CONTENTS

The Galilee Research Center for Applied Mathematics

The Galilee Research Center for Applied Mathematics (GRCAM) was established by the Department of Mathematics at Braude College in 2005. Its main aim is supporting the research activities of the Department's faculty members through scientific collaborations as well as promoting joint projects with the College's engineering departments and with industry. GRCAM has organized and hosted over 25 conferences and workshops since its establishment. We strongly believe that high quality research is crucial for maintaining excellence in teaching, in addition to its contribution to the prestige of Braude College as an academic center.

GRCAM maintains strong relations and has ongoing collaborative projects with universities in Israel and abroad including, among others, the University of Rome Tor Vergata, the Royal Institute of Technology in Stockholm, the University of California, Berkeley, the University of South Florida, the Max Planck Institute Leipzig, the Fraunhofer Institute for Industrial Mathematics, the Technical University of Kaiserslautern, and the University of Innsbruck. GRCAM has supported visits by mathematicians from various universities, generating a lively and fruitful exchange of ideas. These activities have led to publications in high-ranking scientific journals.

The research fields we are engaged in include: complex analysis, dynamical systems, geometry and its applications, partial differential equations and applications to natural sciences, optimization, Lie algebras, group theory and mathematical education. GRCAM promotes the use of mathematical models in industry.

The president of Braude College approved the formal bylaws of the center and its new management.

The Center Management:


Prof. Yaniv Almog


Prof. Mark Elin


Assoc. Prof. Aviv Gibali (Head, Mathematics Department)


Prof. Lavi Karp (Head, GRCAM)


Assoc. Prof. Haggai Katriel


Assoc. Prof. Arie Maharshak (President, Braude College of Engineering)


Assoc. Prof. Sarit Sivan (Head, Research Authority)


Dr. Eitan Yudilevich (Executive Director, BIRD Foundation)

COOPERATING UNIVERSITIES


Bar-Ilan University, Ramat Gan, Israel


Holon Institute of Technology, Israel


Tel Aviv University, Israel


The Hebrew University of Jerusalem, Israel


The Technion – Israel Institute of Technology, Haifa, Israel


University of Haifa, Israel


Australian National University, Canberra, Australia


Curtin University, Australia


University of Innsbruck, Innsbruck, Austria


Free University of Brussels, Belgium


College of Science, Civil Aviation University of China


Dalian University of Technology, China


Le Plessis-Robinson, France


Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany


Heinrich-Heine-Universität Düsseldorf, Germany


TU Bergakademie Freiberg, Germany


Fraunhofer Institute for Industrial Mathematics (ITWM), Germany


Imperial College, London, Great Britain


Institute of Mathematical Sciences, Chennai, India


Università di Roma “Tor Vergata”, Italy


Tohoku University, Japan


Ss. Cyril and Methodius University of Skopje, Republic of Macedonia


University of Warmia and Mazury, Olsztyn, Poland


Moscow State Technical University, Russia


University of Alicante, Alicante, Spain


Universidad Complutense Madrid, Spain


Universidad de Sevilla, Spain


Stony Brook University, New York, USA

RESEARCH ACTIVITY

RESEARCH GROUPS

ALGEBRA

Abed Abedelfatah, Mark N. Berman, and Ofir Schnabel

The algebra research group has two broad areas of interest. One area concerns classical questions in algebra. These include twisted group algebras as a tool for understanding algebraic concepts such as simply-graded algebras and units of (twisted) group rings, and the so-called isomorphism problems for (twisted) group rings. Other classical topics include the Hilbert function of graded algebra, Betti numbers of monomial ideals and face numbers of simplicial complexes. The second broad area of interest concentrates on Lie algebras and the subgroup growth of finitely generated groups. A unifying theme in all our work is the application of methods from other branches of mathematics to develop algebraic theories. Especially prominent here are representation theory and combinatorial methods. Representation theory is of independent importance as a tool in many areas of mathematics and science. This focus connects us to the scientific community at large.

Keywords: Lie algebras, representation theory, Hilbert functions, Betti numbers, regular sequences, simplicial complexes, graded ideals, graded algebras, twisted group rings, projective representations, groups of central type, finitely generated nilpotent groups, zeta functions of groups, pro-isomorphic zeta functions, algebraic groups, p-adic integration.

OPTIMIZATION, CONTROL THEORY AND DIFFERENTIAL GAMES

Aviv Gibali, Valery Y. Glizer, and Vladimir Turetsky

Optimization theory focuses on finding a best element with respect to some criterion, from a set of alternatives. Many real-world problems are modeled as either single- or multi-objective optimization ones and optimization theory, investigating the existing solutions, develops iterative methods for finding one or several equivalent solutions.

Control theory examines ways to manipulate input to a dynamical systems to obtain desired behavior and output.

Differential game theory models and studies problems in the context of dynamical systems.

Assoc. Prof. Gibali's research focuses on mathematical theory and development of iterative algorithms for solving feasibility problems and their applications to industrial problems such as radiation therapy treatment planning and image processing.

Prof. Turetsky is engaged in studying pursuit–evasion games with perfect and imperfect information; robust control; generalized linear-quadratic games; optimal control; cheap control problems; differential games with hybrid dynamics; invariant sets for feedback strategies; and inverse problems of signal restoration and differentiation.

Prof. Glizer's research focuses on control problems and differential games with singularly perturbed dynamics; cheap control problems; singular control problems; robust control problems; differential games with perfect and imperfect information; differential games with hybrid dynamics; singular differential games; multi-objective differential games; singularly perturbed ODEs, PDEs, functional-differential equations, difference equations; nonlinear stochastic differential and difference equations; nonlinear theory of generalized functions and its applications.

Keywords: Feasibility problems, control design, noncooperative and antagonistic games, single and multi-objective optimization, real-world problems.

DYNAMICAL SYSTEMS AND NONLINEAR ANALYSIS

Mark Elin, Fiana Jacobzon, Haggai Katriel, Marina Levenshtein, and David Shoikhet

The interest of mathematicians in the general theory of dynamical systems dates back to the early 20th century. Our research focuses on fixed point theory, operator and resolvent methods and their applications to autonomous, and nonautonomous differential equations. A question of central interest is classifying certain families of holomorphic mappings in a Banach space with respect to conjugacy. We also study the asymptotic behavior of discrete and continuous time semigroups and semicocycles (in one-dimensional and multidimensional settings), and boundary rigidity problems for semigroups and their generators. We are also interested in the criteria for analytic extension of semigroups with respect to their parameter.

Keywords: Semigroups and semicocycles, infinitesimal generator, filtration of generators, nonlinear resolvent, analytic semigroups, asymptotic behavior.

GEOMETRIC FUNCTION THEORY / COMPLEX ANALYSIS

Mark Elin, Fiana Jacobzon, Marina Levenshtein, Emil Saucan, and David Shoikhet

Geometric function theory, which focuses on the geometric properties of univalent mappings, has been an active field for over a century. Well-known results in this field include the Riemann mapping theorem, hyperbolic geometry, the Schwarz lemma, the Julia-Wolff-Caratheodory theorem and others.

Our research focuses on biholomorphic mappings on a unit ball, in one-dimensional and multidimensional complex spaces. We study the geometric structure of these mappings, including star-like and spiral-like mappings with respect to an interior point or a boundary point, hyperbolically convex mappings and so on. Geometric characteristics of images involve distortion and covering theorems and boundary behavior of different classes of mappings as well as interpolation and extremal problems.

Another field of study is quasiconformal and quasiregular mappings, which are both of theoretical interest as generalizations of conformal mappings and of applied interest, as they arise naturally in the context of computer graphics and imaging, in particular in medical imaging.

Keywords: Starlike, spirallike functions, distortion theorems, boundary behavior, hyperbolic convexity, quasiconformal and quasiregular mappings, dilation, imaging.

GEOMETRY AND ITS APPLICATIONS

Emil Saucan

Geometry, the study of shape and space, is a central field of mathematics. Among its various subfields, one that has recently become very active is discrete differential geometry, both due to its intrinsic beauty, and because of its many applications in computer graphics, imaging, computer-aided design, complex networks and pattern recognition. In particular, we study discrete Ricci curvature and flows, and their applications to complex networks, imaging and deep learning, which work has proven to be very fruitful. The role of discrete Ricci curvature in medical imaging, mainly for anomaly detection in CT and MIR images, is another promising direction of study.

Keywords: Discrete Ricci curvature and flow, Forman curvature, Ollivier curvature, complex network understanding and long-time evolution, anomaly detection in medical images.

MATHEMATICAL EDUCATION

Buma Abramovitz, Miryam Berezina, Fiana Jacobzon, and Ludmila Shvartsman

Our research seeks to develop methods for teaching mathematics at the undergraduate level aiming to improve students' understanding.

Keywords: Mathematical education, understanding, undergraduate level.

PARTIAL DIFFERENTIAL EQUATIONS AND APPLICATIONS TO NATURAL SCIENCES

Yaniv Almog, Tamar Gadrich, Lavi Karp, Haggai Katriel, Yakov Lutsky, and Victor Ostrovski

Mathematical models are important tools that help us understand the behavior of complex systems in all branches of science. The mathematical analysis of such models can shed light on the natural phenomena that the former describe.

Partial differential equations (PDEs) are central to modeling physical phenomena. Work on PDEs, motivated by fluid mechanics, wave motion, and electromagnetism, began in the eighteenth century. Since then, the range of applications where PDEs are used has expanded rapidly, and nowadays PDEs are applied in quantum mechanics, general relativity, and geometry as well as in other fields such as mathematical biology and financial mathematics. The group's research deals with several aspects of this vast field.

The Euler–Einstein system is a system of PDEs that combines the systems of fluids (Euler equations) and general relativity (Einstein equations). Euler equations describe the motion of fluids, while Einstein equations describe the curvature of the spacetime caused by the presence of matter.

Free boundary problems are concerned with solutions of differential equations whose boundaries are unknown in advance. We are interested in the free boundary problems that arise from potential theory and Hele–Shaw flows.

The study of hydrodynamic stability explores the transition of steady flows to weak turbulence. As has been observed in numerous experiments, when the steady flow loses its stability, the flow becomes time-dependent and vortex motion appears. Our focus is on linear stability analysis of incompressible laminar flows. While it is commonly agreed that the transition to turbulence results from nonlinear effects, the properties of the linearized Navier–Stokes operator play a significant role in the nonlinear stability analysis.

Mathematical biology involves the study of dynamical systems relevant to biological phenomena, at different levels: from the subcellular level (biochemical kinetics, gene regulation) through the level of the organism (physiological processes, inter-host dynamics of infections, cancer), up to the level of populations (ecology, epidemiology, population genetics and evolution). Using modern statistical methods. we investigate, both theoretically and mathematically, dynamic models, the formulation of new models, and the fitting of mathematical models to experimental, clinical and epidemiological data.

Keywords: Mathematical modeling, partial differential equations, Euler–Einstein systems, free boundary problems, mathematical biology, ecology, epidemiology, hydrodynamic stability.

SELECTED PUBLICATIONS

BOOKS

D. X. Gu, and **E. Saucan**, Differential Geometry, Classical and Discrete, (2022) CRC Press/Taylor & Francis/CRC Press, 608 pages. https://doi.org/10.1201/9781003350576

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Y. Almog, and B. Helffer, On the stability of laminar flows between plates, Archive for Rational Mechanics and Analysis, 241 (2021), 1281–1401. https://doi.org/10.1007/s00205-021-01673-0

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M. Elin, and **F. Jacobzon**, The Fekete-Szegö problem for spirallike mappings and non-linear resolvents in Banach spaces, Studia Universitatis Babeş-Bolyai Mathematica, 67 (2022), No. 2, 329–344. http://dx.doi.org/10.24193/subbmath.2022.2.09

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M. Elin, and **F. Jacobzon**, Families of inverse functions: coefficient bodies and the Fekete-Szegö problem, Mediterranean Journal of Mathematics **19**(93) (2022). https://doi.org/10.1007/s00009-022-02017-2

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Y. Tang, H. Lin, **A. Gibali,** and Y. J. Cho, Convergence analysis and applications of the inertial algorithm solving inclusion problems, Applied Numerical Mathematics, 175 (2022), 1–17. https://doi.org/10.1016/j.apnum.2022.01.016

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U. Brauer, and **L. Karp**, The non–isentropic Euler-Einstein system written in a symmetric hyperbolic form, in Anomalies in Partial Differential Equations, Springer INdAM Series 43 (2021), 63–-76. https://doi.org/10.1007/978-3-030-61346-4_3

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T. Gadrich, and **G. Katriel**, Estimating the rate of defects under imperfect sampling – A new approach, Probability in the Engineering and Informational Sciences,35(2) (2021), 242–257. https://doi.org/10.1017/s0269964819000391

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E. Saucan, A. Samal, and J. Jost, A simple differential geometry for complex networks, Network Science, 9(51) (2021), S106–S133. https://doi.org/10.1017/nws.2020.42

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V. Turetsky, M. Weiss, and T. Shima, A combined linear--quadratic/bounded control differential game guidance law, IEEE Transactions on Aerospace and Electronic Systems , 57 (2021), 3452–3462. https://doi.org/10.1109/TAES.2021.3083574

CONFERENCES, WORKSHOPS & SEMINARS

Y. Almog

- Mathematical Aspects of the Physics with Non Self-adjoint Operators: 10 years after. Marseille, February 1-5, 2021. Paper presented (via Zoom): "On the stability of laminar flows between plates"
- BIRS workshop: Mathematical aspects of the Physics with non-self-Adjoint Operators, July 10-15, 2022, Banff, Alebrta. Paper presented: "On the stability of symmetric flows in a two-dimensional tunnel"

M. Elin

- International Conference on Complex Analysis and Related Topics, Lviv, Ukraine, 2021
- 16th International Symposium on Geometric Function Theory and Applications, Sibiu, Romania, 2021
- Workshop on Geometric Function Theory in Several Complex Variables and Complex Banach Spaces, Cluj-Napoca, Romania, 2021
- "Holomorphic Semigroups in Rome" Workshop, Rome, Italy, 2022
- VII International Conference of Mathematics and Computer Science "Congressio-Mathematica", Olsztyn, Poland, 2022
- Workshop on Complex Analysis and Dynamical Systems, in honor of the retirement of Professor David Shoikhet, Braude College, 2022
- Workshop dedicated to the memory of Prof. Gabriela Kohr, on Geometric Function Theory in Several Complex Variables and Complex Banach Spaces, second ed., Cluj-Napoca, Romania, 2022
- Professor S. Reich's Seminar on Nonlinear Analysis and Optimization, Technion, Israel, 2021
- Seminar on (Hyper)Complex Analysis and Geometry, Politecnico di Milano, Italy, 2022

F. Jacobzon

- "The Fekete-Szegö problem for spirallike mappings and non-linear resolvents in Banach spaces", Geometric Function Theory in Several Complex Variables and Complex Banach Spaces, Cluj-Napoca, Romania, December 1–3., 2022

- "An 'inverse Fekete-Szegö problem' and filtration of generators", Complex Analysis video seminars, University College London, June 25, 2022
- Complex Analysis and Related Topics, Lvov, Ukraine June 28–July 1, 2021

A. Gibali

- EURO 2022, Espoo, Finland, July 3-6, 2022. Symposium Innovation on Teaching Mathematics (iTEM) at High Education Institutions: Experiences on Classroom, Tenerife, Spain, March 15–18, 2022
- Third IMA and OR Society Conference on Mathematics of Operational Research, April 20–23, 2021
- EUROPT2021 – Toulouse, France, July 7–9, 2021
- Optimization, Algorithms and Industrial Application, Braude, March 4, 2021
- Doing Your PostDoc in Germany – Info Webinar, Embassy of the Federal Republic of Germany, March 1, 2021 (online)
- The Felix Klein Autumn Workshop, Fraunhofer ITWM September 16–18, 2020 (online).
- Expert Sessions "Projection Methods". A weekly online seminar series July 23– August 26, 2020

L. Karp

- The continuity of the flow map with applications to Euler-Poisson equation, Mathematical Perspectives of Gravitation beyond the Vacuum, Regime, Erwin Schrödinger International Institute for Mathematics and Physics (ESI) University of Vienna, February 2021.
- The continuity of the flow map with applications to Euler-Poisson equation, The 13th ISAAC Congress, Ghent University Belgium, August 2021.
- On global existence of Euler-Nordström system, China-Israel Workshop on PDEs and Mathematical Physics, Tel Aviv University. August 2021.

G. Katriel

- 15th World Congress on Computational Mechanis & 8th Asian Pacific Congress on Computational Mechanics – WCCM-XV, Yokohama, Japan, July 31–August 5, 2022 (online)

SELECTED DEPARTMENT SEMINARS HELD IN 2021–2022

2021

April 13 – Prof. Ronald Lok Ming Lui, The Chinese University of Hong Kong, China – From computational quasiconformal geometry to deep learning for image processing

April 20 – Prof. Na Lei, Dalian Institute of Technology, China – Geometric GAN based on optimal transformation.

June 8 – Prof. Marcelina Mocanu, Vasile Alecsandri University of Bacau, Romania – Intrinsic metrics in proper subdomains of the complex plane

June 22 – Dr. Renu Chaudhary, Technion, Israel – Approximate controllability of a stochastic differential system of fractional order

August 10 – Prof Daoud Bshouty, Technion, Israel – Introduction to harmonic mappings 1

August 24 – Prof Daoud Bshouty, Technion, Israel – Introduction to harmonic mappings 2

August 31 – Prof Daoud Bshouty, Technion, Israel – Introduction to harmonic mappings 3

September 29 – Prof Daoud Bshouty, Technion, Israel – Introduction to harmonic mappings 4

November 9 – Dr. Anna Song, Imperial College of London, England – A curvature functional for generating tubular shapes generalizing the Helfrich model for bio membranes

November 16 – Prof. Ehud Yariv, Technion, Israel – Flows about superhydrophobic surfaces

November 23 – Dr. Rotem Assouline, Weizmann Institute of Science, Israel – Isometric embeddings into surfaces of moderately varying curvature

December 14 – Prof. Felix del Teso, Universidad Complutense de Madrid, Spain – The Liouville theorem and linear operators satisfying the maximum principle

2022

March 22 – Dr. Walaa Asakly, University of Haifa, Israel – Bell numbers, Stirling numbers and set partitions

April 26 – Prof Jürgen Jost, MPI MIS, Leipzing, Germany – Mathematical principles of network analysis