INSTITUT
MITTAG-LEFFLER

THE ROYAL SWEDISH ACADEMY OF SCIENCES

Annual Report 2022

Institut Mittag-Leffler

Institut Mittag-Leffler is an international center for research and postdoctoral training in the mathematical sciences. It was founded in 1916 by professor Gösta Mittag-Leffler and is the oldest mathematics research institute in the world. It operates under the auspices of the Royal Swedish Academy of Sciences and is governed by a board with representatives from all Nordic countries.

The premises of the institute encompass several buildings: the main building with library, offices for the staff, and office and discussion spaces for researchers, a seminar room building, and five other buildings with housing facilities for visiting researchers.

The mission of Institut Mittag-Leffler is to support international top-level research in mathematics, with special attention to the development in the Nordic countries. The institute is a hub for the international mathematical research community and for mathematicians in the Nordic countries.

The main activities include research programs, conferences, workshops, seminars and summer schools, that all aim to conduct and develop current mathematical research. Research programs and conferences have organizing committees approved by the IML board. Based on the recommendations of the organizing committees, senior and junior mathematicians are invited to stay and work at the institute. Junior program participants (postdocs or advanced PhD students) are offered fellowships to finance their stays. There are yearly calls, and fellowship recipients are chosen by the organizing committee together with the director. Although senior and junior mathematicians from the Nordic countries are given some priority, the institute works actively to ensure diversity among program participants.

The institute also publishes two mathematical journals, *Acta Mathematica* (founded by Gösta Mittag-Leffler in 1882) and *Arkiv för matematik* (founded in 1903). *Acta Mathematica* is one of a small number of exclusive world-leading international mathematics research journals and one of the highest rated journals in the mathematical world. All volumes of these journals are freely available online.

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Content

Annual Report 2022

Photo: Cristian Wahlén

The Director of Institut Mittag-Leffler,

A BRIEF REVIEW OF 2022

During 2022, the institute has continued its efforts to attract world leading mathematicians to programs, as well as the dialogue with Nordic mathematics departments, other international mathematics research institutes, the Swedish Research Council, the Wallenberg Foundations, and the Verg Foundation. Editorial work with *Acta Mathematica* and *Arkiv för Matematik* during the year has been successful, both journals perform well and continue to attract very good submissions. The cooperation with International Press continues.

During 2022, the institute organized two research programs: *Higher algebraic structures in algebra*, *topology and geometry* and *Geometric Aspects of Nonlinear Partial Differential Equations*.

During 2022, problems caused by the covid pandemic gradually decreased, two of the summer conferences had to go on-line only, but since then things are back to normal. Many of the new practices we established during the pandemic are still used. For example, programs and conferences are organized using the IML app which together with the seamless zoom-integration of the seminar room has allowed for very good access for remote participants. This means in particular that program participants who cannot make it to the IML for the full duration of programs can still take active part in the research also when not physically present.

The institute works in close cooperation with *The Royal Swedish Academy of Sciences* and is involved in different Nordic and international collaborations. In March, the institute participated in the yearly meeting of ERCOM, a committee of the European Mathematical Society including around 30 European research institutes in mathematics, in Bilbao.

Institut Mittag-Leffler is very grateful to all those who have contributed during 2022. First and foremost, to all mathematicians who choose to conduct their research at the institute and to contribute to its scientific environment, especially to our colleagues in Sweden and other Nordic countries. We also thank all organizations who has contributed to us financially: The Academy of Finland, The Acta Mathematica Foundation, Anna-Greta and Holger Crafoord Foundation, Brummer & Partners, Chalmers/Gothenburg University, The Danish Mathematical Society, G S Magnuson Foundation, the Knut and Alice Wallenberg Foundation, Linköping University, Luleå University of Technology, Lund University, the Research Council of Norway, KTH Royal Institute of Technology, Jacob and Marcus Wallenberg's memorial foundation, Stockholm University, The Swedish Research Council, The Verg Foundation, Umeå University and Uppsala University.

Tobias Ekholm, *Director*

Photo: Cristian Wahlén

THE BOARD OF INSTITUT MITTAG-LEFFLER

The board of Institut Mittag-Leffler consists of representatives of the Nordic countries and members appointed by the class of mathematics of the Royal Swedish Academy of Sciences.

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MEETING OF MATHEMATICS DEPARTMENT CHAIRS AT INSTITUT MITTAG-LEFFLER

Institut Mittag-Leffler hosts a Nordic chair meeting yearly, inviting the heads of mathematical departments and the chairs of mathematical associations from the Nordic countries. The 2022 meeting was held on December 19 – 20 and attended by mathematics department chairs from seven Swedish, two Danish, two Norwegian, one Finnish, and one Icelandic university.

PUBLICATIONS

Acta Mathematica

2 volumes/year (4 issues, totally around 800 pages). The issues 228:1, 228:2, 229:1 and 229:2 were published including 9 articles in total.

EDITORIAL COMMITTEE

Editor-in-Chief:
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International Press of Boston, Inc.

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Kurt Johansson
KTH Royal Institute of Technology, Stockholm

Eero Saksman
University of Helsinki

Arkiv för matematik

1 volume/year (2 issues, around 400 pages)

The issues 60:1 and 60:2 were published including 19 articles in total.

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ANNA-GRETA AND HOLGER CRAFOORD FOUNDATION

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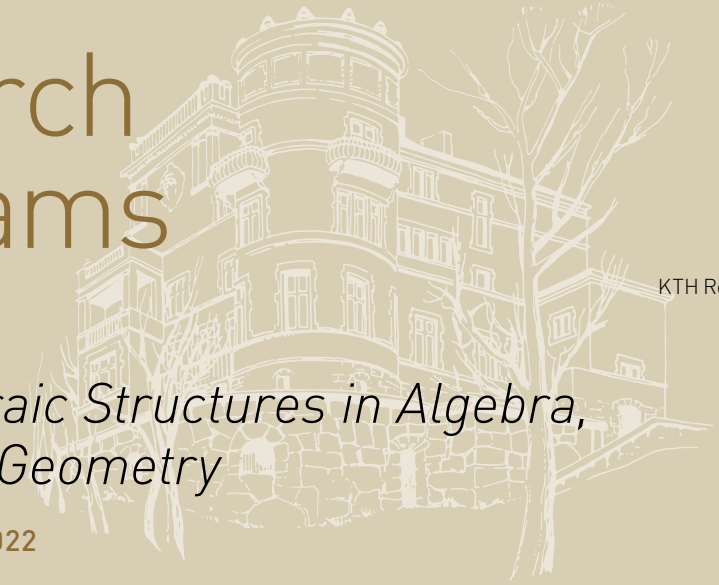
Research Programs



Higher Algebraic Structures in Algebra, Topology and Geometry

January 10–April 29, 2022

Organizers:

Gregory Arone
Stockholm University

Tilman Bauer
KTH Royal Institute of Technology

Alexander Berglund
Stockholm University

Søren Galatius
University of Copenhagen

Jesper Grodal
University of Copenhagen

Thomas Kragh
Uppsala University

SCIENTIFIC REPORT

Description of scientific area

This was a multifaceted program that brought together researchers from different branches of algebra, topology, and geometry where higher algebraic structures play a role, such as algebraic K-theory, operads, equivariant homotopy theory, infinity categories, and Floer homotopy theory. One of the goals was to get researchers from these different subfields to interact, and to find common projects or problems. A particular emphasis was put on getting the post-docs to interact with each other.

Milestones and achievements

Much progress was made by several researchers. Examples include the following: Breakthrough computations of algebraic K-groups of basic prime power local rings and related rings was made (by Antieau-Krause-Nikolaus). Methods and ideas from rational homotopy theory and deformation theory in characteristic zero were extended to the p-adic and integral setting (by Horel, Brantner, and Fresse). New results on rational cohomology of classifying spaces of fibrations were established (by Stoll and Berglund-Zeman). New results on spaces of automorphisms and embeddings of manifolds, employing various forms of functor calculi, concordance theory, configuration space methods, as well as new inventions such as the "Disc-structure space" were obtained (by Krannich, Kupers, Randal-Williams, Turchin, and Weiss), and on homological stability and stable cohomology for mapping class groups and congruence subgroups of special linear groups (by Randal-Williams, Wahl). Results on topological Hochschild and cyclic homology and factorization homology were extended from the classical to the equivariant setting (by Klang, Hess, Ramzi, Dotto, Bayindir, Hilman, Rognes, Lenz, Horev, Hebestreit). An interpretation of topological weak Jacobi forms of arbitrary weights and levels in terms of topological modular forms modules was found (by Bauer-Meier).

New directions

The program witnessed several new directions. Examples include the following. New models for rational homotopy types that synthesizes Quillen's and Sullivan's classical work with Getzler's Lie theory for L-infinity algebras (Vallette and Lucio). New approaches to formality of manifolds was found. (by Cirici, Milivojevic, Stelzig, and Zoller). First steps towards Floer homotopy of Chern-Simons theory were taken (by Kragh and Stoffregen) and progress on twisted S^1-spectra representing Seiberg-Witten theory (by Behrens-Hedenlund-Kragh) was made.

Successful seminars and/or workshops

There were 90 min research seminars every Tuesday and Thursday afternoon during the program. In these seminars, invited speakers from within the program spoke about their recent work. We encouraged the speakers to keep the first half of the talks expository. We also offered the opportunity to post preparatory reading assignments, all in order for the participants to get the most out of these talks. This worked very well, although the preparatory reading option was only used by some of the speakers. Most of the talks were given in-person (with a small number of exceptions) and was recorded and live-streamed to the remote audience. This setup worked very well.

There were seven special junior sessions on Fridays, where young researchers (usually post-docs) would give half-hour talks on their research in a more informal setting. Also these talks were recorded and live-streamed. As a consequence of the talks, every participant got the possibility to present their work, albeit briefly, something that is particularly important for junior researchers to increase their visibility and interactions.

Finally, there were further additional specialized talks that were often longer than the usual seminars and somewhat informal, inviting more discussion.

Specially invited participants and/or speakers

The following participants were invited to share their knowledge of research around the theme of the program:
Mohammed Abouzaid
Kathryn Hess
Thomas Nikolaus
Oscar Randal-Williams
Bruno Vallette and Nathalie Wahl

SEMINARS

JANUARY 11, 2022
Emily Riehl
Johns Hopkins University
Arrow induction and the dependent Yoneda lemma

JANUARY 13, 2022
Victor Turchin
Kansas State University
Smoothing theory deloopings of disk embedding and diffeomorphism spaces

JANUARY 14, 2022
Alice Hedenlund
Uppsala University
Spectral sequences via décalage

JANUARY 14, 2022
Niall Taggart
Utrecht University
Comparing functor calculi

JANUARY 14, 2022
Hadrien Espic
Stockholm University
Koszul Duality for Categories with a Fixed Object Set

JANUARY 14, 2022
Luca Pol
Universität Regensburg
Local Gorenstein duality in chromatic group cohomology

JANUARY 18, 2022
Joana Cirici
Universitat de Barcelona
A-infinity structures on almost complex manifolds

JANUARY 20, 2022
Geofforoy Horel
Université Paris 13
Finite type knot invariants and the Goodwillie-Weiss tower

JANUARY 21, 2022
Calista Bernard
University of Minnesota
Twisted homology operations

JANUARY 21, 2022
YajitJain
Brown University
Topologically trivial families of smooth h-cobordisms

JANUARY 21, 2022
Kevin Piterman
University of Buenos Aires
Topology and representation theory of the frame complex of unitary groups

JANUARY 21, 2022
Robin Sroka
McMaster University
On the high-dimensional rational cohomology of special linear groups

JANUARY 25, 2022
Oscar Randal-Williams
University of Cambridge
The Torelli Lie algebra

JANUARY 27, 2022
Alexander Kupers
University of Toronto
Embedding calculus for surfaces

FEBRUARY 1, 2022
Martin Markl
The Czech Academy of Sciences
Combinatorics of multilinear differential operators, or still another explanation of the ubiquity of Lie and strongly homotopy Lie algebras

FEBRUARY 3, 2022
Markus Hausmann
Stockholm University
Bordism of commuting involutions

FEBRUARY 8, 2022
Achim Krause
University of Münster
A spherical HKR theorem

FEBRUARY 10, 2022
Manuel Krannich
University of Münster
The Disc-structure space

FEBRUARY 11, 2022
Andrea Bianchi
University of Copenhagen
Symmetric groups, Hurwitz spaces and moduli spaces of surfaces

FEBRUARY 11, 2022
Tobias Lenz
Rheinische Friedrich-Wilhelms-Universität Bonn
G-global algebraic K-theory

FEBRUARY 11, 2022
Jack Davies
Utrecht University
Stable operations and topological modular forms

FEBRUARY 11, 2022
Aleksandar Milivojevic
Max Planck Institute
Formality and non-zero degree maps

FEBRUARY 15, 2022
Benoit Fresse
Université de Lille
Cochain models of operads and topological realizations of the graded Poisson operads

FEBRUARY 17, 2022
Vladimir Dotsenko
University of Strasbourg
DT invariants of symmetric quivers and the Koszul duality theory

FEBRUARY 18, 2022
Özgür Bayindir
Université Paris 13
Adjoining roots to ring spectra and algebraic K-theory

FEBRUARY 18, 2022
Sylvain Douteau
Université Grenoble Alpes
An illustration of stratified homotopy theory

FEBRUARY 18, 2022
Kaif Hilman
University of Copenhagen
Equivariant algebraic K-theory and multiplicative norms

FEBRUARY 18, 2022
Maxime Ramzi
University of Copenhagen
Galois descent in topological Hochschild homology

FEBRUARY 22, 2022
Thomas Nikolaus
University of Münster
Algebraic L-Theory

FEBRUARY 24, 2022
Stefan Behrens
Bielefeld University
Some thoughts about monopole h-invariants

FEBRUARY 25, 2022
Nils Prigge
Stockholm University
Characteristic classes of framed fibre bundles

FEBRUARY 25, 2022
Louis Hainaut
Stockholm University
Configuration spaces on a wedge of spheres

FEBRUARY 25, 2022
Guillaume Laplante-Anfossi
Université Sorbonne Paris Nord
Diagonals of polytopes and higher structures

FEBRUARY 25, 2022
Thomas Blom
Stockholm University
Replacing functors by enriched ones

MARCH 1, 2022
Fabian Hebestreit
University of Bonn
Symplectic groups and cobordism categories

MARCH 3, 2022
Dan Petersen
Stockholm University
Hyperelliptic curves, scanning, and moments of quadratic L-functions

MARCH 4, 2022
Thomas Kragh
Uppsala University
An Introduction to Symplectic Geometry for Algebraic Topologists

MARCH 8, 2022
Inbar Klang
Columbia University
Equivariant Hochschild theories from a shadow perspective

MARCH 10, 2022
Michael Weiss
University of Münster
Configuration space methods applied to automorphism groups of spheres

MARCH 15, 2022
Stefan Schwede
Universität Bonn
Global localization and equivariant Thom spectra

MARCH 17, 2022
Irakli Patchkoria
University of Aberdeen
Franke's conjecture and derived infinity categories

MARCH 22, 2022
Emanuele Dotto
University of Warwick
The geometric fixed points of real topological cyclic homology

MARCH 24, 2022
Lukas Brantner
University of Oxford / Université Paris-Saclay
Lie algebras, Galois theory, and deformations of Calabi-Yau varieties

MARCH 25, 2022
Asaf Horev
Stockholm University
Equivariant factorization homology

MARCH 25, 2022
Eva Belmont
University of California San Diego
v_1-periodic R-motivic homotopy groups

MARCH 25, 2022
Erik Lindell
Stockholm University
Abelian cycles in the homology of the Torelli group

MARCH 29, 2022
Bruno Vallette
Université Sorbonne Paris Nord
Higher Lie theory

MARCH 31, 2022
Natalia Castellana
Universitat Autònoma de Barcelona
Stratification for spaces with Noetherian mod p cohomology

APRIL 1, 2022
Josefien Kuijper
Stockholm University
A general descent principle for compact support extensions

APRIL 1, 2022
Victor Roca Lucio
Université Paris 13
The integration of curved absolute homotopy Lie algebras

APRIL 1, 2022
Robin Stoll
Stockholm University
The stable cohomology of self-equivalences of connected sums of products of spheres

APRIL 5, 2022
Sylvain Courte
Université Grenoble Alpes
Twisted generating functions and the nearby Lagrangian conjecture (I)

APRIL 5, 2022
Daniel Álvarez-Gavela
Massachusetts Institute of Technology
Twisted generating functions and the nearby Lagrangian conjecture (II)

APRIL 7, 2022
Mohammed Abouzaid
Columbia University
Complex cobordism, Hamiltonian loops and global Kuranishi charts

APRIL 12, 2022
John Rognes
University of Oslo
Algebraic K-theory of elliptic cohomology

APRIL 13, 2022
Matthew Stoffregen
Michigan State University
A Seiberg-Witten Floer stable homotopy type

APRIL 14, 2022
Nathalie Wahl
University of Copenhagen
A new proof of best slope stability for the mapping class group of surfaces

APRIL 19, 2022
Kathryn Hess
The École polytechnique fédérale de Lausanne
THH, shadows, and bicategorical traces

APRIL 21, 2022
Craig Westerland
University of Minnesota
Braided Hopf algebras, operads, and partitions

APRIL 26, 2022
Lennart Meier
Universiteit Utrecht
From elliptic genera to equivariant topological modular forms

APRIL 28, 2022
Paolo Salvatore
Università di Roma Tor Vergata
Hopf rings with divided powers and the cohomology of free E-infinity spaces

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Tomas Zeman
Stockholm University, Stockholm, Sweden

Research Programs

Geometric Aspects of Nonlinear Partial Differential Equations

August 29 - December 09, 2022

Organizers:

Panagiota Daskalopoulos
Columbia University

Alessio Figalli
ETH Zürich

Erik Lindgren
Uppsala University

Henrik Shahgholian
KTH Royal Institute of Technology

Susanna Terracini
University of Turin

SCIENTIFIC REPORT

Description of scientific area

The program aimed at the study of recent trends in non-linear partial differential equations, especially problems where geometric methods and approaches are considered as central tools.

Particular topics considered include: Fully nonlinear PDEs, regularity of free boundaries, optimal transport problems, geometric flows, functional inequalities and segregation/ interaction of species.

Milestones and achievements

The program witnessed several outstanding talks. For example, the colloquium talk of A. Figalli where he reported on recent joint work with Eberle and Weiss, concerning the solution of the classification of global solutions to the obstacle problems in dimension 3. This has been a challenging problem, and it goes back to Newton's work on no-gravity-in-cavity problems.

Other examples are the talks by Xavier Ros (awarded with the Gold Medal Guido Stampacchia), in which he spoke on recent progress on the regularity theory for non-local parabolic obstacle problems and by Panagiota Daskalopoulos (to receive the 2023 Ruth Lyttle Satter Prize) in which she spoke on ancient solutions to geometric flows. Other achievements include substantial progress on higher order Harnack principles via degenerate equations made by a group during their stay at the IML.

New directions

During the program new directions that probably can have bearing in the next few years have been discussed. One such direction is the concept of free boundaries in Sobolev maps, with constraints. Such problems where popular in early 1980's but were not pursued because of lack of techniques. With modern techniques in free boundary problems, it seems that several problems in this direction can be worked out and quite likely be solved. Another direction is the boundary Harnack principle and unique continuation properties that seem to link each other. In particular, the problem of nodal sets can be seen through the boundary Harnack principle and correspond to comparing zeros of solutions to PDEs. There was also substantial progress in nonlinear functional inequalities. A counterexample to a conjecture for infinity-ground states in a square was constructed explicitly. This explains why recent attempts to prove this conjecture has failed and also suggests new strategies to further understand the simplicity in convex sets. In addition, more general Hardy-Sobolev inequalities were discussed. These are L^q - L^p versions of the classical L^2 - L^2 Hardy inequality, where progress towards understanding how and why existence of extremals may or may not occur.

Successful seminars and/or workshops

There were four talks weekly, except during the special workshop weeks. A main focus was to give younger participants the opportunity to hold seminars and present their research, but there were also numerous seminars given by more senior participants.

There were two workshops during the program. The introductory workshop which included three mini courses and three invited talks by Mark Allen, Dennis Krivenstov, Rutgers, and Yannick Sire.

The second workshop included 14 scientific talks by, among others, Panagiota Daskalopoulos,

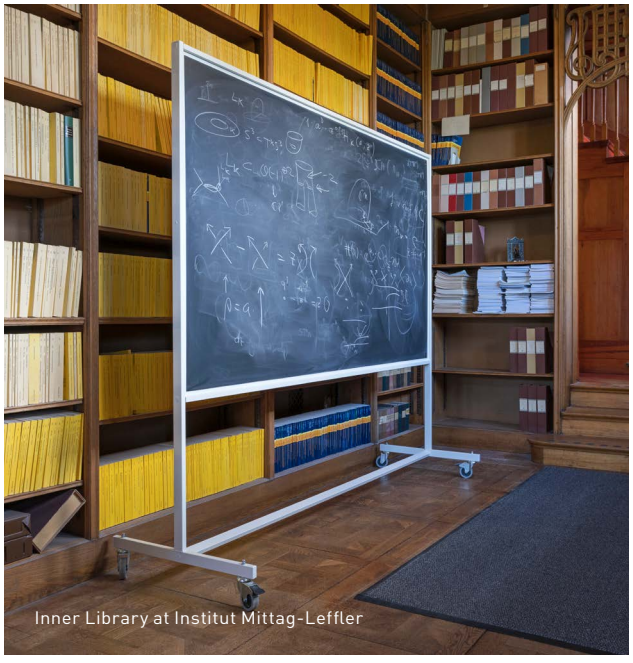
Xavier Ros-Oton, Mikko Salo, Alessio Figalli, Georg Weiss, and Susanna Terracini.

Specially invited participants and/or speakers

During the first workshop special invitees included the following internationally renowned speakers to give mini courses, Donatella Danielli, Nicola Garofalo, and Xavier Cabré.

Except for the speakers already in the program, we invited the following external participants to the second workshop: Iwona Chlebicka, Jean Dolbeault, Cristiana De Filippis, Antoine Henrot, and Giuseppe Mingione.

Photo: Markus Marcetic



Inner Library at Institut Mittag-Leffler

SEMINARS

AUGUST 30, 2022
Lorenzo Brasco
University of Ferrara
Hardy's inequality for convex sets: local and nonlocal

SEPTEMBER 1, 2022
Giovanni Franzina
Istituto per le Applicazioni del Calcolo Mauro Picone
Isolation results for Lane-Emden equations with sublinear power

WORKSHOP 2022-09-05–2022-09-09

SEPTEMBER 5, 2022
Donatella Danielli
Arizona State University
Regularity results for a class of penalized boundary obstacle problems

SEPTEMBER 5, 2022
Nicola Garofalo
University of Padova
Fractional calculus and heat equation: from the classics to present time

SEPTEMBER 5, 2022
Mark Allen
Brigham Young University
Sharp quantitative Faber-Krahn inequalities and the Alt-Caffarelli-Monotonicity formula

SEPTEMBER 6, 2022
Xavier Cabré
ICREA and Universitat Politecnica de Catalunya
Regularity of stable solutions to semilinear elliptic equations up to dimension 9

SEPTEMBER 6, 2022
Xavier Cabré
ICREA and Universitat Politecnica de Catalunya
Regularity of stable solutions to semilinear elliptic equations up to dimension 9

SEPTEMBER 6, 2022
Nicola Garofalo
University of Padova
Fractional calculus and heat equation: from the classics to present time

SEPTEMBER 6, 2022
Dennis Krivenstov
Rutgers University
Linear stability implies nonlinear stability for quantitative Faber-Krahn

SEPTEMBER 7, 2022
Donatella Danielli
Arizona State University
Regularity results for a class of penalized boundary obstacle problems

SEPTEMBER 7, 2022
Xavier Cabrél
CREA and Universitat Politecnica de Catalunya
Regularity of stable solutions to semilinear elliptic equations up to dimension 9

SEPTEMBER 7, 2022
Nicola Garofalo
University of Padova
Fractional calculus and heat equation: from the classics to present time

SEPTEMBER 8, 2022
Donatella Danielli
Arizona State University
Regularity results for a class of penalized boundary obstacle problems

SEPTEMBER 8, 2022
Xavier Cabré
ICREA and Universitat Politecnica de Catalunya
Regularity of stable solutions to semilinear elliptic equations up to dimension 9

SEPTEMBER 8, 2022
Nicola Garofalo
University of Padova
Fractional calculus and heat equation: from the classics to present time

SEPTEMBER 8, 2022
Yannick Sire
Johns Hopkins University
Liquid crystals with free boundaries

SEPTEMBER 9, 2022
Xavier Cabré
ICREA and Universitat Politecnica de Catalunya
Regularity of stable solutions to semilinear elliptic equations up to dimension 9

SEPTEMBER 9, 2022
Donatella Danielli
Arizona State University
Regularity results for a class of penalized boundary obstacle problems

SEPTEMBER 9, 2022
Nicola Garofalo
University of Padova
Fractional calculus and heat equation: from the classics to present time

SEPTEMBER 13, 2022
Max Engelstein
University of Minnesota
Harmonic Analysis tools for Free Boundary problems

SEPTEMBER 13, 2022
Veronica Felli
University of Milano-Bicocca
Local asymptotics and unique continuation from boundary points for fractional equations

SEPTEMBER 14, 2022
Michel Chipot
University of Zurich
On the Leray problem and the Poiseuille flow

SEPTEMBER 16, 2022
Postdoc Session

SEPTEMBER 20, 2022
Antonella Nastasi
University of Palermo
Regularity for quasiminimizers of an anisotropic problem

SEPTEMBER 22, 2022
Ryan Hynd
University of Pennsylvania
Extremal functions for Morrey's inequality

SEPTEMBER 22, 2022
Leon Bungert
University of Bonn
Tackling L∞ eigenvalue problems with convex analysis

SEPTEMBER 27, 2022
Juan Luis Vázquez
Universidad Autonoma de Madrid
Anisotropic Nonlinear Diffusion Equations

OCTOBER 4, 2022
Mikko Parviainen
University of Jyväskylä
Stochastic tug-of-war type games and partial differential equations

OCTOBER 6, 2022
Pengfei Guan
McGill University
Geometric flows from viewpoint of calculus of variations

OCTOBER 6, 2022
Guofang Wang
University of Freiburg
Optimal geometric inequalities of hypersurfaces with or without boundary

OCTOBER 11, 2022
Harish Shrivastava
Tata Institute of Fundamental Research
Variational solution to Bernoulli type free transmission problems

OCTOBER 13, 2022
Roberto Ognibene
University of Pisa
Capacity and torsional rigidity: two measures of spectral stability

OCTOBER 13, 2022
Sunghan Kim
Uppsala University
On vectorial obstacle problems

OCTOBER 18, 2022
Seongmin Jeon
KTH Royal Institute of Technology
Almost minimizers for a cooperative system with free boundary

OCTOBER 20, 2022
Simon Larson
University of Gothenburg
On a class of mean value inequalities in convex domains

OCTOBER 20, 2022
Bernd Kawohl
University of Cologne (Retired)
On Reuleaux and Cohn-Vossen, or buttons and balls that cannot run away

WORKSHOP 2022-10-31–2022-11-04

OCTOBER 31, 2022
Georg Weiss
University of Duisburg-Essen
Complete classification of global solutions to the obstacle problem

OCTOBER 31, 2022
Nicola Soave
Politecnico di Milano
The nodal set of solutions of some sublinear equations, with or without homogeneity

OCTOBER 31, 2022
Jean Dolbeault
Université Paris Dauphine-PSL
Stability estimates in critical functional inequalities

OCTOBER 31, 2022
Mikko Salo
University of Jyväskylä
Free boundary methods in inverse problems

NOVEMBER 1, 2022
Antoine Henrot
Institut Elie Cartan - Universite de Lorraine
Bounds for the first (non-trivial) Neumann eigenvalue and partial results on a nice conjecture

NOVEMBER 1, 2022
Susanna Terracini
University of Turin
Higher order boundary Harnack principle on nodal domains via degenerate equations

NOVEMBER 1, 2022
Iwona Chlebicka
Faculty of Mathematics, Informatics, and Mechanics, University of Warsaw
Absence of Lavrentiev's gap for anisotropic functionals

NOVEMBER 1, 2022
Cristiana Di Filippis
University of Parma
Schauder estimates for any taste

NOVEMBER 2, 2022
Sunghan Kim
Uppsala University
Some standard tools for the classical obstacle problem

NOVEMBER 2, 2022
Alessio Figalli
ETH Swiss Federal Institute of Technology in Zürich
Free boundary regularity for the obstacle problem

NOVEMBER 3, 2022
Panagiota Daskalopoulos
Columbia University
Ancient solutions to geometric flows

NOVEMBER 3, 2022
Matteo Bonforte
Universidad Autonoma de Madrid and ICMAT
Stability in Gagliardo-Nirenberg-Sobolev inequalities: nonlinear flows, regularity and the entropy method

NOVEMBER 4, 2022
Guiseppe Mingione
University of Parma
Nonlinear potential theoretic methods in nonuniformly elliptic problems

NOVEMBER 4, 2022
Xavier Ros-Oton
Univeristy of Zürich
Parabolic obstacle problems with critical or supercritical scaling

NOVEMBER 8, 2022
Hui Yu
National University of Singapore
Rate of blow up in the thin obstacle problem

NOVEMBER 8, 2022
Nicolo Forcillo
University of Bologna
The one-phase Stefan problem: a perturbativeapproach for the free boundary regularity

NOVEMBER 11, 2022
Giorgio Tortone
University of Pisa
On the regularity of the optimal shapes for a class of integral functionals

NOVEMBER 11, 2022
Stefano Vita
University of Turin
Higher order boundary Harnack principle via degenerate equations

NOVEMBER 15, 2022
Peter Lindqvist
Norwegian University of Science and Technology
The Infinity-Eigenvalue Problem

NOVEMBER 15, 2022
Mats Ehrnström
Norwegian University of Science and Technology
Smooth stationary water waves with exponentially localised vorticity

NOVEMBER 17, 2022
Alessandra De Luca
University of Venice
Nonlocal capillarity problems with anisotropic kernels

NOVEMBER 17, 2022
Simon Eberle
University of Duisburg-Essen
On the behavior of the regular part of the free boundary close to singularities in the obstacle problem

NOVEMBER 22, 2022
Giovanna Citti
University of Bologna
Schauder estimates at the boundary in Carnot groups

NOVEMBER 22, 2022
Kaj Nyström
Uppsala University
Parabolic uniform rectifiability and caloric measure I: A_\infty implies parabolic uniform rectifiability of a parabolic Lipschitz graph

NOVEMBER 24, 2022
Juan Manfredi
University of Pittsburgh
Semi-discrete approximations to p-harmonic functions.

NOVEMBER 24, 2022
Seyed Alireza Tavakoli
Uppsala University
Regularity properties of parabolic nonlocal nonlinear equations

NOVEMBER 25, 2022
Karl Brustad
Norwegian University of Science and Technology
The Infinity-potential in the square

NOVEMBER 29, 2022
Sebastian Schwarzacher
Uppsala Universitet
Global Schauder estimates for the p-Laplacian and p-Stokes operator for rough domains

NOVEMBER 29, 2022
Mohammad Safdari
Sharif University of Technology
Nonlocal equations with gradient constraints

DECEMBER 1, 2022
John Lewis
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Failure of Fatou type theorems for Solutions to PDE of p-Laplace Type in Domains with Flat Boundaries \subset \rn{n} and in the unit disk of \rn{2}

DECEMBER 1, 2022
Anders Björn
Linköping University
The Dirichlet problem and Green functions for p-harmonic functions on R^n and metric spaces

DECEMBER 6, 2022
Jana Björn
Linköping University
Barrier families and boundary regularity for the porous medium equation

DECEMBER 6, 2022
Felix del Teso
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The Liouville Theorem and linear operators satisfying the maximum principle

DECEMBER 8, 2022
Minhyun Kim
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Wiener criterion for nonlocal Dirichlet problems

DECEMBER 8, 2022
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Solutions with moving singularities for nonlinear diffusion equations

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National University of Singapore, Singapore

Conferences

The Boltzmann Equation: In the Trail of Torsten Carleman

MAY 16 - MAY 20, 2022

Organizers:

Håkan Andréasson
Chalmers/University of Gothenburg

Eric Carlen
The State University of New Jersey

Irene Gamba
University of Texas at Austin

Anne Nouri
Aix-Marseille University

Bernt Wennberg
Chalmers/University of Gothenburg

SCIENTIFIC REPORT

Description of scientific area

After Boltzmann published his works on the kinetic theory of gases, and the equation that bears his name, in 1872, it took 60 years before T. Carleman gave the first proof of existence of solutions to this equation in a famous paper in Acta Mathematica. Carleman continued his research on this subject for the rest of his life. The results of his investigations appeared in a posthumously edited book with important contributions by Carleson and Frostman in 1957, which has been very influential in the subsequent development of the mathematical aspects of kinetic theory of gases. Equally important for the kinetic theory of gases was Leif Arkeryd's paper from 1972, and his work also marked a new start of kinetic theory in Sweden. It is in celebration of Leif Arkeryd's 80th birthday that this workshop is taking place.

The Boltzmann equation is a nonlinear integro-differential equation which is very challenging from a mathematical point of view. The spatially homogeneous version of the equation, which was the subject of Carleman's ground-breaking paper, is today fairly well understood. The ideas that have emerged in developing this part of the theory have turned out to be extremely useful also beyond the kinetic theory of gasses, and have been applied in other fields such as biology, economics, and machine learning.

The theory of the spatially inhomogenous version of the equation is far less complete, and continues to be actively investigated and new significant progress in this area was the focus of a number of the talks at the meeting.

The enormous progress that has been achieved in the past few decades is based on the development of general tools for PDEs, functional analysis and probability theory, and a careful and innovative use of the particular structure of this equation. However, there are still many open questions related to the classical Boltzmann equation as well as to many related equations taking into account relativistic or quantum effects, or particular models for many physical phenomena.

Milestones and achievements

There has been exciting recent progress in developing the theory of the spatially inhomogeneous Boltzmann equation though the theory remains far from complete. Two problems involving scaling limits are under active investigations and were discussed at this meeting. The first problem is the derivation of the equation from the underlying reversible Newtonian mechanics of colliding particles. For almost 50 years, the results of Lanford on this problem were unsurpassed, and little was known about the derivation from quantum mechanics. Although many new results have been obtained in the last few years, there is still not a fully satisfactory derivation of the Boltzmann equation as the limit of a classical (or quantum) particle system. Recently, much new progress has been made on these questions and this was presented in several talks at the conference, both for the derivation from classical and from quantum mechanics. For example, results related to this were presented in the workshop, dealing with fluctuations around the solutions to the deterministic Boltzmann equation or the derivation of a Vlasov equation from a many-body fermionic system, to give two examples.

The second problem is the derivation of hydrodynamic equations from the Boltzmann equations, and progress in this direction was also presented at the meeting. Much progress followed in recent years with the introduction of velocity averaging methods, which is also useful in proving the existence of solutions. However, that tool is not always available, and ways around this difficulty for studying some problems were presented. Several new results on the well-posedness of both classical and quantum Boltzmann equations were also presented, as well as for the related Landau and Fokker-Planck equations. Another interesting topic concerned equilibria and the trend to equilibrium for kinetic equations.

New directions

Machine learning is perhaps one of the currently most studied research topics, and it was shown in the conference how kinetic models can be useful for solving the related non-convex optimization problems. In recent years kinetic theory has proven useful for modeling many physical, biological, social and other phenomena, and new results concerning models for collective dynamics, animal evolution and models for polyatomic gases were also presented. Another new direction involved quantum problems in kinetic theory, both from the point of view of deriving kinetic equation from the Schrödinger equation to the problem of studying kinetic equations incorporating quantum effects, e.g., from particle statistics. Indeed, this has been a focus of Leif Arkeryd's recent work on kinetic theory of anyons.

Successful seminars and/or workshops

One measure of the success of the whole program is the participation. Though the meeting took place when covid travel restrictions made physical participation difficult or impossible for many experts in the field, the facilities at IML were at maximum capacity with physical participants, and the program made good use of the excellent facilities at IML for online participation. In fact, the number of online participants, 26, was slightly more than the number of physical participants, and this number included several speakers. The online participants were active in the discussions after the talks, something that is often lacking at hybrid meetings we have attended. This is a testament to both the interest of the talks and the effectiveness of the IML facilities.

Specially invited participants and/or speakers

We were very glad to see a large number of participants from different subfields of kinetic theory, and from many parts of the world. By means of digital tools we could have online participants who were not able to attend in person. Among all participants, we wish to single out one: Leif Arkeryd. His contributions to kinetic theory are very important, and he is still actively pursuing research in the field, more than 50 years after the publication of his first papers.

Photo: Cristian Wahlén

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Shih-Hsien Yu
National University of Singapore, Singapore, Singapore

Photo: Markus Marcetic

Wallenbergsalen, seminar room in Kuskvillan

Schocksymposium

MAY 25, 2022

Organizers:

Michael Benedicks
KTH Royal Institute of Technology

Photo: Institut Mittag-Leffler

Description of scientific area

The Rolf Schock symposium was held in recognition of the 2020 Rolf Schock prize in mathematics awarded to Nikolai Makarov *for his significant contributions to complex analysis and its applications to mathematical physics*.

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Photo: Cristian Wahlén

Göran Gustafsson Symposium

MAY 30 – JUNE 1, 2022

Organizers:
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Dan Petersen
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David Rydh
KTH Royal Institute of Technology

Description of scientific area

The aim of this meeting was to bring together experts in Hodge theory and combinatorics of matroids, and the recent breakthrough interactions between the two fields.

Algebraic geometry has been recognized as a deep and powerful tool in combinatorics at least since Stanley's proof of the g-theorem (McMullen's conjecture), which characterizes all possible sequences counting the numbers of faces in each dimension of a simplicial polytope. Stanley's proof, in a remarkable three-page 1980 paper, uses the Hard Lefschetz theorem for the toric variety associated to the polytope. His proof is now a prototype of an established paradigm for proving properties of integer sequences: to prove positivity, show that they are Betti numbers of some geometric object; to prove unimodality, use Hard Lefschetz; and to prove log-concavity, use the Hodge–Riemann bilinear relations from Hodge theory.

A more recent paradigm is the possibility of doing algebraic geometry without algebra and without geometry. The prototype here is the 2017 proof by Adiprasito–Huh–Katz of the Heron–Rota–Welsh conjecture on the log-concavity of the characteristic polynomial of matroids. Recall that matroids are combinatorial structures which axiomatize the notion of linear dependence, and that a matroid is said to be representable over a field F if it can be realized by a family of vectors in a vector space over F. The

Heron–Rota–Welsh conjecture was known before Adiprasito–Huh–Katz for matroids representable over the complex numbers, by work of Feichtner–Yuzvinsky. But the conjecture was for an arbitrary matroid, which might not be associated to any type of geometry at all. The proof by Adiprasito–Huh–Katz builds an object from combinatorics, which ought to play the role of the cohomology ring, and proves Poincaré duality, Hard Lefschetz and the Hodge–Riemann bilinear relations for this object directly. More recently, Braden–Huh–Matherne–Proudfoot–Wang have developed a combinatorial analogue of Goresky–MacPherson's intersection cohomology for an arbitrary matroid, and used it to prove the Dowling–Wilson top-heavy conjecture (known previously in the representable case by work of Huh–Wang) and non-negativity of coefficients of matroid Kazhdan–Lusztig polynomials (known previously in the representable case by work of Elias–Proudfoot–Wakefield). This is all very remarkable – apparently one can do abstract Hodge theory for matroids and related combinatorial objects, but we do not yet understand why.

At the forefront of all these developments is June Huh, who delivered the plenary lecture series at the symposium. Huh's work is characterized by a childlike curiosity and fearlessness, and has led to several completely unexpected developments. Among June Huh's many awards and honors are the New Horizons in Mathematics prize, the Samsung Ho-Am prize, and the Fields medal in 2022.

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Photo: Markus Marcetic

The main library of Institut Mittag-Leffler

Photo: Cristian Wahlén

Moduli of Curves in Stockholm

JUNE 02 – JUNE 03, 2022

Organizers:

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Lars Halvard Halle
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Description of scientific area

A conference on the occasion of Carel Faber's 60th birthday.

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Photo: Markus Marcetic

The round library at Institut Mittag-Leffler

EWM-EMS Summer School: Chromatic Homotopy Theory and Friends
Online conference

JUNE 07 – JUNE 10, 2022

Organizers:
Tilman Bauer
KTH Royal Institute of Technology
Agnès Beaudry
University of Colorado at Boulder
Irina Bobkova
Texas A&M University
Vesna Stojanoska
University of Illinois at Chicago

SCIENTIFIC REPORT

Description of scientific area

Chromatic homotopy theory is a cornerstone in modern algebraic topology. It is a conceptual and computational framework for identifying and explaining large scale periodic patterns in stable homotopy groups. Its origins go back to the work of Adams and Quillen in the 1960s. It became established as an essential computational tool with the work of Miller–Ravenel–Wilson in the 1970s, and a theoretical organizational tool with the work of Devinatz–Hopkins–Smith in the 1980s. Since then, various theoretical developments, such as the Goerss–Hopkins–Miller construction of Morava E-theory and topological modular forms, and Lurie's establishment of spectrally derived algebraic geometry as a practical tool, have turned chromatic homotopy theory into a cornerstone of algebraic topology. Briefly, the height filtration on formal groups dictates a filtration of stable homotopy theory; this is the chromatic filtration. As one concrete implication, it presents every spectrum as built from its localizations with respect to the height n Morava K-theories $K(n)$. Then we have two distinct research goals: The local problem of understanding the $K(n)$-local categories for each n, and the assembly problem – gluing the information together into global knowledge about spectra and the stable homotopy category.

Work within each of these goals broadly falls within one of two categories: general structural results, or explicit computational understanding. When it comes to concrete computational data, only chromatic levels 0 and 1 are relatively well-understood through their relationship with rational homotopy theory and topological K-theory respectively. Chromatic level two is the subject of intense and fruitful recent and ongoing investigation.

Milestones and achievements

Beyond ensuring a diverse participation, we took the following steps to create an inclusive atmosphere during the Summer School. We recruited speakers not only for their excellence in research, but also based on their reputation as being approachable and valuing the importance of creating a friendly and respectful community. Before the workshops began, participants were paired in a mentor/mentee relationship, mentors chosen among willing organizers, speakers and senior participants.

New directions

The main goal of this Summer School was to provide such an access point to chromatic homotopy theory.

Specially invited participants and/or speakers

The backbone of the proposed summer school was a series of four lectures on chromatic homotopy theory, by Constanze Roitzheim. The goals of this lecture series were to provide a user-friendly introduction to this theoretically as well as computationally challenging area of mathematics that follows a path from basic principles to a current research topic chosen by the speaker. Other participants that could be mentioned include Eva Belmont, Paul Goerss, and Dan Isaksen.

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Photo:Markus Marcetic

Institut Mittag-Leffler, the villa was built and extended during 1890–1906

Photo: Cristian Wahlén

EWM-EMS Summer School: The Cauchy Problem in General Relativity

JUNE 13–JUNE 17, 2022

Organizers:

Melanie Graf
University of Tübingen

Anna Sakovich
Uppsala University

Katrin Wendland
Trinity College

Zoe Wyatt
University of Cambridge

SCIENTIFIC REPORT

Description of scientific area

The Cauchy problem in general relativity is a rapidly growing, interdisciplinary field that lies at the crossroads of geometric analysis, the analysis of PDEs and mathematical physics. While Einstein introduced his theory of gravity and eponymous equations in 1915, it was not until the seminal work of Yvonne Choquet-Bruhat in 1952 that the formulation of Einstein's equations as a well-posed evolutionary Cauchy problem was rigorously given thereby providing the foundations for a systematic study of the solutions of Einstein's equations. Our summer school focused on a few current research directions with its origins in the work of Choquet-Bruhat: geometric and analytic properties of initial data for the Cauchy problem, evolutionary aspects of the Cauchy problem: long term behavior, dynamical stability, formation of singularities, and the study of the universe as a Lorentzian geometry.

Milestones and achievements

An important landmark in the study of initial data for the Cauchy problem is the positive mass theorem. The first proof was obtained by Schoen and Yau in the early 1980s. This result, to date proven in dimensions less than 8, says that the ADM energy-momentum vector of asymptotically Euclidean initial data satisfying

the dominant energy condition must be either future timelike or null. A flagship result in the study of the dynamical aspects of the Cauchy problem is the nonlinear stability of Minkowski spacetime proven by Christodoulou and Klainerman in 1993. Assuming that initial data is small, they construct global solutions to the Einstein vacuum equations, which look, at late times, like the Minkowski space-time: in particular, they are free of black holes and singularities. The main highlight in Lorentzian geometry is undoubtedly the singularity theorems of Hawking and Penrose. These were proven in the late 1960s and describe a situation where the existence of a spatial region with strong gravitation leads to the formation of a singularity.

New directions

The positive mass theorem has recently been given a number of new proofs providing further insights in the properties of initial data. The so-called equality case, a problem of describing all initial data sets satisfying the dominant energy condition and having null ADM energy-momentum vector has recently been resolved in the work of Huang and Lee. Extensions of these results to higher dimensions and other geometries at infinity are current active research topics. Since the aforementioned work of Christodoulou and Klainerman many researchers have been looking into ways to address the stability of classical black hole solutions, and recently we have seen tremendous progress in this direction, for instance in the work of Dafermos, Holzegel, Rodnianski and Taylor. Another active topic is understanding how robust certain features of black holes are, such as their causal geodesic incompleteness, under perturbations of initial data. Complementary to this are important cosmological questions, such as determining whether the cosmological assumption of spatial homogeneity and isotropy can in fact be deduced under an evolutionary procedure. Concerning recent developments in the area of Lorentzian geometry, topics of current interest include establishing causality theory and singularity theorems in low regularity, and developing a comprehensive metric theory of Lorentzian manifolds.

Successful seminars and/or workshops

The goal of our summer school was to introduce graduate students and junior postdocs working in the field of mathematical general relativity to the current research areas described above. Thus, our summer school featured three mini-courses, one in each of the described areas.

Annegret Burtscher gave a mini-course entitled *Nonsmooth spacetimes in general relativity*. In her first lecture she reviewed some basic properties of causality theory and time functions, and discussed additional geometric properties needed for a well-posed initial value formulation of the Einstein equations in the standard smooth setting. In her second lecture she moved on to discuss pathologies and fundamental problems that can arise in the non-smooth setting such as existence of causal bubbles and non-openness of the timelike future of a point. The final third lecture discussed the notion of null distance that can be used to endow (non-smooth) spacetimes with a metric space structure and she outlined recent applications of this construction to convergence of warped product spacetimes.

Lan-Hsuan Huang gave a mini-course entitled *The equality case in positive mass theorems*, based on her recent joint work with Dan Lee. In the first lecture she reviewed some preliminaries concerning the positive mass theorem and presented the original variational argument used by Schoen and Yau to characterize the equality case under the assumption that the extrinsic curvature of the initial data set vanishes. Having emphasized that this approach cannot be extended to the general case, in the second lecture she presented an alternative novel approach inspired by Bartnik's quasi-local mass program and based on constrained minimization and the method of Lagrange multipliers. Subsequently, in the third lecture she showed how this approach can be adapted to the case of general initial data showing that in low dimensions initial data realizing the equality case in the positive mass theorem must be a slice of Minkowski spacetime. She also pointed out that this conclusion remains true in higher dimensions provided that stronger asymptotic conditions are imposed, and counterexamples were constructed in situations when these conditions are not assumed.

Gustav Holzegel gave a mini-course entitled *The Stability Problem for Black Holes* based on his recent work with Dafermos, Rodnianski and Taylor concerning the nonlinear stability of the Schwarzschild solution. In the first lecture some motivation to the problem was

provided and results for the covariant wave equation on Schwarzschild and Kerr spacetimes were reviewed with emphasis on the interplay of the PDE techniques with the geometric features of black hole spacetimes. The second lecture was concerned with linear stability of Schwarzschild and Kerr spacetimes, in particular topics such as the double null gauge, the Teukolsky equation and the Chandrasekhar transformation theory, and estimates for the system of gravitational perturbations were discussed. The third lecture focused on some aspects of the non-linear stability problem for Schwarzschild including the main architecture of the proof, non-linear error estimates, constructing teleological double null gauges, and modulation of angular momentum parameters.

As a complement to mini-courses we had two parallel Small Group Sessions which were meant to provide our participants with relevant hands-on experience. Led by Carla Cederbaum, one of the groups studied explicit examples related to the notion of total mass and total center of mass in Newtonian gravity and general relativity. The other group, led by Elena Giorgi performed some computations in Kerr spacetime illuminating the role of its hidden symmetry due to a Killing tensor, called the Carter tensor.

In addition, we had 11 talks by our junior participants covering a variety of topics related to the subject of the summer school.

Specially invited participants and/or speakers

All our mini-course and small group session leaders are successful, internationally renowned mathematicians. We want to take this opportunity to highlight two of our mini-course leaders whose participation in the summer school was partially supported by the Clay Mathematical Institute through its Enhancement and Partnership Program.

Lan-Hsuan Huang who gave the mini-course *The equality case in positive mass theorems* is a recipient of an NSF Career Award (2015), Simons Fellowship in Mathematics of the Simons Foundation (2018), and a von Neumann Fellowship at the Institute for Advanced Study (2018-2019). She was a plenary speaker at the International Congress on Mathematical Physics in Geneva, Switzerland, in 2021.

Gustav Holzegel who gave the mini-course *The Stability Problem for Black Holes* holds an ERC Consolidator Grant (2018), the Whitehead Prize from the London Mathematical Society (2016), and a Blavatnik Award (2019). He has been invited to speak at the International Congress of Mathematicians in 2022.

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Photo: Markus Marcetic

Gösta´s study

Photo: Institut Mittag-Leffler

Frontiers of Quantitative Symplectic and Contact Geometry

JUNE 27 - JULY 01 2022

Organizers:

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SCIENTIFIC REPORT

Description of scientific area

The first rigidity results in symplectic topology were proved by Gromov in the mid 1980s through his method of pseudoholomorphic curves. These results showed that symplectic and Hamiltonian diffeomorphisms satisfy certain interesting restrictions that make them very special compared to merely volume preserving maps. Rigidity phenomena include non-squeezing, non-existence of symplectic camels, and non-displaceability of certain subsets under Hamiltonian diffeomorphisms. Despite these rigidity properties, Hamiltonian diffeomorphisms still constitute an infinite-dimensional group. Quantitative symplectic and contact geometry, roughly speaking, concerns the study of the infinite-dimensional group of Hamiltonian symplectomorphisms (respectively contacto-morphisms) through the canonical Hofer norm (respectively Hofer-Shelukhin norm). Since these norms only depend on the C^0-behavior of the involved Hamiltonian functions, the rigidity properties exhibited by Hamiltonian diffeomorphisms are expected (and have been shown) to persist under certain C^0-limits. The next question is then to understand the correct definition of a C^0-limit of Hamiltonian diffeomorphisms. In fact, the first steps of C^0 symplectic geometry were already taken in the 1980s, when Eliashberg resolved Gromov's alternative by showing that the limit of a sequence of symplectomorphisms (respectively contactomorphisms) that converge in the C^0 -norm is again symplectomorphism (respectively contactomorphism), under the assumption that the limit is smooth.

Milestones and achievements

In 2007 Oh and Müller invented the notion of a C^0 Hamiltonian homeomorphism. The goal was to answer a question of Fatih from 1980 concerning the simplicity of the group of area preserving homeomorphisms of the two-sphere. Oh and Müller introduced the notion of C^0 Hamiltonian homeomorphisms as a conjectured non-trivial normal subgroup, which then would provide a negative answer to Fatih's question. They even provided a potential candidate of a map which clearly is an area preserving homeomorphism, but which was conjectured to not be a C^0 Hamiltonian homeomorphism. In 2020 Polterovich and Shelukhin made groundbreaking work by providing new types of spectral-invariants for the Hamiltonian diffeomorphism group of the two-sphere, defined by using the symmetric product. They also gave the first examples of Lagrangian Poincaré recurrence in dimension greater than two in its strongest form. This work inspired Christopher Gardiner, Humilière and Seyfaddini to define similar new invariants for configurations of Lagrangians in surfaces. Using these invariants they managed to answer Fatih's question in the negative: Oh and Müller were correct when they predicted the non-simplicity of the group of area preserving homeomorphisms.

New directions

During the workshop the natural questions that follow the answer to Fatih's conjecture were emphasised at several occasions. This concerns e.g., the classification of the normal subgroups of the group of continuous C^0-Hamiltonians in the sense of Oh-Müller. Another emerging field of study is the enhancement of the rich set of algebraic invariants in the form of Fukaya categories to include quantitative data. There were several seminars at the workshop that dealt with these questions.

Successful seminars and/or workshops

The problems treated during our problem session outlined several important questions to be answered in the coming years. For example, a natural set of follow-up questions to the simplicity conjecture were presented. Participants ranged from advanced graduate students to senior faculty. Post-docs and junior faculty were given the opportunity to present their work, while some graduate students presented their interests via the problem session. Since the topic of the conference was focused, the common overlap of interests naturally induced much vertical integration between senior and junior participants during the breaks. The talks were also grouped roughly by topic, so that in a given morning or afternoon session, consecutive and near-adjacent talks naturally blended with one another. The hybrid format gave access to a core of remote participants who could not attend for various reasons, including three who gave talks.

Specially invited participants and/or speakers

Senior participants included Dusa McDuff, Yong-Geun Oh and Leonid Polterovich who are founders of the field of quantum spectral invariants, quasi-morphisms, symplectic embeddings and C^0-Hamiltonian dynamics. In addition, the groups whose work led to the solution of Fatih's conjecture actively participated at the workshop.

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Photo: Institut Mittag-Leffler

Enumerative Invariants, Quantum Fields and String Theory Correspondences

JULY 25–JULY 29, 2022

Organizers:

Michele Del Zotto
Uppsala University

Albrecht Klemm
University of Bonn

Guglielmo Lockhart
Organisation Européenne pour la Recherche Nucléaire (CERN)

SCIENTIFIC REPORT

Description of scientific area

The central subjects of the workshop were the enumerative geometry of Calabi-Yau manifolds and its connections to other areas of current research in mathematics and theoretical physics. This field has undergone rapid development in recent years. In the context of mathematics, this includes novel results on Donaldson-Thomas (DT) invariants, on wall crossing, on the automorphic properties of invariants of elliptically-fibered manifolds. From a physics perspective this goes hand in hand with a deeper understanding of quantum field theories/supergravity theories and their twisted partition functions, which brings into play various different perspectives including twisted/topological M-theory, higher dimensional Superconformal field theories (SCFT), and string theory correspondences.

Milestones and achievements

The overarching goal of the workshop was to bring together theoretical physicists and mathematicians working on enumerative geometry and related areas, in order to promote the dissemination of recent results and build new bridges across interdisciplinary boundaries. The workshop was attended by leading researchers in mathematics and string theory, a significant fraction of whom attended in person. Talks covered a wide range of topics of interest to both communities, including enumerative geometry and topological string theory,

supersymmetric gauge theories, low-dimensional topology (e.g., invariants of three manifolds and Donaldson theory for four manifolds), cohomological Hall algebras and Yangians, as well as arithmetic geometry. When possible, an effort was made to bring out possible links between the ongoing developments in mathematics and theoretical physics in areas of common interest. Participants reacted on the whole with enthusiasm to the interdisciplinary approach and choice of topics, and contributed actively during the talks with stimulating questions bridging across the two scientific communities, as well as with spontaneous discussions following the talks.

New directions

The talks presented at the workshop highlighted and generated interactions on a range of new directions in enumerative geometry and connected areas. In the context of enumerative geometry/topological string theory, new directions that were covered include: automorphic properties and holomorphic anomaly equations associated to enumerative invariants, new connections to arithmetic geometry, novel relations between different classes of invariants, enumerative geometry of Calabi-Yau threefolds with orbifold singularities of various kinds and in particular in presence of torsion, connections to combinatorics of crystal melting and quiver Yangians, resurgence methods and progress toward a non-perturbative formulation of quantum geometry.

Further novel directions that were covered included: various aspects of supersymmetric gauge theory (instanton counting, wall crossing, connections to Donaldson theory, cohomological Hall algebras and their relation to the Alday-Gaiotto-Tachikawa conjecture), advances in the computation open string enumerative invariants by theoretical physics techniques, and topological invariants of three-manifolds and quantum modularity.

Successful seminars and/or workshops

The central topics of enumerative geometry and its physical counterparts were covered in depth by a series of successful seminars that discussed this subject from different angles. We highlight in particular the following contributions:

Wolfgang Lerche
Matrix Factorizations and Homological Mirror Symmetry

Thorsten Schimannek
Counting BPS states with discrete charges in M-theory

Sheldon Katz
The partition function of Calabi-Yau threefolds with torsion

Georg Oberdieck
Holomorphic anomaly equations for Pandharipande-Thomas invariants of elliptic threefolds

Murad Alim
Non-perturbative quantum geometry, resurgence and BPS structures

Albrecht Klemm
Calabi-Yau Manifolds, Modularity and Arithmetic Geometry

Jim Bryan
A theory of Gopakumar-Vafa invariants for orbifold Calabi-Yau threefolds

Vivek Shende
Open curve counting in CY3

Masahito Yamazaki
Quiver Yangians and Crystal Meltings

These seminars contributed to the goal of establishing new grounds and open directions for the field. Additionally, a number of seminars were focused on the closely-related subject of supersymmetric gauge theory and its associated mathematical structures. We highlight the following seminars: *Cohomological Hall algebras and affine Yangians*, by Francesco Sala, *Topological correlators of 4d N=2* and 5d N=1 super Yang-Mills*, by Jan Manschot, *Tetrahedron instantons*, by Xinyu Zhang, *Wall-crossing from Higgs bundles to vortices* by Du Pei, *Enumerative perspective on q-series invariants in topology*, by Sergei Gukov, *CGP invariants of 3-manifolds and BPS q-series*, by Pavel Putrov, and *Insights from the quantum modularity of 3-manifold invariants*, by Ioana Coman.

Specially invited participants and/or speakers

The workshop featured a number of talks by leading international researchers in mathematics and physics, including:

Jim Bryan
Sergei Gukov
Sheldon Katz
Kimyeong Lee
Wolfgang Lerche
Jan Manschot
Nikita Nekrasov
Vivek Shende
Masahito Yamazaki

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Emerging Mathematical Frontiers in Molecular Evolution

AUGUST 01–AUGUST 05, 2022

Organizers:
Guillaume E. Scholz
Universität Leipzig
Peter F. Stadler
Universität Leipzig
Marc Hellmuth
Stockholm University
Katharina T. Huber
University of East Anglia

SCIENTIFIC REPORT

Description of scientific area

One of the main tasks in phylogenomics is the reconstruction of detailed evolutionary scenarios of taxa (e.g., species) and underlying entities (e.g., genes, genomic markers or parasites) that evolve alongside these taxa. While the history of such taxa can be described independently from the history of the underlying entities, only a detailed scenario (i.e., a reconciliation between these histories) can provide the full picture of evolution. In particular, such full scenarios provide a framework to understand the evolutionary dependencies of the underlying taxa and the considered entities in more detail; a task that is crucial for a deeper understanding of the behavior of tumors, the evolution of viruses, the understanding of drug resistance in bacteria forced by horizontal gene transfer and many more.

Many methods that deal with the latter type of problem have been investigated in the past. Although numerous deep results have been established over the years, much remains to be done because of the increasing amount of data and the exciting challenges they pose for mathematical phylogenomics.

Milestones and achievements

With this conference, we had the opportunity to bring together experts and young scientists whose center of interest revolves around mathematical phylogenomics. All participants were offered the possibility to present their latest works and projects. Each session centered around one area of mathematics (combinatorics, algebra, statistics) that was designed to be accessible both to experts and non-experts.

New directions

In addition to the aforementioned novel approaches, we observed an increased interest in combining tools and techniques from seemingly unrelated areas of mathematics. In that regard, exchanges and discussions triggered by the talks turned out to be very helpful in order to better understand what these fields can bring to each other. We expect to see in the near future an increased number of hybrid methods aimed at tackling current and future problems raised by the study of evolution.

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Photo: Markus Marcetic

Acta Mathematica was founded by Gösta Mittag-Leffler 1882

Photo: Cristian Wahlén

Quantum Fields and Probability

AUGUST 08–AUGUST 12, 2022

Organizers:
Antti Kupiainen
University of Helsinki
Fredrik Viklund
KTH Royal Institute of Technology

SCIENTIFIC REPORT

Description of scientific area

Quantum field theories (QFTs) have been successfully applied to model and analyze diverse physical phenomena such as critical behavior in statistical mechanics and interactions of fundamental particles. However, except in special cases, the rigorous mathematical understanding of QFTs, including fundamental questions about their very construction, remains limited. During this workshop, a principal aim was to explore and develop the mathematical underpinnings of QFT from a probabilistic perspective. Areas of special focus included recent developments based on the Gaussian free field and Liouville quantum gravity, rigorous aspects of lattice Yang-Mills theories, as well as integrable lattice models and new links to analysis.

Milestones and achievements

While the Institute and workshop allowed for ideal working conditions for existing collaborations, significant effort was made to bring together a scientifically diverse set of participants that rarely otherwise have a chance to interact in the same workshops. As a result, besides the seminar talks, many informal discussions took place sharing new problems and ideas between participants from somewhat different areas. In terms of recent milestone achievements, participants highlighted for instance Guillarmou's report on the recent breakthrough work on probabilistically defining conformal blocks in 2D Liouville CFT in the context of Segal's axioms of CFT, obtained in collaboration with Kupiainen, Rhodes and Vargas.

New directions

Several people from different communities (Abdessalem, Forsström, Garban, Sepulveda, Lupu) discussed models with global and local gauge symmetries like the *O(N)* spin model in dimensions bigger than 3, *U(1)* gauge theory or gauge theories with finite abelian gauge groups. This clearly emerges as a new exciting direction with different groups bringing different methods from classical statistical mechanics, from the study of the Gaussian free field, but also more surprisingly from Bayesian statistics. Interesting links between the so-called Patrascioiu-Seiler proposal for the *O(N)* model (Aru, Garban, Sepulveda) and similar phenomena in the arboreal gas (Helmuth). Spurred by talks of Kytöla, Peltola and Camia interesting discussions on the possibility of formulating Segal's axioms for minimal models took place. This points towards intriguing new challenge for the community.

Successful seminars and/or workshops

Besides talks mentioned above, one could mention Lawler's lecture on his recent independent approach to SLE/GFF couplings and Liouville quantum gravity.

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Yilin Wang
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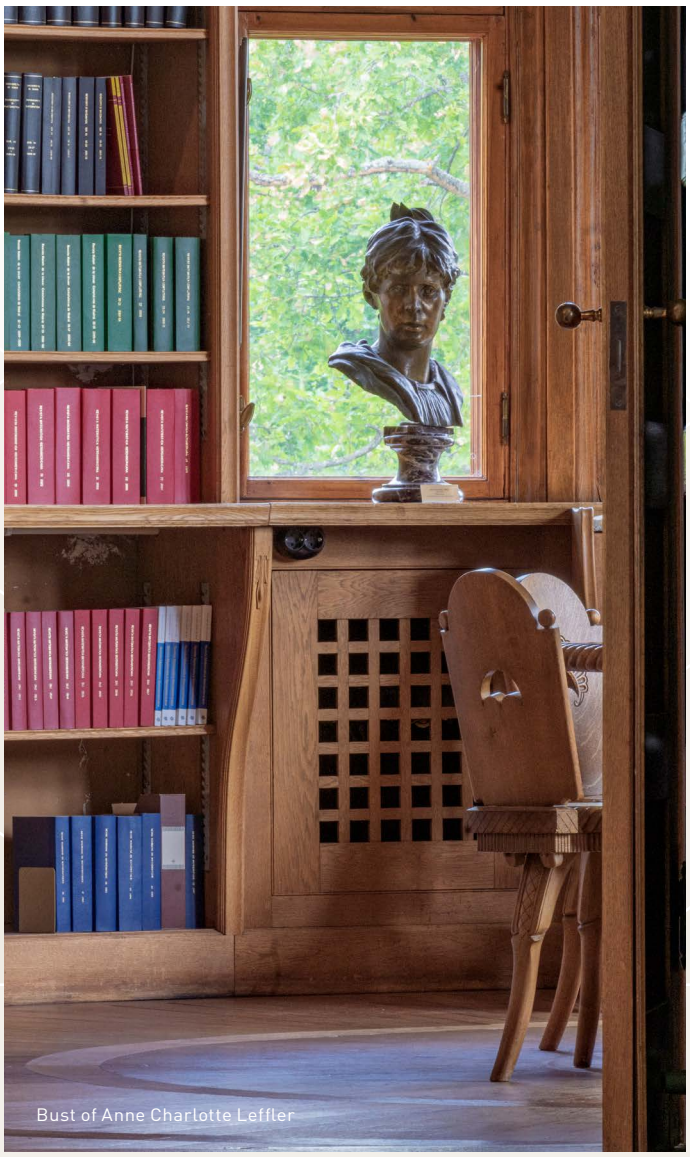
Wei Wu
NYU Shanghai, Shanghai, China

Photo: Markus Marcetic

Entrence hall main building

Other Events

Photo: Markus Marcetic



Bust of Anne Charlotte Leffler

Kleindagarna

For each edition of the Klein days, high school teachers of mathematics were invited for three days, to Institut Mittag-Leffler, together with mathematics professors and university teachers. They inspire each other and develop tomorrow's mathematics lessons for high school students, by combining the pedagogical expertise of high school teachers with the advanced subject knowledge of higher mathematics.

The purpose of Kleindagarna is to fill the gap between the knowledge and learning within mathematics in upper secondary schools in Sweden and the university level of mathematics by giving insight into the respective mathematical approaches and teaching situations.

Kleindagarna is an appreciated learning and development opportunity aiming to create lessons in mathematics with an instant impact on high school students all around Sweden.

Organizer:

Mats Boij
Chair of The Swedish National Committee for Mathematics and professor in mathematics at KTH Royal Institute of Technology, Stockholm

Supporting organization:

Brummer & Partners

Photo: Institut Mittag-Leffler

Kleindagarna I

JUNE 20–JUNE 22, 2022

LECTURERS

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Stockholm University, Stockholm

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Erik Lindell
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Johan Falk
Skolverket

Per-Ola Fredriksson
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Rose-Marie Hammar
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Malin Mattsson
Norra Reals gymnasium, Stockholm

Mikael Sund
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Jie Sundström
Sven Eriksongymnasiet, Borås

Marianne Thuring
Elof Lindälvs Gymnasium, Kungsbacka

Erik Ulfsson
Katedralskolan, Lund

Pär Olof Wendelstam

Photo: Institut Mittag-Leffler

Kleindagarna II

AUGUST 15–AUGUST 17, 2022

LECTURERS

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LESSON PILOTS

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Erik Nilsson
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Tim Hylén
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Camilla Larsson
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Torsbergsgymnasiet, Bollnäs

Tomas Westman
Stockholm Science & Innovation School, Kista

Financial Report

Förvaltningsberättelse

MAKARNA MITTAG-LEFFLERS MATEMATISKA STIFTELSE
Org.nr 802408-0890

VERKSAMHETEN

Allmänt om verksamheten

Makarna Mittag-Lefflers matematiska stiftelse har sitt säte i Stockholm. Stiftelsens ändamål är att inom de fyra nordiska länderna, Sverige, Danmark, Finland och Norge, och alldeles särskilt Sverige, för framtiden uppehålla och ytterligare utveckla den ställning, vilken den rena matematiken i dessa länder numera intager, samt att härvid även bereda aktning och rättvist uppskattande utom Nordens gränser för dessa länders insats inom tankelivets högsta område. Makarna Mittag-Lefflers matematiska stiftelse bedriver verksamhet bl.a., i form av tidskriftsutgivning varför alla uttag redovisas över resultaträkningen som kostnader för drift av stiftelsen.

KVA förvaltar ett kapital med ett marknadsvärde som per 2022-12-31 uppgår till 2 359 mkr via sina anknutna stiftelser. KVA och dess anknutna stiftelsers kapital (exklusive Stiftelsen Anna-Greta och Holger Crafoords fond) förvaltas av Carnegie enligt av akademistyrelsen fastställda riktlinjer.

Makarna Mittag-Lefflers matematiska stiftelses andel uppgår till 11,63%.

Stiftelsen har inte haft några anställda och inga löner och ersättningar har utbetalats under året.

Främjande av ändamålet

Resultatet från stiftelsens verksamhet exklusive de finansiella posterna uppgår till -9 013 863 kr som därmed tas från fonden för att driva Institut Mittag-Leffler och utge tidskrifterna Acta Mathematica och Arkiv för Matematik. Eftersom Makarna Mittag-Lefflers matematiska stiftelse bedriver verksamhet, och därmed är klassad som närings-drivande, redovisas alla uttag som kostnader för drift av stiftelsen.

Väsentliga händelser under räkenskapsåret

Inga väsentliga händelser finns att rapportera.

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Flerårsöversikt

	2022	2021	2020	2019	2018
Huvudintäkter	20 217 859	7 817 711	25 525 568	25 529 537	14 205 623
Årets resultat	-3 084 598	22 417 021	11 374 962	16 933 114	-6 556 296
Ingående kapital	224 134 909	201 717 888	190 342 926	173 409 812	179 966 108
Utgående kapital	221 050 310	224 134 909	201 717 888	190 342 926	173 409 812
Årlig förändring i %	-1,38%	11,11%	5,98%	9,76%	-3,64%

Vad beträffar stiftelsens resultat och ställning i övrigt, hänvisas till efterföljande resultat- och balansräkningar med tillhörande noter.

RESULTATRÄKNING

	Not	2022	2021
Stiftlesens intäkter			
Bidrag		19 506 945	6 596 758
Nettoomsättning		0	3 111
Övriga stiftelseintäkter		710 913	1 217 842
		20 217 859	**7 817 711**
Stiftelsens kostnader			
Övriga externa kostnader	2	-27 727 537	-10 024 120
Av- och nedskrivningar av materiella anläggninstillgångar		-624 453	-427 250
Övriga stiftelserkostnader		-879 732	-976 425
		-29 231 722	**-11 427 795**
Rörelseresultat		**-9 013 863**	**-3 610 084**
Finansiella poster			
Resultat från övriga finansiella anläggningstillgångar	3	5 479 719	25 417 166
Övriga ränteintäkter och liknande resultatposter	4	449 547	609 939
		5 929 266	**26 027 105**
Årets resultat		**-3 084 598**	**22 417 021**

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BALANSRÄKNING

Tillgångar		2022	2021
Anläggningstillgångar			
Materiella anläggningstillgångar			
Inventarier, verktyg och installationer	5	466 914	338 689
Förbättringsutgifter på annans fastighet	6	13 243 664	13 687 323
Pågående nyanläggning		-	2 642 531
		13 243 664	16 668 543
Finansiella anläggningstillgångar			
Andra långfristiga värdepappersinnehav	7	224 600 595	224 572 547
		224 600 595	224 572 547
Summa anläggningstillgångar		**238 311 173**	**241 241 090**
Omsättningstillgångar			
Kortfristiga fordringar			
Övriga fordringar		238 311 173	7 358 156
Förutbet. kostnader och uppl. intäkter		584 547	2 607 313
		5 405 514	9 965 469
Kassa och bank		3 086 435	2 487 102
Summa omsättningstillgångar		8 491 949	12 452 571
Summa tillgångar		**246 803 121**	**253 693 661**

Eget kapital och skulder			
Bundet eget kapital			
Bundet eget kapital vid räkenskapsårets början		211 177 213	191 801 952
Förändringar av bundet kapital		-1 244 829	19 375 261
Bundet eget kapital vid räkenskapsårets slut		209 932 384	211 177 213
Fritt eget kapital			
Fritt eget kapital vid räkenskapsårets början		12 957 695	9 915 936
Överfört till och från bundet eget kapital		1 244 829	-19 375 261
Lämnade och återförda anslag		-	-
Årets resultat		-3 084 598	22 417 021
Fritt eget kapital vid räkenskapsårets slut		11 117 926	12 957 696
Summa eget kapital		**221 050 310**	**224 134 908**
Kortfristiga skulder			
Leverantörsskulder		1 640 071	615 427
Övriga skulder		-	-
Uppl. kostnader och förutbet. intäkter		24 112 741	28 943 326
		25 752 812	29 558 753
Summa skulder		**25 752 812**	**29 558 753**
Summa tillgångar		**246 803 121**	**253 693 661**

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NOTER

Not 1 – Redovisnings- och värderingsprinciper

Allmänna redovisningsprinciper
Årsredovisningen har upprättats i enlighet med Årsredovisningslagen och Bokföringsnämndens allmänna råd (BFNAR 2016:10) Årsredovisning i mindre företag.

Avskrivningsprinciper för anläggningstillgångar
Följande avskrivningstider tillämpas

Materiella anläggningstillgångar

Inventarier, verktyg och installationer	3–5 år
Förbättringsutgifter på annans fastighet	10–40 år

Eget kapital
Bundet eget kapital består dels av det ursprungliga donationskapitalet, dels av rearesultat som förs direkt mot bundet eget kapital. Utöver detta ingår även kapitaliseringar, årlig avsättning om 10 % på räntor och utdelningar. Fritt kapital avser den del av kapitalet som kan disponeras för utdelningar.

Not 2 – Övriga externa kostnader

	2022	2021
Lokalkostnader	-6 650 778	-3 630 846
Projektkostnader	-16 121 088	-2 546 976
IT-kostnader	-700 588	-565 737
Personalkostnader	-2 410 030	-2 591 936
Övrigt	-1 845 053	-688 623
	-27 727 537	**-10 024 120**

Not 3 – Resultat från övriga finansiella anläggningstillgångar

Utdelningar	6 982 002	6 047 162
Ränteintäkter	539 667	730 663
Realisationsresultat	-2 041 950	18 639 341
	5 479 719	**25 417 166**

Not 4 – Övriga ränteintäkter och liknade resultatposter

Fondrabatter	449 547	581 374
Kursvinst	0	28 565
	449 547	**609 939**

Not 5 – Inventarier, verktyg och installationer

Ackumulerade anskaffningsvärden		
Vid årets början	1 822 833	1 637 363
Nyanskaffningar	243 340	185 470
Vid årets slut	**2 066 173**	**1 822 833**
Netto anskaffningsvärde	**2 066 173**	**1 822 833**
Ackumulerade avskrivningar enligt plan		
Vid årets början	-1 484 144	-1 421 559
Årets avskrivning på anskaffningsvärden	-115 115	-62 585
Vid årets slut	**-1 599 259**	**-1 484 144**
Redovisat värde vid årets slut	**466 914**	**338 689**

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Not 6 - Förbättringsutgifter på annans fastighet

	2022	2021
Ackumulerade anskaffningsvärden		
Vid årets början	17 038 061	5 760 419
Nyanskaffningar	65 679	11 277 642
Vid årets slut	17 103 740	17 038 061
Netto anskaffningsvärde	17 103 740	17 038 061
Ackumulerade avskrivningar enligt plan		
Vid årets början	-3 350 738	-2 986 073
Årets avskrivning på anskaffningsvärden	-509 338	-364 665
Vid årets slut	-3 860 076	-3 350 738
Redovisat värde vid årets slut	**13 243 664**	**13 687 323**

Not 7 – Andra långfristiga värdepappersinnehav

Ackumulerade anskaffningsvärden		
Vid årets början	224 572 547	199 486 067
Köp	224 572 547	54 369 488
Försäljning	-31 679 247	-29 283 007
Utgående anskaffningsvärden	224 600 595	224 572 547
Bokfört värde	224 600 595	224 572 547
Marknadsvärde	267 874 253	329 063 825

Stockholm den 7 juni 2023

Hans Ellegren
Ständig sekreterare

Min revisionsberättelse har avgivits den

Magnus Prööm
Auktoriserad revisor

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