. Tempo, R. Troncoso, *Enhanced conformal BMS3 symmetries*, [arXiv:2501.00439](#) [hep-th].
- D. Grumiller, L. Montecchio, M. S. Nejadi, *Carroll dilaton supergravity in two dimensions*, [arXiv:2409.17781](#) [hep-th].
- J. Hartong, G. Palumbo, S. Pekar, A. Pérez, S. Prohazka, *Fractons on curved spacetime in $2 + 1$ dimensions*, [arXiv:2409.04525](#) [hep-th].
- E. Have, K. Nguyen, S. Prohazka, J. Salzer, *Massive carrollian fields at timelike infinity*, [arXiv:2402.05190](#) [hep-th].
- D. Iosifidis, M. Karydas, A. Petkou, K. Siampos, *On the geometric origin of the energy-momentum tensor improvement terms*, [arXiv:2503.21609](#) [hep-th].

- S. Majumdar, *On the Carrollian nature of the light front*, [arXiv:22406.10353](#)[hep-th].
- R. McNees, C. Zwickel, *The symplectic potential for leaky boundaries*, [arXiv:2408.13203](#)[hep-th].
- J. A. O'Connor, S. Pekar, *A note on non-Lorentzian duality symmetries*, [arXiv:2409.12279](#)[hep-th].
- G. Oling, J. F. Pedraza, *Mixmasters in Wonderland: Chaotic dynamics from Carroll limits of gravity*, [arXiv:2409.05836](#)[hep-th].
- S. Pekar, A. Pérez, P. Salgado-Rebolledo, *Cartan-like formulation of electric Carrollian gravity*, [arXiv:2406.01665](#)[hep-th].
- A. Pérez, St. Prohazka, A. Seraj, *Fracton Infrared Triangle*, [arXiv:2310.16683](#)[hep-th].
- R. Ruzziconi, S. Stieberger, T. R. Taylor, B. Zhu, *Differential equations for Carrollian amplitudes*, [arXiv:2407.04789](#)[hep-th].
- D. Vassilevich, *Carroll limit of a one-loop effective action*, [arXiv:2410.23616](#)[hep-th].
- P. M. Zhang, Q. L. Zhao, M. Elbistan, P. A. Horvathy, *Gravitational wave memory: further examples*, [arXiv:2412.02705](#)[gr-qc].
- P. M. Zhang, Q. L. Zhao, J. Balog, P. A. Horvathy, *Displacement memory for flyby*, [arXiv:2407.10787](#)[gr-qc].
- P.-M. Zhang, P. A. Horvathy, *Displacement within velocity effect in gravitational wave memory*, [arXiv:2405.12928](#)[gr-qc].

Nonlinear Waves and Relativity (FSD)

- F. Cacciafesta, P. D'Ancona, Z. Yin, J. Zhang, *Dispersive estimates for Dirac equations in Aharonov-Bohm magnetic fields: massless case*, [arXiv:22407.12369](#)[math.AP].
- G. Chen, J. Luhrmann, *Asymptotic stability of the sine-Gordon kink*, [arXiv:2411.07004](#)[math.AP].
- R. Donninger, B. Schörkhuber, *Self-similar blowup for the cubic Schrödinger equation*, [arXiv:2406.16597](#)[math.AP].
- D. Fajman, M. Ofner, T. Oliynyk, Z. Wyatt, *Stability of fluids in spacetimes with decelerated expansion*, [arXiv:2501.12798](#)[gr-qc].
- S. Haque, R. Killip, M. Visan, Y. Zhang, *Global well-posedness and equicontinuity for mKdV in modulation spaces*, [arXiv:2411.05300](#)[math.AP].
- S. Herr, M. Ifrim, M. Spitz, *Modified scattering for the three dimensional Maxwell-Dirac system*, [arXiv:2406.02460](#)[math.AP].
- M. Kowalski, *Dispersive decay for the energy-critical nonlinear Schrödinger equation*, [arXiv:2411.01466](#)[math.AP].
- Y. Li, J. Luhrmann, *Asymptotic stability of solitary waves for the 1D focusing cubic Schrödinger equation under even perturbations*, [arXiv:2408.15427](#)[math.AP].

The Landscape vs. the Swampland (WTV)

- V. Aragam, S. Paban & R. Rosati, *Primordial Stochastic Gravitational Wave Backgrounds from a Sharp Feature in Three-field Inflation II: The Inflationary Era*, [arXiv:2409.09023](#)[astro-ph.CO].
- G. Aldazabal, E. Andrés, A. Font, K. Narain & I. G. Zadeh, *Asymmetric orbifolds, rank reduction and heterotic islands*, [arXiv:2501.17228](#)[hep-th].
- G. F. Casas & I. Ruiz, *Cosmology of light towers and swampland constraints*, [arXiv:2409.08317](#)[hep-th].
- J. Calderón-Infante, M. Delgado, Y. Li, D. Lust & A. M. Uranga, *Classical black hole probes of UV scales*, [arXiv:2502.03514](#)[hep-th].

- M. Dierigl & D. Novičić, *The Axion is Going Dark*, [arXiv:2409.02180](#)[hep-th].
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- Y. Hendi, M. Larfors & M. Walden, *Learning Group Invariant Calabi-Yau Metrics by Fundamental Domain Projections*, [arXiv:2407.06914](#)[hep-th].
- P. Lin & G. Shiu, *Schwinger Effect of Extremal Reissner-Nordström Black Holes*, [arXiv:2409.02197](#)[hep-th].
- M. Rajaguru, A. Sengupta & T. Wrase, *Fully stabilized Minkowski vacua in the 2^6 Landau-Ginzburg model*, [arXiv:2407.16756](#)[hep-th].
- F. Tonioni, *Curvature-induced moduli stabilization* [arXiv:2407.21104](#)[hep-th].
- V. Van Hemelryck, *Weak G_2 -manifolds and scale separation in M-theory from type IIA backgrounds*, [arXiv:2408.16609](#)[hep-th].

Linking Microscopic Processes to the Macroscopic Rheological Properties in Inert and Living Soft Materials (DFC)

- M. Brizioli, M. A. Escobedo-Sánchez, P. M. McCall, Y. Roichman, V. Trappe, M. L. Gardel, S. U. Egelhaaf, F. Giavazzi, R. Cerbino, *One- and two-particle microrheology of soft materials based on optical-flow image analysis*, <https://doi.org/10.1039/D4SM01390E>.
- T. Ghosh, P. Sollich & S. Kumar Nandi, *An elastoplastic model approach for the relaxation dynamics of active glasses* [arXiv:2411.10793](#)[cond-mat.soft].

WORKSHOPS

Rare events in Dynamical Systems (ZPS)

- Max Auer, Roland Zweimüller, *Local limit theorems for hitting times and return times of small sets* [arXiv:2312.14581](#)[math.DS].
- Peter Balint, Dalia Terhesiu, *Generalized law of iterated logarithm for the Lorentz gas with infinite horizon*, [arXiv:2403.19582](#)[math.PR].

Synthetic Curvature Bounds for Non-Smooth Spaces: Beyond Finite Dimension (KDR)

- S. Honda, A. Mondino, *Poincaré inequality for one forms on four manifolds with bounded Ricci curvature*, [arXiv:2405.19168](#)[math.DG].
- L. Dello Schiavo, M. Magnabosco, C. Rigoni, *Gradient flows of (K, N) -convex functions with negative N* , [arXiv:2412.04574](#)[math.FA].

Determinacy, Inner Models and Forcing Axioms (SSM)

- J. Aguilera, *Boolean completeness of infinitary logic with arbitrary signatures*, preprint.
- J. Aguilera, *Local Hanf-Tarski numbers*, preprint.
- F. Barrera, V. Dimonte, S. Müller, *The λ -PSP at λ -coanalytic sets*, preprint.
- D. Ikegami, M. Viale, *Universally Baire sets in 2^κ* , preprint.
- L. Koschat, S. Thei, *A factorization theorem for weak projections*, preprint.
- S. Müller, B. Wcisło, *A model with fragments of projective determinacy and failures of DC*, preprint.

Spin-Orbit Entangled Quantum Magnetism (FPM)

L. Pourovskii, D. Fiore Mosca, L. Celiberti, S. Khmelevskiy, A. Paramekanti, C. Franchini, *Hidden multipolar phases in spin-orbit entangled correlated insulators*, in: Nature Review Materials, 2025.

N. Iwahara, L. Pourovskii, C. Franchini, B. Kim, *Physics of Osmates: A Theoretical Perspective*, in: Topical Review to Journal of Physics: Condensed Matter, 2025.

Algebraicity and Transcendence for Singular Differential Equations (HBI)

S. Yokura, *A naive co-operational bivariant theory derived from cohomology operations*, preprint.

Lensing and Wave Optics in Strong Gravity (COZ)

J. C. L. Chan, C. Dyson, M. Garcia, J. Redondo-Yuste & L. Vujeva, *Lensing and wave optics in the strong field of a black hole*, [arXiv:2502.14073](#)[gr-qc].

J. Samsing, L. Zwick, P. Saini, D. D’Orazio, K. Hendriks, J. M. Ezquiaga, R. K. Lo, L. Vujeva, G. D. Radev, & Y. Yu, *Measuring the Transverse Velocity of Strongly Lensed Gravitational Wave Sources with Ground Based Detectors*, [arXiv:2412.14159](#)[astro-ph.HE].

J. Samsing, L. Zwick, P. Saini, K. Hendriks, R. K. L. Lo, L. Vujeva, G. D. Radev & Y. Yu, *Constraining Proper Motion of Strongly Lensed Eccentric Binary Mergers using Doppler Triangulation*, [arXiv:2501.12494](#)[astro-ph.HE].

L. Zwick & J. Samsing, *The Proper Motion of Strongly Lensed Binary Neutron Star Mergers in LIGO/Virgo/Kagra can be Constrained by Measuring Doppler Induced Gravitational Wave Dephasing*, [arXiv:2502.03547](#)[astro-ph.CO].

RESEARCH IN TEAMS (RIT)

A. Brunk, A. Jüngel, M. Lukáčová-Medvid’ová, *A structure-preserving numerical method for quasi-incompressible Navier–Stokes–Maxwell–Stefan systems*, [arXiv:2504.11892](#)[math.NA].

N. S. Deger, J. Rosseel, H. Samtleben, *General Supersymmetric Solution of Minimal Massive Supergravity*, [arXiv:2410.07964](#)[hep-th].

N.S. Deger & J. Rosseel, *Third Way Deformation of New and General Massive Gravities*, in preparation.

N. S. Deger, C. A. Deral, *Timelike supersymmetric solutions of $D=3, N=4$ supergravity*, [arXiv:2411.04437](#)[hep-th].

E. Einstein, S. Krishna M S, M. Montee, T. Ng, M. Steenbock, *Random quotients of free products*, [arXiv:2502.08630](#)[math.GR].

E. Feireisl, A. Jüngel, and M. Lukáčová-Medvid’ová. *Regularity and well-posedness of the Euler system in gas dynamics for dissipative solutions. Submitted for publication*, [arXiv:2501.05134](#)[math.AP].

C. I. Pérez-Sánchez, *The loop equations for noncommutative geometries on quivers*, [arXiv:2409.03705](#)[math-ph].

SENIOR RESEARCH FELLOWS PROGRAMME (SRF)

B. Gasparini, R. Atlas, A. Voigt, M. Krämer and P.N. Blossey, *Tropical cirrus evolution in a km-scale model with improved ice microphysics*, EGU sphere [preprint], 2025, <https://doi.org/10.5194/egusphere-2025-203>.

H. Nahari and T. Strobl, *The minimal Lie groupoid and infinity algebroid of the singular octonionic Hopf foliation*, [arXiv:2412.21135](#)[math.DG].

Z. Ravanpak, *NL Bialgebras*, accepted for publication in *Advances in Theoretical and Mathematical Physics*.

Z. Ravanpak and C. Vizman, *Metric degeneracies and gradient flows on symplectic leaves*, [arXiv:2505.08948](#)[math.DG].

T. Strobl and R. Suszek, *Principaloid bundles* [arXiv:2503.09886](#)[math.DG].

JUNIOR RESEARCH FELLOWS PROGRAMME (JRF)

M. Ashwinkumar, A. Kidambi, J. Leedom, M. Yamazaki, *Generalized Narain Theories Decoded: Discussions on Eisenstein series, Characteristics, Orbifolds, Discriminants and Ensembles in any Dimension*, <https://arxiv.org/abs/2311.00699>[hep-th].

E. Gasperín, M. Magdy, F. C. Mena, *Asymptotics of spin-0 fields and conserved charges on n-dimensional Minkowski spaces*, [arXiv:2408.03389](#)[gr-qc].

K. Kumar & H.C. Steinacker, *Modified Einstein equations from the 1-loop effective action of the IKKT model*, *Class.Quant.Grav.* 41 (2024) 18, 185007.

E. Schesler, *Finitely generated infinite torsion groups that are residually finite simple*, [arXiv:2407.05533](#)[math.GR].

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.

SLE11 = Nonlinear Water Waves, 2011

DPS22 = Large Deviations, Extremes and Anomalous Transport in Non-equilibrium Systems, 2022

LCW19 = Quantum Simulation - from Theory to Application, 2019

MKS21 = Memory Effects in Dynamical Processes: Theory and Computational Implementation, 2021

JRF = Junior Research Fellows

URF22 = Special Research Fellow Programme

C. Tresca, P.M. Forcella, A. Angeletti, L. Ranalli, C. Franchini, M. Reticcioli, G. Profeta, *Evidence of Molecular Hydrogen in the N-doped LuH3 System: a Possible Path to Superconductivity?*, [arXiv:2308.03619](#)[cond-mat.supr-con], (JRF23).

Christopher H. Cashen, Pallavi Dani, Alexandra Edletzberger, Annette Karrer, *RAAGedy right-angled Coxeter groups*, [arXiv:2506.16789](#)[math.GR], (RIT23).

L. F. Elizondo-Aguilera, T. Rizzo, T. Voigtmann, *From Subaging to Hyperaging in Structural Glasses*, In: *Physical Review Letters* 129, 238003 (2022), (MKS21).

R. Holtzman, Ch. Maes, *Acceleration from a clustering environment*, [arXiv:2405.19432](#)[cond-mat.stat-mech], (DPS22).

T. Kano, *Tunamis on a deep open sea and on a sloping beach – a mathematical theory*, [arXiv:2409.17269](#)[physics.ao-ph], (SLE11).

N. Mohseni, C. Navarrete-Benlloch, T. Byrnes, F. Marquardt, *Deep recurrent networks predicting the gap evolution in adiabatic quantum computing*, [arXiv:2109.08492](#)[quant-ph], (LCW19).

A. Nadtochiy, O. K. Suwal, D.-S. Kim, O. Korotchenkov, *Revealing CdSe quantum dots plasmonics confined in Au nanotrenches by thermoacoustic spectroscopy*, in: ACS Applied Optical Materials 1, 1272–1280 (2023), (URF22).

A. B. Nadtochiy, A. M. Gorb, B. M. Gorelov, O. I. Polovina, O. Korotchenkov, V. Schlosser, *Model approach to thermal conductivity in hybrid graphene-polymer nanocomposites*, in: Molecules 28, 7343 (2023), (URF22).

P. Rioseco and O. Sarbach, *Phase space mixing of a Vlasov gas in the exterior of a Kerr black hole*, [arXiv:2302.12849](#) (JRF 2021).

List of all visitors in 2024

A total of 959 scientists visited the ESI in 2024.

The gender distribution is as follows:

female: 193

male: 703

prefer not to disclose: 12

non-binary: 1

unspecified: 50

Affiliation by country:

AUS, Australia: 4

AUT, Austria: 213

BEL, Belgium: 25

BRA, Brazil: 1

BGR, Bulgaria: 2

CAN, Canada: 13

CHL, Chile: 8

CHN, China: 10

HRV, Croatia: 2

CZE, Czech Republic: 13

DNK, Denmark: 10

EST, Estonia: 2

FIN, Finland: 7

FRA, France: 101

DEU, Germany: 113

GRC, Greece: 2

HKG, Hong Kong: 1

HUN, Hungary: 4

IND, India: 21

IRN, Iran (Islamic Republic of): 2

IRL, Ireland: 4

ISR, Israel: 7

ITA, Italy: 69

JPN, Japan: 18

KOR, Korea (Republic of): 7

MKD, Macedonia (the former Yugoslav Republic of): 1

MEX, Mexico: 1

NLD, Netherlands: 28

NIU, Niue: 1

NOR, Norway: 1
 POL, Poland: 17
 PRT, Portugal: 7
 ROU, Romania: 5
 SAU, Saudi Arabia: 3
 SRB, Serbia: 1
 SGP, Singapore: 2
 ESP, Spain: 31
 SWE, Sweden: 18
 CHE, Switzerland: 23
 TUR, Turkey: 4
 UKR, Ukraine: 2
 GBR, United Kingdom of Great Britain and Northern Ireland: 69
 USA, United States of America: 120
 VEN, Venezuela (Bolivarian Republic of): 1

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

CDFG24 = Carrollian Physics and Holography
 CHS24 = Stochastic Partial Differential Equations
 COZ24 = Lensing and Wave Optics in Strong Gravity
 DFC24 = Linking Microscopic Processes to the Macroscopic Rheological Properties in Inert and Living Soft Materials
 DFC24School = Non-equilibrium Processes in Physics and Biology
 EM24 = ESI Medal Award Ceremony 2024
 FPM24 = Spin-Orbit Entangled Quantum Magnetism
 FSD24 = Nonlinear Waves and Relativity
 HBI24 = Algebraicity and Transcendence for Singular Differential Equations
 IMO24 = IMO Training 2024
 IS24 = Individual Visiting Scientists 2024
 JRF24 = Junior Research Fellow
 KDR24 = Synthetic Curvature Bounds for Non-Smooth Spaces: Beyond Finite Dimension
 MB24 = One World Optimization Seminar in Vienna
 RIT24 = Research in Teams
 SCA24 = Transport Properties in Soft Matter Systems
 SRF24 = Senior Research Fellow
 SSG24 = Chromatin Modeling: Integrating Mathematics, Physics, and Computation for Advances in Biology and Medicine
 SSM24 = Determinacy, Inner Models and Forcing Axioms
 WBS24 = Exactly Solvable Models
 WTV24 = The Landscape vs. the Swampland
 ZPS24 = Rare Events in Dynamical Systems

Achúcarro Ana, Leiden U; 2024-07-15 - 2024-07-24, WTV24
 Adolf Dominik; 2024-06-23 - 2024-07-05, SSM24
 Afxonidis Evangelos, U de Oviedo; 2024-04-15 - 2024-04-19, CDFG24
 Aggarwal Ankit, TU Vienna; 2024-04-01 - 2024-04-26, CDFG24
 Agrawal Shreyansh, SISSA, Trieste; 2024-04-06 - 2024-04-21, CDFG24
 Agresti Antonio, TU Delft; 2024-02-11 - 2024-02-16, CHS24

Ahmad Faisal, U Aix-Marseille; 2024-08-17 - 2024-08-31, DFC24School
Ahmadi Seyyed Alireza, U of Sistan and Baluchestan; 2024-03-18 - 2024-03-22, ZPS24
Ahookhosh Masoud, U Antwerpen; 2024-06-01 - 2024-06-09, MB24
Aichelburg Peter C., U of Vienna; 2024-04-17 - 2024-04-26, CDFG24; 2024-12-09 - 2024-12-13, COZ24
Aime Stefano, ESPCI, Paris; 2024-09-08 - 2024-09-14, DFC24
Ajith Parameswaran, ICTS; 2024-12-07 - 2024-12-14, COZ24
Alattar Mohammad, Durham U; 2024-05-21 - 2024-05-25, KDR24
Alekshev Anton, U Genève; 2024-07-23 - 2024-07-26, WBS24
Alonso Ruiz Patricia, TAMU, College Station; 2024-05-20 - 2024-05-25, KDR24; 2024-05-25 - 2024-06-21, FSD24
Alvarez Laura, U Bordeaux; 2024-04-01 - 2024-04-05, SCA24
Amar Selim, Stanford U; 2024-06-09 - 2024-06-22, FSD24
Ammon Martin, U of Jena; 2024-04-07 - 2024-04-19, 2024-04-21 - 2024-04-23, CDFG24
Anderson Lara, Virginia Tech; 2024-06-29 - 2024-07-05, WTV24
Andersson Lars, BIMSA, Beijing; 2024-06-20 - 2024-06-26, FSD24
Andréasson Håkan, Chalmers U of Technology, Gothenburg; 2024-05-05 - 2024-05-17, FSD24
Andretta Alessandro, U Torino; 2024-06-23 - 2024-06-28, SSM24
Andriot David, LAPTh Annecy; 2024-07-10 - 2024-07-18, WTV24
Anzeletti Lukas, TU Vienna; 2024-02-13 - 2024-02-16, CHS24
Aoki Hiroki, Tokyo U of Science; 2024-10-09 - 2024-10-19, HBI24
Apers Fien, U Oxford; 2024-07-01 - 2024-07-12, WTV24
Armas Jay, U of Amsterdam; 2024-04-14 - 2024-04-18, CDFG24
Artyukhin Sergey, IIT, Genova; 2024-09-22 - 2024-09-27, FPM24
Aschenbrenner Matthias, U of Vienna; 2024-10-13 - 2024-10-19, HBI24
Aspero David, U of East Anglia, Norwich; 2024-06-23 - 2024-06-29, SSM24
Aubin-Frankowski Pierre-Cyril, TU Vienna; 2024-06-05 - 2024-06-07, MB24
Auer Max, U of Maryland; 2024-03-16 - 2024-03-25, ZPS24
Avadanei Ovidiu-Neculai, UC, Berkeley; 2024-05-12 - 2024-05-18, FSD24
Azmi Behzad, U Konstanz; 2024-06-02 - 2024-06-08, MB24
Backhouse Drew, KCL, London; 2024-12-08 - 2024-12-14, COZ24
Bagayoko Vincent, U Paris Cité; 2024-10-07 - 2024-10-17, HBI24
Bagchi Arjun, IITK, Kanpur; 2024-04-01 - 2024-04-09, CDFG24
Bagnara Marco, SNS Pisa; 2024-02-11 - 2024-02-17, CHS24
Bahar Ivet, Stony Brook U, New York; 2024-03-01 - 2024-03-07, SSG24
Bain Nicolas, UCB Lyon; 2024-04-02 - 2024-04-05, SCA24
Bakhtin Yuri, NYU, New York; 2024-02-11 - 2024-02-17, CHS24
Balcerek Michal, UST Wroclaw; 2024-04-02 - 2024-04-05, SCA24
Balint Peter, BME, Budapest; 2024-03-18 - 2024-03-25, ZPS24
Banica Valeria, Sorbonne U, Paris; 2024-05-19 - 2024-05-24, FSD24
Bansal Sukrti, TU Vienna; 2024-07-08 - 2024-07-26, WTV24
Bansard-Tresse Dylan, Ecole Polytechnique; 2024-03-17 - 2024-03-23, ZPS24
Barbu Viorel, U A.I.Cuza, Iasi; 2024-02-10 - 2024-02-17, CHS24
Barilari Davide, UP; 2024-05-20 - 2024-05-24, KDR24
Barnich Glenn, ULB, Brussels; 2024-04-24 - 2024-04-26, CDFG24
Barrera Fernando, U of Udine; 2024-06-23 - 2024-06-29, SSM24
Barsode Ankur, ICTS; 2024-12-08 - 2024-12-15, COZ24
Battaglia Cleis, U of Edinburgh; 2024-03-01 - 2024-03-07, SSG24
Baumsteiger Jakob, U Bologna; 2024-09-22 - 2024-09-28, FPM24
Beauvillain Mathieu, École Polytechnique, Palaiseau; 2024-04-08 - 2024-04-17, CDFG24

Beck Amir, Tel Aviv U; 2024-06-03 - 2024-06-07, MB24
Bednarczuk Ewa, Polish Academy of Science, Warsaw; 2024-06-02 - 2024-06-06, MB24
Beig Robert, U of Vienna; 2024-04-17 - 2024-04-26, CDFG24
Bekaert Xavier, U of Tours; 2024-03-29 - 2024-04-12, CDFG24
Ben-Achour Jibril, ENS, Lyon; 2024-04-02 - 2024-04-19, CDFG24
Benko Matúš, JKU, Linz; 2024-06-03 - 2024-06-07, MB24
Ben Zion Matan Yah, Radboud U; 2024-04-02 - 2024-04-06, SCA24
Bergshoeff Eric, U Groningen; 2024-03-29 - 2024-04-12, CDFG24
Bernhardt Louie, U Melbourne; 2024-06-16 - 2024-06-22, FSD24
Bertolini Erica, DIAS, Dublin; 2024-04-14 - 2024-04-20, CDFG24
Bertolini Timo, U of Vienna; 2024-02-12 - 2024-02-16, CHS24
Bessegua Matteo, U degli Studi dell'Insubria; 2024-04-01 - 2024-04-06, SCA24
Beukers Frits, Utrecht U; 2024-10-13 - 2024-10-19, HBI24
Bhardwaj Srishti, IIT Roorkee; 2024-09-22 - 2024-09-28, FPM24
Bi Dapeng "Max", Northeastern U, Boston; 2024-09-07 - 2024-09-20, DFC24
Biermann Silke, École Polytechnique, Palaiseau; 2024-09-25 - 2024-09-27, FPM24
Bischofberger Irmgard, MIT, Cambridge; 2024-09-08 - 2024-09-14, DFC24
Biswas Tanmay, TU Vienna; 2024-08-19 - 2024-08-30, DFC24School
Bizón Piotr, Jagiellonian U, Krakow; 2024-06-15 - 2024-06-21, FSD24
Black Adam, Yale U, New Haven; 2024-05-27 - 2024-06-06, FSD24
Blitz Samuel, Masaryk U, Brno; 2024-04-14 - 2024-04-19, 2024-04-21 - 2024-04-24, CDFG24
Błoński Piotr, CATRIN, Olomouc; 2024-09-22 - 2024-09-29, FPM24
Bluegel Stefan, FZ Jülich; 2024-09-22 - 2024-09-27, FPM24
Blumenhagen Ralph, MPP, Munich; 2024-07-14 - 2024-07-19, WTV24
Böhm Gregor, U of Vienna; 2024-10-07 - 2024-10-18, HBI24
Bomze Immanuel, U of Vienna; 2024-06-03 - 2024-06-05, MB24
Bonfanti Alessandra, Politecnico Milano; 2024-09-08 - 2024-09-18, DFC24; 2024-08-18 - 2024-08-26, DFC24School
Bonk Andras, U of Vienna; 2024-05-13 - 2024-06-21, FSD24
Borthwick Jack, McGill U; 2024-04-09 - 2024-04-17, CDFG24
Borza Samuel, SISSA, Trieste; 2024-05-20 - 2024-05-25, KDR24
Bost Jean-Benoît, U Paris Sud, Orsay; 2024-10-13 - 2024-10-19, HBI24
Bostan Alin, INRIA Paris; 2024-10-06 - 2024-10-18, HBI24
Bot Radu Ioan, U of Vienna; 2024-06-02 - 2024-06-08, MB24
Boş Cassandra, BRG1; 2024-10-28 - 2024-10-31, IMO24
Boulanger Nicolas, U of Mons; 2024-04-14 - 2024-04-20, CDFG24
Bouzid Mehdi, CNRS, U Grenoble Alpes; 2024-08-18 - 2024-08-22, DFC24School
Braga Ginevra, Gran Sasso Science Institute, L'Aquila; 2024-12-08 - 2024-12-13, COZ24
Branding Volker, U of Vienna; 2024-06-17 - 2024-06-21, FSD24
Bräuer Letizia, BRG Enns; 2024-10-27 - 2024-10-31, IMO24
Bressan Alberto, Penn State U; 2024-12-06 - 2024-12-08, EM24
Brigati Giovanni, ISTA, Klosterneuburg; 2024-05-23 - 2024-05-25, KDR24
Brito Richard, IST Lisboa; 2024-12-08 - 2024-12-14, COZ24
Brown Francis, U Oxford; 2024-10-13 - 2024-10-18, HBI24
Brueckner David, ISTA, Klosterneuburg; 2024-03-07 - 2024-03-08, SSG24
Bruin Henk, U of Vienna; 2024-03-18 - 2024-03-22, ZPS24
Buchacher Manfred, JKU, Linz; 2024-10-07 - 2024-10-19, HBI24
Buchholz Detlev, U Göttingen; 2024-10-07 - 2024-10-11, IS24
Bui Philipp, Wiedner Gymnasium Wien; 2024-10-27 - 2024-10-31, IMO24

Buonomo Dario, U Roma Tre; 2024-08-18 - 2024-08-30, DFC24School
 Buric Maja, U of Belgrade; 2024-07-23 - 2024-07-27, WBS24
 Byars Allison, U of Wisconsin; 2024-05-12 - 2024-05-23, FSD24
 Bystricky Kerstin, U Toulouse Capitole; 2024-03-04 - 2024-03-09, SSG24
 Caddeo Alessio, U de Oviedo; 2024-04-14 - 2024-04-20, CDFG24
 Calderon-Infante Jose, CERN, Geneva; 2024-06-29 - 2024-07-21, WTV24
 Calisti Matteo, U of Vienna; 2024-05-21 - 2024-05-24, KDR24
 Campoleoni Andrea, U of Mons; 2024-04-01 - 2024-04-12, CDFG24
 Cap Andreas, U of Vienna; 2024-04-09 - 2024-04-18, CDFG24
 Capone Federico, U of Jena; 2023-04-14 - 2023-04-24, CDFG24
 Carbone Johanna Paulina, TU Vienna; 2024-09-23 - 2024-09-27, FPM24
 Carney Meagan, U of Queensland, Brisbane; 2024-03-17 - 2024-03-22, ZPS24
 Cartiş Coralia, U Oxford; 2024-06-05 - 2024-06-07, MB24
 Castellini Stefano, U degli Studi di Milano; 2024-08-18 - 2024-08-30, DFC24School
 Castro Francisco, U of Sevilla; 2024-10-06 - 2024-10-19, HBI24
 Celiberti Lorenzo, U of Vienna; 2024-09-23 - 2024-09-27, FPM24
 Cerbino Roberto, U of Vienna; 2024-09-30 - 2024-10-11, 2024-09-09 - 2024-09-20, DFC24; 2024-04-02 - 2024-04-05, SCA24; 2024-08-19 - 2024-08-30, DFC24School
 Cerdin Tristan, Sorbonne U, Paris; 2024-08-18 - 2024-08-30, DFC24School
 Chabert Ambre, ENS Paris; 2024-05-14 - 2024-05-19, 2024-06-16 - 2024-06-21, FSD24
 Chakrabarti Buddhapriya, U of Sheffield; 2024-03-03 - 2024-03-09, SSG24
 Chakraborty Bulbul, Brandeis U; 2024-09-13 - 2024-09-20, 2024-09-08 - 2024-09-13, DFC24
 Chakraborty Debayan, IISER Bhopal; 2024-04-02 - 2024-04-06, SCA24
 Chamorro Burgos Miguel Ángel, U of Sevilla; 2024-08-18 - 2024-08-31, DFC24School
 Chan William, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
 Chandra Ajay, Imperial College London; 2024-02-11 - 2024-02-17, CHS24
 Charalambous Panagiotis, SISSA, Trieste; 2024-04-07 - 2024-04-20, CDFG24
 Charras Guillaume, U College London; 2024-09-10 - 2024-09-15, DFC24
 Chaudhuri Pinaki, IMSC; 2024-09-08 - 2024-09-14, DFC24
 Chazottes Jean-Rene, Ecole Polytechnique; 2024-03-17 - 2024-03-22, ZPS24
 Che Mauricio, Durham U; 2024-05-20 - 2024-05-24, KDR24
 Chen Gong, GATECH, Atlanta; 2023-05-07 - 2023-05-10, FSD24
 Chenchene Enis, U of Vienna; 2024-06-03 - 2024-06-07, MB24
 Chervanyov Alexander, U Münster; 2024-04-02 - 2024-04-05, SCA24
 Chibotaru Liviu, KU Leuven; 2024-09-22 - 2024-09-28, FPM24
 Chiu Christopher, KU Leuven; 2024-10-05 - 2024-10-19, HBI24
 Choi Han Gil, IBS, Daejeon; 2024-12-08 - 2024-12-13, COZ24
 Choudhary Monika, India; 2024-08-18 - 2024-09-02, DFC24School
 Christol Gilles, U Jussieu; 2024-10-14 - 2024-10-18, HBI24
 Chruściel Piotr T., U of Vienna; 2024-04-17 - 2024-04-26, CDFG22023-04-29 - 2023-06-10, FSD24; 2024-12-06 - 2024-12-06, EM24
 Ciambelli Luca, ULB, Brussels; 2024-04-15 - 2024-04-19, CDFG24
 Cipelletti Luca, U de Montpellier; 2024-08-17 - 2024-08-24, DFC24School
 Cody Sean, UC, Berkeley; 2023-06-23 - 2023-07-06, SSM24
 Cohen Nathan, U of Vienna; 2024-07-24 - 2024-07-26, WBS24
 Cojocaru Vlad, Utrecht U and Babes-Bolyai U; 2024-03-03 - 2024-03-08, SSG24
 Coldstream Jonathan, U of Edinburgh; 2024-04-01 - 2024-04-05, SCA24
 Collot Charles, CY Cergy Paris U; 2024-06-09 - 2024-06-22, FSD24
 Combettes Patrick, NC State U, Raleigh; 2024-06-03 - 2024-06-08, MB24

Cominetti Roberto, U Adolfo Ibanez, Santiago de Chile; 2024-06-02 - 2024-06-08, MB24
Cong Wan, U of Vienna; 2024-04-15 - 2024-04-25, CDFG24; 2024-12-09 - 2024-12-13, COZ24
Conlon Joseph, U Oxford; 2024-08-01 - 2024-08-11, WTV24
Cont Nicolò, Vrije U Brussels; 2024-05-20 - 2024-05-24, KDR24
Cornalba Federico, U Bath; 2024-02-11 - 2024-02-16, CHS24
Corsi Flavia, IMBA, Vienna; 2024-03-04 - 2024-03-07, SSG24
Cosma Maria Pia, Center for Genomic Regulation, Barcelona; 2024-03-04 - 2024-03-06, SSG24
Costa Matteo, U Bologna; 2024-09-23 - 2024-09-27, FPM24
Côte Raphaël, IRMA, Strasbourg; 2024-05-13 - 2024-05-17, FSD24
Cox Sonja, U of Amsterdam; 2024-02-11 - 2024-02-12, CHS24
Cremonini Sera, Lehigh U, Bethlehem; 2024-07-07 - 2024-07-20, WTV24
Cristin Javier, ICS, CNR, Rome; 2024-04-01 - 2024-04-05, SCA24
Cristoferi Riccardo, Radboud U; 2024-04-22 - 2024-04-26, SRF0124
Csetnek Robert, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Csontosova Diana, Masaryk U, Brno; 2024-09-22 - 2024-09-27, FPM24
Cummings James, Carnegie Mellon U, Pittsburgh; 2024-06-23 - 2024-06-29, SSM24
Cunha Pedro, U of Aveiro; 2024-12-08 - 2024-12-14, COZ24
Curtis Frank, Lehigh U, Bethlehem; 2024-06-02 - 2024-06-07, MB24
Cusin Giulia, IAP, Paris; 2024-12-08 - 2024-12-12, COZ24
Cvetič Mirjam, UPenn, Philadelphia; 2024-06-30 - 2024-07-12, WTV24
Dabrowski Ludwik, SISSA, Trieste; 2024-07-23 - 2024-07-26, WBS24
Daghofer Maria, U Stuttgart; 2024-09-22 - 2024-09-26, FPM24
D'Ancona Piero, U Roma 1, Sapienza; 2024-06-11 - 2024-06-18, FSD24
Dappiaggi Claudio, U of Pavia; 2024-04-21 - 2024-04-26, CDFG24
Dareiotis Kostantinos, U Leeds; 2024-02-12 - 2024-02-16, CHS24
Das Arnav, CalTech; 2024-07-15 - 2024-08-09, WTV24
Dasaro Dario, ENS de Lyon; 2024-03-03 - 2024-03-14, SSG24
Dasgupta Keshav, McGill U; 2024-07-15 - 2024-07-20, WTV24
De Bondt Ben, U Münster; 2024-06-23 - 2024-06-29, SSM24
Debussche Arnaud, ENS Rennes; 2024-02-11 - 2024-02-18, CHS24
Deger Nihat Sadik, Boğaziçi U; 2024-08-10 - 2024-09-29, RIT0324
Deiringer Nora, Georg-August-U, Göttingen; 2024-08-18 - 2024-08-31, DFC24School
Deka Uddeeta, ICTS, Trieste; 2024-12-08 - 2024-12-15, COZ24
Delanoe-Ayari Helene, U Lyon; 2024-09-08 - 2024-09-14, DFC24
Delaygue éric, Institute Camille Jordan, U Lyon; 2024-10-13 - 2024-10-19, HBI24
Delfante Arnaud, U of Mons; 2024-04-07 - 2024-04-13, CDFG24
Delgado Matilda, UAM-CSIC, Madrid; 2024-07-15 - 2024-07-23, WTV24
Del Gado Emanuela, Georgetown U; 2024-09-08 - 2024-09-18, DFC24
Dellago Christoph, U of Vienna; 2024-12-06 - 2024-12-07, EM24
Dello Schiavo Lorenzo, ISTA, Klosterneuburg; 2024-05-21 - 2024-05-24, KDR24
Del Monte Giovanni, Utrecht U; 2024-09-08 - 2024-09-13, DFC24
Deng Qin, MIT, Cambridge; 2024-05-20 - 2024-05-25, KDR24
De Simone Gianfranco, U of Udine; 2024-04-12 - 2024-04-21, CDFG24
Dessi Francesca, U Lund; 2024-08-18 - 2024-08-30, DFC24School
Detournay Stephane, Vrije U Brussels; 2024-03-31 - 2024-04-06, CDFG24
De Vicente Daniel, U of Vienna; 2024-06-03 - 2024-06-06, MB24
Dhivakar Prateksh, IITK, Kanpur; 2024-04-15 - 2024-04-26, CDFG24
Dierigl Markus, LMU Munich; 2024-07-26 - 2024-08-02, WTV24
Di Franco Jasmin, U of Vienna; 2024-08-19 - 2024-08-30, DFC24School

Di Rocco Sandra, KTH Stockholm; 2024-12-06 - 2024-12-08, EM24
Dmitriev Vladimir, IMBA, Vienna; 2024-03-04 - 2024-03-04, SSG24
Dodson Benjamin, Johns Hopkins U, Baltimore; 2024-06-15 - 2024-06-22, FSD24
Dogic Zvonimir, UC, Santa Barbara; 2024-09-08 - 2024-09-14, DFC24
Domann Stephan, DLR, Köln; 2024-08-18 - 2024-08-31, DFC24School
Donnay Laura, SISSA, Trieste; 2024-04-02 - 2024-04-26, CDFG24
Donninger Roland, U of Vienna; 2024-04-29 - 2024-06-21, FSD24
Döşeme Hatice, IBG, Izmir; 2024-03-03 - 2024-03-09, SSG24
Dutta Sudipta, IITK, Kanpur; 2024-04-07 - 2024-04-13, CDFG24
Duyckaerts Thomas, U Paris-Nord; 2024-05-19 - 2024-05-24, FSD24
Ecker Florian, TU Vienna; 2024-04-02 - 2024-04-26, CDFG24
Eckstein Jonathan, Rutgers U; 2024-06-02 - 2024-06-08, MB24
Ederer Claude, ETH Zurich; 2024-09-22 - 2024-09-27, FPM24
Eichmair Michael, U of Vienna; 2024-12-06 - 2024-12-07, EM24
Eisenkölbl Theresia, U of Vienna; 2024-06-19 - 2024-06-21, 2024-10-28 - 2024-10-31, IMO24
Eriksson Olle, Uppsala U; 2024-09-23 - 2024-09-24, FPM24
Eskew Monroe, U of Vienna; 2024-06-24 - 2024-06-28, SSM24
Estrada Alejandro, U of Vienna; 2024-12-09 - 2024-12-13, COZ24
Eterovic Sebastian, U Leeds; 2024-10-06 - 2024-10-18, HBI24
Etheredge Muldrow, UMass Amherst; 2024-07-01 - 2024-07-27, WTV24
Ezquiaga Jose M., NBI, Copenhagen; 2024-12-08 - 2024-12-13, COZ24
Faber Eleonore, U of Graz; 2024-10-13 - 2024-10-16, HBI24
Fadili Jalal, CNRS-ENSICAEN, U of Caen; 2024-06-02 - 2024-06-05, MB24
Fajman David, U of Vienna; 2024-05-02 - 2024-06-21, FSD24; 2024-04-15 - 2024-04-19, CDFG24; 2024-12-09 - 2024-12-13, COZ24
Fatalini Azul, U Münster; 2024-06-23 - 2024-06-28, SSM24
Feireisl Eduard, Academy of Sciences, Prague; 2024-10-02 - 2024-10-14, 2024-12-08 - 2024-12-15, RIT0124
Fernandez Merino Manuel, Center for Genomic Regulation, Barcelona; 2024-03-03 - 2024-03-08, SSG24
Ferrario Benedetta, U of Pavia; 2024-02-12 - 2024-02-16, CHS24
Ferreira Rita, KAUST, Thuwal; 2024-04-20 - 2024-04-27, SRF0124
Ficek Filip, U of Vienna; 2024-05-07 - 2024-06-21, FSD24; 2024-12-09 - 2024-12-13, COZ24
Fielding Suzanne, Durham U; 2024-09-08 - 2024-09-13, DFC24
Figueroa-O'Farrill José, U of Edinburgh; 2024-04-07 - 2024-04-19, CDFG24
Fiore Mosca Dario, École Polytechnique, Palaiseau, U of Vienna; 2024-09-23 - 2024-09-27, FPM24
Fiorucci Adrien, TU Vienna; 2024-04-01 - 2024-04-26, CDFG24
Fischer Vera, U of Vienna; 2024-06-24 - 2024-06-28, SSM24
Fitzgerald Eavan, ISTA, Klosterneuburg; 2024-08-19 - 2024-08-30, DFC24School
Flaim Marco, HCM, Bonn; 2024-05-20 - 2024-05-25, KDR24
Fleury Pierre, CNRS, Montpellier; 2024-12-08 - 2024-12-14, COZ24
Foffi Giuseppe, Paris-Saclay U; 2024-09-03 - 2024-09-18, DFC24; 2024-08-18 - 2024-08-26, DFC24School
Fogh Ellen, EPFL, Lausanne; 2024-09-24 - 2024-09-24, FPM24
Fonseca Irene, Carnegie Mellon U, Pittsburgh; 2024-04-07 - 2024-04-28, SRF0124
Font Anamaria, UCV, Caracas; 2024-07-07 - 2024-07-20, WTV24
Foondun Mohammad, U Strathclyde, Glasgow; 2024-02-11 - 2024-02-14, CHS24
Franchini Cesare, U of Vienna; 2024-09-23 - 2024-09-27, FPM24
Franosch Thomas, U of Innsbruck; 2024-04-02 - 2024-04-05, SCA24
Fredenhagen Stefan, U of Vienna; 2024-04-01 - 2024-04-26, CDFG24; 2024-07-24 - 2024-07-26, WBS24

Freidel Laurent, Perimeter Institute, Waterloo; 2024-04-14 - 2024-04-24, CDFG24
Freitas Jorge, U Porto; 2024-03-17 - 2024-03-21, ZPS24
Fresán Javier, Sorbonne U, Paris; 2024-10-13 - 2024-10-18, HBI24
Freund Valerie, U Leipzig; 2024-05-20 - 2024-05-26, KDR24
Friedrich Bjoern, U Heidelberg; 2024-06-30 - 2024-07-12, WTV24
Friedrich Helmut, MPIGP, Potsdam; 2024-12-05 - 2024-12-08, EM24
Friz Peter K., TU Berlin; 2024-02-14 - 2024-02-16, CHS24
Fruton Paul, U degli Studi di Milano; 2024-08-19 - 2024-08-30, DFC24School
Fuchs Gunter, CUNY, New York; 2024-06-23 - 2024-06-29, SSM24
Fudenberg Geoff, U of Southern California, Los Angeles; 2024-03-09 - 2024-03-15, SSG24
Fuentealba Oscar, ULB, Brussels; 2024-04-07 - 2024-04-13, CDFG24
Fürnsinn Florian, U of Vienna; 2024-10-07 - 2024-10-19, HBI24
Fürthauer Sebastian, TU Vienna; 2024-03-10 - 2024-03-15, SSG24; 2024-08-19 - 2024-08-30, DFC24School;
2024-08-19 - 2024-10-11, DFC24
Gabl Markus, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Galaz-García Fernando, Durham U; 2024-05-19 - 2024-05-24, KDR24
Gappo Takehiko, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Garcia Matilde, NBI, Copenhagen; 2024-12-08 - 2024-12-14, COZ24
García Cortés Francisco, U of Sevilla; 2024-10-06 - 2024-10-20, HBI24
Garini Yuval, Technion Haifa; 2024-03-03 - 2024-03-08, SSG24
Gassiat Paul, Dauphine U, Paris; 2024-02-11 - 2024-02-14, CHS24
Gaulin Bruce, McMaster U, Hamilton; 2024-09-22 - 2024-09-28, FPM24
Gegelia Nutsa, U Mainz; 2024-10-05 - 2024-10-19, HBI24
Geiller Marc, ENS Lyon; 2024-04-14 - 2024-04-18, CDFG24
Gennaioli Luca, SISSA, Trieste; 2024-05-20 - 2024-05-24, KDR24
Gerard Patrick, U Paris-Saclay; 2024-05-06 - 2024-05-10, FSD24
Germain Pierre, Imperial College London; 2024-05-08 - 2024-06-21, FSD24
Gervasone Rafael, Politecnico Milano; 2024-04-01 - 2024-04-06, SCA24
Gess Benjamin, Bielefeld U; 2024-02-12 - 2024-02-16, CHS24
Geva Galor, U Autonoma de Madrid; 2024-04-02 - 2024-04-05, SCA24
Giardino Serena, MPIGP, Potsdam; 2024-12-08 - 2024-12-14, COZ24
Giavazzi Fabio, U degli Studi di Milano; 2024-09-08 - 2024-09-13, DFC24
Gibaud Thomas, ENS de Lyon; 2024-09-08 - 2024-09-14, DFC24
Gibertini Marco, U Modena; 2024-09-23 - 2024-09-27, FPM24
Gigli Nicola, SISSA, Trieste; 2024-05-20 - 2024-05-24, KDR24
Giselsson Pontus, Lund U; 2024-06-03 - 2024-06-07, MB24
Gittus Oliver, ENS de Lyon; 2024-03-04 - 2024-03-11, SSG24
Giulini Domenico, Leibniz U Hannover; 2024-12-05 - 2024-12-08, EM24
Glatz Valentin, BG/BRG Graz; 2024-06-19 - 2024-06-22, 2024-10-28 - 2024-10-31, IMO24
Głódkowski Aleksander, UST Wroclaw; 2024-04-14 - 2024-04-21, CDFG24
Glogić Irfan, U of Vienna; 2024-05-01 - 2024-06-19, FSD24
Goldberg Gabriel, UC, Berkeley; 2024-06-23 - 2024-07-07, SSM24
Goloborodko Anton, IMBA, Vienna; 2024-03-04 - 2024-03-15, SSG24
Golyshov Vasily, Abdus Salam ICTP, Trieste; 2024-10-14 - 2024-10-19, HBI24
Gomis Joaquim, U of Barcelona; 2024-04-07 - 2024-04-20, CDFG24
Goncharuk Anna, Karazin U; 2024-10-06 - 2024-10-11, HBI24
Gordina Maria (Masha), U of Connecticut; 2024-05-20 - 2024-05-26, KDR24
Goriely Zakkai, UC, Berkeley; 2024-06-23 - 2024-06-29, SSM24
Gorny Wojciech, U of Vienna; 2024-05-21 - 2024-05-24, KDR24

Goyal Srashti, MPIGP, Potsdam; 2024-12-08 - 2024-12-14, COZ24
Grad Sorin-Mihai, ENSTA Paris; 2024-06-05 - 2024-06-08, MB24
Gray Finnian, U of Vienna; 2024-12-09 - 2024-12-13, COZ24
Gray James, Virginia Tech; 2024-06-29 - 2024-07-05, WTV24
Grieco Alessandra, UAM-CSIC, Madrid; 2024-07-07 - 2024-07-13, WTV24
Grigoriev Maxim, U of Mons; 2024-04-06 - 2024-04-13, CDFG24
Grigoryev Sergei, Penn State U; 2024-03-03 - 2024-03-12, SSG24
Grimmer Benjamin, Johns Hopkins U, Baltimore; 2024-06-03 - 2024-06-07, MB24
Grosberg Alexander, NYU, New York; 2024-03-03 - 2024-03-17, SSG24
Grosse Harald, U of Vienna; 2024-07-22 - 2024-07-26, WBS24
Grumiller Daniel, TU Vienna; 2024-04-02 - 2024-04-28, CDFG24
Guatterri Giuseppina, Politecnico Milano; 2024-02-11 - 2024-02-15, CHS24
Güler Osman, U of Maryland; 2024-06-02 - 2024-06-07, MB24
Gundlach Carsten, U Southampton; 2024-05-12 - 2024-05-18, FSD24
Gürbüzbalaban Mert, Rutgers U; 2024-06-01 - 2024-06-05, MB24
Gutierrez Susana, U of Birmingham; 2024-05-20 - 2024-05-25, FSD24
Guzzetti Davide, SISSA, Trieste; 2024-10-06 - 2024-10-20, HBI24
Gyöngy István, U of Edinburgh; 2024-02-11 - 2024-02-16, CHS24
Gyulchev Galin, Sofia U; 2024-12-08 - 2024-12-14, COZ24
Haghshenas Mahdi, Imperial College London; 2024-06-16 - 2024-06-22, FSD24
Hairer Martin, Imperial College London; 2024-02-13 - 2024-02-16, CHS24
Halдар Astik, U of Saarland; 2024-08-18 - 2024-08-31, DFC24School
Hall Kai, Imperial College London; 2024-07-15 - 2024-07-17, WTV24
Halool Ahmed, KAU, Jeddah; 2024-09-23 - 2024-09-27, FPM24
Hamada Yuta, KEK, Tsukuba; 2024-07-11 - 2024-07-12, 2024-07-12 - 2024-07-17, WTV24
Hannezo Edouard, ISTA, Klosterneuburg; 2024-08-28 - 2024-09-12, DFC24; 2024-08-29 - 2024-08-30, DFC24School
Hannuksela Otto, CU Hong Kong; 2024-12-09 - 2024-12-13, COZ24
Haraoka Yoshishige, Josai U; 2024-10-13 - 2024-10-19, HBI24
Harden James, U of Ottawa; 2024-09-08 - 2024-09-21, DFC24
Hardouin Charlotte, IMT, Toulouse; 2024-10-06 - 2024-10-18, HBI24
Harikumar Sreekanth, NCBJ, Otrock; 2024-12-09 - 2024-12-13, COZ24
Harte Abraham, Dublin City U; 2024-12-08 - 2024-12-13, COZ24
Hartong Jelle, U of Edinburgh; 2024-04-02 - 2024-04-05, CDFG24
Häupl Magdalena, U of Vienna; 2024-08-19 - 2024-08-30, DFC24School
Hausenblas Erika, MontanU Leoben; 2024-02-11 - 2024-02-16, CHS24
Hauser Herwig, U of Vienna; 2024-10-07 - 2024-10-18, HBI24
Have Emil, NBI, Copenhagen; 2024-04-01 - 2024-04-05, CDFG24
Haziot Susanna, Brown U, Providence; 2024-06-09 - 2024-06-22, FSD24
He Niao, ETH Zurich; 2024-06-02 - 2024-06-08, MB24
He Zhiqiang, CNRS -U Grenoble Alpes; 2024-10-06 - 2024-10-19, HBI24
Hebecker Arthur, U Heidelberg; 2024-07-21 - 2024-07-27, WTV24
Hee-Cheol Kim, Postech, Pohang; 2024-07-14 - 2024-07-21, WTV24
Heidenreich Ben, UMass Amherst; 2024-06-29 - 2024-07-19, WTV24
Henneaux Marc, Collège de France, Paris; 2024-04-07 - 2024-04-13, CDFG24
Henney-Turner Christopher, Polish Academy of Science, Warsaw; 2024-06-22 - 2024-07-06, SSM24
Herdeiro Carlos A. R., U of Aveiro; 2024-12-12 - 2024-12-15, COZ24
Herfray Yannick, U of Tours; 2024-04-02 - 2024-04-28, CDFG24
Herr Sebastian, U of Bielefeld; 2024-05-09 - 2024-05-19, FSD24

Herraез Alvaro, MPP, Munich; 2024-07-08 - 2024-07-21, WTV24
 Heuchl Raphael, BG Oberschützen; 2024-06-19 - 2024-06-22, IMO24
 Hiebler Moritz, AAU, Klagenfurt; 2024-06-19 - 2024-06-21, 2024-10-27 - 2024-10-31, IMO24
 Hintermüller Michael, WIAS, Berlin; 2024-06-02 - 2024-06-07, MB24
 Hirai Daigorou, Nagoya U; 2024-09-24 - 2024-09-28, FPM24
 Hoffelner Stefan, U Münster; 2024-06-24 - 2024-06-28, SSM24
 Hogan James, UCLA; 2024-05-10 - 2024-05-20, FSD24
 Hollnbuchner Michael, BRG Linz; 2024-10-29 - 2024-10-30, IMO24
 Hollweck Jakob, U of Jena; 2024-04-07 - 2024-04-14, CDFG24
 Holy Peter, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
 Honda Shouhei, Tohoku U; 2024-05-20 - 2024-05-25, KDR24
 Horvathy Peter, U of Tours; 2024-04-15 - 2024-04-24, CDFG24
 Hössel Tobias, U of Jena; 2024-04-07 - 2024-04-14, CDFG24
 Hsia Steven Weiling, Masaryk U, Brno; 2024-07-02 - 2024-07-04, WTV24
 Hsieh Ya-Ping, ETH Zurich; 2024-06-01 - 2024-06-10, MB24
 Huebsch Marie Therese, VASP, Vienna; 2024-09-23 - 2024-09-27, FPM24
 Huiskens Gerhard, U Tübingen; 2024-12-06 - 2024-12-08, EM24
 Hulett David Alexander, U of Vienna; 2024-06-03 - 2024-06-07, MB24
 Iannella Martina, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
 Ifrim Mihaela, U of Wisconsin-Madison; 2024-04-28 - 2024-05-24, FSD24
 Iglesias José, U of Twente; 2024-04-21 - 2024-04-26, SRF0124
 Ikegami Daisuke, SYSU, Guangzhou; 2024-06-22 - 2024-07-05, SSM24
 Ionescu Alexandru, Princeton U; 2024-06-09 - 2024-06-22, FSD24
 Iosub Daniel, HU of Jerusalem; 2024-06-23 - 2024-06-29, SSM24
 Isa Lucio, ETH Zurich; 2024-04-02 - 2024-04-05, SCA24
 Iseppi Roberta Anna, Georg-August-U, Göttingen; 2024-07-28 - 2024-08-10, 2024-08-18 - 2024-09-01, 2024-12-16 - 2024-12-20, RIT0524
 Ivanovici Oana, CNRS, Paris; 2024-06-09 - 2024-06-19, FSD24
 Iwahara Naoya, U Chiba; 2024-09-22 - 2024-09-29, FPM24
 Izmetiev Ivan, TU Vienna; 2024-06-20 - 2024-06-20, 2024-10-29 - 2024-10-29, IMO24
 Jalaal Mazi, U of Amsterdam; 2024-09-07 - 2024-09-13, DFC24
 Jamali Safa, Northeastern; 2024-09-06 - 2024-09-13, DFC24
 Jana Debayan, SINP, Kolkata; 2024-08-18 - 2024-08-31, DFC24School
 Janquart Justin, UCLouvain; 2024-12-09 - 2024-12-14, COZ24
 Janssen Liesbeth, TU Eindhoven; 2024-04-02 - 2024-04-05, SCA24
 Jena Pratikshya, IIT Banaras; 2024-08-18 - 2024-08-31, DFC24School
 Jensen Kristan, U of Victoria; 2024-04-14 - 2024-04-19, CDFG24
 Jeon Jae-Hyung, Postech, Pohang; 2024-04-01 - 2024-04-07, SCA24
 Joseph Darin, U Bologna; 2024-09-23 - 2024-09-27, FPM24
 Jost Daniel, ENS Lyon; 2024-02-29 - 2024-03-07, SSG24
 Jow Dylan, Stanford U; 2024-12-08 - 2024-12-13, COZ24
 Jüngel Ansgar, TU Vienna; 2024-02-12 - 2024-02-16, CHS24; 2024-10-02 - 2024-10-14, 2024-12-06 - 2024-12-20, RIT0124
 Junghans Daniel, TU Vienna; 2024-07-01 - 2024-07-30, WTV24
 Kadar Istvan, U of Cambridge; 2024-05-12 - 2024-05-17, 2024-06-17 - 2024-06-21, FSD24
 Kahl Gerhard, TU Vienna; 2024-04-02 - 2024-04-05, SCA24
 Kalafatakis Nikolaos, U of Vienna; 2024-08-19 - 2024-08-30, DFC24School
 Kalck Martin, U of Graz; 2024-10-06 - 2024-10-09, 2024-10-16 - 2024-10-16, HBI24
 Kamal Ahmed Rakin, Masaryk U, Brno; 2024-07-04 - 2024-08-09, WTV24

Kantorovich Sofia, U of Vienna; 2024-04-02 - 2024-04-05, SCA24
Kapec Daniel, Harvard U, Cambridge; 2024-03-30 - 2024-04-07, CDFG24
Kaplan Ariel, Technion Haifa; 2024-03-03 - 2024-03-07, SSG24
Karapetyants Mikhail, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Karas Vladimir, CAS AI, Prague; 2024-12-09 - 2024-12-13, COZ24
Katsnelson Mikhail, Radboud U; 2024-09-22 - 2024-09-27, FPM24
Kauers Manuel, JKU, Linz; 2024-10-07 - 2024-10-18, HBI24
Kawanoue Hiraku, Chubu U, Kasugai City; 2024-10-04 - 2024-10-19, HBI24
Kee Hae-Young, U Toronto; 2024-09-22 - 2024-09-26, FPM24
Kehle Christoph, MIT, Cambridge; 2024-05-12 - 2024-05-18, FSD24
Kellay Hamid, LOMA, CNRS, Bordeaux; 2024-04-02 - 2024-04-05, SCA24
Kellner Jakob, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Kempe Julia, CIMS, New York; 2024-12-06 - 2024-12-08, EM24
Kennedy Juliette, U Helsinki; 2024-06-23 - 2024-06-28, SSM24
Kervyn Xavier, LMU Munich; 2024-04-07 - 2024-04-13, CDFG24
Ketterer Christian, ALU Freiburg; 2024-05-20 - 2024-05-25, KDR24
Khaliullin Giniyat, MPI Stuttgart; 2024-09-22 - 2024-09-27, FPM24
Khmelevskiy Sergii, TU Vienna; 2024-09-23 - 2024-09-27, FPM24
Killip Rowan, UCLA; 2024-06-09 - 2024-06-22, FSD24
Kim Bongjae, KNU, Daegu; 2024-09-22 - 2024-09-28, FPM24
Kim Jungho, Argonne National Laboratory; 2024-09-23 - 2024-09-28, FPM24
Kim Yong Baek, U Toronto; 2024-09-22 - 2024-09-26, FPM24
Kivimäki Siiri, U Helsinki; 2024-06-23 - 2024-06-29, SSM24
Klein Christian, U of Burgundy, Dijon; 2024-05-21 - 2024-05-24, FSD24
Koch Herbert, U Bonn; 2024-05-12 - 2024-05-24, FSD24
Koivusalo Henna, U Bristol; 2024-03-18 - 2024-03-22, ZPS24
Kontsevich Maxim, IHES, Bures-sur-Yvette; 2024-10-15 - 2024-10-17, HBI24
Kopfer Eva, HCM, Bonn; 2024-05-20 - 2024-05-23, KDR24
Korzyński Mikołaj, CFT PAN, Warsaw; 2024-12-08 - 2024-12-14, COZ24
Koschat Lukas, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Kostrzon Jan, U Warsaw; 2024-06-23 - 2024-07-06, SSM24
Kotov Alexei, U Hradec Králové; 2024-10-18 - 2024-10-27, SRF0324
Koutschan Christoph, RICAM, Linz; 2024-10-07 - 2024-10-18, HBI24
Kowalczyk Michal, U de Chile, Santiago; 2024-05-12 - 2024-05-18, FSD24
Kowalski Matthew, UCLA; 2024-05-12 - 2024-05-20, FSD24
Kozłowska Mariana, KIT, Karlsruhe; 2024-03-03 - 2024-03-08, SSG24
Kraft Daniela, Leiden U; 2024-04-02 - 2024-04-04, SCA24
Krajewski Thomas, U Aix-Marseille; 2024-07-27 - 2024-08-10, 2024-08-19 - 2024-08-31, 2024-12-16 - 2024-12-20, RIT0524, 2024-07-25 - 2024-07-28, WBS24
Krämer Martina, U Mainz; 2024-10-20 - 2024-10-25, ESL01124
Krapf Diego, CSU, Fort Collins; 2024-04-01 - 2024-04-05, SCA24
Krattenthaler Christian, U of Vienna; 2024-10-07 - 2024-10-19, HBI24
Kravets Nina, LOMA, CNRS, Bordeaux; 2024-04-02 - 2024-04-05, SCA24
Kremp Helena, TU Vienna; 2024-02-13 - 2024-02-16, CHS24
Kreuzer Philipp, BRG Graz, Petersgasse; 2024-06-19 - 2024-06-22, IMO24
Krieger Joachim, EPFL, Lausanne; 2024-06-10 - 2024-06-14, FSD24
Kröncke Klaus, KTH Stockholm; 2024-06-08 - 2024-06-21, FSD24
Kruschewski Jan, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Kubicek Valentina, BRG Schloss Wagrain Vöcklabruck; 2024-06-19 - 2024-06-22, 2024-10-27 - 2024-

10-31, IMO24

Kulkarni Vinayak Mallikarjun, JNCASR, Jakkur; 2024-04-02 - 2024-04-15, CDFG24
Kumar Kaushlendra, QMU London; 2024-06-07 - 2024-06-25, JRF0723
Kumhera Bernd, U of Vienna; 2024-03-18 - 2024-03-22, ZPS24
Kunde Philipp, Jagiellonian U, Krakow; 2024-03-17 - 2024-03-22, ZPS24
Kunzinger Michael, U of Vienna; 2024-04-29 - 2024-06-21, FSD24
Kurzthaler Christina, PKS-MPG, Dresden; 2024-04-02 - 2024-04-03, SCA24
Kuwae Kazuhiro, Fukuoka U; 2024-05-20 - 2024-05-25, KDR24
Kuznetsov Andrey, U of Vienna; 2024-04-02 - 2024-04-05, SCA24
Lahnsteiner Johannes, NORDITA, Stockholm; 2024-04-08 - 2024-04-12, CDFG24
Langmann Edwin, KTH Stockholm; 2024-07-24 - 2024-07-27, WBS24
Lardot Antoine, École Polytechnique, Palaiseau; 2024-06-10 - 2024-06-22, FSD24
Larfors Magdalena, Uppsala U; 2024-07-08 - 2024-07-19, WTV24
Laszlo Szilard Csaba, U Cluj-Napoca; 2024-06-02 - 2024-06-08, MB24
Le Tri Minh, TU Vienna; 2024-05-20 - 2024-05-24, KDR24
Lechner Gandalf, FAU Erlangen-Nürnberg; 2024-07-23 - 2024-07-26, WBS24
Lechtenfeld Olaf, Leibniz U Hannover; 2024-07-23 - 2024-07-26, WBS24
Lee Kiyeon, KAIST; 2024-05-12 - 2024-05-17, FSD24
Lee Seung-Joo, IBS, Daejeon; 2024-07-15 - 2024-07-20, WTV24
LeFloch Philippe G., Sorbonne U, Paris; 2024-05-14 - 2024-05-18, 2024-06-16 - 2024-06-21, FSD24
LeGoff Magali, U of Innsbruck; 2024-09-08 - 2024-09-12, DFC24
Leigh Rob, U Illinois; 2024-03-31 - 2024-04-06, CDFG24
Lemaitre Anael, U Gustave Eiffel, Paris; 2024-09-08 - 2024-09-13, DFC24; 2024-08-18 - 2024-09-13, DFC24School
Lenzmann Enno, U of Basel; 2024-05-06 - 2024-05-09, FSD24
Leocmach Mathieu, CNRS / U Lyon 1; 2024-09-08 - 2024-09-14, DFC24
Levajkovic Tijana, TU Vienna; 2024-02-12 - 2024-02-16, CHS24
Levene Stephen, U Texas, Dallas; 2024-03-03 - 2024-03-09, SSG24
Levinson Derek, UCLA; 2024-06-22 - 2024-07-07, SSM24
Levis Demian, U of Barcelona; 2024-04-01 - 2024-04-05, SCA24
Lezaic Marjana, FZ Jülich; 2024-09-22 - 2024-09-27, FPM24
Li Guoyin, UNSW Sydney; 2024-05-31 - 2024-06-08, MB24
Li Ruowei, MPI MIS, Leipzig; 2024-05-20 - 2024-05-25, KDR24
Li Tjonnie, KU Leuven; 2024-12-08 - 2024-12-15, COZ24
Li Warren, Princeton U; 2024-06-16 - 2024-06-22, FSD24
Li Xinwei, NUS, Singapore; 2024-09-22 - 2024-09-28, FPM24
Li Yixuan, MPP, Munich; 2024-07-14 - 2024-07-23, WTV24
Liberati Diego, National Research Council; 2024-04-02 - 2024-04-05, SCA24
Lietz Andreas, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Lin Xinyi, BNU, Beijing; 2024-12-08 - 2024-12-14, COZ24
Lindblad Hans, Johns Hopkins U, Baltimore; 2024-04-28 - 2024-06-21, FSD24
Ling Chengcheng, U Augsburg; 2024-02-12 - 2024-02-16, CHS24
Lizana Ludvig, Umeå U; 2024-03-06 - 2024-03-13, SSG24
Lo Rico, NBI, Copenhagen; 2024-12-09 - 2024-12-13, COZ24
Lockhart Guglielmo, Uni Bonn; 2024-07-26 - 2024-08-03, WTV24
Loges Gregory, KEK, Tsukuba; 2024-07-01 - 2024-07-12, WTV24
Loos Sarah, U of Cambridge; 2024-04-01 - 2024-04-05, SCA24
López Jose, ENS Lyon; 2024-08-18 - 2024-08-31, DFC24School
Lovrekovic Iva, TU Vienna; 2024-04-01 - 2024-04-27, CDFG24

Löwen Hartmut, U Düsseldorf; 2024-04-02 - 2024-04-05, SCA24
Lu Ethan, Stanford U; 2024-06-16 - 2024-06-22, FSD24
Luber Rafael, BG/BRG Graz Carneri; 2024-06-19 - 2024-06-22, 2024-10-27 - 2024-10-31, IMO24
Lučić Danka, JYU, Jyväskylä; 2024-05-20 - 2024-05-25, KDR24
Lücke Philipp, U Hamburg; 2024-06-23 - 2024-06-28, SSM24
Lührmann Jonas, TAMU, College Station; 2024-05-17 - 2024-07-11, FSD24
Luk Jonathan, Stanford U; 2024-06-16 - 2024-06-22, FSD24
Lukáčová Mária, U Mainz; 2024-10-02 - 2024-10-14, 2024-12-08 - 2024-12-20, RIT0124
Luke Russell, U Göttingen; 2024-06-03 - 2024-06-05, MB24
Luo Tom, CUHK Shenzhen; 2024-06-02 - 2024-06-08, MB24
Lupsasca Alex, Vanderbilt U, Nashville; 2024-12-09 - 2024-12-13, COZ24
Luque-Rioja Clara, U Complutense de Madrid; 2024-08-19 - 2024-08-31, DFC24School
Lüst Dieter, LMU Munich; 2024-07-15 - 2024-07-17, WTV24
Lüst Severin, CNRS, Montpellier; 2024-07-07 - 2024-07-13, WTV24
Maas Jan, ISTA, Klosterneuburg; 2024-02-12 - 2024-02-16, CHS24; 2024-05-21 - 2024-05-24, KDR24
Mackay Euan, U Dundee; 2024-08-18 - 2024-08-31, DFC24School
MacKintosh Frederick C., Rice U, Houston; 2024-09-07 - 2024-09-14, DFC24
Maghami Nooshin Darban, U of Sistan and Baluchestan; 2024-03-18 - 2024-03-22, ZPS24
Magnabosco Mattia, U Oxford; 2024-05-20 - 2024-05-25, KDR24
Magrinya Paula, U Autonoma de Madrid; 2024-04-01 - 2024-04-05, SCA24
Maire Raphaël, U Paris-Saclay; 2024-08-18 - 2024-08-31, DFC24School
Maitrejean Driss, ENS Paris; 2024-06-17 - 2024-06-21, 2024-05-14 - 2024-05-19, FSD24
Maity Swarnendu, JNCASR, Jakkur; 2024-09-08 - 2024-09-16, DFC24
Májek Juraj, ISTA, Klosterneuburg; 2024-04-02 - 2024-04-05, SCA24
Majumdar Sucheta, CPT, Marseille; 2024-04-03 - 2024-04-13, CDFG24
Makridou Andriana, UAM-CSIC, Madrid; 2024-07-01 - 2024-07-13, WTV24
Malézy Cyril, École Polytechnique, Palaiseau; 2024-06-15 - 2024-06-22, FSD24
Maliborski Maciej, U of Vienna; 2024-04-29 - 2024-06-21, FSD24; 2024-12-09 - 2024-12-13, COZ24
Malitskyi Yurii, U of Vienna; 2024-06-02 - 2024-06-08, MB24
Mamandur Kidambi Abhiram, MPI MIS, Leipzig; 2023-09-14 - 2023-12-14, 2024-04-06 - 2024-05-04, 2024-04-01 - 2024-04-06, JRF0823; 2024-10-05 - 2024-10-19, HBI24
Manini Davide, Technion Haifa; 2024-05-19 - 2024-05-26, KDR24
Manta Alessandro, U of Vienna; 2024-07-01 - 2024-08-04, WTV24
Marbach Sophie, CNRS, Paris; 2024-04-02 - 2024-04-05, SCA24
Marchesano Fernando, UAM-CSIC, Madrid; 2024-07-15 - 2024-07-27, WTV24
Markov Mikhail, U of Mons; 2024-04-06 - 2024-04-13, CDFG24
Martens Kirsten, CNRS, U Grenoble Alpes; 2024-09-08 - 2024-09-13, DFC24
Martinelli Francesco, ETH Zurich; 2024-09-22 - 2024-09-27, FPM24
Martinez Ryan, UC, Berkeley; 2024-06-16 - 2024-06-22, FSD24
Martucci Luca, U Padova; 2024-07-21 - 2024-07-27, WTV24
Masiero Federica, U Milano-Bicocca; 2024-02-12 - 2024-02-16, CHS24
Matulich Javier, UAM-CSIC, Madrid; 2024-04-09 - 2024-04-23, CDFG24
Mayo Manuel, US; 2024-08-18 - 2024-08-31, DFC24School
McNulty Michael, Michigan State U, East Lansing; 2024-04-30 - 2024-05-31, FSD24
Meadows Toby, UC Irvine; 2024-06-22 - 2024-06-29, SSM24
Mele Lea, U of Mons; 2024-04-07 - 2024-04-21, CDFG24
Melillo Stefania, ICS, CNR, Rome; 2024-04-01 - 2024-04-05, SCA24
Mellit Anton, U of Vienna; 2024-10-14 - 2024-10-18, HBI24
Menadeo Nicola, Scuole Normale Meridionlae, Napoli; 2024-12-08 - 2024-12-13, COZ24

Mertikopoulos Panayotis, CNRS, Grenoble; 2024-06-02 - 2024-06-08, MB24
Metzler Ralf, U of Potsdam; 2024-04-02 - 2024-04-05, SCA24
Miao Zheng, Lehigh U, Bethlehem; 2024-07-01 - 2024-07-19, WTV24
Mieling Thomas, U of Vienna; 2024-12-09 - 2024-12-13, COZ24
Millet Annie, U Paris Sorbonnes; 2024-02-11 - 2024-02-19, CHS24
Minasian Ruben, IPhT Saclay; 2024-07-30 - 2024-08-08, WTV24
Mitra Prahar, U of Amsterdam; 2024-04-01 - 2024-04-06, CDFG24
Mitrovic Vesna, Brown U, Providence; 2024-09-21 - 2024-09-28, FPM24
Mohamed Mariem Magdy Ali, QMU London; 2024-05-01 - 2024-06-30, JRF0224
Möller Jakob, U of Vienna; 2024-05-13 - 2024-06-21, FSD24
Moncrief Vincent, Yale U, New Haven; 2024-05-04 - 2024-06-30, FSD24
Mondal Saikat, IITK, Kanpur; 2024-04-15 - 2024-04-26, CDFG24
Mondino Andrea, U Oxford; 2024-05-20 - 2024-05-25, KDR24
Montecchio Luciano, TU Vienna; 2024-04-02 - 2024-04-22, CDFG24
Montee MurphyKate, Carleton, Northfield; 2024-05-23 - 2024-06-23, RIT0424
Montero Miguel, IFT UAM-CSIC, Madrid; 2024-06-30 - 2024-07-19, WTV24
Mordukhovich Boris, Wayne State U, Detroit; 2024-06-03 - 2024-06-08, MB24
Moreno Miguel, U Helsinki; 2024-06-22 - 2024-06-28, SSM24
Moretti Marco, Politecnico Milano; 2024-09-25 - 2024-09-27, FPM24
Moritz Jakob, CERN, Geneva; 2024-07-27 - 2024-08-04, WTV24
Morozov Alexandre, Rutgers U; 2024-03-10 - 2024-03-16, SSG24
Morpurgo Alberto, U of Geneva; 2024-09-22 - 2024-09-25, FPM24
Moscatelli Frederick, U of Vienna; 2024-04-29 - 2024-06-21, FSD24
Motohashi Hayato, Kogakuin U; 2024-12-08 - 2024-12-14, COZ24
Much Albert, U Leipzig; 2024-07-23 - 2024-07-27, WBS24
Münch Florentin, MPI MIS, Leipzig; 2024-05-20 - 2024-05-25, KDR24
Munoz Claudio, U de Chile, Santiago; 2024-06-16 - 2024-06-22, FSD24
Murali Ashwin, Birla Institute of Technology and Science, Pilani; 2024-04-14 - 2024-04-26, CDFG24
Muraveva Valeriia, U of Potsdam; 2024-08-18 - 2024-09-01, DFC24School
Muroi Toshihiko, U Tokyo; 2024-09-22 - 2024-09-28, FPM24
Muscolino Federica, San Sebastian U; 2024-04-15 - 2024-04-25, CDFG24
Nakanishi Kenji, Kyoto U; 2024-05-13 - 2024-05-19, FSD24
Nandi Saroj Kumar, Tata IFR, Hyderabad; 2024-09-08 - 2024-09-21, DFC24
Narváez Macarro Luis, U of Sevilla; 2024-10-04 - 2024-10-14, HBI24
Necoara Ion, U Politehnica Bucharest; 2024-06-03 - 2024-06-08, MB24
Nedkova Petya, Sofia U; 2024-12-08 - 2024-12-14, COZ24
Nenov Rossen, Acoustics Research Institute, Vienna; 2024-06-03 - 2024-06-07, MB24
Nguyen Kevin, ULB, Brussels; 2024-04-01 - 2024-04-06, CDFG24
Nicol Matthew, U of Houston; 2024-03-17 - 2024-03-23, ZPS24
Nicolae Adriana, Babes-Bolyai U, Cluj-Napoca; 2024-06-02 - 2024-06-08, MB24
Niemi Antti, NORDITA, Stockholm; 2024-04-02 - 2024-04-05, SCA24
Nikolic Branislav, U Delaware; 2024-09-22 - 2024-09-29, FPM24
Nordenskiöld Lars, NTU Singapore; 2024-03-02 - 2024-03-08, SSG24
Novo João, U of Aveira; 2024-12-08 - 2024-12-14, COZ24
Nowbagh Abhimanyu, U Düsseldorf; 2024-04-01 - 2024-04-05, SCA24
Nualart Eulalia, U of Barcelona; 2024-02-12 - 2024-02-15, CHS24
Oancea Marius A., U of Vienna; 2024-12-09 - 2024-12-13, COZ24
Obers Niels, NBI, Copenhagen; 2024-04-02 - 2024-04-04, CDFG24
Obied Georges, U Oxford; 2024-07-14 - 2024-07-20, WTV24

O'Connor Josh, U of Mons; 2024-04-07 - 2024-04-13, CDFG24
Ofner Maximilian, U of Vienna; 2024-04-29 - 2024-06-21, FSD24
Oh Sung-Jin, UC, Berkeley; 2024-05-12 - 2024-05-24, FSD24
Oh Tadahiro, U of Edinburgh; 2024-06-16 - 2024-06-22, FSD24
Ohanyan Argam, U of Vienna; 2024-05-19 - 2024-05-26, KDR24
Ohta Shin-ichi, U Osaka; 2024-05-20 - 2024-05-25, KDR24
Oling Gerben, U of Edinburgh; 2024-04-01 - 2024-04-07, CDFG24
Olivares Sánchez Héctor Raúl, U of Aveira; 2024-12-09 - 2024-12-15, COZ24
Olsen Thomas, TU Denmark, Kongens Lyngby; 2024-09-24 - 2024-09-27, FPM24
Olson Wilma, Rutgers U; 2024-03-03 - 2024-03-08, SSG24
Ondreját Martin, Czech Academy of Sciences, Prague; 2024-02-12 - 2024-02-16, CHS24
Onufriev Alexey, Virginia Tech; 2024-03-03 - 2024-03-08, SSG24
Orlando Federico, Politecnico Milano; 2024-09-23 - 2024-09-27, FPM24
Orozco Modesto, IRB, Barcelona; 2024-03-01 - 2024-03-07, SSG24
Orrieri Carlo, U of Pavia; 2023-02-11 - 2023-02-15, CHS24
Ortellado Laureano, CNRS - U Grenoble Alpes; 2024-08-18 - 2024-08-31, DFC24School
Ostermann Matthias, U of Vienna; 2024-05-13 - 2024-06-21, FSD24
Paban Sonia, Harvard U, Cambridge; 2024-07-07 - 2024-07-18, WTV24
Padgett Adele, U of Vienna; 2024-10-07 - 2024-10-19, HBI24
Pagnini Gianni, BCAM, Bilbao; 2024-04-01 - 2024-04-05, SCA24
Pal Sourav, SINP, Kolkata; 2024-08-18 - 2024-08-31, DFC24School
Palumbo Giandomenico, DIAS, Dublin; 2024-04-23 - 2024-04-26, CDFG24
Panchenko Anna, Queen's U, Kingston; 2024-03-03 - 2024-03-15, SSG24
Pang Jong-Shi, U of Southern California, Los Angeles; 2024-05-31 - 2024-06-07, MB24
Pannier Michel, U Napoli; 2024-04-07 - 2024-04-14, CDFG24
Pano Yorgo, École Polytechnique, Palaiseau; 2024-04-02 - 2024-04-05, CDFG24
Paramakanti Arun, U Toronto; 2024-09-22 - 2024-09-28, FPM24
Parameswaran Susha, U Liverpool; 2024-07-10 - 2024-07-24, WTV24
Parra de Freitas Hector, Harvard U, Cambridge; 2024-07-07 - 2024-07-13, WTV24
Parrini Noémie, U of Mons; 2024-04-07 - 2024-04-19, CDFG24
Pasterski Sabrina, Perimeter Institute, Waterloo; 2024-04-22 - 2024-04-26, CDFG24
Pastore Raffaele, Naples U; 2024-09-10 - 2024-09-14, DFC24
Pausader Benoit, Brown U, Providence; 2024-05-26 - 2024-06-22, FSD24
Pauwels Edouard, TSE, Toulouse; 2024-06-02 - 2024-06-07, MB24
Pavarini Eva, FZ Jülich; 2024-09-22 - 2024-09-27, FPM24
Paycha Sylvie, U of Potsdam; 2024-07-24 - 2024-07-26, WBS24
Pekar Simon, SISSA, Trieste; 2024-03-31 - 2024-04-28, CDFG24
Pène Françoise, UBO, Brest; 2024-03-17 - 2024-03-29, ZPS24
Peng Bo, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Perales Raquel, CIMAT, Guanajuato; 2024-05-20 - 2024-05-24, KDR24
Perez Alfredo, CECS, Valdivia; 2024-04-15 - 2024-04-27, CDFG24
Pérez Sánchez Carlos, U Heidelberg; 2024-07-27 - 2024-08-10, 2024-08-19 - 2024-08-31, 2024-12-16 - 2024-12-20, RIT0524
Perlick Volker, U Bremen; 2024-12-08 - 2024-12-14, COZ24
Persson Tomas, Lund U; 2024-03-17 - 2024-03-21, ZPS24
Peruani Fernando, U of Cergy-Pontoise; 2024-04-02 - 2024-04-06, SCA24
Petkou Anastasios, Aristotle U of Thessaloniki; 2024-03-31 - 2024-04-07, CDFG24
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Petropoulos Marios, École Polytechnique, Palaiseau; 2024-04-01 - 2024-04-09, CDFG24

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Phalempin Maxence, U degli Studi di Firenze; 2024-03-17 - 2024-03-22, ZPS24
Philipp Dennis, ZARM, Bremen; 2024-12-08 - 2024-12-11, COZ24
Pichon Eric, MPI MIS, Leipzig; 2024-10-04 - 2024-10-13, HBI24
Picozzi Silvia, CNR-SPIN, Chieti; 2024-09-24 - 2024-09-26, FPM24
Pihlajamaa Ilian, TU Eindhoven; 2024-04-01 - 2024-04-07, SCA24
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Pinar Mustafa, Bilkent U, Ankara; 2024-06-02 - 2024-06-08, MB24
Pinheiro Diana, Vienna Biocenter; 2024-09-09 - 2024-09-13, DFC24; 2024-08-30 - 2024-08-30, DFC24School
Pinto Diogo, U Roma 1; 2024-09-08 - 2024-09-14, DFC24
Pinto Martin, U de Chile, Santiago; 2024-08-18 - 2024-09-01, DFC24School
Pittalis Stefano, CNRNANO, Modena; 2024-09-22 - 2024-09-27, FPM24
Plumb Kemp, Brown U, Providence; 2024-09-23 - 2024-09-28, FPM24
Pong Ting Kei, PolyU, Hong Kong; 2024-06-02 - 2024-06-08, MB24
Porrati Massimo, NYU, New York; 2024-04-14 - 2024-04-21, CDFG24
Posch Alexander, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Possobon Renata, MPI MIS, Leipzig; 2024-05-20 - 2024-05-25, KDR24
Pourovskii Leonid, École Polytechnique, Palaiseau; 2024-09-22 - 2024-09-27, FPM24
Pozzan Elena, U Torino; 2024-06-23 - 2024-06-28, SSM24
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Prohazka Stefan, U of Vienna; 2024-04-01 - 2024-04-26, CDFG24; 2024-07-01 - 2024-08-09, WTV24
Puhm Andrea, U of Amsterdam; 2024-04-01 - 2024-04-03, CDFG24
Pulita Andrea, U Grenoble Alpes; 2024-10-06 - 2024-10-19, HBI24
Pultar Dominik, BRG Wien 6; 2024-06-19 - 2024-06-21, 2024-10-28 - 2024-10-31, IMO24
Puosi Francesco, U Gustave Eiffel, Paris; 2024-09-08 - 2024-09-15, DFC24
Pynn-Coates Nigel, U of Vienna; 2024-10-07 - 2024-10-19, HBI24
Quattrocchi Filippo, ISTA, Klosterneuburg; 2024-05-21 - 2024-05-24, KDR24
Quilliam Jeffrey, U of Sherbrooke; 2024-09-23 - 2024-09-27, FPM24
Raclariu Ana-Maria, U of Amsterdam; 2024-04-01 - 2024-04-06, CDFG24
Rączka Feliks, IMPAN, Warsaw; 2024-10-06 - 2024-10-19, HBI24
Rainer Armin, U of Vienna; 2024-10-07 - 2024-10-19, HBI24
Rajaguru Muthusamy, Lehigh U, Bethlehem; 2024-07-01 - 2024-08-02, WTV24
Rajala Otto, U Helsinki; 2024-06-23 - 2024-06-28, SSM24
Raml Thomas, MPP, Munich; 2024-07-15 - 2024-07-19, WTV24
Ramos Laurence, CNRS, Montpellier; 2024-09-08 - 2024-09-14, DFC24; 2024-08-17 - 2024-08-24, DFC24School
Ravanpak Zohreh, WU of Timisoara; 2024-10-14 - 2024-12-20, SRF0324
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Rees-Zimmerman Clare, U Oxford; 2024-08-18 - 2024-08-31, DFC24School
Rejzner Kasia, U of York; 2024-07-23 - 2024-07-27, WBS24
Rezzolla Luciano, Goethe U Frankfurt; 2024-12-08 - 2024-12-11, COZ24
Richtarik Peter, KAUST, Thuwal; 2024-06-02 - 2024-06-07, MB24
Righi Nicole, KCL, London; 2024-07-08 - 2024-07-20, WTV24
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Rioseco Paola, U de Chile, Santiago; 2024-06-17 - 2024-06-21, FSD24
Rockafellar Terry Ralph, U of Washington, Seattle; 2024-05-31 - 2024-06-07, MB24
Röckner Michael, U of Bielefeld; 2024-02-13 - 2024-02-18, CHS24
Rodgers Ronnie, NORDITA, Stockholm; 2024-04-08 - 2024-04-13, CDFG24
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Ruiz Ignacio, UAM-CSIC, Madrid; 2024-07-07 - 2024-07-20, WTV24
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Ryu Ernest, Seoul National U; 2024-06-02 - 2024-06-08, MB24
Saarinen Tapio, U Helsinki; 2024-06-23 - 2024-06-29, SSM24
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Saha Amartya, IITK, Kanpur; 2024-04-13 - 2024-04-27, CDFG24
Sako Akifumi, Tokyo U of Science; 2024-06-09 - 2024-06-12, IS24; 2024-07-22 - 2024-07-27, WBS24
Salez Thomas, CNRS, Bordeaux; 2024-04-01 - 2024-04-04, SCA24
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Salluce Domenico Giuseppe, U of Udine; 2023-04-13 - 2023-04-20, CDFG24
Salvy Bruno, Inria Lyon; 2024-10-06 - 2024-10-11, HBI24
Salzer Jakob, ULB, Brussels; 2024-04-01 - 2024-04-07, CDFG24
Sämann Clemens, U Oxford; 2024-05-20 - 2024-05-24, KDR24; 2024-06-10 - 2024-06-14, FSD24
Samsing Johan, NBI, Copenhagen; 2024-12-09 - 2024-12-11, COZ24
Sanchez-Moreno Royer Pablo, U Gustave Eiffel, Champs-sur-Marne; 2024-08-17 - 2024-09-02, DFC24School
Sánchez Muñoz Victoria, NUI Galway; 2024-04-30 - 2024-07-01, JRF0324
Sanna Samuele, U Bologna; 2024-09-22 - 2024-09-27, FPM24
Santiago Suárez Juan M, U Paris Cité; 2024-06-23 - 2024-06-29, SSM24
Sanwal Akansha, U of Innsbruck; 2024-05-12 - 2024-05-14, FSD24
Sappl Lisa, U of Vienna; 2024-08-19 - 2024-08-30, DFC24School
Sastry Srikanth, JNCASR, Jakkur; 2024-09-08 - 2024-09-13, 2024-09-13 - 2024-09-17, DFC24
Sauer Florian, U of Vienna; 2024-08-19 - 2024-08-31, DFC24School
Saussol Benoit, U Aix-Marseille; 2024-03-17 - 2024-03-22, ZPS24
Savaré Giuseppe, U Bocconi, Milano; 2024-05-20 - 2024-05-24, KDR24
Scalfi Laura, FU Berlin; 2024-04-02 - 2024-04-05, SCA24
Scalisi Marco, MPP, Munich; 2024-07-14 - 2024-07-19, WTV24
Scarpa Luca, Politecnico Milano; 2024-02-08 - 2024-02-16, CHS24
Schachner Andreas, LMU Munich; 2024-07-08 - 2024-07-29, WTV24
Schesler Eduard, FernU Hagen; 2024-05-01 - 2024-06-30, JRF0424
Schichl Hermann, U of Vienna; 2024-06-04 - 2024-06-06, MB24
Schicho Josef, JKU, Linz; 2024-10-10 - 2024-10-18, HBI24
Schiessel Helmut, TU Dresden; 2024-03-01 - 2024-03-10, SSG24

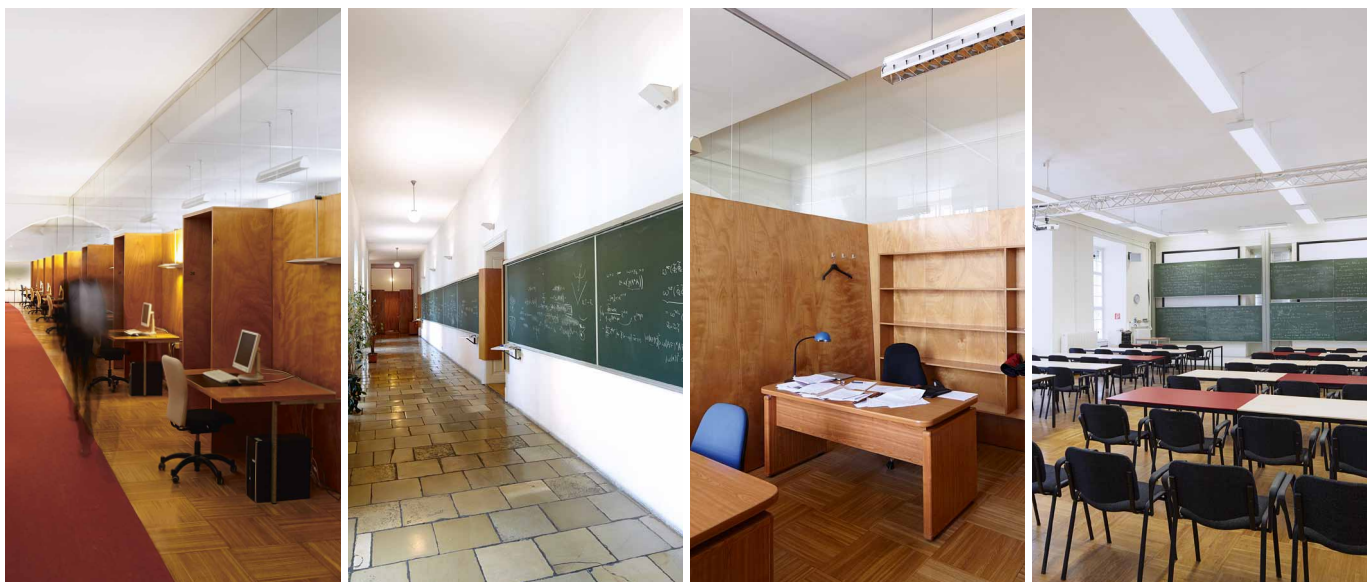
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Schindler Chiara, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Schindler Ralf, WWU Münster; 2024-06-21 - 2024-07-01, SSM24
Schindler Tanja, Jagiellonian U, Krakow; 2023-03-18 - 2023-03-22, ZPS24
Schlag Wilhelm, Yale U, New Haven; 2024-05-25 - 2024-06-06, FSD24
Schlick Tamar, NYU, New York; 2024-03-01 - 2024-03-09, SSG24
Schlosser Michael, U of Vienna; 2024-10-06 - 2024-10-20, HBI24
Schlue Volker, U Melbourne; 2024-05-12 - 2024-05-19, 2024-06-02 - 2024-06-22, FSD24
Schlutzenberg Farmer, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Schmeiser Christian, U of Vienna; 2024-02-12 - 2024-02-16, CHS24
Schmid Tobias, EPFL, Lausanne; 2024-05-10 - 2024-05-24, FSD24
Schmidt Cernohorska Marketa, Academy of Sciences, Prague; 2024-08-19 - 2024-08-30, DFC24School
Schmitt Marita, WIAS, Berlin; 2024-07-23 - 2024-07-28, IS24
Schomerus Volker, DESY Hamburg; 2024-07-24 - 2024-07-26, WBS24
Schörkhuber Birgit, U of Innsbruck; 2024-05-12 - 2024-05-17, FSD24
Schrittesser David, HIT, Harbin; 2024-06-24 - 2024-06-29, SSM24
Schrott Stefan, U of Vienna; 2024-02-12 - 2024-02-16, CHS24
Schuch Norbert, U of Vienna; 2024-12-06 - 2024-12-07, EM24
Schuh Katharina, TU Vienna; 2024-02-12 - 2024-02-16, CHS24
Schütz Robert, UC, Berkeley; 2024-06-23 - 2024-07-06, SSM24
Schwermer Joachim, U of Vienna; 2024-12-05 - 2024-12-08, EM24
Sciortino Alfredo, CEA, ESPCI, Paris; 2024-04-02 - 2024-04-05, SCA24; 2024-12-06 - 2024-12-08, EM24
Scita Giorgio, IFOM, Milan; 2024-09-09 - 2024-09-15, DFC24
Secchi Eleonora, ETH Zurich; 2024-08-25 - 2024-08-29, DFC24School
Sedlmayer Michael, U of Vienna; 2024-06-03 - 2024-06-07, MB24
Semola Daniele, ETH Zurich; 2024-05-22 - 2024-05-25, KDR24
Sengo Ivo, UAVR; 2024-12-08 - 2024-12-14, COZ24
Senthilkumar Suganthan, PKS-MPG; 2024-08-18 - 2024-08-31, DFC24School
Seraj Ali, ULB, Brussels; 2024-04-16 - 2024-04-26, CDFG24
Sethi Savdeep, U of Chicago; 2024-07-14 - 2024-07-21, WTV24
Shah Tanushree, U of Glasgow; 2024-02-01 - 2024-05-01, JRF0324
Shahshahani Sohrab, UMass Amherst; 2024-05-11 - 2024-05-25, FSD24
Shanmugalingam Nageswari, U of Cincinnati; 2024-05-20 - 2024-05-25, KDR24
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Shi Yihong, Max Planck Institute for Dynamics and Self-Organization; 2024-04-02 - 2024-04-05, SCA24
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Siampos Konstantinos, Aristotle U of Thessaloniki; 2024-04-07 - 2024-04-12, CDFG24
Sieling Christoph, U of Jena; 2024-04-07 - 2024-04-14, CDFG24
Simon Walter, U of Vienna; 2024-12-09 - 2024-12-13, COZ24
Sinapova Dima, Rutgers U; 2024-06-23 - 2024-06-28, SSM24
Singer Michael, NC State U, Raleigh; 2024-10-06 - 2024-10-20, HBI24
Singewald Tanja Denise, JKU, Linz; 2024-09-09 - 2024-09-13, DFC24
Singh Amartya Harsh, SISSA, Trieste; 2024-04-06 - 2024-04-21, CDFG24
Siskind Benjamin, TU Vienna; 2024-06-24 - 2024-06-28, SSM24
Skarke Harald, TU Vienna; 2024-07-01 - 2024-08-09, WTV24
Sknepnek Rastko, U Dundee; 2024-08-26 - 2024-08-31, DFC24School

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Smrek Jan, U of Vienna; 2024-03-04 - 2024-03-15, SSG24
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Soffer Avy, Rutgers U; 2024-06-15 - 2024-06-20, FSD24
Soler Pablo, U de Oviedo; 2024-07-13 - 2024-07-25, WTV24
Sollich Peter, Georg-August-U, Göttingen; 2024-09-08 - 2024-09-14, DFC24
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Sorouri Shervin, U Münster; 2024-06-23 - 2024-07-05, SSM24
Spitz Martin, Bielefeld U; 2024-06-09 - 2024-06-22, FSD24
Sposini Vittoria, U of Vienna; 2024-04-01 - 2024-04-05, SCA24
Staño Roman, U of Vienna; 2024-08-19 - 2024-08-30, DFC24School
Stark Holger, TU Berlin; 2023-03-24 - 2023-04-05, SCA24
Staudigl Mathias, U of Mannheim; 2024-05-30 - 2024-06-07, MB24
Steel John, UC, Berkeley; 2024-06-22 - 2024-07-06, SSM24
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Stefanelli Ulisse, U of Vienna; 2024-02-12 - 2024-02-16, CHS24; 2024-05-23 - 2024-05-24, KDR24
Stefanescu Eduard, TU Graz; 2024-02-12 - 2024-02-16, CHS24
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Stieberger Stephan, MPP, Munich; 2024-04-14 - 2024-04-24, CDFG24
Straffellini Cesare, U of Barcelona; 2024-06-23 - 2024-07-06, SSM24
Strehn Jan, BG/BRG/WRG Wien 13; 2024-06-19 - 2024-06-21, IMO24
Streltsov Sergey; 2024-09-21 - 2024-09-28, FPM24
Strobl Thomas, U Lyon; 2024-10-07 - 2024-12-28, SRF0324; 2024-07-24 - 2024-07-26, WBS24; 2024-08-28 - 2024-09-06, IS24
Strohmaier Alexander, U Hannover; 2024-07-23 - 2024-07-27, WBS24
Sturm Karl-Theodor, U Bonn; 2024-05-20 - 2024-05-23, KDR24
Suszek Rafał R., U Warsaw; 2024-11-01 - 2024-11-12, SRF0324
Suyamprakasam Sudhagar, NCAC PAS, Warsaw; 2024-12-08 - 2024-12-14, COZ24
Suzuki Kohei, Durham U; 2024-05-20 - 2024-05-25, KDR24
Switzer Corey, U of Vienna; 2024-06-28 - 2024-06-28, SSM24
Swygert Sarah, CSU, Fort Collins; 2024-03-03 - 2024-03-13, SSG24
Szabo Richard, Heriot-Watt U, Edinburgh; 2024-07-24 - 2024-07-27, WBS24
Szabó Szilárd, ELTE Budapest; 2024-10-17 - 2024-10-17, HBI24
Szasz Domokos, BME, Budapest; 2024-03-16 - 2024-03-22, ZPS24
Szeftel Jérémie, Sorbonne U, Paris; 2024-06-16 - 2024-06-20, FSD24
Tadros Poula, Charles U, Prague; 2024-04-02 - 2024-04-26, CDFG24
Tamm Mikhail, Tallinn U; 2024-03-03 - 2024-03-10, SSG24
Tan Wen-Di, ULB, Brussels; 2024-04-21 - 2024-04-27, CDFG24
Tang Yunqing, CalTech; 2024-10-06 - 2024-10-19, HBI24
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Tatar Radu, U Liverpool; 2024-07-01 - 2024-07-11, WTV24
Tataru Daniel, UC, Berkeley; 2024-05-01 - 2024-05-26, FSD24
Taujanskas Greg, U of Cambridge; 2024-04-15 - 2024-04-19, CDFG24
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Trang Nam, UNT, Denton; 2024-06-24 - 2024-07-05, SSM24
Trappe Veronique, U of Fribourg; 2024-09-08 - 2024-09-14, DFC24
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