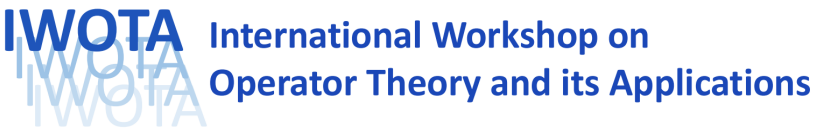
36TH INTERNATIONAL WORKSHOP ON
OPERATOR THEORY AND ITS APPLICATIONS

Book of Abstracts

University of Twente

July 14–18, 2025



The Organizers

The organizers of IWOTA 2025 are *Felix Schwenninger* (Twente), *Emiel Lorist* (Delft) and *Hans Zwart* (Twente).

The organizing team further consists of *Philip Preußler*, *Nathanael Skrepek*, *Filippo Testa*, *Jens de Vries* (all Twente), *Alexander Wierzba* (Twente/Wuppertal) and *Linda Wychgel-van Dalm* (Twente). The IWOTA2025 logo was designed by Elke de Vries.

The organizers are grateful to the IWOTA steering committee, particularly, *William Helton* and *Jani Virtanen* for continuous support and advice within the scientific committee of IWOTA 2025.

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Welcome Message

Dear Colleagues,

with great pleasure we welcome you to the 36^{th} International Workshop on Operator Theory and its Applications (IWOTA) hosted at the University of Twente.

The IWOTA conference series, initiated by Israel Gohberg, has grown and thrived over the decades, establishing itself as an annual fixed point for the community. While rooted in operator theory, IWOTA embraces a wide spectrum of topics across pure and applied mathematics–and beyond. This book of abstracts reflects that rich breadth, showcasing both long-standing themes central to IWOTA's tradition and emerging intersections with other fields, classical and modern alike.

As organizers, we are delighted to present this diverse and expansive collection of contributions. It is a privilege to witness the depth and variety of work represented in this volume.

The evolution of IWOTA into what it is today has been shaped by the academic and personal influence of several key scholars. In this year's edition, we honor the memory of *Harry Dym*, *Rien Kaashoek*, *Heinz Langer*, and *Nikolai Vasilevski*—not only towering figures in our field and inspiring teachers, but also cherished colleagues and friends to many within the IWOTA community. We pay tribute to their legacy through a series of dedicated sessions held in their honor.

On behalf of the organizing committee, we thank you for your participation and contributions. We look forward to an inspiring and successful conference.

Felix Schwenninger, *Emiel Lorist* and *Hans Zwart*
IWOTA 2025 Organizing Committee

Program at a Glance

Scientific Program

The scientific program will take place in the building complex **Waaier–Carré** on campus of the University of Twente. All used lecture halls as well as coffee breaks and lunches are within close vicinity (max. of 3 mins walking distance, 3 floors).

- The *registration* on Monday (starting at 10:00) will take place on the first floor (British) of the **Waaier** building.
- All *coffee* and *lunch breaks* (included in the conference fee) will also take place on the first floor of the **Waaier** building (right outside Lecture hall Waaier 1).
- *Plenary* and *semi-plenary talks* will take place in Lecture halls 1, 2 and 3 of the **Waaier** building.
- The *parallel sessions* will mainly take place in the **Carré** building (denoted CR) and **Hal B** (denoted HB), which is a side wing of the **Carré** building. The sessions in honour of H. Langer, H. Dym, R. Kaashoek and N. Vasilevski will take place in Waaier 3.

To navigate on campus and inside buildings, we recommend using the map

https://use.mazemap.com/#v=1&campusid=171

For titles and abstracts of all talks, see the book of abstracts or

https://skrepek.at/iwota2025.

The latter also provides links to the digital map of the specific rooms.

Plenary Speakers

- José Manuel Conde Alonso (Universidad Autónoma de Madrid)
- Roland Speicher (Saarland University)

- Hélène Frankowska (CNRS and Sorbonne Université, Paris)
- Philipp Grohs (University of Vienna and Austrian Academy of Sciences)
- Volker Mehrmann (TU Berlin), ILAS Lecture
- Luz Roncal (Basque Center for Applied Mathematics, Ikerbasque, and University of the Basque Country)
- Walter van Suijlekom (Radboud University Nijmegen)
- Quanhua Xu (Université Marie & Louis Pasteur (Besançon) and Harbin Institute of Technology)

Semi-Plenary Speakers

- Catalin Badea (Université de Lille and University of Reading)
- Marcin Bownik (University of Oregon)
- Hamza Fawzi (University of Cambridge)
- Jochen Glück (University of Wuppertal)
- Constanze Liaw (University of Delaware)
- Rob Martin (University of Manitoba)
- Jaydeb Sarkar (Indian Statistical Institute)
- Felix Voigtländer (Katholische Universität Eichstätt–Ingolstadt)
- Yi Wang (Chongqing University)
- Marcus Waurick (TU Bergakademie Freiberg)
- Ian Wood (University of Kent)

Contributed Sessions

- S1: Differential operators in mathematical physics (K. Pankrashkin, M. Serri)
- S2: Harmonic analysis on groups and manifolds (J. van Velthoven, T. Bruno and E. Papageorgiou)
- S3: Linear systems and control theory (H. Gernandt, N. Skrepek)
- S4: Matrix theory and linear algebra I (H. Woerdeman, A. Ran)

- S5: Matrix theory and linear algebra II, in honour of Rien Kaashoek (H. Woerdeman, A. Ran)
- S6: Moment problems and applications (R. Curto, A. Zalar)
- S7: Multivariable operator theory (S. ter Horst, R. Yang and J. Ball)
- S8: Non-commutative function theory and free analysis (R. Martin and M. Jury)
- S9: Noncommutative geometry (S. Zegers, S. Geffen and S. Bhattacharjee)
- S10: Numerical ranges and spectral sets (R. O'Loughlin, I. Spitkovsky, M. Wojtylak)
- S11: Open problems in harmonic analysis (G. Brocchi, G. Negro)
- S12: Operator learning and functional representation (F. Bartolucci, C. Brune, J. A. Iglesias and M. Carioni)
- S13: Operator semigroups and related operators (K. Kruse, J. Bonet);
- S14: Operator theory and hypercomplex analysis (A. de Martino, M. Ferreira and D. Legatiuk)
- S15: Operator theory on function spaces (J. Virtanen, C. Bellavita)
- S16: Operator theory on function spaces, in honour of Nikolai Vasilevski (J. Virtanen, C. Bellavita)
- S17: Positivity and dynamical systems (O. van Gaans, S. Arora)
- S18: Quantum information theory (J. Volčič, M.-O. Renou)
- S19: Session in honour of Harry Dym (W. Helton and D. Kimsey)
- S20: Spaces of analytic functions (N. Chalmoukis, M. Hartz)
- S21: Spectral theory, in honour of Heinz Langer (C. Tretter, C. Trunk)
- S22: Open session: Operator Theory and its Applications (P. Preußler, J. de Vries, H. Zwart)
- S23: Advanced matrix techniques in the numerical solution of differential equations (M. Ben-Artzi, P. Boito, Y. Eidelman)

Social Program

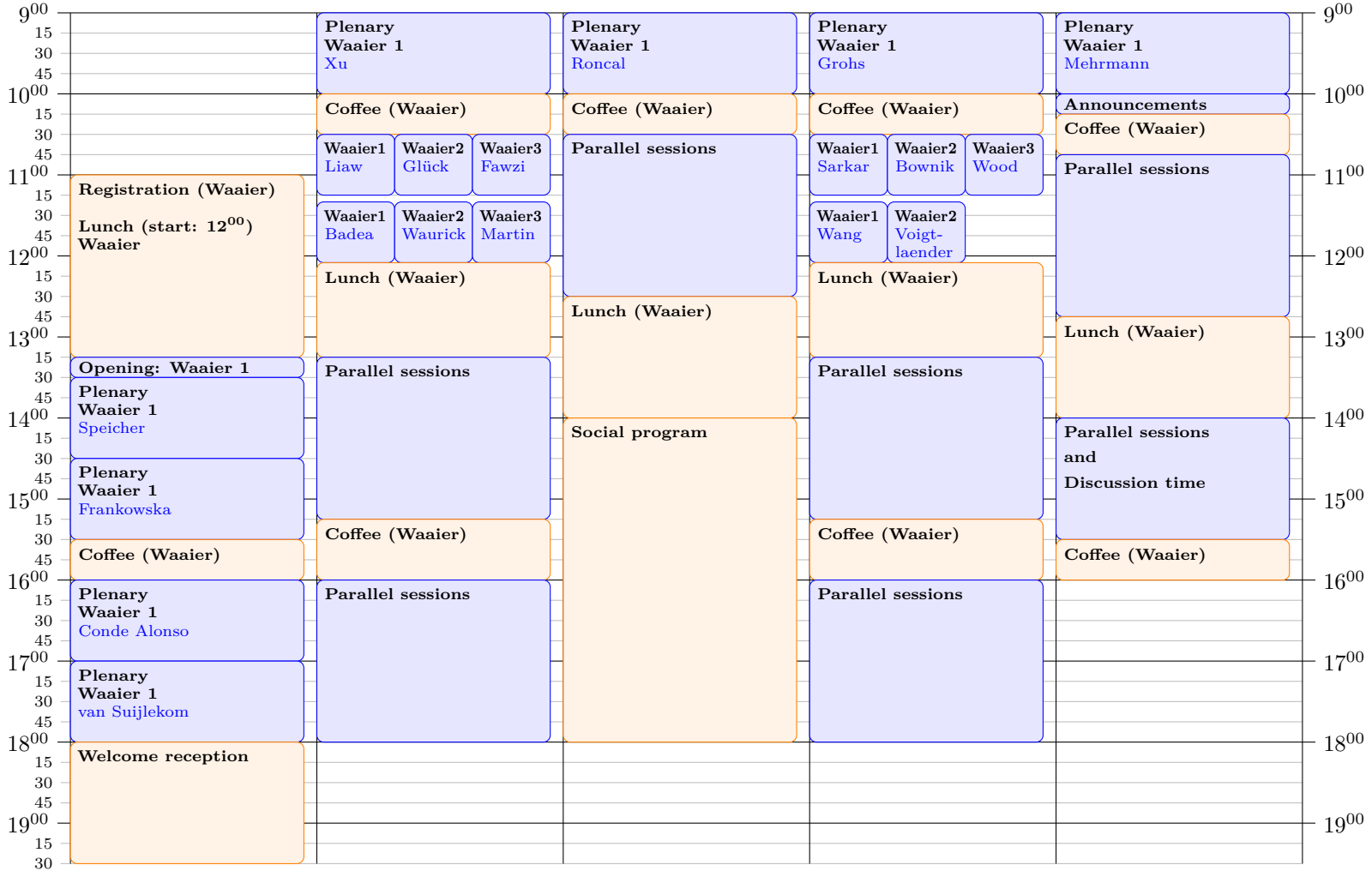
The social program on Wednesday afternoon consists of the following options:

1. A trip to the city of Ootmarsum;
   departure by bus; meeting point: 14.00 at O&O square (outside **Waaier** building).

2. A trip to Haaksbergen (historic train ride),
   departure by bus; meeting point: 14.00 at O&O square (outside **Waaier** building).

3. A city tour in Enschede;
   starting at 16.00, meet at **Oude Markt** (city center).

The conference dinner (Thursday 18:30) will be held at the lounge of De Grolsch Veste, the football stadium of FC Twente. We will collectively walk there from campus. Parking lots are available there as well as a bus stop (Line 1, see below) and the train station "Enschede Kennispark".


Monday
Tuesday
Wednesday
Thursday
Friday
Registration (Waaier)
Lunch (start: 12^00) Waaier
Opening: Waaier 1
Plenary Waaier 1 Speicher
Plenary Waaier 1 Frankowska
Coffee (Waaier)
Plenary Waaier 1 Conde Alonso
Plenary Waaier 1 van Suijlekom
Welcome reception
Plenary Waaier 1 Xu
Coffee (Waaier)
Waaier1 Liaw
Waaier2 Glück
Waaier3 Fawzi
Waaier1 Badea
Waaier2 Waurick
Waaier3 Martin
Lunch (Waaier)
Parallel sessions
Coffee (Waaier)
Parallel sessions
Plenary Waaier 1 Roncal
Coffee (Waaier)
Parallel sessions
Lunch (Waaier)
Social program
Plenary Waaier 1 Grohs
Coffee (Waaier)
Waaier1 Sarkar
Waaier2 Bownik
Waaier3 Wood
Waaier1 Wang
Waaier2 Voigt-laender
Lunch (Waaier)
Parallel sessions
Coffee (Waaier)
Parallel sessions
Plenary Waaier 1 Mehrmann
Announcements
Coffee (Waaier)
Parallel sessions
Lunch (Waaier)
Parallel sessions and Discussion time
Coffee (Waaier)

Overview contributed sessions

	Tuesday 13:15–15:15				Tuesday 16:00–18:00			
S01	CR 3E	1. Boscain	2. Neel	3. Nicolussi	4. Grieser				
S02	CR 2N	1. Martini	2. Ganguly	3. Plewa	4. Federico	CR 2N	1. Russ	2. Tralli	3. Bownik	4. Führ
S03	HB 2B	1. Klioba	2. Aigner	3. Uteshova	4. Wierzba	HB 2B	1. Glück	2. Vanspranghe	3. Testa	4. Zeelie
S04	CR 2L	1. Evert	2. Kimsey	3. Netzer	4. Thiersen	CR 2L	1. van Rensburg	2. Roca	3. Liu	4. Khare
S05										
S06						CR 2M	1. Benhida	2. Exner	3. Stochel	4. Nailwal
S07	CR 2K	1. Dritschel	2. Ding	3. Bala	4. Biswas	CR 2K	1. Ball	2. Debnath	3. Bailey	4. Sarkar
S08										
S09	CR 2H	1. Brix	2. Li	3. Bruce	4. Forough	CR 2H	1. Sibbel	2. Kopsacheilis	3. Kumar	
S10	CR 2G	1. Woerdeman	2. Blaschke	3. Lemos	4. Szymański	CR 2G	1. Mashreghi	2. de Vries	3. Blazhko	4. Dronka
S11										
S12										
S13	CR 3C	1. Chalmoukis	2. Gómez-Cabello	3. Abadias	4. Asensio	CR 3C	1. Jordá	2. Sevilla	3. López-Martínez	4. Jornet
S14	CR 3A	1. Sabadini	2. Bernstein	3. Hogan	4. Schneider	CR 3A	1. Diki	2. Ferreira	3. Legatiuk	4. D. Alpay
S15	CR 3B	1. Norrbo	2. LO	3. Choe	4. Gilmore	CR 3B	1. Wu	2. Moreno López	3. Wang	4. Lv
S16										
S17	HB 2A	1. Glück	2. Mui	3. Ploß	4. Wirth	HB 2A	1. Drnovšek	2. Stennder	3. Amin	4. Kulkarni
S18										
S19										
S20										
S21	Waaier 3	1. de Snoo	2. D. Alpay	3. Mehrmann	4. Tretter	Waaier 3	1. Ran	2. Lindner	3. Gernandt	4. Trunk
S22	HB 2D	1. Gürdal–Kolanci	2. Kosiek	3. Koczorowski	4. Daw. Bugajewski	HB 2D	1. Périce	2. Uysal	3. Chongdar	4. Zhang
S23										

	Wednesday 10:30–12:30							
S01								
S02								
S03	**HB 2B**	1. Waurick	2. Morandin	3. Wojtylak	4. Preuster			
S04								
S05								
S06	**CR 2L**	1. Trachana	2. White	3. Zerouali				
S07	**CR 2K**	1. Pal	2. Lykova	3. Baran	4. Young			
S08	**CR 2M**	1. Volčič	2. Vinnikov	3. Sampat	4. Lu			
S09								
S10	**CR 2G**	1. Jana	2. Malman	3. Soares	4. Pikul			
S11	**CR 2N**		2. Bartolucci	3. Pérez	4. Chalmoukis			
S12								
S13								
S14	**CR 3A**	1. Schlosser	2. De Martino	3. Pinton	4. Faustino			
S15	**CR 3B**	1. Câmara	2. Ptak	3. Ostermann	4. Asghari			
S16								
S17	**HB 2A**	1. Tiersma	2. Peperko	3. Barbieri	4. Gaans			
S18								
S19	**Waaier 3**	1. Dym	2. Dewilde	3. Helton	4. Derkach	5. Vinnikov	6. Kimsey	7. Sarkar	8. Gauntlett
S20	**CR 2H**	1. Jury	2. Lamberti	3. Gumenyuk	4. Marano			
S21								
S22	**HB 2D**	1. Nandan	2. Fl. Hinostrosa	3. Augustine	4. Balazs			
S23								

	Thursday 13:15–15:15				Thursday 16:00–18:00			
S01	CR 3E	1. Falconi	2. Mikkelsen	3. Melgaard	4. Ishida	CR 3E	1. de Nittis	2. Tsaava	3. Kutsenko	4. Schlosser
S02										
S03										
S04										
S05	Waaier 3	1. Bart	2. Van Dooren	3. Dopico	4. Wojtylak	Waaier 3	1. Ran	2. Horst	3. Farenick	4. Woerdeman
S06	CR 2L	1. Yoo	2. Pietrzycki	3. Jabłoński	4. Moore					
S07										
S08	CR 2M	1. Speicher	2. Tornes	3. Pascoe		CR 2M	1. Helton	2. Štrekelj	3. Evert	4. Salomon
S09	CR 2H	1. Nuland	2. Arici	3. Mesland	4. Suijlekom	CR 2H	1. Gerontogiannis	2. Kyed	3. van den Dungen	4. Chen
S10										
S11	CR 2N	1. Reguera	2. Roncal	3. Casarino	4. Ciatti	CR 2N	1. Conde Alonso	2. Haar	3. Senger	
S12	CR 2K	1. van Leeuwen	2. Naldi	3. Heinlein	4. Gumber	CR 2K	1. Barboni	2. Heeringa	3. Korolev	4. Ruiz-Balet
S13	CR 3C	1. Kriegler	2. Roodenburg	3. Sarnowski	4. Klioba	CR 3C	1. Trostorff	2. Buchinger	3. Fkirine	4. Budde
S14	CR 3A	1. Kimsey	2. Fernandez	3. El Haoui	4. N. Alpay	CR 3A	1. Vajiac	2. Vajiac	3. Luna-Eli.	
S15	CR 3B		2. Dellepiane	3. Tutberidze	4. Tephnadze	CR 3B	1. Jain	2. Palacios	3. Stochmal	4. Bugajewska
S16	CR 3B	1. Sarkar								
S17										
S18	CR 2G	1. Huber	2. Schötz	3. Heinävaara	4. Britz	CR 2G	1. Xu	2. Baroni	3. Schmidt	4. Open problems
S19										
S20	HB 2A	1. Instanes	2. Deterding	3. Kourou	4. Dayan	HB 2A	1. Manolaki	2. N. Alpay	3. Malman	4. Martin
S21										
S22	HB 2D	1. Dar. Bugajewski	2. Badanin	3. Yu	4. Muratbekov	HB 2D	1. Dabra	2. Kiwerski	3. Tomaszewski	4. Wilson
S23	HB 2B	1. Melgaard	2. Ben-Artzi	3. Fishelov	4. Haimovici	HB 2B	1. Eidelman	2. Boito		

	Friday 10:45–12:45					Friday 14:00–15:30			
S01	CR 3E	1. Post	2. Merz	3. Fürst	4. Karabash				
S02	CR 2N	1. Oussa	2. Enstad	3. Beltiţă					
S03									
S04	CR 2L	1. Maestripieri	2. Shekhawat	3. Soto-González					
S05									
S06	CR 3A	1. Kuhlmann	2. Buchała	3. Atanasiu					
S07	CR 2K	1. Curto	2. Wang	3. Kumar	4. Kimsey	CR 2K	1. Vinnikov	2. Mal	3. Ahmed
S08	CR 2M	1. Ayun	2. Kiri						
S09	CR 2H	1. Leimbach	2. Wagner	3. Duhan	4. Reimann				
S10									
S11									
S12									
S13	CR 3C	1. Oliva-Maza	2. Arora	3. Preußler	4. Seifert				
S14									
S15									
S16	Waaier 3	1. Virtanen	2. Enciso-Molina	3. Duduchava	4. Quiroga-Bar.				
S17									
S18	CR 2G	1. Helton	2. Farkas	3. Wright	4. Rahaman				
S19									
S20									
S21									
S22	HB 2D	1. Zemánek	2. Ospanov	3. Niikuni	4. Świderski	CR 2M	1. Subhadip Pal	2. Das	3. Sahasrabuddhe
S23									

Chapter 1

Plenary Sessions

The non-commutative rank of matrices in non-commuting variables and free probability

Roland Speicher

Saarland University
speicher@math.uni-sb.de

Monday
13:30
Waaier 1

Abstract. I will address the noncommutative version of the Edmonds' problem, which asks to determine the rank of a matrix in non-commuting variables. I will provide an algorithm for the calculation of this rank by relating the problem with the distribution of a basic object in free probability theory, namely operator-valued semicircular elements. The distribution of such an operator-valued semicircular element can only have an atom at zero and the size of this atom determines the rank. In order to have a certificate for maximal rank, one has to exclude such an atom; and for numerical control on this one needs a priori-information about how much weight such a distribution can accumulate around zero. There has been some promising recent progress on such questions.

I will present the main questions, ideas and results without assuming any prior knowledge on free probability theory.

The talk is based on joint works with Johannes Hoffmann, Tobias Mai, and Sheng Yin.

Invariance of Sets under Transport Control Systems in Wasserstein Spaces

Hélène Frankowska

CNRS and Sorbonne Université, Paris
helene.frankowska@imj-prg.fr

Monday
14:30
Waaier 1

Abstract. The theory of meanfield control appeared during the past fifteen years due to growing occurrences of control-theoretic questions in the context of large systems of interacting agents. Broadly speaking, the term meanfield control covers a large range of models in which a centralised entity aims at stirring a large number of agents so as to achieve a desired goal. In this context, an increasing number of contributions have aimed at extending the foundations of optimal control theory developed in vector spaces and over differentiable manifolds to Wasserstein spaces and their manifold-like interpretation elaborated by McCann, Otto and Ambrosio-Gigli- Savaré. The main motivation for doing so is that most deterministic meanfield control problems are naturally formulated within this framework. At present, the underlying corpus of results comprises general and satisfactory optimality conditions, both in the form of the celebrated Maximum Principle or the Hamilton-Jacobi equations.

This talk is devoted to the invariance properties of subsets of probability measures under controlled transport equations. More precisely, I will discuss viability and invariance properties of proper subsets of Wasserstein spaces $\mathcal{P}_p(R^d)$ of Borel probability measures with finite $p-$momentum and $p \geq 1$. The dynamical system is a nonlocal one, described by the transport control system

$$\partial_t \mu(t) + \operatorname{div}(f(\mu(t), u(t))\mu(t)) = 0, \quad \mu(0) = \mu_0,\ u(t) \in U$$

where $f\colon \mathcal{P}_p(R^d) \times U \to \operatorname{Lip}(R^d, R^d)$, $\operatorname{Lip}(R^d, R^d)$ denotes the vector space of bounded Lipschitz maps from R^d into itself, U is a compact metric space, $\mu_0 \in \mathcal{P}_p(R^d)$ and controls are Lebesgue measurable functions $u\colon R_+ \to U$.

A subset $Q \subset \mathcal{P}_p(R^d)$ is called viable under the transport control system if for every $\mu_0 \in Q$, there exists a solution $\mu(\cdot)$ such that $\mu(t) \in Q$ for all $t \geq 0$. Q is called invariant under the transport control system if every such solution satisfies $\mu(t) \in Q$ for all times $t \geq 0$. To characterise these two properties in the spirit of the classical results an analogue of tangents to Q is introduced.

Two cases have to be distinguished. When $p > 1$ the characterisations are stronger and follow from some duality arguments [1]. In contrast for $p = 1$ the Euler approximation scheme is applied [2] to get viable solutions.

References

[1] Bonnet B. & Frankowska H.; *Viability and invariance of proper sets for continuity inclusions in Wasserstein spaces*, SIMA, 56 (2024), 2863-2914.

[2] Bonnet B., Corella A. & Frankowska H.; *Viability theorem in 1-Wasserstein space*, submitted, 2025.

Schur-type multipliers on Schatten-von Neumann classes as singular integral operators

José Manuel Conde Alonso
Universidad Autónoma de Madrid
jose.conde@uam.es

Monday
16:00
Waaier 1

Abstract. A Schur multiplier S_M is a linear operator that associated to a matrix $M = [m_{i,j}]_{i,j}$ that acts on other matrices by entrywise multiplication, that is,

$$S_M(A) = [m_{i,j}a_{i,j}]_{i,j}, \quad A = [a_{i,j}]_{i,j}.$$

The boundedness of Schur multipliers in the Schatten-von Neumann classes is an interesting question in operator algebra that was already considered by Grothendieck. We will explain how smoothness of the matrix M –seen as a function of two variables– is key to finding sufficient conditions for the boundedness of the corresponding Schur multiplier and other operators of the same flavor. This will come from a surprising connection with Fourier multipliers and noncommutative Calderón-Zygmund theory. Based on joint works with Adrián M. González Pérez, Javier Parcet and Eduardo Tablate.

Noncommutative geometry and operator systems

Walter van Suijlekom
Radboud University Nijmegen
waltervs@math.ru.nl

Monday
17:00
Waaier 1

Abstract. We give an overview of the recent interactions between noncommutative geometry and operator systems. We will see that the structure of an operator system is the minimal structure required to be able to speak of positive elements, states, pure states, etc. After presenting the general theory, we will illustrate this by many examples, ranging from spectral truncations of geometric spaces, to metric spaces up to a finite resolution. We will also present a general approach to analyzing (Gromov-Hausdorff) convergence results, which we will illustrate once again in these examples.

Analysis on twisted crossed products

Quanhua Xu

Université Marie & Louis Pasteur (Besançon) and Harbin Institute of Technology
qxu@univ-fcomte.fr

Tuesday
09:00
Waaier 1

Abstract. Given a twisted W*-dynamic system $(\mathcal{M}, \alpha, \sigma, \Gamma)$ let $\mathcal{M} \rtimes_{\alpha,\sigma} \Gamma$ be the associated twisted crossed product. In this talk, we first consider permanent properties under twisted crossed product like injectivity and w*-amenability. The second part of the talk is devoted to the study of Fourier multipliers on $\mathcal{M} \rtimes_{\alpha,\sigma} \Gamma$. We give criteria of completely bounded L_p Fourier multipliers and establish a link between Fourier and Schur multipliers.

This talk is based a joint work with Xiao Xiong and Kai Zeng.

Unique continuation properties: from discrete to continuous

Luz Roncal

Basque Center for Applied Mathematics, Ikerbasque, and University of the Basque Country
lroncal@bcamath.org

Wednesday
09:00
Waaier 1

Abstract. Discrete and continuum operators often exhibit different unique continuation properties: uniqueness features which hold in the continuum setting stop being true in discrete scenarios, or quantitative forms of unique continuation are manifestly diverse according to the setting.

We will give an overview of recent results on unique continuation properties for solutions of discrete equations on a lattice $(h\mathbb{Z})^d$. By discussing quantitative forms of unique continuation, on the one hand we will illustrate that some of these properties which fail in the lattice can be recovered if small correction terms (in the lattice size) are added and, on the other hand we will investigate interpolation phenomena between continuum and discrete scales.

Based on joint works with Aingeru Fernández-Bertolin, Angkana Rüland, and Diana Stan.

Perspectives on Deep Learning in Scientific Computing

Philipp Grohs

University of Vienna and Austrian Academy of Sciences
philipp.grohs@univie.ac.at

Thursday
09:00
Waaier 1

Abstract. In recent years, Deep Learning methods have gained attention in

scientific computing. Examples include using neural networks as numerical ansätze for solving partial differential equations, and constructing data-driven surrogate models to replace complex first-principles simulations. Despite the initial excitement, these methods have had mixed success compared to established algorithms, with only a few cases where they clearly outperform traditional approaches.

In this talk, I will present fundamental upper and lower bounds on the complexity of Deep Learning-based algorithms for problems in scientific computing. These results help explain why these methods perform poorly on many standard problems, but also show when improvements over classical methods can be expected. One such example is the electronic Schrödinger equation, where we now achieve experimental accuracy for molecular systems of unprecedented size. I will show some empirical results and conclude with a discussion of open mathematical questions.

Passivity, Port-Hamiltonicity and Hypocoercivity of Descriptor Systems

Volker Mehrmann

TU Berlin
mehrmann@math.tu-berlin.de

Friday
09:00
Waaier 1

Abstract. The class of port-Hamiltonian system is a wonderful model class. It allows for modularized modeling of complex systems because it is invariant under power-conserving interconnection, conservation of energy is replaced by a power-balance equation which ensures basic physical principles also for open systems, the class is invariant under weak formulation and Galerkin projection and properties like (asymptotic) stability and (strict) passivity are directly encoded in the mathematical structure, which makes the models robust under perturbations. The class also allows for an extension to descriptor systems, so that constraints are easily incorporated. We present an overview of the model class and its properties and, using the concept of hypocoercivity, we also discuss what the benefits of the structure are in the analysis of the long and short time decay behavior of solutions which can be qualitatively characterized. Since the port-Hamiltonian structure is not unique, we also discuss how to use the freedom in the representation to optimize the robustness of models.

References

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Chapter 2

Semi-Plenary Sessions

An Overview of Aleksandrov–Clark Theory and some Generalizations

Constanze Liaw

University of Delaware
liaw@udel.edu

Tuesday
10:30
Waaier 1

Abstract. Aleksandrov–Clark theory lives at the intersection of analytic function theory, operator theory, spectral theory, and perturbation theory. Following Clark's discovery — that all rank-one perturbations of the compressed shift that are also unitary have a particular, simple form — a rich theory was developed connecting the spectral properties of those unitary rank one perturbations with properties of functions from the model space, more precisely, with their non-tangential boundary values. Some intriguing perturbation results were obtained via complex function theory. Throughout we will allude to some generalizations such as non-inner θ, finite rank perturbations, functions of several variables, etc.

Maximal inequalities and spectral theory

Jochen Glück

University of Wuppertal
glueck@uni-wuppertal.de

Tuesday
10:30
Waaier 2

Abstract. A sequence of operators (T_n) on an L^p-space is said to satisfy a *maximal inequality* if there exists a number $M \geq 0$ such that

$$\Big\| \sup_{n \geq 0} |T_n f| \Big\|_p \leq M \|f\|_p$$

for all $f \in L^p$. Those inequalities are an important and classical tool in harmonic analysis and ergodic theory.

In this talk we discuss how maximal inequalities can be interpreted from an order theoretic point of view and how this perspective is useful in operator theory. In particular, we derive the following result: If T is a positive linear operator on L^p for $p \in [1, \infty)$ and the powers (T^n) satisfy a maximal inequality, then T has at most finitely many spectral values on the unit circle. This has remarkable consequences in the regularity theory of strongly continuous operator semigroups.

Convex optimization and quantum information

Hamza Fawzi

Department of Applied Mathematics and Theoretical Physics, University of Cambridge
hf323@cam.ac.uk

Tuesday
10:30
Waaier 3

Abstract. Matrix entropies and relative entropies play a crucial role in quantum theory. In this overview talk, I plan to discuss various theoretical and computational aspects of these entropy functionals from a convex optimization viewpoint, motivated by concrete problems in quantum information, and quantum many-body theory.

Spectral sets and inequalities for analytic functions

Catalin Badea

Université de Lille, France and University of Reading, UK
catalin.badea@univ-lille.fr;
c.badea@reading.ac.uk

Tuesday
11:20
Waaier 1

Abstract. It is a known fact in operator-related function theory that the Schwarz-Pick inequality for a Schur function (the invariant form of the Schwarz lemma) is equivalent to the renowned von Neumann inequality for 2×2 matrices. In this talk, we explore several applications, extensions, and analogues of this equivalence, with a focus on more general spectral sets, invariant distances and several inequalities for analytic functions.

The Schur topology and Homogenisation for PDEs

Marcus Waurick

TU Bergakademie Freiberg
marcus.waurick@math.tu-freiberg.de

Tuesday
11:20
Waaier 2

Abstract. In this talk, we describe a common principle underlying all

classical homogenisation problems. More precisely, given a linear, potentially time-dependent partial differential equation (PDE) with highly oscillatory coefficients, the objective is to find a PDE model that best approximates the given one on large scales. This approach is mathematically formalised by performing a limiting procedure corresponding to the fictitious limit in which the ratio of micro- to macro-scale tends to zero.

We introduce the Schur topology, a topology on a subset of bounded linear operators on Hilbert space, which precisely models the limiting behaviour on the set of coefficients. This framework enables us to formulate and prove homogenisation theorems for a broad class of PDEs, including Maxwell's equations and systems describing, for instance, thermoelasticity or piezo-electromagnetism. From this perspective, operator-theoretic explanations for the emergence of memory effects can be provided, along with an explicit procedure for computing homogenised coefficients, particularly for PDE systems.

The content of the talk draws on a wide body of work developed over the past 15 years.

Entire and meromorphic non-commutative functions

Robert Martin

University of Manitoba

Robert.Martin@umanitoba.ca

Tuesday
11:20
Waaier 3

Abstract. We study the ring of entire functions in several non-commuting (NC) variables, defined as the complex formal power series in d NC variables, $d \in \mathbb{N}$, that have an infinite "Cauchy–Hadamard radius of convergence". Such power series define holomorphic and analytic matrix-valued functions on the entire $d-$dimensional NC universe of $d-$tuples of square matrices of any fixed finite size via evaluation. Applying P.M. Cohn's theory of localization of non-commutative rings combined with non-commutative Hardy space and operator–theoretic techniques, we show that the ring of entire NC functions has a (unique and universal) field of fractions, the field of globally meromorphic NC functions.

As an application, we prove that any meromorphic NC function has well-defined evaluations and domain in $d-$tuples over any stably-finite C^*-algebra, extending a theorem of Cohn for NC rational functions.

This is joint work with Méric L. Augat (James Madison University) and Eli Shamovich (Ben-Gurion University of the Negev).

References

[1] M.L. Augat, R.T.W. Martin and E. Shamovich. Operator realizations of non-commutative analytic functions. *Forum of Mathematics, Sigma*, In press, 2025.

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Commutant lifting, interpolation, and perturbations on the polydisc

Jaydeb Sarkar

Indian Statistical Institute
jay@isibang.ac.in

Thursday
10:30
Waaier 1

Abstract. The fundamental theorem on commutant lifting due to Sarason does not carry over to the setting of the polydisc. This talk will present two distinct classifications addressing commutant lifting in the polydisc setting. The first classification links the lifting problem to the contractivity of certain linear functionals. The second classification reformulates the lifting problem in terms of nonnegative real numbers. We will also solve the Nevanlinna-Pick type interpolation problem for bounded analytic functions on the polydisc. If time permits, we will talk about a solution to a perturbation problem for bounded analytic functions. This talk is based on joint work with Deepak K. D.

Diagonals of self-adjoint operators

Marcin Bownik

University of Oregon
mbownik@uoregon.edu

Thursday
10:30
Waaier 2

Abstract. Given a self-adjoint operator T on a separable infinite-dimensional Hilbert space we study the problem of characterizing the set $\mathcal{D}(T)$ of all possible diagonals of T. We present two types of results.

For compact operators T, we give a complete characterization of diagonals modulo the kernel of T. That is, we characterize $\mathcal{D}(T)$ for the class of operators sharing the same nonzero eigenvalues (with multiplicities) as T. Moreover, we determine $\mathcal{D}(T)$ for a fixed compact operator T, modulo the kernel problem for positive compact operators with finite-dimensional kernel.

For operators T with at least two points in their essential spectrum $\sigma_{ess}(T)$, we give a complete characterization of $\mathcal{D}(T)$ for the class of self-adjoint operators sharing the same spectral measure as T with a possible exception of multiplicities of eigenvalues at the extreme points of $\sigma_{ess}(T)$. We also give a more precise description of $\mathcal{D}(T)$ for a fixed self-adjoint operator T, albeit modulo the kernel problem for special classes of operators. These classes consist of operators T for which an extreme point of the essential spectrum $\sigma_{ess}(T)$ is also an extreme point of the spectrum $\sigma(T)$.

Results for compact operators generalize a characterization of diagonals of trace class positive operators by Arveson and Kadison [1] and diagonals of compact positive operators by Kaftal and Weiss [7] and Loreaux and Weiss [8]. Results for non-compact operators generalize a characterization of diagonals of orthogonal projections by Kadison [5, 6], Blaschke-type results of Müller and Tomilov [9], and a characterization of diagonals of operators with finite spectrum by Jasper and the author [2]. This talk is based on a joint work with Jasper [3, 4].

References

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[2] M. Bownik, J. Jasper, *The Schur-Horn theorem for operators with finite spectrum*, Tran. Amer. Math. Soc. **367** (2015), 5099–5140.

[3] M. Bownik, J. Jasper, *Diagonals of self-adjoint operators II: non-compact operators*, Math. Ann. **391** (2025), 431–507.

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Interface Problems for Non-Selfadjoint Maxwell Equations

Ian Wood

University of Kent

i.wood@kent.ac.uk

Thursday
10:30
Waaier 3

Abstract. In this talk, we consider the spectrum of a non-selfadjoint operator pencil generated by the time-harmonic Maxwell problem with an interface between two dispersive media.

The dependence on the spectral parameter, i.e. the frequency, appears in the dielectric function and we make no assumptions on its form. In

particular, to model dispersive media, the dielectric function is allowed to be complex, yielding a non-selfadjoint problem.

We consider the different types of essential spectrum arising in this model. We will look at some simple examples where the spectrum can be explicitly determined, as well as what can be said in the more general situation.

This is joint work with Malcolm Brown (Cardiff), Tomas Dohnal (Halle), Karl Michael Schmidt (Cardiff) and Michael Plum (Karlsruhe).

References

[1] B. M. Brown, T. Dohnal, M. Plum, I. Wood. Spectrum of the Maxwell Equations for a Flat Interface between Homogeneous Dispersive Media. *Comm. Pure and Appl. Math.*, 406(3), 2025. doi.org/10.1007/s00220-024-05154-9.

Cyclic commuting tuples, linear functionals and RKHS

Yi Wang

Chongqing University
wang_yi@cqu.edu.cn

Thursday
11:20
Waaier 1

Abstract. Given a commuting n-tuple of bounded linear operators $\mathbf{T} = (T_1, \cdots, T_n)$ on a Hilbert space $\mathcal{H}$ and a distinguished cyclic vector $h \in \mathcal{H}$, we study the class of the tuple $(\mathbf{T}, h)$ under unitary equivalence. Let

$$F(z, w) := \langle e^{\langle \mathbf{T}, w \rangle} h, e^{\langle \mathbf{T}, z \rangle} h \rangle_{\mathcal{H}}, \quad z, w \in \mathbb{C}^n.$$

Then F is a positive definite kernel function on $\mathbb{C}^n$. Let $\mathcal{H}(F)$ be the reproducing kernel Hilbert space defined by F. We show that the tuple $\mathbf{T}^*$ is unitarily equivalent to the tuple of differential operators on $\mathcal{H}(F)$. As a consequence, the joint eigenvalues of $\mathbf{T}^*$ can be characterized in terms of F. We use this model to give an answer to the following question: if we equip $\mathbb{C}[z_1, \cdots, z_n]$ with the semi-inner product $\langle p, q \rangle_{\mathbf{T},h} = \langle p(\mathbf{T})h, q(\mathbf{T})h \rangle_{\mathcal{H}}$, when is this semi-inner product defined by a compactly supported distribution? (That is, a continuous linear functional on $\mathcal{C}^\infty(\mathbb{C}^n)$.)

On the Lipschitz constant of random ReLU neural networks

Felix Voigtlaender

Katholische Universität Eichstätt–Ingolstadt, Mathematical Institute for Machine Learning and Data Science
felix.voigtlaender@ku.de

Thursday
11:20
Waaier 2

Abstract. Despite their decisive success in many applications, trained deep neural networks are known to be vulnerable to so-called *adversarial*

examples, meaning small (sometimes imperceptible) perturbations to the input that cause large adversarial perturbations to the network outputs. It is thus of great interest to study the robustness of neural networks, as measured for instance by their Lipschitz constant. In this talk, we will present several results in this direction, which together yield an almost sharp characterization of the Lipschitz constant of *randomly initialized* neural networks with the ReLU activation function, both in expectation and with high probability. Such randomly initialized networks are important objects of study, since they serve as the initialization for training, and since it has been observed that they can be used to quickly gauge the relative performance of neural networks of different sizes.

This is joint work with Sjoerd Dirksen (Utrecht University), Paul Geuchen (KU), Dominik Stoeger (KU), and Thomas Telaar (ex KU).

Chapter 3

Special Sessions

S1: Differential operators in mathematical physics

Organizers: Konstantin Pankrashkin, Marcello Serri.

Heat and Schroedinger evolution on surfaces embedded in 3D contact SR manifolds

Ugo Boscain

Sorbonne Université (Paris VI), France
ugo.boscain@upmc.fr

Tuesday
13:15
CR 3E

Abstract. In this talk I consider a surface embedded in a 3D contact sub-Riemannian manifold. Such a surface inherits a field of direction (with norm) from the ambient space. This field of directions is singular at characteristic points (i.e., where the surface is tangent to the set of admissible directions). In this talk we will study when the normed field of directions permits to give to the surface the structure of metric space (of "SNCF" type). I will also study how to define the heat and the Schroedinger equation on such a structure and if the singular points are "accessible" or not. When the singular points are accessible we will study self-adjoint extensions with Kirchhoff like boundary conditions.

Non-Markovian coupling of sub-Riemannian diffusions

Robert Neel

Lehigh University, USA
rwn209@lehigh.edu

Tuesday
13:45
CR 3E

Abstract. We describe the classical Markov couplings of Riemannian Brownian motions and how these natural constructions fail in sub-Riemannian geometry, even for the simplest case of the Heisenberg group. After reviewing the situation, we describe an improvement and extension of recent constructions of non-Markovian reflection couplings on sub-Riemannian model spaces by Banerjee-Gordina-Mariano and Bénéfice. Moreover, this construction is relatively simple and geometrically appealing, being based on global symmetries of the underlying spaces. This talk is based on joint work with Liangbing Luo.

Heat kernels on infinite graphs, isoperimetry, and the Laguerre operator

Noema Nicolussi

TU Graz, Austria
nicolussi@math.tugraz.at

Tuesday
14:15
CR 3E

Abstract. There is a compelling interplay between the behavior of heat kernels for a Laplacian and isoperimetric properties of the underlying geometric space. In this talk, we study infinite weighted graphs and use isoperimetry to establish heat kernel estimates for their Laplacians (i.e. ultracontractivity estimates and Gaussian decay). In particular, this provides a conceptual explanation for recent results on heat kernels of the discrete Laguerre operator.

Based on joint work with Matthias Keller (University of Potsdam), Aleksey Kostenko (University of Ljubljana) and Christian Rose (University of Potsdam).

The Dirichlet-Neumann operator for fibred cusp geometries

Daniel Grieser

University of Oldenburg, Germany
daniel.grieser@uol.de

Tuesday
14:45
CR 3E

Abstract. We consider Riemannian manifolds with boundary where the boundary exhibits singularities of fibred cusp type, or are conformal to these.

A simple example is the complement of two touching balls in $\mathbb{R}^n$. This type of singularity (at the touching point), in case $n = 2$, is often called an incomplete cusp (or horn). Other examples, conformal to these types of spaces and with 'singularity' at infinity, are fundamental domains of Fuchsian groups and uniformly fattened infinite cones in $\mathbb{R}^n$.

The Dirichlet-Neumann (DN) operator on a Riemannian manifold with boundary maps Dirichlet boundary data of harmonic functions to their Neumann data. This operator is well studied in the smooth compact case, for example it is known that it is a pseudodifferential operator (PsiDO), and its spectrum (the Steklov eigenvalues) has been studied intensively, as well as the inverse problem for it.

We show that the DN operator for fibred cusp singularities are in a PsiDO calculus adapted to the geometry, the so-called phi-calculus. This yields a precise description of their integral kernels near the singularities. In the talk I will introduce the necessary background on the phi-calculus, and also discuss some of the spectral properties of the DN operator in this setting.

This is joint work with K. Fritzsch und E. Schrohe.

Γ-convergence in semiclassical analysis

Marco Falconi

Politecnico di Milano, Italy
marco.falconi@polimi.it

Thursday
13:15
CR 3E

Abstract. In this talk I present a couple of applications of Γ-convergence of functionals in problems of semiclassical analysis. In particular, we study the semiclassical behavior of entropy and free energy for systems of confined particles; and the quasi-classical limit of charges in interaction with a semiclassical force field, in a regime in which the charge distribution becomes point-like in the semiclassical limit. Based on joint works with Z. Ammari, S. Breteaux, M. Correggi, J. Faupin, R. Gautier.

Sharp semiclassical spectral asymptotics for Schrödinger operators without full regularity

Søren Mikkelsen

University of Helsinki, Finland
soren.mikkelsen@helsinki.fi

Thursday
13:45
CR 3E

Abstract. In this talk we will discuss some recent results on sharp semiclassical spectral asymptotics for Schrödinger operators obtained without full regularity. We will in the talk present the results and discuss what challenges arise when full regularity is not assumed.

Energy-localized Egorov theorem for matrix-valued Schrödinger operator without Cordes's hyperbolicity condition

Michael Melgaard

University of Sussex, UK
m.melgaard@sussex.ac.uk

Thursday
14:15
CR 3E

Abstract. We establish a semi-classical Egorov type theorem for a matrix-valued Schrödinger operator, frequently arising in important applications, which does not satisfy typically imposed hypotheses, e.g., Cordes's hyperbolicity condition [1]. The proof combines a number of new ideas and the techniques involve h-pseudodifferential operator calculus, Riesz projection formula, energy localization, and detailed study of the Heisenberg equations on symbol level using the time-dependent Schrödinger equation to justify an auxiliary localized initial condition which allows for a detailed analysis of the Hamiltonian flow and the derivation of key estimates for the solutions to new auxiliary Heisenberg equations.

References

[1] Z. Chen, M. Melgaard. Energy-localized Egorov theorem for matrix-valued Schrödinger operator without Cordes's hyperbolicity condition. *Houston J. Math.* (2025), to appear.

Rollnik-type perturbations for fractional Schrödinger operators

Atsuhide Ishida

Tokyo University of Science, Japan
aishida@rs.tus.ac.jp

Thursday
14:45
CR 3E

Abstract. The Rollnik perturbation for the standard Schrödinger operator was proposed by H. Rollnik in 1956, and nowadays, we know some applications in spectral and scattering theory. In this talk, we consider Rollnik-type perturbations for fractional Schrödinger operators based on kernel estimates of the resolvent. In particular, I will discuss self-adjointness, the stability of the essential spectrum, and related topics. This talk is joint work with J. Lőrinczi and G. Ascione (arXiv:2405.08805).

Topological phases of non-interacting systems: A general approach based on states

Giuseppe de Nittis

Pontificia Universidad Católica de Chile (PUC), Chile

gidenittis@mat.puc.cl

Thursday
16:00
CR 3E

Abstract. In this work we provide a classification scheme for topological phases of certain systems whose observable algebra is described by a trivial C*-bundles. The classification is based on the study of the homotopy classes of configurations, which are maps from a quantum parameter space to the space of pure states of a reference fiber C*-algebra. Both the quantum parameter space and the fiber algebra are naturally associated with the observable algebra. A list of various examples described in the last section shows that the common classification scheme of non-interacting topological insulators of type AI is recovered inside this new formalism.

Transmission problems for a second order differential equation on a hypersurface with Lipschitz boundary in the generic Bessel potential spaces

Medea Tsaava

University of Georgia, Tbilisi

m.tsaava@ug.edu.ge

Thursday
16:30
CR 3E

Abstract. We are given a hypersurface $\mathcal{C} \subset \mathbb{R}^3$ with the Lipschitz boundary $\Gamma := \partial\mathcal{C}$, which contains angular points $c_1, \dots, c_n$. The surface is divided by a finite number of curves $\mathcal{T}_1, \dots, \mathcal{T}_m$ in nonintersecting domains $\mathcal{C}_1, \dots, \mathcal{C}_{m+1}$ and in each domain $\mathcal{C}_k$ is given the Laplace-Beltrami equation with lower order perturbations $\Delta_{\mathcal{C}} u + \boldsymbol{P}_k(\mathcal{D})u = f_k$, $k = 1, \dots, m+1$. Dirichlet, Neumann, and mixed-type BVPs are considered on the outer boundary Γ, while on curves $\mathcal{T}_1, \dots, \mathcal{T}_m$ are prescribed transmission conditions. BVP is treated in a nonclassical setting, when solutions, restricted to subsurfaces $\mathcal{C}_k$ belong to generic Bessel potential spaces with exponential weights $\mathbb{GH}^s_p(\mathcal{C}_k, \rho)$, $s > 1/p$, $1 < p < \infty$, $\rho(t) := \prod_{j=1}^{n} |t - c_j|^{\beta_j}$ for all $k = 1, \dots, m+1$. We reduce the problem to the equivalent Boundary pseudodifferential equation (BPsDE) on the boundary of the subsurfaces $\partial\mathcal{C}_k$, $k = 1, \dots, m+1$. We remove transmission conditions and transmission curves, reducing BPsDE to Fredholm-equivalent BPsDE only on the outer boundary of the surface $\Gamma = \partial\mathcal{C}$. Then we apply the localization and reduce the obtained BPsDE to the investigation of the Model BPsDE corresponding to BVPs for the Laplace

equation in a planar angular domains $\Omega_{\alpha_j} \subset \mathbb{R}^2$, $j = 1, 2, \ldots, n$, associated with the angular points $c_1, c_2, \ldots, c_n$. We investigate the BIE model in the generic Bessel potential spaces with weight $\mathbb{GH}^s_p(\Omega_{\alpha_j}, t^{\beta_j})$. Explicit criteria of the Fredholm property of the initial BVPs are obtained. In contrast to the same BVPs in the classical Bessel potential spaces $\mathbb{H}^s_p(\mathcal{C})$, the Fredholm property in the generic Bessel potential spaces $\mathbb{GH}^s_p(\mathcal{C}_k, \rho)$ with weight is independent of the smoothness parameter s.

This is a joint work with Professor Roland Duduchava.

Analytic solutions of wave equation in infinite domain with waveguides, local defects, and sources

Anton Kutsenko

University of Hamburg, Germany
akucenko@gmail.com

Thursday
17:00
CR 3E

Abstract. Analytic solution of the wave equation in an infinite domain with waveguides, local defects, and sources is derived. Numerical simulations based on the analytic solution do not have the same drawback as numerical solutions on bounded domains, where dealing with reflected waves from artificial boundaries is necessary. Some aspects of inverse problems: recovering defect properties from wave information, and modeling of cloaking devices (invisible regions) will also be discussed.

Schrödinger operators with delta-potentials on unbounded Lipschitz surfaces

Peter Schlosser

University of Graz, Austria
schlosser.p@gmx.at

Thursday
17:30
CR 3E

Abstract. In this talk I will investigate the the self-adjoint Schrödinger operator

$$A_\alpha = -\Delta - \alpha\delta(x - \Sigma),$$

in $d \geq 2$ dimensions, with a δ-potential supported on an unbounded Lipschitz hypersurface $\Sigma \subseteq \mathbb{R}^d$ of strength $\alpha \in L^p(\Sigma) + L^\infty(\Sigma)$. We show the uniqueness of the ground state and, under some additional assumptions on the potential strength α and the surface Σ, we determine the essential spectrum of A_α. In the special case that Σ is a hyperplane, we obtain a Birman-Schwinger principle with the Birman-Schwinger operator being the $(d-1)$-dimensional relativistic Schrödinger operator

$$D_{\alpha,\lambda} = 2(-\Delta - \lambda)^{\frac{1}{2}} - \alpha, \qquad \lambda < 0.$$

As an application we prove an optimization result for the bottom for the spectrum of A_α.

Convergence of first order operators on thick graphs (joint work with Pavel Exner)

Olaf Post

Uni Trier, Germany
olaf.post@uni-trier.de

Friday
10:45
CR 3E

Abstract. In this talk we discuss the convergence of first order operators on a thickened graph (a graph-like space) towards a similar operator on the underlying metric graph. On the graph-like space, the first order operator is of the form exterior derivative (the gradient) on functions and its adjoint (the negative divergence) on closed 1-forms (irrotational vector fields). Under the assumption that each cross section of the tubular edge neighbourhood is convex, that each vertex neighbourhood is simply connected and under suitable uniformity assumptions (which hold in particular, if the spaces are compact) we establish generalised norm resolvent convergence of the first order operator on the graph-like space towards the one on the metric graph. The square of the first order operator is of Laplace type; on the metric graph, the function (0-form) component is the usual standard (Kirchhoff) Laplacian. A key ingredient in the proof is a uniform Gaffney estimate: such an estimate follows from an equality relating here the divergence operator with all (weak) partial derivatives and a curvature term, together with a (localised) Sobolev trace estimate.

On the electron distribution of relativistic atoms and heat kernel bounds

Konstantin Merz

TU Braunschweig, Germany
k.merz@tu-bs.de

Friday
11:15
CR 3E

Abstract. The study of the electron distribution in atoms and molecules is paramount in quantum physics and chemistry. By the uncertainty principle, the innermost electrons move with velocities which are a substantial fraction of the speed of light. Hence, a relativistic description is mandatory. In this talk, we present new pointwise upper bounds for the sum of the squares of the eigenfunctions of the relativistic Chandrasekhar operator, in particular for each angular momentum channel separately. Our proof is concise and primarily relies on recently established heat kernel bounds for Hardy perturbations of subordinated Bessel heat kernels. This talk is based on joint

works with Krzysztof Bogdan and Tomasz Jakubowski, and with Rupert Frank.

Spectral shift of Callias type operators

Oliver Fürst

University of Bonn, Germany
ofuerst@math.uni-bonn.de

Friday
11:45
CR 3E

Abstract. The spectral shift function is a central object in mathematical scattering theory, which was developed in the 50's by M. Krein. In the late 80's it reemerged in the context of index theory, both as a replacement of Fredholm index and spectral flow for non-Fredholm operators. Recently several extensions of the "Index=Spectral Flow"-theorem have been found in this more general setting.

In this talk we treat the natural extension in higher dimensions, which corresponds to the Callias index theorem. The regularization scheme in this setup involves higher order spectral shift functions, which were conjectured originally in the 80's by Koplienko. Their existence in all cases have only been shown in the relatively recent past in 2013 by D. Potapov, A. Skripka, and F. Sukochev.

We present a non-Fredholm version of the classical Callias index theorem and give some concrete examples, in which the regularized index may assume any real number.

Descriptions of deterministic and random absorbing boundary conditions for acoustic systems

Illia Karabash

University of Bonn, Germany
karabash@iam.uni-bonn.de

Friday
12:15
CR 3E

Abstract. Motivated by engineering and Photonics research on resonators in structured deterministic or stochastic environments, we introduce rigorous randomizations of boundary conditions for acoustic wave equations in Lipschitz domains. First, a parametrization of essentially all m-dissipative boundary conditions in the boundary L2-space is constructed with the use of boundary tuples. Randomizations of these boundary conditions lead to acoustic operators random in the resolvent sense. We prove this using Neumann-to-Dirichlet maps and generalized Krein resolvent formulae. We give a description of random m-dissipative boundary conditions that produce acoustic operators with almost surely (a.s.) compact resolvents, and so, also with a.s. discrete spectra. Based on these results, examples of mathematically convenient randomizations are constructed in terms of eigenfunctions of

Laplace-Beltrami operators on boundaries. We show that, for these special randomizations, the resolvent compactness is connected with the Weyl law for Laplace-Beltrami eigenvalues, and also discuss available Weyl-asymptotic results for the case of nonsmooth boundaries.

S2: Harmonic analysis on groups and manifolds

Organizers: Jordy van Velthoven, Tommaso Bruno, Effie Papageorgiou.

Riesz transforms on $ax + b$ groups (and beyond) via operator-valued multiplier theorems

Alessio Martini

Politecnico di Torino
alessio.martini@polito.it

Tuesday
13:15
CR 2N

Abstract. We prove the L^p-boundedness in the full range $1 < p < \infty$ of the first-order Riesz transforms associated with the natural left-invariant Laplacian on an $ax + b$ group with a right Haar measure. This is a neat example of singular integral operators in a nondoubling setting, as $ax + b$ groups have exponential growth and the Riesz transforms are singular both locally and at infinity. Our result settles a question left open in previous work of Hebisch and Steger and of Gaudry and Sjögren, as we can treat the case $p > 2$ for the whole vector of Riesz transforms. An operator-valued Fourier multiplier theorem turns out to be key to this purpose. Our approach proves to be applicable even beyond $ax+b$ groups, but open problems remain about endpoint results at $p = \infty$.

References

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[2] A. Martini and P. Plewa, Singular integrals on $ax + b$ hypergroups and an operator-valued spectral multiplier theorem. `arXiv:2409.12833`.

[3] A. Martini and P. Plewa, L^p-boundedness of Riesz transforms on solvable extensions of Carnot groups. `arXiv:2409.13233`.

Dimension free estimates for the vector-valued Hardy–Littlewood maximal function on the Heisenberg group

Pritam Ganguly

University of Paderborn
pritamg@math.upb.de

Tuesday
13:45
CR 2N

Abstract. Dimension-free estimates for the Hardy–Littlewood maximal operator made their debut in the seminal work of Stein and Strömberg in the 1980s. Their breakthrough introduced a new perspective in harmonic analysis, highlighting the importance of obtaining bounds that are independent of

the ambient dimension. Since then, such estimates have become a central focus in the field, owing to their strength, generality, and applicability in both Euclidean and non-Euclidean settings.

In this talk, we will discuss dimension-free estimates for the vector-valued Hardy–Littlewood maximal operator associated with averages over Korányi balls in the Heisenberg group. A key ingredient in our approach is the establishment of L^p bounds for vector-valued Nevo–Thangavelu spherical maximal functions, which play a crucial role in our analysis. This is joint work with Abhishek Ghosh.

Singular integrals on solvable extensions of stratified groups

Paweł Plewa

Wrocław University of Science and Technology
pawel.plewa@pwr.edu.pl

Tuesday
14:15
CR 2N

Abstract. Let N be a stratified Lie group and let G be the semi-direct product $N \rtimes \mathbb{R}$, where $\mathbb{R}$ acts on N via automorphic dilations. Homogeneous left-invariant sub-Laplacians on N and $\mathbb{R}$ can be lifted to G and their sum Δ is a homogeneous left-invariant sub-Laplacian on G. We prove a Mihlin–Hörmander multiplier type theorem for Δ on G for a wide class of step 2 groups N. Furthermore, we study first-order Riesz transforms R_j, $j = 0, \dots, d$, on G for an arbitrary stratified group N. We prove $L^p(G)$ boundedness of R_j in the full range $p \in (1, \infty)$.

This talk is based on joined papers with Alessio Martini [1, 2, 3].

References

[1] A. Martini, P. Plewa, *A sharp multiplier theorem for solvable extensions of Heisenberg and related groups*, *Ann. Mat. Pura Appl.* 203 (2024), 1361–1408.

[2] A. Martini, P. Plewa, *L^p-boundedness of Riesz transforms on solvable extensions of Carnot groups*, preprint (2024), arXiv:2409.13233.

[3] A. Martini, P. Plewa, *Singular integrals on $ax+b$ hypergroups and an operator-valued spectral multiplier theorem*, preprint (2024), arXiv:2409.12833.

On the existence of a Weyl Calculus on Graded Groups

Serena Federico

University of Bologna
serena.federico2@unibo.it

Tuesday
14:45
CR 2N

Abstract. In this talk, I will discuss a class of quantizations on graded Lie groups, the so-called τ-quantizations, for which the corresponding pseudo-differential calculus is established. The fundamental question we will try to

answer is the following: which one among the symmetric τ-quantizations corresponds to the Weyl quantization in the graded setting? We will give an exhaustive answer in the case of the Heisenberg group and a partial answer in the general graded group setting.

Riesz transforms and reverse inequalities in Riemannian manifolds

Emmanuel Russ

Aix-Marseille University
emmanuel.russ@univ-amu.fr

Tuesday
16:00
CR 2N

Abstract. Let (M, g) be a complete Riemannian manifold, Δ the Laplace Beltrami operator and ∇ the Riemannian gradient. We discuss the validity of inequalities $\||\nabla f|\|_p \lesssim \left\|\Delta^{\frac{1}{2}} f\right\|_p$ and $\left\|\Delta^{\frac{1}{2}} f\right\|_p \lesssim \||\nabla f|\|_p$, $1 < p < \infty$, under various geometric assumptions. The role of Poincaré inequalities will be highlighted. These are joint works with Baptiste Devyver.

A Liouville theorem for equations with drift terms

Giulio Tralli

University of Ferrara
giulio.tralli@unife.it

Tuesday
16:30
CR 2N

Abstract. In this talk we discuss the validity of Liouville theorems for nonnegative solutions to (possibly degenerate) elliptic equations with constant diffusion and linear drift. Assuming that the drift term has imaginary spectrum, we show such Liouville property as a by-product of an invariant Harnack inequality for ancient solutions to the relevant parabolic equations. Our proof relies on the classical potential theory approach for harmonic functions, on the group-translation invariance of the parabolic operator, and on new doubling properties. We focus on the role of the large scale geometry underlying the class of operators under discussion. The talk is based on a joint work with A.E. Kogoj and E. Lanconelli.

Parseval wavelet frames on Riemannian manifolds

Marcin Bownik

University of Oregon
mbownik@uoregon.edu

Tuesday
17:00
CR 2N

Abstract. We present the construction of Parseval wavelet frames in $L^2(M)$ for a general Riemannian manifold M. We also show the existence of wavelet

unconditional frames in $L^p(M)$ for $1 < p < \infty$. The construction relies on the smooth orthogonal projection decomposition of the identity operator on $L^2(M)$. We also show a characterization of Triebel-Lizorkin $\mathbf{F}^s_{p,q}(M)$ and Besov $\mathbf{B}^s_{p,q}(M)$ spaces on compact manifolds in terms of magnitudes of coefficients of Parseval wavelet frames. We achieve this by showing that Hestenes operators are bounded on $\mathbf{F}^s_{p,q}(M)$ and $\mathbf{B}^s_{p,q}(M)$ spaces on manifolds M with bounded geometry.

This talk is based on a joint work with Dziedziul and Kamont.

Dilational symmetries of Besov-type decomposition spaces

Hartmut Führ

RWTH Aachen University
fuehr@mathga.rwth-aachen.de

Tuesday
17:30
CR 2N

Abstract. Given a function space, it is natural ask which linear changes of variable $f \mapsto f \circ A$, for a given invertible matrix A, leave the space invariant.

In this talk we present a systematic approach that allows to answer this question for a large class of smoothness spaces, the so-called *decomposition spaces* of Besov type, $D(\mathcal{P}, L^p, \ell^q_v)$ [1, 3].

Decomposition spaces are defined in terms of suitable coverings $\mathcal{P} = (P_i)_{i\in I}$ of a certain frequency domain $\Omega = \bigcup \mathcal{P}$. It turns out that A leaves the full scale of decomposition spaces associated to $\mathcal{P}$ invariant iff multiplication by A^{-T} induces a bijection of Ω onto itself that is quasi-isometric with respect to the metric induced by the covering [2].

We present various settings where this criterion can be employed to explicitly compute dilational symmetry groups of decomposition spaces, in particular generalized wavelet coorbit spaces. We also discuss the impact of these results on classification problems.

References

[1] H. G. Feichtinger and P. Gröbner. Banach spaces of distributions defined by decomposition methods. I *Math. Nachr.* **123** 97–120, 1985.

[2] H. Führ and R. Raisi Tousi. Dilational symmetries of decomposition and coorbit spaces *Appl. Comput. Harmon. Anal.* **69** (2024), Paper No. 101610

[3] F. Voigtlaender. Embeddings of decomposition spaces *Mem. Amer. Math. Soc.* **287**, 2023.

Zak–Transform Zeros, Orbit Dynamics, and the $(n, 1)$ Case of the HRT Conjecture

Vignon Oussa
Bridgewater State University
voussa@bridgew.edu

Friday
10:45
CR 2N

Abstract. The Heil–Ramanathan–Topiwala (HRT) conjecture asserts that every finite, non-trivial Gabor system is linearly independent. After briefly reviewing its motivation in time-frequency analysis, I will focus on the mixed-integer $(n, 1)$ configuration, in which $n - 1$ time-frequency shifts are lattice points and one is not. The Zak transform is our principal tool. For a square-integrable window with continuous Zak transform, the zero set Z is invariant under the toral translation generated by an off-integer shift. Three orbit types then arise:

1. **Dense orbits.** If a dense orbit meets the zero set even once, continuity forces it to be the whole torus, and this is only possible if the window function is trivial. This settles the $(n, 1)$ case for every window in the Wiener space and, therefore, for all Schwartz windows.

2. **Infinite but non-dense orbits.** Here, the size of the zero set Z becomes decisive: Z cannot be infinite and discrete. This eliminates large classes of windows, including totally positive functions of finite type.

3. **Finite orbits.** This corresponds to the off-integer point being rational in all its components, which has already been settled.

The talk is dedicated to the memory of Jean-Pierre Gabardo.

Existence of Schwartz frames in lattice orbits of nilpotent Lie groups

Ulrik Bo Rufus Enstad
University of Oslo
ubenstad@math.uio.no

Friday
11:15
CR 2N

Abstract. Gabor systems are sequences of time-frequency shifts applied to a single function, the associated window. When a Gabor system is a frame and the window is Schwartz, we call it a Schwartz Gabor frame. It is an open problem to characterize those lattices that admit Schwartz Gabor frames, and in this talk I will present some recent progress for the case of so-called rational lattices.

Gabor frames are special cases of coherent frames arising from the representation theory of nilpotent Lie groups. I will also discuss the problem of which lattices admit Schwartz frames in this setting. The talk is based on joint work with Hannes Thiel and Eduard Vilalta.

Square integrable representations of solvable Lie groups

Ingrid Beltiţă

Simion Stoilow Institute of Mathematics of the Romanian Academy
Ingrid.Beltita@imar.ro

Friday
11:45
CR 2N

Abstract. We characterize the square-integrable representations of simply connected solvable Lie groups in terms of a correspondence between the (generalized) orbits of the coadjoint action and the (quasi-) equivalence classes of normal representations. The case of the nilpotent Lie groups will receive special attention.

The talk reports on joint work with Daniel Beltiţă and Jordy Timo van Velthoven.

References

[1] Ingrid Beltiţă, Daniel Beltiţă, Square-integrable representations and the coadjoint action of solvable Lie groups *Forum Math.*, 79:693–715, 2025.

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S3: Linear systems and control theory

Organizers: Hannes Gernandt, Nathanael Skrepek.

Taming uncertain systems: Approximation of Random Evolution Equations

Katharina Klioba

Delft University of Technology
k.klioba-1@tudelft.nl

Tuesday
13:15
HB 2B

Abstract. A common challenge in modelling control systems consists in finding appropriate system parameters, such as diffusion coefficients. One possibility to overcome this challenge is to model them by a random variable, resulting in a random evolution equation. Solving such equations numerically requires a discretisation in space, in time, and of random coefficients. Methods to treat these three problems separately are well-known, including rates of convergence, however, the random nature can lead to problems when combining them.

In this talk, an abstract framework based on semigroup theory is presented, leading to convergence rates for the full discretisation of evolution equations corresponding to a random family of forms determined by finite-dimensional noise. Uncertainty quantification is performed by means of a polynomial chaos expansion (PCE). The main result are regularity conditions on the random forms under which convergence of polynomial order in randomness is obtained, depending on the smoothness of the coefficients and the Sobolev regularity of the initial value. To illustrate this interplay of different discretisation schemes, results are discussed for random anisotropic diffusion.

This is joint work with Christian Seifert from Hamburg University of Technology.

Evolutionary equations with state-dependent delay

Bernhard Aigner

TU Bergakademie Freiberg
bernhard.aigner@doktorand.tu-freiberg.de

Tuesday
13:45
HB 2B

Abstract. I will showcase recent applications of the theory of evolutionary equations, which provides weak solutions to a large class of PDEs in

exponentially weighted L^2-spaces, to state-dependent delay differential equations. This leads to an improvement of well-posedness results for ODEs, i.e., equations of the form

$$\begin{aligned} x'(t) &= F(t, x_{(t)}) \\ x_{(0)} &= \Phi, \end{aligned}$$

where F is a suitably Lipschitz-continuous right hand side, $x_{(t)}$ denotes the history of the state x and Φ is a Lipschitz-continuous prehistory with essentially bounded derivative.

Furthermore, we will investigate evolutionary equations of the form

$$(\partial_t M_0 + M_1 + A)u(t) = F(t, u_{(t)}),$$

where $M_0, M_1 \in \mathcal{L}_{\mathrm{b}}(\mathrm{H})$ and A is a skew-adjoint unbounded operator acting on a Hilbert space H. Under suitable assumptions on M_0, M_1, A and the right hand side one can show well-posedness of an extrapolated problem, proving well-posedness of the initial value problem in a weakened sense.

The results are based on joint work with Marcus Waurick.

On boundary value problems for differential-algebraic equations

Roza Uteshova

Institute of Mathematics and Mathematical Modeling

r.uteshova@math.kz

Tuesday
14:15
HB 2B

Abstract. We study two-point boundary value problems for linear differential-algebraic equations with constant coefficients in the general case where the associated matrix pair may be singular. By employing the Kronecker canonical form, we decompose the system into simpler subsystems and apply a parameterization method that reduces the boundary value problem to a system of algebraic equations. This enables us to derive explicit solvability and uniqueness criteria. The results yield a unified framework for analyzing such problems and are illustrated with examples.

This is joint work with Carsten Trunk and Henrik Winkler (Technische Universität Ilmenau).

This research is supported by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (grant No. AP23485618) and by European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement ID: 873071, project SOMPATY (Spectral Optimization: From Mathematics to Physics and Advanced Technology).

A dual notion to BIBO stability

Alexander A. Wierzba
University of Wuppertal
a.a.wierzba@utwente.nl

Tuesday
14:45
HB 2B

Abstract. In this contribution we consider BIBO stability of infinite-dimensional linear state-space systems and the related notion of L^1-to-L^1 input-output stability (abbreviated *LILO*). We show that in the case of finite-dimensional input and output spaces, both are equivalent and preserved under duality transformations. In the general case, neither of these properties is satisfied, but BIBO and LILO stability remain dual to each other. As an application, we demonstrate how the connection between these two notions can be employed to derive a sufficient condition for BIBO stability of distributed port-Hamiltonian systems.

This contribution is based upon joint work with Felix L. Schwenninger [1, 2].

References

[1] F. L. Schwenninger, A. A. Wierzba. A dual notion to BIBO stability *Journal of Mathematical Analysis and Applications*, 545(2):129156, 2025. doi:10.1016/j.jmaa.2024.129156.

[2] F. L. Schwenninger and A. A. Wierzba. BIBO stability of port-Hamiltonian systems, arXiv:2410.12697 [math.OC], 2024. doi:10.48550/arXiv.2410.12697.

Admissiblity of positive control and observation operators

Jochen Glück
University of Wuppertal
glueck@uni-wuppertal.de

Tuesday
16:00
HB 2B

Abstract. We consider infinite-dimensional linear systems of the form

$$\dot{x}(t) = Ax(t) + Bu(t),$$
$$y(t) = Cx(t),$$

where A generates a strongly continuous operator semigroup on the state space of the system and B and C are so-called control and observation operators that can be unbounded.

In many applications the operators A, B and C act on function spaces. The case where B and C, as well as the semigroup generated by A, map positive functions to positive functions, has recently attracted interest in

the literature since it occurs in various concrete models and has surprising theoretical implications. In this talk we discuss the consequences of those positivity properties on the admissibility of the operators B and C.

Admissibility theory in abstract Sobolev scales and applications

Nicolas Vanspranghe

Tampere University
nicolas.vanspranghe@tuni.fi

Tuesday
16:30
HB 2B

Abstract. We investigate admissibility properties of control and observation operators shifted along continuous scales of spaces. Our motivation and prototype case is the multidimensional wave equation with Neumann boundary control and Dirichlet velocity observation, which notably fails to be *well-posed* as a linear system. Specialized to such models, our results allow us to derive high-frequency transfer function asymptotics that capture sharp time-domain interior and boundary regularity properties established in the PDE literature. In turn, the resulting frequency-domain estimates make possible an analysis of the non-uniform stabilization problem via Russell's principle. As an application we prove new energy decay rates for the waves posed in a rectangle and subject to Neumann feedback on an arbitrary open subset of the boundary. We also discuss connections between the wave and the Schrödinger equations in terms of regularity and observability.

This talk is based on [1], which is a joint work with Lassi Paunonen (Tampere University) and David Seifert (Newcastle University).

References

[1] L. Paunonen, D. Seifert, and N. Vanspranghe. Admissibility theory in abstract Sobolev scales and transfer function growth at high frequencies, 2024. arXiv:2412.14786.

Well-posedness of Hodge wave systems on compact manifolds

Filippo Testa

University of Twente
f.testa@utwente.nl

Tuesday
17:00
HB 2B

Abstract. The study of the Hodge wave equation, formulated on L^2 differential forms on a compact manifold, is of interest both from the point of view of geometry and for the study of PDEs, as it is generalizes the scalar wave equation and it is deeply connected with Maxwell's equations.

In this talk, we will discuss the well-posedness of the Hodge wave equation, by rewriting it as a first order system and identifying an appropriate boundary triplet for the resulting operator. We will discuss how to properly define the correct boundary spaces using the language of exterior calculus and present a class of boundary conditions which guarantee well-posedness.

The Output Feedback Case of $\mathcal{H}_2$-Optimal Control for Poset-Causal Systems

Jacobus Zeelie

North-West University, South Africa
jaccie.zeelie@nwu.ac.za

Tuesday
17:30
HB 2B

Abstract. In this talk, we study $\mathcal{H}_2$-control problem for a sub-class of decentralized systems, known as poset-causal systems.

Poset-causal systems consist of interconnected subsystems where each subsystem is a causal LTI system with local inputs, states and outputs. The underlying connection structure between subsystems can be modelled by a partial order. This results in a block sparsity pattern in the overall system matrices.

The $\mathcal{H}_2$-control problem for poset-causal systems has been solved in various special cases, in particular the state feedback case has been solved for general poset-causal systems and the output feedback case has been solved for the simplest sub-class of poset-causal systems, the two player problem.

We suggest four approaches for constructing viable controllers for the output feedback case of the $\mathcal{H}_2$-control problem for general poset-causal systems.

References

[1] L. Lessard and S. Lall, Optimal controller synthesis for the decentralized two-player problem with output feedback, *In 2012 American Control Conference (ACC)*, pp. 6314–6321, IEEE, 2012.

[2] P. Shah, A partial order approach to decentralized control, PhD thesis, Massachusetts Institute of Technology, 2011.

[3] J. Swigart and S. Lall, Optimal Synthesis and Explicit State-Space Solution for a Decentralized Two-Player Linear Quadratic Regulator, *49th IEEE Conference on Decision and Control*, pp. 132–137, 2010.

[4] K. Zhou, J. Doyle and K. Glover, *Robust and Optimal Control*, Prentice Hall, 1996.

Stability theorems for port-Hamiltonian systems

Marcus Waurick
TU Bergakademie Freiberg
marcus.waurick@math.tu-freiberg.de

Wednesday
10:30
HB 2B

Abstract. We present recent developments concerning theorems that characterise stability with specific decay rates for a certain class of time-dependent partial differential equations. This class comprises (systems of) one-dimensional hyperbolic-type equations, known as port-Hamiltonian systems (pHS). Naturally, the developed criteria depend on the model ingredients and characterise the decay solely through matrix conditions.

Structure-preserving model reduction of linear time-varying port-Hamiltonian systems

Riccardo Morandin
OvGU Magdeburg
riccardo.morandin@ovgu.de

Wednesday
11:00
HB 2B

Abstract. Many physical processes can be naturally modeled using port-Hamiltonian (pH) systems, which are inherently passive and stable, and allow for structure-preserving interconnection, making them particularly suitable for the modeling of complex networks. Furthermore, many dedicated numerical methods have been developed to exploit and preserve the structure of pH systems, e.g., for space- and time-discretization, and model order reduction (MOR).

In our work, we focus on the structure-preserving MOR of linear time-varying (LTV) pH systems. LTV systems appear quite naturally in many applications, e.g., in the linearization of nonlinear systems around non-stationary reference solutions, or when some of the system parameters are time-dependent. In this talk we introduce a general approach based on (Petrov)-Galerkin projection for the structure-preserving MOR of LTV-pH systems. This includes (but is not limited to) the extension of the effort constraint method to LTV-pH systems. Furthermore, we combine balancing and projection to obtain a reduced model that is guaranteed to be pH. We exhibit numerical experiments to validate our algorithms.

This is joint work with Karim Cherifi (University of Wuppertal).

Detection of the index and discretization of the port-Hamiltonian descriptor systems

Michał Wojtylak

Jagiellonian University, Kraków, Poland
michal.wojtylak@uj.edu.pl

Wednesday
11:30
HB 2B

Abstract. We propose a method for detecting Kronecker blocks of size two in port-Hamiltonian pencils of the form

$$\lambda E - (J - R)Q,$$

where Q^*E and R are positive definite, and J is a skew-Hermitian matrix. The method is based on first-order perturbation theory and an additional randomisation step.

We present both mathematical estimates and numerical results. Further, we study the impact of proximity to unstable systems on the numerical solutions (via the midpoint rule) of the corresponding DAE.

Additionally, we study the behaviour of the systems close to the set of systems of index 2 in the unstructured case. In this situation, our theory will be supported by the pseudospectral shadowing technique, see Banks et al., Comm. Pure Appl. Math. 2021.

The talk is based on joint work with Hanna Blazhko.

Extension theory via boundary triplets for implicit port-Hamiltonian systems

Till Preuster

Chemnitz University of Technology
till.preuster@mathematik.tu-chemnitz.de

Wednesday
12:00
HB 2B

Abstract. We present a framework for analyzing constrained linear partial differential equations using parametric representations of linear relations. Central to our approach is a novel definition of boundary triplets for symmetric linear relations expressed in range representation. Unlike classical boundary triplet theory, our formulation defines the corresponding boundary map on the domain of the parameterizing operators, rather than on the relation itself. This shift enables a systematic characterization of abstract boundary conditions under which the associated dynamics is governed by a self-adjoint or maximally dissipative linear relation. We illustrate the methodology with the example of the Dzektser equation.

S4: Matrix theory and linear algebra I

Organizers: Hugo Woerdeman, André Ran.

Inclusion constants for matrix convex sets relevant to quantum incompatibility

Eric Evert

University of Florida
ericevert@ufl.edu

Tuesday
13:15
CR 2L

Abstract. Matrix convex sets are dimension free generalizations of classical convex sets which include tuples of self-adjoint $n \times n$ matrices of all sizes n. Given a classical convex set C, the extension of C to a matrix convex set is not unique. In fact there are typically infinitely many matrix convex sets which agree with C when restricted to their first level. Of particular note is the minimal matrix convex set $\mathrm{co}^{\mathrm{mat}}(C)$ generated by C, which is the set of all matrix convex combinations of elements of C.

Given a matrix convex set K, the first level of K, denoted $K(1)$ is itself a convex set. Thus, a major direction of research in matrix convexity is to determine the *inclusion constant* for K. Here, the inclusion constant for K is the smallest constant s such that $K \subseteq s \cdot \mathrm{co}^{\mathrm{mat}}(C)$. For particular choices of K, e.g., when K is the matrix diamond, this question is closely connected to the joint measurability of measurements in quantum information. By exploiting connections to extreme points of matrix convex sets, we present a variety of results and conjectures related to inclusion constants for these settings of interest.

This talk is based on joint work with Andreas Bluhm, Igor Klep, Victor Magron, and Ion Nechita.

Schur parameters and orthogonal polynomials in a free nc setting

David Kimsey

Newcastle University
david.kimsey@newcastle.ac.uk

Tuesday
13:45
CR 2L

Abstract. In this talk we will showcase a correspondence theorem between noncommutative kernels over the free monoid in d noncommuting words and Jury and Martin's nc measures (i.e., linear functionals over the d-variate disk system). We will construct orthogonal polynomials with respect to nc measures, discuss their determinantal zeros and show that they obey a

certain Szegő recurrence relation which is highly analogous to the univariate commutative setting. Finally, we will introduce a Christoffel function, based on an nc measure, and show how it connects to some of the previously mentioned objects.

This talk is based on joint work with Connor Gauntlett.

Self-Dual Tensor Products for Finite-Dimensional Convex Cones and Operator Systems

Tim Netzer

University of Innsbruck, Austria
tim.netzer@uibk.ac.at

Tuesday
14:15
CR 2L

Abstract. We show that there exists a functorial and self-dual tensor product on the categories of finite-dimensional convex cones and on finite-dimensional operator systems. We further describe how all functorial tensor products explicitly arise from the well-known minimal and maximal tensor products.

Circularity of the quaternionic numerical range

Madelein Thiersen

North-West University, South Africa
madelein.thiersen@nwu.ac.za

Tuesday
14:45
CR 2L

Abstract. We studied the numerical range of a quaternion matrix which is not necessarily convex. This talk gives a characterization for when the quaternionic numerical range of a matrix is a closed ball with center 0. We want to derive a quaternion version of a result from [1]. A Fejér–Riesz factorization of matrix-valued trigonometric polynomials is used in their proof and is also necessary here, thus we provide a Fejér–Riesz factorization within the subalgebra of complex matrices associated with quaternion matrices. See also our paper [2], published under my maiden name, van Straaten.

References

[1] Edward Poon, Ilya M. Spitkovsky, Hugo J. Woerdeman. Factorization of singular matrix polynomials and matrices with circular higher rank numerical ranges. *SIAM J. Matrix Anal. Appl.* 43(3), 1423–1439, 2022.

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An interlacing result for Hermitian matrices in Minkowski space

Dawie Janse van Rensburg

North-West University, Potchefstroom, South Africa
dawie.jansevanrensburg@nwu.ac.za

Tuesday
16:00
CR 2L

Abstract. In this paper we will look at the well known interlacing problem, but here we consider the result for Hermitian matrices in the Minkowski space, an indefinite inner product space with one negative square. More specific, we consider the $n \times n$ matrix $A = \begin{bmatrix} J & u \\ -u^* & a \end{bmatrix}$ with $a \in \mathbb{R}$, $J = J^*$ and $u \in \mathbb{C}^{n-1}$. Then A is H-selfadjoint with respect to the matrix $H = I_{n-1} \oplus (-1)$. The canonical form for the pair (A, H) plays an important role and the sign characteristic coupled to the pair is also discussed.

References

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Row completion and partial prescription of structural data of polynomial and rational matrices

Alicia Roca

Universitat Politècnica de València, IMM, Spain
aroca@mat.upv.es

Tuesday
16:30
CR 2L

Abstract. The *matrix completion problem* consists in characterizing the existence of a matrix with certain properties when a submatrix is prescribed. Completion problems frequently arise in applications, for instance in structural changes of the dynamics of a system or in pole placement problems in control theory. They are also closely related to perturbation problems.

The existence of a polynomial matrix when its complete structural data (invariant factors, invariant orders at infinity, and column and row minimal indices) and some of its rows are prescribed is studied in [1, 3]. The same problem is solved for rational matrices in [3].

We have also solved the corresponding problem of partial prescription of the structural data, i.e., when only some of the four types of invariants are prescribed, analyzing all of the possibilities ([3, 4]). We will show here some cases.

Obviously, the results obtained hold for the corresponding column completion problems.

This is a joint work with Agurtzane Amparan, Itziar Baragaña and Silvia Marcaida, Universidad del País Vasco UPV/EHU, Spain.

References

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An unconditional decomposition of the Schatten-p classes.

Zhen-Chuan Liu

Universidad Autónoma de Madrid

liu.zhenchuan@uam.es

Tuesday
17:00
CR 2L

Abstract. In the 1980s, J. Bourgain established a Marcinkiewicz-type testing condition for Toeplitz type Schur multipliers. Recently, we have shown that an analogue of J. Bourgain's theorem is applicable to non-Toeplitz type Schur multipliers as well.

As an application, we obtain an unconditional decomposition for the Schatten-p class with $1 < p < \infty$. This talk is based on joint work with Chian Yeong Chuah and Tao Mei.

One hundred years of the Schur product theorem

Apoorva Khare

Indian Institute of Science, Bengaluru

khare@iisc.ac.in

Tuesday
17:30
CR 2L

Abstract. Let $\mathbb{P}_n$ denote the cone of positive operators on $\mathbb{F}^n$, where $\mathbb{F} = \mathbb{R}$ or $\mathbb{C}$. Schur showed [*Crelle*, 1911] that the entrywise product (fixing a basis of $\mathbb{F}^n$) preserves $\mathbb{P}_n$. In their 1925 book, Pólya–Szegő deduced that applying entrywise a convergent power series with nonnegative coefficients also preserves $\mathbb{P}_n(\mathbb{R})$. In the hundred years since then, many questions on positivity preservers have come up, and we discuss some classical and modern

results. We also provide an improvement of the Schur product theorem itself, over $\mathbb{F}^n$ and over $\ell^2(\mathbb{F})$.

A Kreĭn-Šmul'jan Theorem Revisited

Alejandra Maestripieri

Instituto Argentino de Matemática Alberto P. Calderón, CONICET, Saavedra 15, Buenos Aires, Argentina

amaestri@fi.uba.ar

Friday
10:45
CR 2L

Abstract. We present a generalization of a Kreĭn-Šmul'jan theorem involving several operators. Given bounded selfadjoint operators $A, B_1, \ldots, B_m$ acting on a Hilbert space $\mathcal{H}$, we provide sufficient conditions for when there are $\lambda_1, \ldots, \lambda_m \in \mathbb{R}$ such that $A + \sum_{i=1}^m \lambda_i B_i$ is positive semidefinite.

This is joint work with Francisco Martínez Pería and Santiago González Zerbo.

A stronger form of Yamamoto's theorem on singular values

Renu Shekhawat

Indian Statistical Institute, Bangalore, India

rs_math1904@isibang.ac.in

Friday
11:15
CR 2L

Abstract. For $A \in M_m(\mathbb{C})$ and $1 \leq j \leq m$, let $s_j(A^n)$ denote the j^{th} largest singular value of A^n. A classical result due to Yamamoto (1970), generalizing the spectral radius formula (1967), asserts that $\lim_{n\to\infty} s_j(A^n)^{\frac{1}{n}}$ is equal to the j^{th}-largest eigenvalue-modulus of A, counted with multiplicity.

In this talk, we will prove a spatial form of Yamamoto's theorem asserting that the normalized power sequence, $\{|A^n|^{\frac{1}{n}}\}$, where $|A| := (A^*A)^{\frac{1}{2}}$, of a matrix $A \in M_m(\mathbb{C})$, converges to a positive-semidefinite matrix, whose j^{th}-largest eigenvalue is equal to the j^{th}-largest eigenvalue-modulus of A. In fact, we will give an explicit description of the limit, in terms of the idempotent valued spectral resolution of A.

We note that the result is due to Nayak [1]; however the proof outlined in this talk will follow a different approach, drawing on the techniques developed in [2].

References

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Eigenvalue asymptotic expansion of large tetradiagonal Toeplitz matrices: cusp case

Alejandro Soto-González

Department of Mathematics, Cinvestav, Mexico
asoto@math.cinvestav.mx

Friday
11:45
CR 2L

Abstract. In a paper from 2021, Albrecht Böttcher, Juanita Gasca, Sergei M. Grudsky, and Anatoli V. Kozak gave a precise and complete description of all types of the limiting Schmidt–Spitzer set for tetradiagonal Toeplitz matrices. In this study, we consider one of these possible cases, when the limiting set consists of two analytic arcs that join at one point forming a cusp. For this family of Toeplitz matrices, we provide asymptotic formulas for every eigenvalue as the order of the matrix tends to infinity. Our analysis provides a theoretical understanding of the structural behavior of the eigenvalues, while the obtained formulas enable high-order precision calculation of the eigenvalues.

This is a joint work with Dr. Sergei M. Grudsky and Dr. Anatolii V. Kozak.

This research has been supported by SECIHTI (Mexico), project "Ciencia de Frontera" FORDECYT-PRONACES/61517/2020, and by Regional Mathematical Center of the Southern Federal University with the support of the Ministry of Science and Higher Education of Russia, Agreement 075-02-2025-1720.

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[2] A. Böttcher, J. Gasca, S.M. Grudsky, A.V. Kozak. Eigenvalue clusters of large tetradiagonal Toeplitz matrices. *Integr. Equat. Oper. Th.*, 93(8), 2021. doi:10.1007/s00020-020-02619-z.

[3] M. Bogoya, J. Gasca, S.M. Grudsky. Eigenvalue asymptotic expansion for non-Hermitian tetradiagonal Toeplitz matrices with real spectrum. *J. Math. Anal.*, 531(1), 2024. doi:10.1016/j.jmaa.2023.127816.

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S5: Matrix theory and linear algebra II, in honour of Rien Kaashoek

Organizers: Hugo Woerdeman, André Ran.

The product/sum identity for logarithmic residues in higher dimensions

Harm Bart

Erasmus University Rotterdam
bart@ese.eur.nl

Thursday
13:15
Waaier 3

Abstract. In the scalar case, the logarithmic residue of the product fg of two analytic functions f and g is the sum of the logarithmic residues of f and g. In this talk attention is paid to what happens in the higher dimensional situation where f and g have values in a complex Banach algebra. In handling the situation where f and g are Fredholm operator valued, elements from the work of Rien Kaashoek play a prominent role.

This is a report on joint work with Torsten Ehrhardt (Santa Cruz, California) and Bernd Silbermann (Chemnitz, Germany).

Loewner linearizations of structured rational matrices

Paul Van Dooren

Department of Mathematical Engineering, Université Catholique de Louvain, Belgium
vandooren.p@gmail.com

Thursday
13:45
Waaier 3

Abstract. We show how to use tangential interpolation techniques to construct structured linearizations for several types of structured rational matrices. The classes studied in this paper are square rational matrices that are either Hermitian, or skew-Hermitian, or complex symmetric, or complex skew-symmetric, upon evaluation on one of the following three curves : the real axis, the imaginary axis, and the unit circle. The proposed linearizations are system matrices for these rational matrices and they preserve the structure of the rational matrices, except for the case of the unit circle. For that case, the rational matrix $R(z)$ is linearized using a palindromic or anti-palindromic system matrix for a modified rational matrix, whose eigenvalues that are not on the unit circle preserve the symmetries of the zeros and poles of $R(z)$. The basic tool used to obtain the results in this paper is tangential interpolation via the Loewner and shifted Loewner

matrices. In the case of preserving symmetries with respect to the unit circle, we combine this with Möbius transforms.

This is joint work with Froilán M. Dopico (Universidad Carlos III de Madrid, Spain), María C. Quintana (Aalto University, Finland) and Vanni Noferini (Aalto University, Finland).

Rosenbrock's Theorem on System Matrices over Elementary Divisor Domains and beyond

Froilán M. Dopico

Universidad Carlos III de Madrid, Leganés (Madrid), Spain
dopico@math.uc3m.es

Thursday
14:15
Waaier 3

Abstract. Rosenbrock's theorem on polynomial system matrices is a classical result in linear systems theory that relates the Smith-McMillan form of a rational matrix G with the Smith form of an irreducible polynomial system matrix P giving rise to G and the Smith form of a submatrix of P. This theorem has been essential in the development of algorithms for computing the poles and zeros of a rational matrix via linearizations and generalized eigenvalue algorithms. In this talk, we extend Rosenbrock's theorem to system matrices P with entries in an arbitrary elementary divisor domain $\mathfrak{R}$ and matrices G with entries in the field of fractions of $\mathfrak{R}$. These are the most general rings where the involved Smith-McMillan and Smith forms both exist and, so, where the problem makes sense. Moreover, we analyze in detail what happens when the system matrix is not irreducible. Finally, we explore how Rosenbrock's theorem can be extended when the system matrix P itself has entries in the field of fractions of the elementary divisor domain.

This is joint work with Vanni Noferini (Aalto University, Finland) and Ion Zaballa (Universidad del País Vasco UPV/EHU, Spain).

The Szász inequality for matrix polynomials

Michał Wojtylak

Jagiellonian University, Kraków, Poland
michal.wojtylak@uj.edu.pl

Thursday
14:45
Waaier 3

Abstract. A polynomial $p(\lambda) = a_d\lambda^d + a_{d-1}\lambda^{d-1} + \ldots + a_1\lambda + 1 \in \mathbb{C}[\lambda]$ is called *stable* if all its zeros lie outside the open upper half-plane. O. Szász [5] discovered an inequality (improved by de Branges [2, Lemma 5])

$$|p(\lambda)| \leq \exp\bigl(\operatorname{Re}(a_1\lambda) + \tfrac{1}{2}(|a_1|^2 - 2\operatorname{Re}(a_2))|\lambda|^2\bigr), \quad \lambda \in \mathbb{C}. \tag{1}$$

The most interesting aspect is that the inequality holds globally on the whole complex plane. Knese in [3, Theorem 1.3] provided a simplified proof and showed the sharpness of the bound.

The aim of this talk is to discuss how this inequality behaves for matrix polynomials. The first result in this direction comes from [4]. Namely, if the numerical range of the matrix polynomial $P(\lambda)$ is contained in the open upper half-plane, then

$$\|P(\lambda)\| \leq 2\exp\Big[\lambda_H\big(\lambda A_1 - |\lambda|^2 A_2\big) + \frac{1}{2}|\lambda|^2\|A_1\|^2\Big], \quad \lambda \in \mathbb{C}, \tag{2}$$

where $\lambda_H(X)$ denotes the largest eigenvalue of the matrix $\mathrm{Re}X = \frac{X+X^*}{2}$.

The above assumption on the numerical range is rather restrictive. Thus, in the next step, we assume instead a factorization of the polynomial into degree one terms $P(\lambda) = \prod_{j=1}^{d}(I + \lambda B_j)$, where $\sum_{1\leq j<k\leq d}\mathrm{tr}(\mathrm{Im}\, B_j\, \mathrm{Im}\, B_k) \geq 0$, receiving

$$\|P(\lambda)\|_F \leq n^{\frac{d}{2}}\exp\Big(\frac{1}{n}\,\mathrm{tr}\,\mathrm{Re}(\lambda A_1) + \frac{1}{2n}\big(\|A_1\|_F^2 - 2\,\mathrm{tr}\,\mathrm{Re}\,A_2\big)|\lambda|^2\Big).$$

As the last step we relate the assumption on factorization to state space models, one of the classical topics investigated by Rien Kaashoek [6].

The talk is based on joint work with P. Pikul and O. Szymański [1].

References

[1] Piotr Pikul, Oskar Szymański, and Michał Wojtylak. The Szász inequality for matrix polynomials and functional calculus. arXiv:2406.08965.

[2] Louis de Branges. Some Hilbert spaces of entire functions. II. *Transactions of the American Mathematical Society*, 99(1):118–152, 1961.

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Wiener-Hopf indices of unitary-valued functions on the imaginary axis

A.C.M. Ran

Vrije Universiteit, Amsterdam, The Netherlands and North-West University, Potchefstroom, South Africa

a.c.m.ran@vu.nl

Thursday
16:00
Waaier 3

Abstract. The talk is concerned with the Wiener-Hopf indices of unitary-valued rational matrix functions on the imaginary axis. These indices play a role in the Fredholm theory for Wiener-Hopf integral operators. Our main result gives formulas for the Wiener-Hopf indices in terms of the matrices appearing in realizations of the factors in a Douglas-Shapiro-Shields factorization of the unitary-valued function. A direct approach using operator theoretic methods is presented. An alternative approach using the Cayley transform which allows to use results for an analogous problem regarding unitary-valued functions on the unit circle and corresponding Toeplitz operators is outlined if time permits.

This is joint work with Freek van Schagen (Vrije Universiteit) and Art Frazho (Purdue University), and is a continuation of earlier work of the same authors in collaboration with Rien Kaashoek.

Spectral properties of unbounded Toeplitz operators with rational symbols

Sanne ter Horst

North-West University

sanne.terhorst@nwu.ac.za

Thursday
16:30
Waaier 3

Abstract. Using state space methods, in this talk we derive spectral properties of operators from a class of unbounded Toeplitz operators with rational matrix symbols. Along the way, we derive a Wiener-Hopf type factorization using algebraic Riccati equations, with stable and semi-stable solutions, to characterize invertibility. The talk is based on material from [2, 1].

References

[1] G.J. Groenewald, S. ter Horst, J. Jaftha and A.C.M. Ran, A Toeplitz-like operator with rational matrix symbol having poles on the unit circle: Matrix representation and spectral analysis, *Afr. Mat.* **36** (2025), article no. 68.

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Boundary representations of some low-dimensional operator systems

Douglas Farenick
University of Regina
douglas.farenick@uregina.ca

Thursday
17:00
Waaier 3

Abstract. A boundary representation of an operator system $\mathcal{R}$ (i.e., a unital selfadjoint subspace of bounded linear Hilbert space operators) is an irreducible representation ρ of $\mathrm{C}^*(\mathcal{R})$, the C^*-algebra generated by $\mathcal{R}$, on a Hilbert space $\mathcal{H}_\rho$ such that the only completely positive linear map $\phi\colon \mathcal{R} \to \mathcal{B}(\mathcal{H}_\rho)$ for which $\phi(x) = \rho(x)$, for each $x \in \mathcal{R}$, is $\phi = \rho$. The Arveson-Davidson-Kennedy theorem asserts that the linear map $\Gamma = \bigoplus_\rho \rho$, where the direct sum is over all boundary representations ρ of $\mathcal{R}$, is a unital complete isometry on $\mathcal{R}$, and, moreover, the C^*-algebra generated by $\Gamma(\mathcal{R})$ is the minimal C^*-cover (also known as the C^*-envelope) of $\mathcal{R}$. However, in practice, the boundary representations can be difficult to identify. In this lecture, I will discuss some ongoing and past work devoted to determining the boundary representations of certain low-dimensional operator systems determined by a single Hilbert space operator.

Contractive realization theory for the annulus and other intersections of discs on the Riemann sphere

Hugo J. Woerdeman
Drexel University
hjw27@drexel.edu

Thursday
17:30
Waaier 3

Abstract. We develop contractive finite dimensional realizations for rational matrix functions of one variable on domains that are not simply connected, such as the annulus. The proof uses multivariable contractive realization results as well as abstract operator algebra techniques. Other results include new bounds for the Bohr radius of the bidisk and the annulus. This talk is based on joint work with Radomił Baran, Piotr Pikul, and Michał Wojtylak.

S6: Moment problems and applications

Organizers: Raul Curto, Aljaž Zalar.

Moment infinite divisibility and Bernstein functions

Chafiq Benhida

University of Lille
chafiq.benhida@univ-lille.fr

Tuesday
16:00
CR 2M

Abstract. Moment infinite divisibility is occupying an important space in the realm of subnormal weighted shifts and this is related to (log) completely alternating/monotone sequences. The last is possibly interpolated by a (log) Bernstein/completely monotone function.

Here, we give a new development and supply new elements in those classes. (Based on a joint work with G. Exner (Bucknell University) and R. Curto (Iwoa University).

Some new sources of (better than) moment sequences

George R. Exner

Bucknell University
exner@bucknell.edu

Tuesday
16:30
CR 2M

Abstract. We present some new approaches to, and examples of, Bernstein and completely monotone functions, and consider their role in the construction of moment sequences. The approach actually provides moment infinitely divisible ($\mathcal{MID}$) sequences for which, given a fixed $p > 0$, raising each term to the p-th power yields again a moment sequence. We show as well that the collection of such $\mathcal{MID}$ sequences is in a natural bijection with the set of all moment sequences. This talk is based on joint work with Chafiq Benhida (Université des Sciences et Technologies de Lille) and Raúl E. Curto (University of Iowa).

When is a CPD weighted shift similar to a subnormal operator?

Jan Stochel

Jagiellonian University
Jan.Stochel@im.uj.edu.pl

Tuesday
17:00
CR 2M

Abstract. An operator T on a Hilbert space H is said to be *conditionally positive definite (CPD)* if for every $f \in H$, the sequence $\{\|T^n f\|^2\}_{n=0}^{\infty}$ is

conditionally positive definite on the semigroup $(\mathbb{Z}_+, +)$, where $\mathbb{Z}_+$ denotes the set of all nonnegative integers. According to the celebrated Lambert's theorem, T is subnormal (i.e., it is the restriction of a normal operator to an invariant subspace) if and only if for every $f \in H$, the sequence $\{\|T^n f\|^2\}_{n=0}^{\infty}$ is positive definite on the semigroup $(\mathbb{Z}_+, +)$. We show that a CPD unilateral weighted shift W_λ of type III is a quasi-affine transform of the operator M_z, representing multiplication by the independent variable "z" on the $L^2(\rho)$-closure of analytic complex polynomials on the complex plane, where ρ is a measure precisely determined by W_λ. Necessary and separately sufficient conditions for a general CPD operator to be similar to a subnormal one are also provided. Furthermore, a variety of explicit classes of non-subnormal CPD unilateral weighted shifts that are similar to subnormal operators are established.

The truncated univariate rational moment problem

Rajkamal Nailwal

Institute of Mathematics, Physics and Mechanics, Ljubljana, Slovenia

raj1994nailwal@gmail.com

Tuesday
17:30
CR 2M

Abstract. Given a closed subset K in $\mathbb{R}$, the rational K–truncated moment problem (K–RTMP) asks to characterize the existence of a positive Borel measure μ, supported on K, such that a linear functional L, defined on all rational functions of the form $\frac{f}{q}$, where q is a fixed polynomial with all real zeros of even order and f is any real polynomial of degree at most $2k$, is an integration with respect to μ. The case of a compact set K was solved in [1], but there is no argument that ensures that μ vanishes on all real zeros of q. An obvious necessary condition for the solvability of the K–RTMP is that L is nonnegative on every f satisfying $f|_K \geq 0$. If L is strictly positive on every $0 \neq f|_K \geq 0$, we add the missing argument from [1] and also bound the number of atoms in a minimal representing measure. We show by an example that nonnegativity of L is not sufficient and add the missing conditions to the solution.

This is a joint work with Aljaž Zalar ([2]).

References

[1] J. Chandler, *Rational moment problems for compact sets.* J. Approx. Theory **79** (1994), 72–88.

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A moment-based approach to electronic structure theory

Matina Trachana

Università degli Studi di Cagliari
matina.trachana@unica.it

Wednesday
10:30
CR 3A

Abstract. In this talk, we will explore the necessary and sufficient conditions under which reduced density matrices correspond to a quantum state. This is a central challenge in quantum chemistry and can be reformulated as a moment problem.

We draw direct connections between this quantum problem and the moment problem, highlighting the challenges we encounter. Unlike the classical moment problem, quantum observables follow a non-commutative algebra that imposes quantum consistency constraints, requiring techniques from positive polynomial optimisation.

This is joint ongoing work with M. Infusino.

Recursive relations for 2-variable weighted shifts

Eddie White

University of Iowa
edward-white-1@uiowa.edu

Wednesday
11:00
CR 2L

Abstract. In this talk we outline a method to determine all recursive relations for the moment matrix of a 2-variable weighted shift, up to total degree k, entirely from the atoms of its representing measure. This allows us to show that the densities of the atoms in the representing measure do not affect the recursive relations for the 2-variable weighted shift. We then show that this method can be used to explicitly construct a Gröbner basis for the ideal of recursive relations for the 2-variable weighted shift.

Propagation phenomena for subnormal matricial weighted shifts

Hassan Zerouali

Mohammed V University in Rabat
elhassan.zerouali@fsr.um5.ac.ma

Wednesday
11:30
CR 2L

Abstract. The well known propagation Stampfli's Theorem states that for a subnormal weighted shift, with nonzero scalar weights, all weights (excluding the first one) are equal when any two consecutive weights are equal. We give in this talk the extension of this result to the case of operator and matricial

subnormal weighted shifts. We also provide an analog of Stampfli's Theorem on flat propagation for the more general case of quadratically hyponormal matricial weighted shifts.

This is joint work with R.E. Curto, A. Ech-charyfy, H. El Azhar, and K. Idrissi.

The Structure of the Core Variety of Moment Sequences with a Unique Representing Measure

Seonguk Yoo

Gyeongsang National University
seyoo@gnu.ac.kr

Thursday
13:15
CR 2L

Abstract. The core variety is known to consist of the atoms of all representing measures of a given moment sequence. Therefore, if one can compute the core variety of a given moment sequence, it results in solving the moment problem. However, in general, explicitly determining the core variety of multidimensional moment sequences is not an easy task. In this talk, we observe the core variety of low-degree moment sequences and examine the structure of the core variety required for a positive definite sextic moment sequence to have a unique representing measure. (This is based on joint work with Aljaž Zalar.)

References

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The Cowen-Douglas operators and analytic continuation

Paweł Pietrzycki

Jagiellonian University
pawel.pietrzycki@im.uj.edu.pl

Thursday
13:45
CR 2L

Abstract. In [1], A. Aleman, S. Richter, and W. T. Ross studied a Banach

space $\mathcal{B}$ of analytic functions on $\mathbb{D}$ which has the following properties:

$$\begin{aligned}
&\mathcal{M}_z\mathcal{B} \subset \mathcal{B},\\
&\mathcal{B} \hookrightarrow \mathrm{Hol}(\mathbb{D}), \text{ the inclusion is continuous},\\
&1 \in \mathcal{B},\\
&\mathcal{L}_\lambda\mathcal{B} \subset \mathcal{B},\\
&\sigma(\mathcal{M}_z) = \overline{\mathbb{D}},
\end{aligned}$$

where for $\lambda \in \mathbb{D}$, the operator $\mathcal{L}_\lambda \colon \mathcal{B} \to \mathcal{B}$ is given by

$$(\mathcal{L}_\lambda f)(z) = \frac{f(z) - f(\lambda)}{z - \lambda}, \qquad z \in \mathbb{D}.$$

This example include the classical Banach spaces of holomorphic functions in the unit disc: the Hardy space, the Bergman space and the Dirichlet space and the Besov space. They related meromorphic continuations of the functions from an $\mathcal{L}$-invariant subspace $\mathcal{M}$ of $\mathcal{B}$ to the spectrum of $\mathcal{L}|_{\mathcal{M}}$. In this general setting, they proved that $\sigma(\mathcal{L}) = \overline{\mathbb{D}}$, $\sigma(\mathcal{L}|_{\mathcal{M}}) \subset \overline{\mathbb{D}}$, for $\mathcal{M}$ invariant subspace of $\mathcal{L}$ and

$$\sigma_{\mathrm{ap}}(\mathcal{L}|_{\mathcal{M}}) \cap \mathbb{D} = \sigma_{\mathrm{p}}(\mathcal{L}|_{\mathcal{M}}) \cap \mathbb{D} = \{a \in \mathbb{D} \colon \frac{1}{1 - az} \in \mathcal{M}\}.$$

Moreover, under a regularity condition on $\mathcal{B}$, they proved that

$$\sigma_{\mathrm{ap}}(\mathcal{L}|_{\mathcal{M}}) \cap \mathbb{T} = \mathbb{T} \setminus \{\frac{1}{\zeta} \colon \text{every } f \in \mathcal{M} \text{ extends to be analytic in a neighborhood of } \zeta\}.$$

In this talk, I will show how to extend these results to a certain subclass of Cowen-Douglas operators.

References

[1] A. Aleman, S. Richter and W. T. Ross. Pseudocontinuations and the backward shift. *Indiana U. Math. J.* **47** (1998), 223–276.

[2] P. Pietrzycki. The Cowen-Douglas operators and analytic continuation. arXiv:2505.05649

Subnormality of B-operators

Zenon Jabłoński

Jagiellonian Uniwersity, Kraków

zenon.jablonski@im.uj.edu.pl

Thursday
14:15
CR 2L

Abstract. In this talk, we discuss operators represented by upper-triangular 2-by-2 block matrices whose entries satisfy certain algebraic constraints.

These operators arose during the study of Brownian isometries conducted by Agler and Stankus. Research on operators of this kind depends on the class to which the operator in the lower right-hand entry belongs. The central focus of the talk will be recent results concerning the subnormality of such operators. The Taylor spectrum will be one of the tools employed in the analysis, and this topic will constitute a large part of the talk. The results presented are based on joint work with Sameer Chavan, Il Bong Jung, and Jan Stochel.

Degree k Column Relations in Moment Matrices

Marc Moore

The University of Iowa
marc-moore@uiowa.edu

Thursday
14:45
CR 2L

Abstract.
Let $M(\gamma)$ be the moment matrix associated with a truncated complex moment sequence $\gamma^{(2k)}$. Let $\mathcal{V} \equiv \mathcal{V}(M(\gamma))$ be the algebraic variety associated with $M(\gamma)$. That is, if $p(z, \overline{z})$ is a polynomial which corresponds to a column relation of $M(\gamma)$, then $\mathcal{V}$ is the intersection of the zero loci of $p(z, \overline{z})$ and $\overline{p(z, \overline{z})}$. If the rank of $M(\gamma)$ is equal to the cardinality of $\mathcal{V}$, we say that the problem is extremal. In this talk, we show that if G is the reduced Gröbner basis for the ideal $I(\mathcal{V})$ associated with $\mathcal{V}$ by Hilbert's Nullstellensatz, then G contains exactly the polynomials which correspond to the rest of the column relations of $M(\gamma)$. Moreover, we can find a numerical condition on the level of the moments which is equivalent to the existance of a representing measure.

Keywords: Truncated Moment Problem, Gröbner Basis .

Study of the Cone of Sums of Squares plus Sums of Nonnegative Circuits

Salma Kuhlmann

Fachbereich Mathematik und Statistik, Universität Konstanz
salma.kuhlmann@uni-konstanz.de

Friday
10:45
CR 2L

Abstract. This is a joint work with Mareike Dressler and Moritz Schick.
In this talk, I present our main results on combining two independent nonnegativity certificates for real homogeneous polynomials: sums of squares (SOS) and sums of nonnegative circuit (SONC) forms. I consider the convex

cone SOS+SONC of forms that decompose into a sum of an SOS and a SONC form, and present an analog of Hilbert's 1888 Theorem for this cone. This follows by exploiting a new necessary condition for membership in the SONC cone.

m-isometric compostion operators on discrete spaces

Michał Buchała

AGH University in Kraków
mbuchala@agh.edu.pl

Friday
11:15
CR 3A

Abstract. In this talk we present characterization of m-isometric composition operators on discrete L^2-spaces. By a discrete space we mean a pair (X, μ), where X is a countable set and μ is a measure such that every point of X is an atom of μ. First, we show that in such a setting a composition operator can be viewed as a weighted shift on a certain graph – we give a full classification of these graphs. Further, we concentrate only on one class of these graphs, namely on graphs with one cycle. In [2] the authors study m-isometricity of composition operators in such a setting, but with additional restriction that the graph has only one branching point. Using different approach we generalize results of [2] to the whole class of composition operators on graphs having one cycle. Several applications will be given. In particular, we solve the Cauchy dual subnormality problem for such operators – a simple formula for moments of the measure representing the sequence $\left(\|C_T'^n e_v\|^2\right)_{n=0}^{\infty}$, where $C_T' = C_T(C_T^* C_T)^{-1}$ is the Cauchy dual of the operator C_T and v is the vertex lying on the cycle, gives us a way of constructing examples violating subnormality of C_T'. The talk is based on [1].

References

[1] M. Buchała. m-isometric composition operators on discrete spaces. *Complex Anal. Oper. Theory* 18, 158 (2024).

[2] Z.J. Jabłoński, J. Kośmider. m-isometric composition operators on directed graphs with one circuit. *Integral Equ. Oper. Theory* 93(5), 50 (2021).

Moment problems and dimensional extensions

Dragu Atanasiu

University of Borås, Sweden
dragu.atanasiu@hb.se

Friday
11:45
CR 3A

Abstract. In this talk I will present solutions of the moment problems of Putinar-Vasilescu type (see [1]).

To obtain these solutions I use different conditions which imply that some unbounded selfadjoint operators are strongly commuting.

The construction of the Hilbert space where these operators are defined is different from the one in [1].

References

[1] M. Putinar and F.H. Vasilescu Solving moment problems by dimensional extension. *Annals of Mathematics*, 149:1087–1107, 1999. doi:10.2307/121083.

S7: Multivariable operator theory

Organizers: Sanne ter Horst, Rongwei Yang, Joe Ball.

On pairs of quadratic forms arising from linear relations over modules

Michael Dritschel

Newcastle University
michael.dritschel@newcastle.ac.uk

Tuesday
13:15
CR 2K

Abstract. Suppose that A and B are selfadjoint operators on a complex inner product space and that B is indefinite. It is obvious that if there is a real constant M such that $\langle (A - MB)x, x\rangle$ is non-negative for all x, then $\langle Ax, x\rangle \geq 0$ for all x such that $\langle Bx, x\rangle = 0$. Remarkably, a theorem of Kreĭn and Shmul'yan states that the converse is true. In joint work with Alejandra Maestripieri, our goal has been to generalize this in two directions. One is to symmetric linear relations, and the other is to such relations over Hilbert (pre-)C^*-modules. Some potential applications are also mentioned.

The essential normality of quotient modules

Lijia Ding

Zhengzhou University
ljding@zzu.edu.cn; ljding@pku.edu.cn

Tuesday
13:45
CR 2K

Abstract. In this talk, I will discuss the $(p; l)$-essential normality of Hilbert quotient submodules over the strongly pseudoconvex finite manifold (W, Ω) satisfying Property (S). Let V be an analytic subvariety in a neighborhood of $\overline{\Omega}$ such that V is smooth on the boundary $\partial\Omega$ with transverse intersections. Denote by $\dim(V \cap \Omega)^+$ the dimension of the noncompact part of the subvariety $V \cap \Omega$. We establish that the holomorphic Sobolev quotient submodule $M_V^\perp$ is $(p; 1)$-essentially normal (equivalently, p-essentially normal) whenever $p > \dim(V \cap \Omega)^+$. Moreover, we prove that $M_V^\perp$ is $(p; l)$-essentially normal whenever $p > \frac{1}{l+1}\dim(V \cap \Omega)^+$ for integers $l \geq 2$. These results diverge from typical observations in the Euclidean setting and reveal distinctive phenomena in non-Stein manifolds. As a consequence, we confirm the geometric Arveson-Douglas Conjecture on strongly pseudoconvex domains for subvarieties with isolated singularities when $l = 1$.

A characteristic function of lifting of row contractions

Neeru Bala

Indian Institute of Technology, Dhanbad, India
neerubala@iitism.ac.in

Tuesday
14:15
CR 2K

Abstract. The characteristic function of row contractions and liftings of row contractions are multianalytic operators which are complete invariants up to unitary equivalence for row contractions and liftings of row contractions, respectively. We provide alternate proofs for these properties of characteristic functions using colligations. We also give a characterization for co-isometric observable colligations with a certain class of basic operators. Finally, we studied Blaschke factor based transformations of the characteristic function of the lifting of a contraction. This is a joint work with Santanu Dey and Reshmi M.N..

References

[1] S. Dey, R. Gohm, and K. J. Haria. Functional Models and Minimal Contractive Liftings. *Complex Anal. Oper. Theory* 9: 933–955, 2015. doi:10.1007/s11785-014-0399-6

[2] S. Dey, R. Gohm and K. J. Haria. Characteristic functions of liftings-II. *Oper. Matrices* 12 (2): 579–601, 2018. doi:10.7153/oam-2018-12-36

Homogeneous analytic Hilbert modules - the case of non-transitive action

Shibananda Biswas

Indian Institute of Science Education and Research Kolkata, India
shibananda@iiserkol.ac.in

Tuesday
14:45
CR 2K

Abstract. In this talk, we explore the structure of analytic Hilbert modules that are homogeneous under the action of the automorphism group of the symmetrized bidisc, $\mathrm{Aut}(\mathbb{G}_2)$. Unlike earlier settings involving transitive group actions, $\mathrm{Aut}(\mathbb{G}_2)$ acts non-transitively on $\mathbb{G}_2$, introducing new complexities. Apart from the weighted Bergman spaces, we construct and examine a new family of $\mathrm{Aut}(\mathbb{G}_2)$-homogeneous analytic Hilbert modules. A characterization of such modules is provided via the curvature of the associated Hermitian holomorphic line bundles over $\mathbb{G}_2$. As a key consequence of one our main theorems, we show that none of the weighted Bergman metrics on $\mathbb{G}_2$ are Kähler–Einstein. This is a joint work with Prahllad Deb, Somnath Hazra, Dinesh Kumar Keshari, and Gadadhar Misra.

The Andô isometric lifting theorem revisited

Joseph A. Ball

Department of Mathematics, Virginia Tech
joball@math.vt.edu

Tuesday
16:00
CR 2K

Abstract. The Andô isometric lifting theorem (from 1963) assets that any commuting pair of contraction operators (T_1, T_2) on a Hilbert space $\mathcal{H}$ can be *lifted* to a commuting pair of isometric operators (V_1, V_2) on a larger Hilbert space $\mathcal{K} \supset \mathcal{H}$ (meaning that $P_{\mathcal{H}} V|_{\mathcal{H}} = T$, or equivalently, $V^*|_{\mathcal{H}} = T^*$. The older Sz.-Nagy dilation isometric lifting theorem (from 1953) is the same statement but with the contractive pair (T_1, T_2) replaced by a single contraction T and the isometric pair (V_1, V_2) replaced by a single isometry V. Remarkably the same statement with T replaced by a commuting tuple $(T_1, \ldots, T_d)$ of contractions and V replaced by a commuting tuple $(V_1, \ldots, V_d)$ of isometries turns out to be false in general for $d > 2$. Over the ensuing decades, Sz.-Nagy together with Foias developed a detailed understanding of the geometric structure of the unitary dilation space of a given Hilbert space contraction operator, as well as a well-worked over canonical functional-model for the contraction operator T which in turn reduces operator-theory questions concerning T to function-theory questions concerning the characteristic operator function $\Theta_T(z)$ (a simpler object to analyze for many examples), while parallel results for the bivariate Andô setting have lagged behind. In this talk on joint work with Haripada Sau (Pune, India), I shall discuss recent results bringing the bivariate Andô setting to a closer parallel with at least some aspects of the univariate Sz.-Nagy-Foias setting.

References

[1] T. Andô On a pair of commutative contractions. *Acta Sci. Math. (Szeged)* **24** (1963), 88-90.

[2] J.A. Ball and H. Sau, Dilation and Model Theory for Pairs of Commuting Contraction Operators. Cambridge Tracts in Mathematics, Cambridge University Press, to appear.

[3] B Sz.-Nagy, C. Foias, H. Bercovici, L. Kérchy. Harmonic Analysis of Operators on Hilbert Space, Second Edition, Springer 2010.

Inner and characteristic functions in polydiscs

Ramlal Debnath

KTH Royal Institute of Technology
ramlaldebnath@gmail.com

Tuesday
16:30
CR 2K

Abstract. Characteristic functions of linear operators are analytic functions that serve as complete unitary invariants. Such functions, as long as they

are built in a natural and canonical manner, provide representations of inner functions and contribute to the development of Hilbert function spaces. In this talk, we shall discuss this problem in polydiscs. In particular, we shall present a concrete description of the characteristic functions of tuples of commuting pure contractions and, consequently, provide a description of inner functions on polydiscs. The talk is based on a joint work with Deepak K. Pradhan and Jaydeb Sarkar.

Characterizing Submodules in $H^2(\mathbb{D}^2)$ Using the Core Function

Victor Bailey

University of Oklahoma
victor.bailey@ou.edu

Tuesday
17:00
CR 2K

Abstract. It is well known that $H^2(\mathbb{D}^2)$ is a RKHS with the reproducing kernel $K(\lambda, z) = \frac{1}{(1-\overline{\lambda_1}z_1)(1-\overline{\lambda_2}z_2)}$ and that for any submodule $M \subseteq H^2(\mathbb{D}^2)$ its reproducing kernel is $K^M(\lambda, z) = P_M K(\lambda, z)$ where P_M is the orthogonal projection onto M. Associated with any submodule M are the core function $G^M(\lambda, z) = \frac{K^M(\lambda,z)}{K(\lambda,z)}$ and the core operator C_M, an integral transform on $H^2(\mathbb{D}^2)$ with kernel function G^M. The utility of these constructions for better understanding the structure of a given submodule is evident from the various works in the past 20 years. In this talk, we will discuss the relationship between the rank, codimension, etc. of a given submodule and the properties of its core function and core operator. In particular, we will discuss the longstanding open question regarding whether we can characterize all submodules whose core function is bounded. This is a joint project with Rongwei Yang and Chao Zu.

Isometric pairs

Jaydeb Sarkar

Indian Statistical Institute
jaydeb@gmail.com; jay@isibang.ac.in

Tuesday
17:30
CR 2K

Abstract. By isometric pairs, we mean pairs of commuting isometries. Part of the talk will be devoted to convincing the audience why isometric pairs matter. For example, how isometric pairs could have a significant impact in function theory, operator theory, operator algebras, etc. The remaining part would be devoted to reporting some fresh understanding of isometric pairs. This talk is based on joint work with Sandipan De, P. Shankar, and T. R. Sankar.

Dilation on an annulus, K-spectral set and interplay with certain varieties in the biball

Sourav Pal

Indian Institute of Technology Bombay, Powai, India

souravpal@iitb.ac.in; souravmaths@gmail.com

Wednesday
10:30
CR 2K

Abstract. A Hilbert space operator T is said to be an $\mathbb{A}_r$-*contraction* if the closure of the annulus

$$\mathbb{A}_r = \{z \in \mathbb{C} \ : \ r < |z| < 1\} \qquad (0 < r < 1)$$

is a spectral set for T. Agler proved the success of rational dilation on $\overline{\mathbb{A}}_r$ in [1]. We prove this famous theorem of Agler in an alternative way by an application of a result due to Dritschel, Jury and McCullough from [2]. We associate with $\mathbb{A}_r$-contractions a certain variety in the closure of the biball $\mathbb{B}_2 = \{(z_1, z_2) \in \mathbb{C}^2 : |z_1|^2 + |z_2|^2 < 1\}$ and study the interplay between them. We also find the minimal spectral sets for $\mathbb{A}_r$-contractions and closely related classes of operators. This talk is based on joint work with Nitin Tomar.

References

[1] J. Agler, Rational dilation on an annulus, *Ann. of Math. (2)*, 121 (3): 537 – 563, 1985, doi:10.2307/1971209

[2] M. Dritschel, M. Jury and S. McCullough, Dilations and constrained algebras, *Oper. Matrices*, 10 (4): 829 – 861, 2016, doi:10.7153/oam-10-48.

[3] S. McCullough, Matrix functions of positive real part on an annulus, *Houston J. Math.*, 21 (3): 489 – 506, 1995, MR1352602.

[4] S. Pal and N. Tomar, Dilation on an annulus, K-spectral set and interplay with certain varieties in the biball, Preprint.

Function theory on the annulus in the dp-norm

Zinaida Lykova

Newcastle University, UK

Zinaida.Lykova@ncl.ac.uk

Wednesday
11:00
CR 2K

Abstract. In this talk we shall use realization theory to prove new results about a class of holomorphic functions on an annulus

$$R_\delta \stackrel{\text{def}}{=} \{z \in \mathbb{C} : \delta < |z| < 1\},$$

where $0 < \delta < 1$. The class of functions in question arises in the early work of R. G. Douglas and V. I. Paulsen on the rational dilation of a Hilbert

space operator T to a normal operator with spectrum in ∂R_δ. Their work suggested the following norm $\|\cdot\|_{\mathrm{dp}}$ on the space $\mathrm{Hol}(R_\delta)$ of holomorphic functions on R_δ,

$$\|\phi\|_{\mathrm{dp}} \stackrel{\mathrm{def}}{=} \sup\{\|\phi(T)\| : \|T\| \le 1, \|T^{-1}\| \le 1/\delta \text{ and } \sigma(T) \subseteq R_\delta\}.$$

By analogy with the classical Schur class of holomorphic functions $\mathcal{S}$ with supremum norm at most 1 on the disc $\mathbb{D}$, it is natural to consider the *dp-Schur class* $\mathcal{S}_{\mathrm{dp}}$ of holomorphic functions of dp-norm at most 1 on R_δ.

Our central result is a generalization of the classical realization formula, for $\phi \in \mathcal{S}$,

$$\phi(z) = A + Bz(1 - Dz)^{-1}C, \text{ for } z \in \mathbb{D},$$

to functions from $\mathcal{S}_{\mathrm{dp}}$. A second result is a Pick interpolation theorem for functions in $\mathcal{S}_{\mathrm{dp}}$ that is analogous to Abrahamse's Interpolation Theorem for bounded holomorphic functions on a multiply-connected domain. For a tuple $\lambda = (\lambda_1, \ldots, \lambda_n)$ of distinct interpolation nodes in R_δ, we introduce a special set $\mathcal{G}_{\mathrm{dp}}(\lambda)$ of positive definite $n \times n$ matrices, which we call *DP Szegő kernels*. The DP Pick problem $\lambda_j \mapsto z_j, j = 1, \ldots, n$, is shown to be solvable if and only if,

$$[(1 - \bar{z}_i z_j) g_{ij}] \ge 0 \text{ for all } g \in \mathcal{G}_{\mathrm{dp}}(\lambda).$$

We prove further that a solvable DP Pick problem has a solution which is a rational function with a finite-dimensional model, an intriguing result which opens up the possibility of a theory of extremal functions from $\mathcal{S}_{\mathrm{dp}}$ analogous to the theory of finite Blaschke products.

The talk is based on joint work with Jim Agler and Nicholas Young:

References

[1] J. Agler, Z.A. Lykova and N.J. Young. Function theory on the annulus in the dp-norm. *arXiv:2505.04483*, 29 pages, May 2025. arxiv:2505.04483

The Bohr Inequality for the Annulus and the Bidisc.

Radomił Baran

Jagiellonian University

radomil.baran@doctoral.uj.edu.pl

Wednesday
11:30
CR 2K

Abstract. The classical Bohr radius K_1 is defined as the supremum over all $r > 0$ such that every function

$$f = \sum_{k=0}^{\infty} a_k z^k$$

analytic in the unit disc with $\|f\|_\infty = \sup_{|z|<1} |f(z)| \leq 1$ satisfies

$$\sum_{k=0}^{\infty} |a_k| r^k \leq 1.$$

It is known that $K_1 = \frac{1}{3}$. One may also consider the multivariable Bohr radius K_d and the Bohr-Agler radius $K(\mathcal{A}_d)$, as in [2]. In this talk, we introduce analogous notions for the annulus. We then establish inequalities relating these radii and, as a consequence, we show that if T is a contractive element in a Banach algebra satisfying $\|T^{-1}\| \leq r^{-1}$ (with $0 < r < 1$), then the annulus with inner and outer radii K_2^{-1} and rK_2 is a $(1+\sqrt{2})$-spectral set. Our approach uses the connection between function algebras of the annulus and the bidisc developed in [1]. Finally, we improve the best previously known upper bound for the two-variable Bohr radius K_2.

This talk is based on joint work with Piotr Pikul, Hugo J. Woerdeman, and Michał Wojtylak.

References

[1] R. Baran, P. Pikul, H. J. Woerdeman, and M. Wojtylak, *Contractive realization theory for the annulus and other intersections of discs on the Riemann sphere*, Preprint, arXiv:2504.03236, April 2025.

[2] G. Knese, *Three radii associated to Schur functions on the polydisk*, Preprint, arXiv:2410.21693, October 2024.

Function theory in the bfd-norm on an elliptical region

Nicholas Young

Newcastle University, U.K.

Nicholas.Young@ncl.ac.uk

Wednesday
12:00
CR 2K

Abstract. I will present a realization formula for bounded holomorphic functions on an elliptical region in the complex plane. The formula is reminiscent of the classical realization formula for functions in the Schur class $\mathcal{S}$. Consider the open elliptical region

$$G_\delta = \Big\{x + iy : x, y \in \mathbb{R}, \frac{x^2}{(1+\delta)^2} + \frac{y^2}{(1-\delta)^2} < 1\Big\},$$

where $0 < \delta < 1$.

The realization formula will apply to functions in the bfd-Schur class $\mathcal{S}_{\text{bfd}}$, which comprises holomorphic functions on G_δ of bfd-norm less than or equal to one. The B. and F. Delyon norm $\|\cdot\|_{\text{bfd}}$ on the space $\text{Hol}(G_\delta)$ of holomorphic functions on G_δ is defined by

$$\|f\|_{\text{bfd}} \stackrel{\text{def}}{=} \sup_{T \in \mathcal{F}_{\text{bfd}}(G_\delta)} \|f(T)\|,$$

where $\mathcal{F}_{\text{bfd}}(G_\delta)$ is the class of operators T such that the closure of the numerical range of T is contained in G_δ. The name of the norm recognizes a celebrated theorem of the brothers Delyon, which implies that $\|\cdot\|_{\text{bfd}}$ is equivalent to the supremum norm $\|\cdot\|_\infty$ on $\text{Hol}(G_\delta)$.

For any function f on G_δ, we define a *bfd-realization* of f to be a formula of the form

$$f(\lambda) = \alpha + \langle \lambda_U(1 - D\lambda_U)^{-1}\gamma, \beta\rangle_{\mathcal{M}} \text{ for all } \lambda \in G_\delta,$$

where α is a scalar, β, γ are vectors in a Hilbert space $\mathcal{M}$, for all $\lambda \in G_\delta$, λ_U denotes the operator $\lambda_U = (\delta U^* - \frac{1}{2}\lambda)(1 - \frac{1}{2}\lambda U^*)^{-1}$ on $\mathcal{M}$, D, U are operators on $\mathcal{M}$ such that U is unitary and the operator

$$\begin{bmatrix} \alpha & 1 \otimes \beta \\ \gamma \otimes 1 & D \end{bmatrix} \text{ is unitary on } \mathbb{C} \oplus \mathcal{M}.$$

Theorem. Let $\delta \in (0, 1)$ and let f be a function on G_δ. The following conditions are equivalent.
(i) f belongs to $\mathcal{S}_{\text{bfd}}$;
(ii) f has a bfd-model;
(iii) f has a bfd-realization.

The talk is based on joint work with Jim Agler and Zinaida Lykova:

References

[1] J. Agler, Z.A. Lykova and N.J. Young. Function theory in the bfd-norm on an elliptical region. *J. Math. Anal. Appl.*, 541(2), Article 128732, 2025 doi:10.1016/j.jmaa.2024.128732.

Polynomial embeddings of unilateral weighted shifts in 2–variable weighted shifts

Raúl E. Curto

The University of Iowa
raul-curto@uiowa.edu

Friday
10:45
CR 2K

Abstract. Given a bounded sequence ω of positive numbers, and its associated unilateral weighted shift W_ω acting on the Hilbert space $\ell^2(\mathbb{Z}_+)$, we consider natural representations of W_ω as a 2–variable weighted shift, acting on the Hilbert space $\ell^2(\mathbb{Z}_+^2)$. Alternatively, we seek to examine the various ways in which the sequence ω can give rise to a 2–variable weight diagram, corresponding to a 2–variable weighted shift. Our best (and more general) embedding arises from looking at two polynomials p and q nonnegative on a closed interval $I \subseteq \mathbb{R}_+$ and the double-indexed moment sequence $\{\int p(r)^k q(r)^\ell d\sigma(r)\}_{k,\ell \in \mathbb{Z}_+}$, where W_ω is assumed to be subnormal with Berger measure σ such that supp $\sigma \subseteq I$; we call such an

embedding a (p, q)–embedding of W_ω. We prove that every (p, q)–embedding of a subnormal weighted shift W_ω is (jointly) subnormal, and we explicitly compute its Berger measure.

We apply this result to answer three outstanding questions:

1. Can the Bergman shift A_2 be embedded in a subnormal 2–variable spherically isometric weighted shift $W_{(\alpha,\beta)}$? If so, what is the Berger measure of $W_{(\alpha,\beta)}$?

2. Can a contractive subnormal unilateral weighted shift be always embedded in a spherically isometric 2–variable weighted shift?

3. Does there exist a (jointly) hyponormal 2–variable weighted shift $\Theta(W_\omega)$ (where $\Theta(W_\omega)$ denotes the classical embedding of a hyponormal unilateral weighted shift W_ω) such that some integer power of $\Theta(W_\omega)$ is not hyponormal?

As another application, we find an alternative way to compute the Berger measure of the Agler j–th shift A_j $(j \geq 2)$. Our research uses techniques from the theory of disintegration of measures, Riesz functionals, and the functional calculus for the columns of the moment matrix associated to a polynomial embedding.

The talk is based on research with Sang Hoon Lee (Chungnam National University, Republic of Korea) and Jasang Yoon (The University of Texas Rio Grande Valley, USA): Polynomial embeddings of unilateral weighted shifts into 2–variable weighted shifts, *Integral Equations Operator Theory* 93(2021), art. 64, 1-29.

Keywords: Polynomial embedding, Spherically quasinormal pair, Recursively generated 2–variable weighted shift, Berger measure.

Cyclic commuting tuples, linear functionals and the von Neumann's inequality

Yi Wang

Chongqing University
wang_yi@cqu.edu.cn

Friday
11:15
CR 2K

Abstract. Given a commuting n-tuple of bounded linear operators $\mathbf{T} = (T_1, \cdots, T_n)$ on a Hilbert space $\mathcal{H}$ and a distinguished cyclic vector $h \in \mathcal{H}$, we study the class of the tuple $(\mathbf{T}, h)$ under unitary equivalence. Let $\Lambda \coloneqq \Lambda_{\mathbf{T},h}$ be the linear functional on $\mathbb{C}[z_1, \cdots, z_n, \bar{z}_1, \cdots, \bar{z}_n]$ determined by

$$\Lambda(z^\alpha \bar{z}^\beta) = \langle \mathbf{T}^\alpha h, \mathbf{T}^\beta h \rangle_{\mathcal{H}}.$$

Then $(\mathbf{T}, h)$ is uniquely determined by Λ up to unitary equivalence. We use this connection to give a uniform explanation of counterexamples of the von Neumann's inequality.

On the Annihilator of a Pair of Commuting Contractions

Poornendu Kumar

University of Manitoba
Poornendu.Kumar@umanitoba.ca

Friday
11:45
CR 2K

Abstract. Given a contraction T on a Hilbert space $\mathcal{H}$, the *annihilator* of T is defined as

$$\mathrm{Ann}(T) = \{f \in H^\infty(\mathbb{D}) : f(T) = 0\},$$

which is a weak-$*$ closed ideal in the Banach algebra $H^\infty(\mathbb{D})$ of bounded analytic functions on the open unit disc $\mathbb{D}$. When this ideal is non-trivial, Beurling's theorem implies that it is generated by an inner function θ. To study such annihilators, one introduces the notion of the *support* of an inner function, defined as the set of points in $\overline{\mathbb{D}}$ where the function either vanishes or cannot be analytically continued through the point. This support encodes both spectral and geometric information about $\mathrm{Ann}(T)$: it coincides with the spectrum of T, and the zero set of θ corresponds precisely to the point spectrum of T.

In this talk, we will discuss the annihilator of a pair of commuting contractions on a Hilbert space, and examine how the notions of support and spectral theory relate in this setting.

This is ongoing joint work with Prof. Raphaël Clouâtre.

The spectral theorem for a commuting tuple normal operators on an arbitrary Clifford module

David Kimsey

Newcastle University
david.kimsey@newcastle.ac.uk

Friday
12:15
CR 2K

Abstract. In this talk we will consider the problem of generating a multidimensional spectral resolution for a tuple of commuting normal operators on a Clifford module over a Clifford algebra which is arbitrary, in the sense that we will allow units to square to be $+1$. We will see that a multidimensional spectral resolution, based on a generalisation of the S-spectrum holds in this setting. Finally, we will discuss some functional calculi applications.

Determinantal representations of stable polynomials on a tube domain

Victor Vinnikov

Dept. of Mathematics, Ben Gurion University of the Negev, Beer Sheva, Israel
vinnikov@math.bgu.ac.il

Friday
14:00
CR 2K

Abstract. We consider:

- a tube domain $\Omega_C = \mathbb{R}^d + iC \subseteq \mathbb{C}^d$ over an open convex cone $C \subseteq \mathbb{R}^d$,
- polynomials $p \in \mathbb{C}[z_1, \ldots, z_d]$ that are Ω_C stable: $p(z) \neq 0$ for all $z \in \Omega_C$, and
- linear determinantal representations that certify Ω_C stability: $p(z) = \det(A_0 + z_1 A_1 + \cdots + z_d A_d)$ for $A_0, A_1, \ldots, A_d \in \mathbb{C}^{N \times N}$ for some $N \in \mathbb{N}$, with $\operatorname{Im} A_0 = \frac{1}{i}(A_0 - A_0^*) \geq 0$, $A_j = A_j^*$ for $j = 1, \ldots, d$, and $x_1 A_1 + \ldots + x_d A_d > 0$ for all $x \in C$.

We show that in case C is a symmetric homogeneous cone (i.e., C coincides with its dual cone for an appropriate choice of a scalar product on $\mathbb{R}^d$ and the group of linear automorphisms $\{T \in \mathrm{GL}(\mathbb{R}^d) \colon T(C) = C\}$ acts transitively on C) and p is strictly stable ($p(z) \neq 0$ for all $z \in \overline{\Omega_C}$ and $p(z)$ is "separated from 0" at infinity) then p always admits a certifying determinantal representations with a factor, i.e., pq admits a certifying determinantal representation for some stable q. The proof is based on a linear matrix inequality representation of C, with the Cayley transform thereof inducing a birational mapping ϕ of $\mathbb{C}^d$ mapping Ω_C bianalytically onto a bounded domain $\mathcal{D}$ of the form $\{z \in \mathbb{C}^d \colon \mathbf{P}_+(z)^* \mathbf{P}_+(z) - \mathbf{P}_-(z)^* \mathbf{P}_-(z) > 0\}$ where $\mathbf{P}_\pm$ are polynomial matrices with $\mathbf{P}_+$ square. The strict stability of p implies that its transform $\tilde{p}$ under ϕ is nonzero on $\overline{\mathcal{D}}$ therefore the corresponding Agler–von Neumann norm of its inverse is finite. A variation of the Hermitian Positivstellensatz and a "lurking contraction" argument used in [1] allows us to construct a finite dimensional contractive realization of $\frac{\epsilon}{\tilde{p}}$ for $\epsilon \ll 1$ giving a determinantal representation of $\tilde{p}$ with a factor that yields after the inverse transform under ϕ a cerifying determinantal representation (with a factor) for p. We will also make some comments relating our results to one of the central questions of convex algebraic geometry, namely the generalized Lax conjecture that every hyperbolicity cone admits a linear matrix inequality representation [2]. This is a joint work with Hugo Woerdeman (Drexel University) [3].

References

[1] A. Grinshpan, D.S. Kaliuzhnyi-Verbovetskyi, V. Vinnikov, and H.J. Woerdeman. Matrix-valued Hermitian Positivstellensatz, lurking contractions, and

contractive determinantal representations of stable polynomials. *Oper. Th. Adv. Appl.* 255:123—136, 2016.

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Cartan Isometries and Toeplitz Operators on Cartan Domains

Milan Kumar Mal

Indian Institute of Technology Madras
milanmal1702@gmail.com,
ma21d018@smail.iitm.ac.in

Friday
14:30
CR 2K

Abstract. Let Ω be a classical Cartan domain, and let S_Ω be the Shilov boundary of the domain Ω. In [1], Athavale introduced the notion of Cartan isometry. In this talk, we provide an intrinsic characterization of a Cartan isometry. Utilizing this characterization, we show that for any $\phi \in \mathrm{Aut}(\Omega)$, the operator tuple $\phi(\boldsymbol{T})$ is a Cartan isometry whenever $\boldsymbol{T}$ is a Cartan isometry.

An algebraic characterization of Toeplitz operators on the Hardy space $H^2(\mathbb{D})$ of the unit disc $\mathbb{D}$ was given by Brown and Halmos in [2]. This has been generalized for the Topelitz operators on the Hardy space $H^2(\mathbb{B})$ of the unit ball $\mathbb{B}$ by Davie and Jewell in [3]. We describe a Brown-Halmos type condition for Toeplitz operators on the Hardy space $H^2(S_\Omega)$ of the Cartan domain Ω. Furthermore, we explore the notion of Toeplitz operators for a Cartan isometry $\boldsymbol{T}$. This talk is based on a joint work with S. Kumar and P. Pramanick.

References

[1] A. Athavale, *A note on Cartan isometries*, New York J. Math., **25** (2019), 934–948.

[2] A. Brown and P.R. Halmos, *Algebraic properties of Toeplitz operators*, J. Reine Angew. Math., **213** (1963/64), 89-102.

[3] A.M. Davie and N.P. Jewell, *Toeplitz operator in several complex variables*, J. Funct. Anal., **26** (1977), 356-368.

Complete Nevanlinna Pick de Branges-Rovnyak spaces

Hamidul Ahmed

Indian Institute of Technology Bombay

hamidulahmedslk@gmail.com

Friday
15:00
CR 2K

Abstract. In this talk, we mainly study de Branges-Rovnyak spaces of certain class of repoducing kernel Hilbert spaces which are complete Nevanlinna-Pick (CNP) spaces. We first introduce the notion of CNP spaces, which is motivated from a function theoretic problem known as Nevanlinna-Pick interpolation problem. A characterization of such spaces in terms of its kernel, commonly known as Quiggin's characterization, is discussed along with few interesting examples. We then introduce the notion of de Branges-Rovnyak spaces of a reproducing kernel Hilbert space, and discuss a recent development on de Branges-Rovnyak spaces of a CNP space which are CNP spaces as well. This leads us to study de Branges-Rovnyak spaces of a non CNP space. By considering a certain class of non-CNP spaces, we provide a complete characterization of its de Branges-Rovnyak spaces which are CNP. The class is wide enough to contain many classical examples of non-CNP spaces such as Bergman space over $\mathbb{D}$ (the unit disc), Hardy spaces over the polydisc etc. Surprisingly, de Branges-Rovnyak spaces of the Hardy space over $\mathbb{D}^2$ which are CNP turns out to be essentially 'one variable' and more importantly, no de Branges-Rovnyak space of the Hardy space over $\mathbb{D}^n$ $(n \geq 3)$ is CNP. Thus, we observe a sharp difference between the case $n = 2$ and $n \geq 3$ which appears in many other operator theoretic context as well.

S8: Non-commutative function theory and free analysis

Organizers: Rob Martin, Michael Jury.

Pointwise spectral equivalences of noncommutative polynomials

Jurij Volčič

University of Auckland
jurij.volcic@auckland.ac.nz

Wednesday
10:30
CR 2M

Abstract. A noncommutative polynomial (an element of the free algebra) can be viewed as a function from tuples of square matrices to square matrices, of arbitrary sizes. This view is adopted in free analysis, where noncommutative polynomials are prototypical examples of more general noncommutative functions. From this perspective, there is a common problem of how much info about a noncommutative polynomial can be recovered from the features of its matrix evaluations. This talk addresses an aspect of this problem, by classifying pairs of noncommutative polynomials whose evaluations share common spectral properties. Concretely, the talk considers pairs of noncommutative polynomials that have pointwise the same rank, eigenvalues, norm, or similar values. For each of these pointwise equivalences, a counterpart in the free algebra (that is, a structure governing it) is presented. Based on joint work with Eli Shamovich.

NC Gleason problem

Victor Vinnikov

Dept. of Mathematics, Ben Gurion University of the Negev, Beer Sheva, Israel
vinnikov@math.bgu.ac.il

Wednesday
11:00
CR 2M

Abstract. For a given Banach algebra $\mathcal{A}$ of analytic functions on a domain $\mathcal{D} \subseteq \mathbb{C}^d$, Gleason problem [1] is whether for all $f \in \mathcal{A}$ with $f(w) = 0$ for some $w \in \mathcal{D}$ there exist $f_1, \dots, f_d \in \mathcal{A}$ s.t. $f = \sum_{j=1}^{d} (z_j - w_j) f_j$. We study the analogue of this problem for nc functions using Taylor–Taylor series amd nc difference–differential calculus; the results are radically different from the commutative case.

This is a joint work with Prahllad Deb (IIIT Dehli) that was originally motivated by our investigation of the nc Cowen–Douglas theory [2].

References

[1] A. M. Gleason. Finitely generated ideals in Banach algebras. *J. Math. Mech.* 13:125–132, 1964.

[2] P. Deb and V. Vinnikov. Towards a noncommutative theory of Cowen-Douglas class of noncommuting operators. Preprint arXiv:2503.08526.

A Non-commutative de Branges-Rovnyak Model for Certain Row Contractions

Jeet Sampat

University of Manitoba
Jeet.Sampat@umanitoba.ca

Wednesday
11:30
CR 2M

Abstract. The classical de Branges-Rovnyak (dBR) model shows that every *completely non-coisometric (CNC)* contraction on a Hilbert space can be represented as the restriction of the adjoint of the shift operator to a de Branges-Rovnyak space.

In this talk, I will discuss the problem of extending the dBR model to arbitrary CNC row contractions, i.e, d-tuples ($d < \infty$) of operators $T = (T_1, \ldots, T_d)$ that act as a contractive row operator on d-copies of some Hilbert space into itself. For the case when T_j's are pair-wise commuting, R.T.W. Martin and A. Ramanantoanina extended the dBR model by considering de Branges-Rovnyak spaces that are contractively contained in the vector-valued Drury-Arveson space on the Euclidean unit ball in $\mathbb{C}^d$. I will show that the techniques used above can be significantly modified to work for the general case as well, although things get tricky since we need to deal with non-commutative versions of de Branges-Rovnyak spaces.

This discussion is based on joint work with R.T.W. Martin at the University of Manitoba.

Dimension of Non-generic Points of NC Implicit Theorem

Jiachen Lu

Washington University in St. Louis
jiachen.l@wustl.edu

Wednesday
12:00
CR 2M

Abstract. A consequence of implicit function theorem is that any algebraic set is generically a complex manifold except at points where Jacobian is not invertible. Accordingly, the non commutative implicit function theorem of Agler- McCarthy [1] might suggest that an nc algebraic set is genetically an nc manifold. However, in this talk, we showed for second order nc polynomials it is the 'non-generic points' that actually have higher dimensions.

References

[1] J. Agler and J. McCarthy *The implicit function theorem and free algebraic sets. Trans. Amer. Math. Soc.*, 368(5):3157–3175, 2016.

Fuglede-Kadison determinants of matrix-valued semicircular elements and capacity estimates

Roland Speicher

Saarland University

speicher@math.uni-sb.de

Thursday
13:15
CR 2M

Abstract. In my plenary talk I pointed out the relevance of having estimates for determinants of operator-valued operators. Here I will provide more details on our calculation of the Fuglede-Kadison determinant of arbitrary matrix-valued semicircular operators in terms of the capacity of the corresponding covariance mapping and on improving a lower bound by Garg, Gurvits, Oliveira, and Widgerson on this capacity, by making it dimension-independent.

This is joint work with Tobias Mai.

Evaluation of uniformly meromorphic NC functions in a stably finite C^*-algebra

Maximilian Tornes

University of Manitoba

tornesm@myumanitoba.ca

Thursday
13:45
CR 2M

Abstract. A descriptor realization is a triple (A, b, c), where $A \in B(\mathcal{H})^d$ and $b, c \in \mathcal{H}$ for some Hilbert space $\mathcal{H}$. This triple can be used to define an analytic non-commutative (nc) function in d variables in a uniformly open neighborhood of 0. In a recent paper [1], Augat, Martin and Shamovich studied the ring of all nc functions for which A is a tuple of compact operators and showed that it is a semifir in the sense of P.M. Cohn. Moreover, they showed that each element of its universal skew field of fractions $\mathcal{M}$ can be identified with a uniformly analytic nc function on a uniformly open and joint-similarity invariant nc domain that is analytic–Zariski open and dense, as well as matrix-norm open and connected, at every level, n, of the nc universe over $\mathbb{C}^d$, for sufficiently large n. $\mathcal{M}$ can be viewed as the skew field of global uniformly meromorphic nc functions.

We show that the elements of $\mathcal{M}$ have well defined domains and evaluations in any stably finite C^*-algebra. This is joint work with Robert Martin and Eli Shamovich.

References

[1] M.L. Augat, R.T.W Martin and E. Shamovich. *Operator realizations of non-commutative analytic functions.* arXiv:2404.16675.

The lifting constant from the cross to the bidisk

J. E. Pascoe

Drexel University
jep362@drexel.edu

Thursday
14:15
CR 2M

Abstract. We will present a proof of the following evidently elementary result: Let f, g be contractive analytic functions on the disk which agree at 0, then there is a function on the bidisk with norm at most two such that its restriction to each of the axes are the two functions respectively.

We discuss the general theory of spectral constants and related lifting problems. The development essentially began with the development of von Neumann's inequality, followed by the initial work of Shields on more complicated domains, Ando's inequality, Crouzeix's conjecture and so on. The theory of Pick interpolation, as developed by Agler and McCarthy gives a connection with the much more concrete lifting problem, or the Cartan Extension theorem with bounds.

Some aspects of quantum circuits

J. William Helton

UC San Diego
helton@ucsd.edu

Thursday
16:00
CR 2M

Abstract. The talk is one of two independent (unentangled) talks on quantum circuits which focus on different aspects of ongoing work on parellelizing a given quantum circuit. This talk will spend more time on basics of quantum circuits, to include analogs with free functions (an emphasis of this session). This will introduce enough background to state our theorem that 'quantum waterfalls' can be effectively parallelized; contrary to a 1997 conjecture. Discussion of the proof will be split between the two talks in a way to be determined. The work is joint with Adam Benne Watts, Joe Slote, Charlie Chen and Igor Klep.

The quantum max cut problem via qudit swap operators

Tea Štrekelj

FAMNIT, University of Primorska
tea.strekelj@famnit.upr.si

Thursday
16:30
CR 2M

Abstract. Swap operators act on the space $(\mathbb{C}^d)^{\otimes n}$ of n qudits by exchanging tensor factors of $(\mathbb{C}^d)^{\otimes n}$. The algebra they generate (called the d-swap matrix algebra) is a subalgebra of $M_{d^n}(\mathbb{C})$. Classically, in physics literature, the case $d = 2$ of qubits has received the most attention. However, in this talk we discuss the properties of the d-swap matrix algebra for the case of a general d. This algebra is semisimple by Maschke's theorem and is in fact identified as a quotient of a free algebra modulo symmetric group relations and a single additional relation of degree d.

As an application, we introduce and discuss the Quantum Max d-Cut (d-QMC) problem. It is a higher-dimensional analog of the QMC (Quantum Max d-Cut with $d = 2$) that has emerged as a test-problem for designing approximation algorithms in quantum physics. For fixed n and a graph G on n vertices, the objective function, the d-QMC Hamiltonian, is defined as a linear expression in the swap operators on $(\mathbb{C}^d)^{\otimes n}$. Using the block decomposition of the swap operators, we compute the maximum eigenvalue of the d-QMC Hamiltonian for a clique. Moreover, using a suitable clique decomposition we solve the d-QMC problem for a larger class of graphs, namely complete bipartite graphs.

This is joint work with Igor Klep and Jurij Volčič.

Real vs complex free spectrahedra: The evils of the reals and the crimes of the complexes

Eric Evert

University of Florida
ericevert@ufl.edu

Thursday
17:00
CR 2M

Abstract. Free spectrahedra, dimension-free solution sets to linear matrix inequalities, are fundamental examples of matrix convex sets. Free spectrahedra exhibit particularly nice properties in relation to their extreme points and duality. However, these results are highly sensitive to the underlying field. For example, while every real free spectrahedron is the matrix convex hull of its free extreme points, complex free spectrahedra can fail to have extreme points altogether.

This talk will highlight important differences between the real and complex settings, focusing on failures of expected properties. For example, we

will show that the free polar dual of a real free spectrahedron is rarely the projection of a real free spectrahedron, contrasting a positive result of Helton, Klep, and McCullough in the complex setting. Blending ideas from both settings, we will construct a matrix convex set that is closed under complex conjugation and is the projection of a free spectrahedron but has no free extreme points, providing a negative answer to a long-standing open question in matrix convexity.

This talk is based on joint work with Benjamin Passer.

Noncommutative ergodic theory and lattices of higher rank Lie groups

Guy Salomon

Holon Institute of Technology
guysal@hit.ac.il

Thursday
17:30
CR 2M

Abstract. I will introduce a noncommutative framework for ergodic theory inspired by SAT (strongly approximately transitive) actions, and describe how this perspective leads to a generalization of a theorem by Nevo and Zimmer concerning nonsingular actions of lattices in higher-rank Lie groups. A key aspect of the construction involves studying extreme points of the space of equivariant unital completely positive maps. I will outline the main ideas behind the proof, which are new even in the classical (commutative) setting. This is joint work with Uri Bader.

Constrained Pick Interpolation and C*-envelopes

Gal Ben Ayun

Ben Gurion University of the Negev
benayung@post.bgu.ac.il

Friday
10:45
CR 2M

Abstract. The classical Pick interpolation problem asks about the existence of an interpolating function from the complex unit disk to itself, and was solved by Pick in 1916. Pick interpolation was extended to multiply-connected domains by Abrahamse and Ball, and to constrained algebras by Davidson, Paulsen, Raghupathi and Singh. Agler, based on the works of Abrahamse, devised a general method for solving interpolation problems based on families of kernels.

The Pick interpolation problem together with a theorem by Sarason can be interpreted in the language of C*-covers, and be used to explicitly compute the C*-envelope of an associated quotient of H^∞. In my talk, I will present the solution to a constrained matricial Pick interpolation problem in the algebra H^∞_{node} - the algebra of bounded analytic functions such that

$f(0) = f(\lambda)$ for some fixed λ in the unit disk. The result will be used to prove a distance formula, and to construct a C*-cover for a quotient of H^∞_{node} that arises naturally from the interpolation problem. Furthermore, for a specific interpolation data of 4 points, I will show that the C* envelope is infinite dimensional.

Noncommutative Geometric Structure of Subhomogeneous Operator Systems

Ran Kiri

Technion Israel
rankiri@campus.technion.ac.il

Friday
11:15
CR 2M

Abstract. Given an operator system $\mathcal{S}$ generating a unital C^*-algebra $\mathcal{A} = C^*(\mathcal{S})$, its *matrix state space* $\mathrm{UCP}(\mathcal{S})$ is the set of all unital and completely positive maps from $\mathcal{S}$ to $\mathbb{M}_n$ for all $n \in \mathbb{N}$. The structure of $\mathcal{S}$ is encoded in the matrix convex structure of $\mathrm{UCP}(\mathcal{S})$ in the sense that two operator systems are completely order isomorphic if and only if there is a matrix affine homeomorphism between their state spaces.

In this talk we will explain what the notion of subhomogeneity could be used for and mention some recent ideas and directions. In particular, we show that the C^*-envelope of a subhomogeneous operator system is a subhomogeneous C^*-algebra. Moreover, we show and extension of Choi's theorem for n-positive maps into $\mathbb{M}_n$ to n-subhomogeneous operator systems.

S9: Noncommutative geometry

Organizers: Sophie Zegers, Shirly Gefen, Suvrajit Bhattacharjee.

Non-Hausdorff étale groupoids and the singular ideal

Kevin Aguyar Brix

University of Southern Denmark
kabrix@imada.sdu.dk

Tuesday
13:15
CR 2H

Abstract. The theory of étale groupoids provides a versatile tool for solving problems arising in, e.g., dynamical systems and geometry with connections to noncommutative geometry and operator algebras. For natural examples, the groupoid need not carry a Hausdorff topology, and this is reflected in the 'singular' ideal in the associated Steinberg or C*-algebras. This ideal is in large part mysterious, but I will report on recent progress based on recent joint work with Julian Gonzales, Jeremy Hume, and Xin Li.

Zappa-Szep product with a twist

Boyu Li

New Mexico State University
boyuli@nmsu.edu

Tuesday
13:45
CR 2H

Abstract. The Zappa-Szep product originated from group theory. It can be viewed as a generalisation of the semi-direct product, where it encodes a two-way interaction instead of a one-way action. One can also view the Zappa-Szep product as a decomposition of a group as a product of two subgroups. In this talk, we will briefly review the Zappa-Szep product construction of groupoids and implications in their C*-algebras. We will define the Zappa-Szep of twisted groupoids, which arises naturally as the Weyl groupoids from Cartan subalgebras. Unlike the Zappa-Szep product of groupoids defined by two-way actions, we show that the actions are in fact encoded by the so-called factorisation map. This is a joint work with Anna Duwenig.

Maximal ideals of reduced group C*-algebras

Chris Bruce

Newcastle University
chris.bruce@newcastle.ac.uk

Tuesday
14:15
CR 2H

Abstract. A group is said to be C*-simple if its reduced C*-algebra is simple. A celebrated result by Kalantar and Kennedy says that a group G is

C*-simple if and only if the action of G on its Furstenberg boundary is free. I will present on recent work in which we extend this result, proving that even the maximal ideal structure of the reduced C*-algebra of a discrete group is governed by the action of G on its Furstenberg boundary: given a point x in the Furstenberg boundary of G, we prove that there is a bijection between maximal ideals of the reduced C*-algebra of G and maximal co-induced ideals of the C*-algebra of the stabiliser subgroup of x. Interestingly, our result reduces the problem of computing maximal ideals in reduced group C*-algebras to computing ideals in C*-algebras of amenable group. This is joint work with Kevin Aguyar Brix, Kang Li, and Eduardo Scarparo.

Quasi-invariant lifts of completely positive maps for groupoid actions

Marzieh Forough

Czech Technical University in Prague
foroumar@fit.cvut.cz

Tuesday
14:45
CR 2H

Abstract. In this talk, I will explain the existence of quasi-invariant lifts for completely positive G-equivariant maps where G is a locally compact, Hausdorff, second countable groupoid. I will also describe how this problem leads to investigating the connection between extensions of G-C*-algebras and groupoid equivariant KK-theory.

This is joint work with Suvrajit Bhattacharjee.

C*-diagonals with Cantor spectrum in Cuntz algebras

Philipp Sibbel

University of Münster
philipp.sibbel@uni-muenster.de

Tuesday
16:00
CR 2H

Abstract. The theory of C*-diagonals and Cartan subalgebras, developed by Kumjian and Renault, plays an interesting role in the classification program for C*-algebras. A Cartan subalgebra exists in every classifiable C*-algebra, and in particular, every classifiable C*-algebra that is stably finite, contains a C*-diagonal. However, the existence of C*-diagonals in Kirchberg algebras remains poorly understood. In this talk, I will give an overview of the theory, and in particular discuss an explicit construction of C*-diagonals with Cantor spectrum in the Cuntz algebra $\mathcal{O}_k$ for finite k. This talk is based on joint work with Wilhelm Winter and Samuel Evington.

Uniform property Gamma and the small boundary property

Grigorios Kopsacheilis

University of Münster
gkopsach@uni-muenster.de

Tuesday
16:30
CR 2H

Abstract. In this talk we discuss a version of a tracial divisibility property, namely uniform property Gamma, defined for sub-C*-algebras. For sub-C*-algebras canonically arising from topological dynamics of amenable groups, we will see how this characterizes the small boundary property of the underlying action, and go over some consequences of this characterization regarding almost finiteness, Jiang-Su stability and product actions. This is joint work with H. Liao, A. Tikuisis and A. Vaccaro.

KMS states on quantum Cuntz-Krieger algebras

Manish Kumar

KU Leuven
manish.kumar@kuleuven.be

Tuesday
17:00
CR 2H

Abstract. KMS states on various classes of C*-algebras such as graph C*-algebras, Cuntz-Krieger algebras, Cuntz-Pimsner algebras are well studied. In this talk, we discuss the KMS states on quantum Cuntz-Krieger algebras associated to quantum graphs. We show that the general criteria for KMS states can be translated into statements about the underlying quantum adjacency operator, somewhat analogously to the case of classical Cuntz-Krieger algebras. This is joint work with Mateusz Wasilewski.

A formula for heat coefficients of the noncommutative torus

Teun van Nuland

TU Delft
t.d.h.vannuland@tudelft.nl

Thursday
13:15
CR 2H

Abstract. Generalizing Weyl's law, the heat trace expansion describes the small-time expansion of $Tr(e^{-tDelta})$ (Delta the Laplace operator) in terms of geometrical data. I will talk about a noncommutative version of that expansion, for a specific noncommutative space introduced by Connes and others in the early 2010s, the conformally deformed noncommutative torus.

On Quadratic Algebras and Essential Normality

Francesca Arici

University of Leiden
f.arici@math.leidenuniv.nl

Thursday
13:45
CR 2H

Abstract. Quadratic algebras offer a natural setting for exploring quantum spaces and deformations, particularly within the framework of quantum groups as envisioned in Manin's program for noncommutative geometry. In this talk, I will present recent developments on extending various operations on quadratic algebras to their C*-algebraic counterparts, with a focus on Veronese powers. This operation plays a pivotal role in analyzing the essential normality of d-tuples of operators.

E-mergence of the spectral localiser

Bram Mesland

University of Leiden
b.mesland@math.leidenuniv.nl

Thursday
14:15
CR 2H

Abstract. The spectral localiser of Loring and Schulz-Baldes gives a method to compute the index pairing between an odd K-theory class and an odd spectral triple as the signature of a certain finite dimensional matrix. A spectral triple determines a natural asymptotic morphism, and thus an element in the E-theory of Connes-Higson. In this talk I will show how the spectral localiser emerges from computing the pairing of the K-theory class with this asymptotic morphism. This new proof sheds some light on the parameters appearing in the spectral localiser formula.

A generalization of K-theory to operator systems

Walter van Suijlekom

Radboud University
waltervs@math.ru.nl

Thursday
14:45
CR 2H

Abstract. We propose a generalization of K-theory to operator systems. Motivated by spectral truncations of noncommutative spaces described by C*-algebras and inspired by the realization of the K-theory of a C*-algebra as the Witt group of hermitian forms, we introduce new operator system invariants indexed by the corresponding matrix size. A direct system is constructed whose direct limit possesses a semigroup structure, and we define the K-group as the corresponding Grothendieck group. This is an invariant of unital operator systems, and, more generally, an invariant up to Morita

equivalence of operator systems. For C*-algebras it reduces to the usual definition. We illustrate our invariant by means of the spectral localizer.

Ideal quantum metrics from fractional Laplacians

Dimitris Gerontogiannis

Polish Academy of Sciences
dgerontogiannis@impan.pl

Thursday
16:00
CR 2H

Abstract. This talk presents a new framework for constructing computable Monge–Kantorovich metrics using Schatten ideals and commutators of fractional Laplacians on Ahlfors regular spaces. These "ideal" metrics admit explicit spectral formulas and naturally respect underlying dynamics. Our methods introduce new tools in noncommutative geometry, including a fractional Weyl law and Schatten-class commutator estimates. As an application, we extend the construction to expansive $\mathbb{Z}^m$-actions and their associated C*-algebras, illustrating the reach of fractional analysis across dynamics, fractal geometry, and quantum metric spaces. This is joint work with Bram Mesland.

Quantum metrics on quantum groups

David Kyed

University of Southern Denmark
dkyed@imada.sdu.dk

Thursday
16:30
CR 2H

Abstract. In Rieffel's theory of compact quantum metric spaces, it is often quite difficult to verify if a given candidate is indeed a quantum metric. Even well-studied cases, such as those arising from length functions on groups, are still far from fully understood. Upon passing from groups to quantum groups, one obtains a wider range of potential examples, and in my talk I will describe a reduction result within this setting and explain how it yields new examples of quantum metric structures. The talk is based on joint work with Are Austad.

Index theory and spectral flow of Toeplitz operators

Koen van den Dungen

University of Bonn
kdungen@uni-bonn.de

Thursday
17:00
CR 2H

Abstract. In this talk I will consider Dirac–Schrödinger operators (or Callias-type operators), which are given by Dirac-type operators on a smooth

manifold, together with a potential. I will describe a general setting with arbitrary signatures (with or without gradings), which allows us to study index pairings and spectral flow simultaneously. I will then provide a Callias Theorem, which computes the index (or the spectral flow) of Dirac–Schrödinger operators in terms of index pairings on a compact hypersurface.

Associated to each Dirac–Schrödinger operator is also a Toeplitz operator, which is obtained by compressing the potential to the kernel of the Dirac operator. The main result is a Toeplitz index theorem (or spectral flow theorem), which relates the index (or spectral flow) of these Toeplitz operators to the index (or spectral flow) of certain Toeplitz operators on the compact hypersurface.

W*-Rigidity of graph product

Enli Chen

TU Delft
e.chen-1@tudelft.nl

Thursday
17:30
CR 2H

Abstract. Graph product is an important construction for groups as well as C* and von Neumann algebras. It can be seen as a generation for both tensor and free products of operator algebras, with some combinatoric information encoded by the graphs. In this talk, we will introduce our recent results about the rigidity properties of graph products in the von Neumann algebras setting. Specifically, if two graph products of arbitrary non-amenable von Neumann algebras taken from some class are isomorphic, we showed that these two graphs must be isomorphic, and two von Neumann algebras for each vertex must be stably isomorphic. This talk is based on the joint work with Matthijs Borst and Martijn Caspers.

Spectral and Fourier truncations

Malte Leimbach

Radboud University
m.leimbach@math.ru.nl

Friday
10:45
CR 2H

Abstract. Physical obstructions on the availability of spectral data can be incorporated into noncommutative geometry in different ways. In this talk we will focus on spectral and Fourier truncations in the setting of compact quantum groups, giving a sketch of how to prove their convergence. Moreover, we will discuss the issue of duality inspired by the duality of the Toeplitz and Fejér–Riesz system which arise from truncations of the circle. Perhaps surprisingly, this duality generally fails already in the case of truncations of the 2-torus. We relate this problem about duality of operator systems to

the problems of extending partially defined positive definite functions and factorizing positive trigonometric polynomials.

Toeplitz Algebras in Noncommutative Finite CW Complexes

Elmar Wagner

University of Michoacan
elmar.wagner@umich.mx

Friday
11:15
CR 2H

Abstract. Noncommutative finite CW complexes are constructed by applying the functor that sends a compact topological Hausdorff space to the C*-algebra of its continuous functions and then allowing the C*-algebras to be noncommutative. The Toeplitz algebra is particularly well suited for these constructions, since the symbol map can be viewed as the restriction of functions on a noncommutative unit disk to the boundary circle. As a consequence, there exists for any 2-dimensional CW complex a noncommutative version constructed in the same way but with the disk algebra replaced by Toeplitz algebra.

A natural question is whether the topological invariants in the form of K-groups remain invariant under this construction. This can be studied most conveniently by using spectral sequences. The objective of the talk is to show that the 2-dimensional case is completely analogous to the classical case. If time permits, some higher-dimensional examples will also be discussed.

Joint work with Arley Yessit Sierra Acosta [1].

References

[1] Arley Yessit Sierra Acosta and Elmar Wagner. Closed Quantum Surfaces from the Toeplitz Extension. Rocky Mountain J. Math. To appear.

Gromov Hausdorff convergence of UCP maps

Ritul Duhan

Indian Institute of Science
ritul2023@iisc.ac.in

Friday
11:45
CR 2H

Abstract. Connes and van Suijlekom introduced spectral truncations in noncommutative geometry in the work:

> Alain Connes and Walter D. van Suijlekom, *Spectral truncations in noncommutative geometry and operator systems*, Comm. Math. Phys. **383**, no. 3 (2021), 2021–2067.

We will show that their framework also ensures the Gromov-Hausdorff convergence of sets of unital completely positive (UCP) maps arising from the truncated systems. This approach is illustrated with explicit examples. The talk will be based on a joint work with Tirthankar Bhattacharyya and Chandan Pradhan.

References

[1] W. van Suijlekom. Gromov-Hausdorff convergence of state spaces for spectral truncations. *J. Geom. Phys.* 162 no. 2 (2021) Paper No. 104075, 11pp. doi:10.1016/j.geomphys.2020.104075.

[2] A. Connes and W. van Suijlekom. Spectral truncations in noncommutative geometry and operator systems. *Commun. Math. Phys.* 383 no. 3 (2021), 2021–2067. doi:10.1007/s00220-020-03825-x.

[3] T. Bhattacharyya, R. Duhan, and C. Pradhan. Gromov-Hausdorff convergence of metric spaces of UCP maps, 2024. arXiv:2410.15454.

Equivariant split extensions and KK-equivalences of quantum flag manifolds

Jesse Reimann

TU Delft

j.reimann@tudelft.nl

Friday
12:15
CR 2H

Abstract. Inspired by Gelfand duality, we can construct "quantum" versions of many classical spaces as noncommutative C*-algebras. Some of those quantum spaces, such as quantum spheres and quantum flag manifolds, possess some particularly nice additional underlying structure – they admit descriptions as graph C*-algebras, i.e., their algebraic structure can be encoded in a directed graph. In particular, properties such as the ideal structure, presence of a unit, or K-theory of the C*-algebra can be read directly from this graph structure.

In this talk, I will introduce graph C*-algebras and discuss how this graph structure allows us to obtain explicit torus-equivariant KK-equivalences in the special case of quantum projective spaces by constructing split exact sequences.

Based on ongoing work with Sophie Zegers.

S10: Numerical ranges and spectral sets

Organizers: Ryan O'Loughlin, Ilya Spitkovsky, Michał Wojtylak.

Matrices with rotation and/or reflection invariant higher rank numerical ranges

Hugo J. Woerdeman

Drexel University
hjw27@drexel.edu

Tuesday
13:15
CR 2G

Abstract. We show that two $n \times n$ matrices have the same Kippenhahn polynomials if and only if they (1) have the same trace and (2) have the same rank-k numerical ranges for $1 \leq k \leq \lfloor \frac{n}{2} \rfloor$. In addition to this result, we provide a second necessary and sufficient condition for an $n \times n$ matrix to have higher rank numerical ranges that are invariant under rotations by $\frac{2\pi}{\ell}$ for some integer $\ell \geq 2$. Finally, we adapt this result to provide another necessary and sufficient condition for an $n \times n$ matrix to have higher rank numerical ranges that are invariant under reflection over the real axis. This talk is based on joint work with Sarah Gift.

Matrices with prescribed boundary of their numerical range and sinusoidal spirals

Petr Blaschke

Silesian University in Opava, Czech republic
petr.blaschke@math.slu.cz

Tuesday
13:45
CR 2G

Abstract. The boundary curve of a numerical range of a finite matrix can be neatly described as a *coval* – i.e., a curve for which there is an algebraic relation between the distances of a finite number of poles to the tangent lines.

In this talk, we will give a coval description for any sinusoidal spiral, i.e., a planar curve given in polar coordinates as

$$r^\alpha = \sin(\alpha\phi),$$

where $\alpha \in \mathbb{R}$, and, for some special values of α, we identify corresponding matrices with matching numerical ranges.

Matrices with hyperbolic J-numerical range

Rute Lemos

CIDMA and University of Aveiro, Portugal
rute@ua.pt

Tuesday
14:15
CR 2G

Abstract. We consider an indefinite inner product space induced by a non-singular signature matrix J. A criterium for no degenerate hyperbolicity of the J-numerical range is presented. This shape characterizes the 2-by-2 case and persists for certain classes of structured matrices independently of their size. Results in this vein are obtained and illustrated, some of them are counterparts of classical numerical range results.

This talk is based on a joint work with N. Bebiano and G. Soares.

This work is supported by the Center for Research and Development in Mathematics and Applications (CIDMA) under the Portuguese Foundation for Science and Technology (FCT, https://ror.org/00snfqn58) Multi-Annual Financing Program for R&D Units (reference UID/04106).

Parameterization of numerical ranges

Konrad Szymański

Research Center for Quantum Information, Slovak Academy of Sciences, Bratislava
k.sz@quantumstat.es

Tuesday
14:45
CR 2G

Abstract. Numerical range $W(X)$ encodes some information about the defining matrix X, but the mapping $X \mapsto W(X)$ is not a bijection. As an elementary example, the numerical range is invariant under conjugation of X by a unitary matrix, but the entire equivalence class goes beyond simple unitary orbits. In this presentation, I study the number of parameters needed to define numerical ranges and closely related joint numerical ranges. Existing bounds on the parameterization dimension are not sharp; in order to investigate this problem further, a novel numerical approach was developed. This involves analysis of the support function of $W(X)$: it is linearized around a fixed operator X', and the kernel of the linear part provides information about the local equivalence. The numerical data supports the conjecture that generically, the numerical range of square complex matrices of size d is defined by $\frac{1}{2}d(d+3)$ real parameters.

A Schwarz-Jack Lemma with Applications in Numerical Ranges

Javad Mashreghi

Laval University
javad.mashreghi@mat.ulaval.ca

Tuesday
16:00
CR 2G

Abstract. The celebrated Crouzeix conjecture asserts that the numerical range of any $n \times n$ matrix is a 2-spectral set. While this result has been established for the case $n = 2$, the conjecture remains open for $n \geq 3$. The existing proofs are highly technical, relying heavily on the explicit formula of the conformal mapping from an ellipse onto the unit disc. The aim of this work is twofold: first, to elucidate the intrinsic properties of the conformal mappings in question, thereby reducing the reliance on explicit formulas; second, to lay conceptual groundwork for broader generalizations. To this end, we present a Schwarz–Jack lemma, which stands as a significant contribution in its own right and forms a central component of the paper. We further establish two distinct conditions under which the Jack condition holds. This lemma is then leveraged to derive a general result on conformal mappings over bi-oval domains, offering an abstract framework that underpins the known proofs of the Crouzeix theorem for $n = 2$ and potentially points the way forward.

Joint work with A. Moucha, R. O'Loughlin, T. Ransford, O. Roth.

Spectral constants via contour integral methods revisited

Jens de Vries

University of Twente
j.devries-4@utwente.nl

Tuesday
16:30
CR 2G

Abstract. We thoroughly analyze the double-layer potential's role in approaches to c-spectral sets in the spirit of Delyon–Delyon (1999), Crouzeix (2007) and Crouzeix–Palencia (2017). While the double-layer potential is well studied, we aim to clarify on several of its aspects in light of these references. In particular, we discuss results that characterize the domain assumptions (convexity and containment of the numerical range) in terms of function and operator theoretic properties of the involved contour integral operators. This talk is based on joint work with Felix Schwenninger, published in [1].

References

[1] F.L. Schwenninger and J. de Vries. The double-layer potential for spectral constants revisited. *Integral Equations and Operator Theory*, 97(2):1–22, 2025. doi:10.1007/s00020-025-02800-2.

The algebraic numerical range as a spectral set in Banach algebras

Hanna Blazhko

Jagiellonian University in Krakow
hanna.blazhko@student.uj.edu.pl

Tuesday
17:00
CR 2G

Abstract. We consider the problem of the existence of an analogue to Crouzeix's constant in Banach algebras. More specifically, for an element T in a Banach algebra $\mathcal{A}$ we define its *numerical range spectral constant* as the smallest positive C such that for every polynomial $p \in \mathbb{C}[\lambda]$ holds

$$\|p(T)\| \leq C \sup_{V(T)} |p|,$$

where $V(T)$ denotes the algebraic numerical range of T. Further, we define the *spectral constant* of the algebra $\mathcal{A}$ as the supremum of numerical range spectral constants of all its elements.

Our results show that the spectral constant of the numerical range

- is at most $1+\sqrt{2}$ for C^*-algebras and equal to Crouzeix's constant for the Calkin algebra;
- is finite in any matrix algebra;
- is infinite for the algebras $\mathbf{B}(\ell^p)$, $p \in [1,2) \cup (2,+\infty)$;
- is infinite for $\mathbf{B}(X)$, where X is a combinatorial Banach space (e.g., Schreier space);
- is between 1.1 and 13 for 2×2 matrices with the ℓ^1-induced norm.

The talk is based on joint work with D. Homza, F. Schwenninger, J. de Vries and M. Wojtylak.

References

[1] H. Blazhko, D. Homza, F. L. Schwenninger, J. de Vries, and M. Wojtylak. The algebraic numerical range as a spectral set in Banach algebras. *Canadian Journal of Mathematics*, pages 1–25, 2025. doi:10.4153/S0008414X25000124.

On the Closure of the Strict Equivalence Orbit of a Matrix Pencil

Maria Dronka

Jagiellonian University
maria.dronka@doctoral.uj.edu.pl

Tuesday
17:30
CR 2G

Abstract. In 1986, A. Pokrzywa characterised the conditions under which a matrix pencil lies in the closure of the strict equivalence orbit of another

pencil. Specifically, given two matrix pencils L and M, with $M \in \overline{\mathcal{O}(L)}$, he introduced six types of operations on the Kronecker Canonical Form (KCF) that are sufficient to relate the KCFs of L and M through a finite sequence of steps.

In the first part of the talk, we present an algorithm derived from Pokrzywa's results, which explicitly constructs a sequence of such operations connecting the KCFs of L and M. In the second part, we introduce a new approach to the problem: an algorithm that starts from the KCF of M and transforms it into that of L.

This work is the result of a collaboration with Fernando De Terán, Froilán M. Dopico, and Patryk Pagacz.

Spectral set, complete spectral set and dilation for Banach space operators

Swapan Jana

Department of Mathematics, Indian Institute of Technology Bombay, Mumbai, India
swapan.jana@iitb.ac.in;
swapan.math2015@gmail.com

Wednesday
10:30
CR 2G

Abstract. Famous results due to von Neumann, Sz.-Nagy and Arveson assert that the following four statements are equivalent; a Hilbert space operator T is a contraction; the closed unit disk $\overline{\mathbb{D}}$ is a spectral set for T; T can be dilated to a Hilbert space isometry; $\overline{\mathbb{D}}$ is a complete spectral set for T. In this article, we show by counter examples that no two of them are equivalent for Banach space operators. If $\mathcal{F}_r$ is the family of all complex Banach space operators having norm less than or equal to r and if D_R denotes the open disk in the complex plane with centre at the origin and radius R, then we show by an application of Bohr's theorem that $\overline{D}_R$ is the minimal spectral set for $\mathcal{F}_r$ if and only if $r = R/3$. For a complex Banach space $\mathbb{X}$, we show that the following statements are equivalent: (i) $\mathbb{X}$ is a Hilbert space; (ii) $\overline{\mathbb{D}}$ is a spectral set for the forward shift operator M_z on $\ell_2(\mathbb{X})$; (iii) $\overline{\mathbb{D}}$ is a spectral set for the backward shift operator $\widehat{M_z}$ on $\ell_2(\mathbb{X})$; (iv) $\overline{\mathbb{D}}$ is a spectral set for every strict contraction on $\mathbb{X}$; (v) $\overline{\mathbb{D}}$ is a complete spectral set for every contraction T on $\mathbb{X}$ with $\|T\| = 1$; (vi) $\overline{\mathbb{D}}$ is a complete spectral set of the identity operator $I_{\mathbb{X}}$ on $\mathbb{X}$. This is a joint work with Sourav Pal.

References

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Three measures, three points and a circle

Bartosz Malman

Mälardalen University
bartosz.malman@mdu.se

Wednesday
11:00
CR 2G

Abstract. Given three points P_1, P_2, P_3 in the plane, what is the radius r of the smallest disk containing all three points? Jung's Theorem states that if $d := \max_{i,j} |P_i - P_j|$ is the maximal pairwise distance between the points, then a disk of radius $r \leq d/\sqrt{3}$ will do the job. For the three vertices of an equilateral triangle we have the equality $d = r/\sqrt{3}$.

This geometric problem comes up in the context of estimating the norm of the Neumann-Poincaré operator on a planar convex domain. The points are generated in a special way, for they are of the form $P_i = \int f d\mu_i$, f being a complex-valued function and μ_i being real-valued measures. It turns out that, in this setting, Jung's Theorem can be improved. This has some consequences related to estimation of spectral constants.

The talk is based on results from my joint work with Javad Mashreghi, Ryan O'Loughlin and Tom Ransford.

On the relation between S-spectrum and right spectrum

Helena Soares

Iscte - University Institute of Lisbon
helena.soares@iscte-iul.pt

Wednesday
11:30
CR 2G

Abstract. When X is a (right) quaternionic Banach space, the S-spectrum of a bounded right linear operator $T \in \mathcal{B}(X)$ is the set

$$\sigma_S(T) = \big\{\lambda \in \mathbb{H} : T^2 - 2Re(\lambda)T + |\lambda|^2 I \text{ is non invertible in } \mathcal{B}(X)\big\}.$$

In the quaternionic setting one cannot simply reproduce the usual notion of spectrum in the complex case. In fact, the operator of right multiplication by a quaternion, $I\lambda : X \to X$ defined by $I\lambda(x) = x\lambda$, is not right $\mathbb{H}$-linear. However, it is clearly $\mathbb{R}$-linear. We thus define a modified (right) spectrum to be the set

$$\sigma(T) = \big\{\lambda \in \mathbb{H} : I\lambda - T \text{ is non invertible in } \mathcal{B}_{\mathbb{R}}(X)\big\},$$

where $\mathcal{B}_{\mathbb{R}}(X)$ is the set of bounded $\mathbb{R}$-linear operators on X.

It is natural to ask how these two spectra relate. We prove that the two sets are equal.

This is joint work with Luís Carvalho, Cristina Diogo and Sérgio Mendes.

Non-elliptic faces of the joint numerical ranges for triples of order-4 Hermitian matrices

Piotr Pikul

Jagiellonian University in Kraków
piotr.pikul@uj.edu.pl

Wednesday
12:00
CR 2G

Abstract. Joint numerical ranges of hermitian matrices are of interest due to their relation to quantum states. The JNR of a triple of hermitian matrices of order 4 represents expected values of three observables applied to all possible two-qubit states.

$$W(A_1, A_2, A_3) = \left\{ \left(\operatorname{tr}(PA_j) \right)_{j=1}^{3} : P \in M_4,\ P \geq 0,\ \operatorname{tr}(P) = 1 \right\}.$$

The configuration of flat portions of the boundary (faces) was studied in case of triples of hermitian 3×3 matrices [1]. For triples of 4×4 matrices, the faces no longer have to be elliptic. The possible non-elliptic faces can be divided into 4 classes (cf. [2]), and 15 configurations of them can be identified. During the talk, this classification and other results describing boundary of the joint numerical ranges will be presented.

This is an ongoing project in collaboration with Konrad Szymański, Stephan Weis, Karol Życzkowski and Ilya Spitkovsky.

References

[1] K. Szymański, S. Weis, K. Życzkowski. Classification of joint numerical ranges of three hermitian matrices of size three, *Linear Alg. and Appl.* 545:148–173, 2018.

[2] D.S. Keeler, L. Rodman, and I.M. Spitkovsky. The numerical range of 3×3 matrices. *Linear Alg. and Appl.* 252:115–139, 1997.

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Critical points of the 4×4 unistochastic map

Hiroshi Nakazato

Hirosaki University (Emeritus), Japan
nakahr@hirosaki-u.ac.jp

Wednesday
12:30
CR 2G

Abstract. Let $U(4)$, B_4 be the unitary group and the Birkhoff polytope of order 4. Define the unistochastic map $\Phi_4 \colon U(4) \to B_4$ by $\Phi_4(U) := U \circ \bar{U}$, where $\circ$ denotes the Hadamard product and $\bar{U}$ is the conjugate of U. A matrix $\Phi_4(U)$ $(U \in U(4))$ is called unistochastic. We determine the critical points of the map Φ_4 and corresponding equation.

S11: Open problems in harmonic analysis

Organizers: Gianmarco Brocchi, Giuseppe Negro.

An overview of time-frequency and time-scale structured measurements in phase retrieval

Francesca Bartolucci

Delft University of Technology, The Netherlands
f.bartolucci@tudelft.nl

Wednesday
11:00
CR 2N

Abstract. We explore the problem of recovering a signal when only the magnitudes of a time-frequency or time-scale representation of the signal are known. From the perspective of inverse problems, answering the questions of uniqueness and stability is essential to theoretically guarantee meaningful reconstruction. In this talk, we present old and new results on these questions and conclude by discussing some open challenges.

The self-improving property of the oscillation of a function

Carlos Pérez

University of the Basque Country and BCAM
cperez@bcamath.org

Wednesday
11:30
CR 2N

Abstract. We will discuss in this lecture the self-improving property of generalized Poncaré-type inequalities. We will achieve this by avoiding classical subrepresentation formulas, an approach that offers greater flexibility and more precise estimates, particularly for measures. We'll illustrate these concepts through Gagliardo–Nirenberg type results and the derivation of sharp weighted fractional-type inequalities. Our most recent results is in a collaborations with I. Gardeazabal and E. Lorist.

Spider's webs and weak type inequalities for maximal functions on Gromov hyperbolic spaces

Nikolaos Chalmoukis

University of Milano-Bicocca
nikolaos.chalmoukis@unimib.it

Wednesday
12:00
CR 2N

Abstract. In this talk we will discuss weak type estimates for the Hardy-Littlewood maximal operator in the context of Gromov hyperbolic metric

measure spaces, which satisfy a locally doubling condition and the measures of balls grows exponentially for large radii. This result generalizes previous results on symmetric spaces of non compact type and rank 1, Damek-Ricci spaces, and Riemannian manifolds of pinched negative curvature. The results are obtained using a new descritization technique which approximates a Gromov hyperbolic metric space by a class of graphs which are called spider's webs. This is a joint work with S. Meda and F. Santagati.

Weak type estimates for Littlewood–Paley–Stein square functions

Maria Carmen Reguera

Universidad de Málaga

m.reguera@uma.es

Thursday
13:15
CR 2N

Abstract. We study weighted weak L^p estimates for a class of non-integral square functions such as the Littlewood–Paley–Stein square functions. We focus on the critical case $p = 2$, still open even in the classical integral case. The proof uses a decoupling of the Muckenhoupt and reverse Hölder contributions of the weight at hand and a new estimate of Gehring's lemma for such weight will be crucial. This is joint work with D. Mena and L. Roncal.

Uniform resolvent estimates and smoothing effects related to Heisenberg sublaplacians

Luz Roncal

Basque Center for Applied Mathematics, Ikerbasque, and University of the Basque Country

lroncal@bcamath.org

Thursday
13:45
CR 2N

Abstract. Uniform resolvent estimates play a fundamental role in the study of spectral and scattering theory for Schrödinger equations. In particular, they are closely connected to global-in-time dispersive estimates, such as Strichartz estimates.

In contrast with the Euclidean setting, a peculiar fact of the Schrödinger evolution equation associated to the sublaplacian on the Heisenberg group is that it fails to be dispersive, as shown by Bahouri, Gérard, and Xu. In fact, Strichartz or $L^p - L^q$ estimates cannot hold in general. In this talk we will discuss uniform resolvent estimates on the Heisenberg group and their application to obtain certain smoothing effects for Schrödinger equations.

Joint work with Luca Fanelli, Haruya Mizutani, and Nico Michele Schiavone.

Some variational and jump inequalities in a nonsymmetric Gaussian setting

Valentina Casarino
Università degli Studi di Padova
valentina.casarino@unipd.it

Thursday
14:15
CR 2N

Abstract. We shall present some recent results, obtained in collaboration with Paolo Ciatti and Peter Sjögren, concerning variational bounds for a nonsymmetric Ornstein–Uhlenbeck semigroup $(\mathcal{H}_t)_{t>0}$. In particular, the weak type $(1,1)$ of the variation operator of order ϱ of $(\mathcal{H}_t)_{t>0}$, with $\varrho > 2$, will be discussed.

If time permits, we shall discuss some open questions concerning jump inequalities (which would provide an endpoint refinement when $\varrho = 2$) in this setting.

References

[1] V. Casarino, P. Ciatti and P. Sjögren, On the variation operator for the Ornstein-Uhlenbeck semigroup in dimension one. *Ann. Mat. Pura Appl.*, 203:205–219, 2024. doi.org/10.1007/s10231-023-01358-3.

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Spectral estimates on the Heisenberg group

Paolo Ciatti
Università di Padova
paolo.ciatti@unipd.it

Thursday
14:45
CR 2N

Abstract. In this talk we shall discuss some estimates concerning the spectral projections of the sub-Laplacian on the Heisenberg group, reviewing their relations with the restriction problem for the Fourier transform on euclidean spaces. We shall, in particular, discuss a positive result concerning the three dimensional Heisenberg group and formulate a conjecture, providing some motivations for it.

This is a joint work done in collaboration with Valentina Casarino.

Cancellative sparse domination

José Manuel Conde Alonso
Universidad Autónoma de Madrid
jose.conde@uam.es

Thursday
16:00
CR 2N

Abstract. We present a sparse domination result that respects the cancellation present in the function. In particular, the $H^1 \to L^1$ boundedness of

Calderón-Zygmund operators follows easily. Our method of proof provides a path to sparse domination results in situations where the weak type $(1,1)$ endpoint is lacking. Based on joint work with Emiel Lorist (TU Delft) and Guillermo Rey (Universidad Autónoma de Madrid).

The Role of Shifted Operators in Creating Sharp Bounds for Multilinear Fourier Multipliers

Andrew Haar

Charles University
andrew.haar674@student.cuni.cz

Thursday
16:30
CR 2N

Abstract. Multilinear harmonic analysis has its roots partially in the study of the well-known Calderón commutators, which were first defined in the 1960s by A. Calderón while examining certain linear PDE. As singular integrals, these commutators are not of convolution type, which complicates the exploration of their properties. We will begin this talk with a brief historical overview of how these commutators came about and how a very natural perspective to take on them is as bilinear—rather than just linear—operators. We will do this with the purpose of witnessing how the need for so-called shifted square and maximal functions arises.

After this historical introduction, the talk will turn towards the modern situation, where researchers have been seeking to prove optimal boundedness results for multilinear Fourier multipliers via recently proven sharp estimates for these shifted maximal and square functions. The talk will, then, conclude with a discussion of the current limitations of these methods.

Dot products determined by fractal sets

Steven Senger

Missouri State University
stevensenger@missouristate.edu

Thursday
17:00
CR 2N

Abstract. Given an integer $d \geq 2$, the Falconer distance problem asks for a threshold s, such that any subset $E \subseteq \mathbb{R}^d$ with Hausdorff dimension bigger than s, the set of distances determined by pairs of points in E must have positive Lebesgue measure. Over the years, this problem has benefitted much from advances in Fourier analysis. However, the corresponding problem, when stated for dot products, has not moved past its initial nontrivial results. We identify one obstacle to progress, and offer potential strategies to overcome it.

S12: Operator learning and functional representation

Organizers: Francesca Bartolucci, Christoph Brune, José A. Iglesias, Marcello Carioni.

An analysis of constraint-relaxation in PDE-based inverse problems

Tristan van Leeuwen

Centrum Wiskunde & Informatica, Amsterdam, The Netherlands
Utrecht University, Utrecht, The Netherlands
t.van.leeuwen@cwi.nl

Thursday
13:15
CR 2K

Abstract. Many inverse problems are naturally formulated as a PDE-constrained optimization problem. These non-linear, large-scale, constrained optimization problems know many challenges, of which the inherent non-linearity of the problem is an important one. In this talk, we focus on a relaxed formulation of the PDE-constrained optimization problem and provide analysis for its properties including convexity under certain assumptions [1]. Starting from an infinite-dimensional formulation of the inverse problem with discrete data, we propose a general framework for the analysis and discretisation of such problems. The relaxed formulation of the PDE-constrained optimization problem is shown to reduce to a weighted non-linear least-squares problem. The weight matrix turns out to be the Gram matrix of solutions of the PDE, and in some cases be estimated directly from the measurements. The latter observation points to a potential way to unify recently proposed data-driven reduced-order models for inverse problems with PDE-constrained optimization. We provide a number of representative case studies and numerical examples to illustrate our findings.

References

[1] van Leeuwen, Tristan, and Yunan Yang. An analysis of constraint-relaxation in PDE-based inverse problems. Inverse Problems 41 025009 (2025).

Learning nonexpansive operators for Plug-and-Play methods

Emanuele Naldi

University of Genoa
emanuele.naldi@edu.unige.it

Thursday
13:45
CR 2K

Abstract. Plug-and-Play (PnP) methods have become increasingly popular in inverse problems due to their strong empirical performance. The central

idea is to replace the proximal operator in iterative optimization algorithms with a denoising function, which may be either handcrafted or learned from data. A fundamental challenge with PnP methods is that, despite promising results and some early theoretical work [1, 2], it is generally difficult to rigorously guarantee their convergence. To retain the classical convergence guarantees of these algorithms, the learning problem can be framed as that of learning a (firmly) nonexpansive operator.

In this talk, we present a statistical learning framework for constructing nonexpansive and firmly nonexpansive operators from data. We first cast the learning task as minimizing expected risk over the set of nonexpansive maps and then we endow the space of operators with a suitable weak* topology, which provides the right compactness and continuity properties to prove Gamma-convergence of the empirical risk minimization problem to its expected risk counterpart.

To implement the approach in practice, we introduce a finite-dimensional approximation based on simplicial partitions, leading to a class of piecewise affine, nonexpansive operators. These operators can be trained by minimizing empirical risk, and we show that as the partition is refined, the learned operator converges to the best nonexpansive solution of the empirical risk minimization problem. Finally, we integrate the learned operator into a Plug-and-Play version of the Chambolle–Pock primal-dual method. Our image denoising experiments illustrate both the interpretability and practical performance of the approach, with results that are comparable to, or better than, those obtained using standard denoising techniques.

References

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[2] J.-C. Pesquet, A. Repetti, M. Terris, and Y. Wiaux. Learning maximally monotone operators for image recovery. *SIAM Journal on Imaging Sciences*, 14(3):1206–1237, 2021. doi:10.1137/20M1387961.

Domain Decomposition for Physics-Informed Learning: Neural Networks and Operators

Alexander Heinlein

Delft University of Technology
a.heinlein@tudelft.nl

Thursday
14:15
CR 2K

Abstract. Physics-informed learning aims to incorporate physical knowledge into neural network models to enable them to solve differential equations. This talk presents recent advances in domain decomposition (DD) techniques

for physics-informed neural networks (PINNs) [5] and physics-informed neural operators [2]. While the PINN approach offers a flexible, mesh-free framework for solving high-dimensional and nonlinear problems, it suffers from ill-conditioning, limited robustness during training, and scalability challenges. We demonstrate how overlapping DD methods can be leveraged to construct scalable architectures that improve convergence and training robustness [4, 1, 3]. In addition to applications to standard PINNs, we extend DD techniques to neural operators. These DD-based neural operators enable efficient and accurate approximation of solution operators for parameterized PDEs. Numerical experiments on multiscale and wave propagation problems illustrate the scalability and performance benefits of domain decomposition in physics-informed learning.

References

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Generative Fourier Neural Operators: A Pseudo-Differential Framework for Learning in Infinite Dimensions

Anupam Gumber

University of Vienna

anupam.gumber@univie.ac.at

Thursday
14:45
CR 2K

Abstract. In scientific machine learning, neural operators have recently emerged as a new frontier, enabling the data-driven approximation of nonlinear solution operators associated with partial differential equations (PDEs).

Unlike traditional deep learning models that operate on finite-dimensional data, neural operators are specifically designed to handle data in the form of functions - such as fields, signals, or PDE solutions - that naturally reside in infinite-dimensional spaces. These function-valued data are common across the natural sciences and engineering, including temperature distributions in climate modeling, stress patterns in materials science, and velocity fields in fluid dynamics. One notable example is the Fourier Neural Operator [1], which has demonstrated excellent performance by leveraging the fast Fourier transform to approximate infinite-dimensional operators using a finite number of parameters. However, standard generative models like GANs and VAEs often struggle to capture the continuity and underlying physics of such infinite-dimensional data.

In this talk, we introduce Generative Fourier Neural Operators (GFNOs) - a new class of generative models designed to learn and output functions in infinite-dimensional spaces. Building on the Fourier Neural Operator framework, GFNOs extend this approach by incorporating a novel pseudo-differential integral operator architecture that enhances generalization and reduces overfitting. We will outline the construction of GFNOs, delve into their mathematical architecture inspired by pseudo-differntial operators, and present a discretization error analysis that offers theoretical insights into their approximation capabilities.

References

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Ultra-fast feature learning for the training of two-layer neural networks in the two-timescale regime

Raphaël Barboni

École Normale Supérieure - PSL
raphael.barboni@ens.fr

Thursday
16:00
CR 2K

Abstract. We study the convergence of gradient methods for the training of mean-field two-layer neural networks with square loss. For this high-dimensional and non-convex optimization problem, most known convergence results are either qualitative or rely on a neural tangent kernel analysis where non-linear representations of the data are fixed. We consider here a Variable Projection (VarPro) algorithm [1] which corresponds to the two-timescale limit of gradient descent [2, 3]. Using that the learning problem belongs to the class of separable non-linear least-square problems, this algorithm eliminates the linear variables and reduces the problem to the training of non-linear features. In a teacher-student scenario, we show such a strategy enables

provable convergence rates for the sampling of a teacher feature distribution. Precisely, in the limit where the regularization strength vanishes, we show that the dynamic of the feature distribution corresponds to a weighted ultra-fast diffusion equation. Relying on recent results on the asymptotic behavior of such PDEs [4], we are able to give guarantees for the convergence of the learned feature distribution towards the teacher distribution at a linear rate

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[3] Raphaël Berthier, Andrea Montanari, and Kangjie Zhou. Learning time-scales in two-layers neural networks. *Foundations of Computational Mathematics*, pages 1–84, 2024. Springer.

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Reproducing kernels for classical Banach and neural network spaces

Tjeerd Jan Heeringa

University of Twente
t.j.heeringa@utwente.nl

Thursday
16:30
CR 2K

Abstract. Reproducing kernel Hilbert spaces (RKHS) play a prominent role in many fields due to their kernel representation. However, many applications involve non-Hilbertian geometry. To address this shortcoming, RKHSs have been generalized to Reproducing Kernel Banach Spaces (RKBS). The kernel representation in RKHS arises because the function evaluations in these spaces are bounded. The Riesz-Fréchet representation theorem tells us that these function evaluations can be represented by an inner product with a kernel function. In RKBS, the function evaluations are still bounded, but Riesz-Fréchet no longer applies. By choosing appropriate pairs of RKBSs, kernel representations can be recovered. If the RKBS is reflexive, there is only one pair (up to isometric isomorphism). If not, then there are at least 2 and up to infinitely many pairs (up to isometric isomorphism). Some pairs have trivial kernels (and thus for practice useless kernels), whereas other have meaningful kernels. Whilst there is no universal approach known for finding a meaningful kernel, many well-known Banach spaces do have one

- including the Bessel Spaces, Paley-Wiener/Bernstein space and Barron spaces.

In this talk, I will discuss the structural differences between RKBS and RKHS. In particular, I will discuss the duality through the RKBS pairs and the resulting kernel representations. This talk concludes with several open problems.

Large-time dynamics in transformer architectures with layer normalisation

Yury Korolev

University of Bath
ymk30@bath.ac.uk

Thursday
17:00
CR 2K

Abstract. Transformers have become the backbone of many modern AI systems. A series of recent works have demonstrated that they can be understood mathematically as transformations of measures. We focus on a special case when the propagation of a measure through the transformer follows a gradient flow in the space of probability measures on the unit sphere under a variant of the Wasserstein metric with a non-local mobility term. This allows us to investigate the emergence of either clusters or absolutely continuous measures in the large-time limit and to characterise them as stationary points of an interaction energy. We further investigate how the stationary points depend on the parameters of the transformer, in particular on the eigenvalues and eigenvectors of the product of the key and query matrices. The rigorous framework for studying the gradient flow that we provide also suggests a possible metric geometry for studying the general case (i.e. one that is not described by a gradient flow).

This is joint work with Martin Burger, Samira Kabri, Tim Roith, and Lukas Weigand (DESY Hamburg).

Transformers and Frank-Wolfe

Domènec Ruiz-Balet

Université Paris Dauphine
domenec.ruiz-i-balet@dauphine.psl.eu

Thursday
17:30
CR 2K

Abstract. Transformers are one of the key architectures in Large Language models. The main difference with classical neural networks is that they parameterize measure-to-measure maps instead of point-to-point maps. The architecture itself can be seen as an interactive particle system. In this talk I will present a connection between transformers and the well known Frank-Wolfe algorithm and I will discuss some of the consequences of this connection.

S13: Operator semigroups and related operators

Organizers: Karsten Kruse, José Bonet.

Composition semigroups and characterizations of VMOA

Nikolaos Chalmoukis

Universitá di Milano Bicocca
nikolaos.chalmoukis@unimib.it

Tuesday
13:15
CR 3C

Abstract. It is a classical observation of Sarason that an analytic function of bounded mean oscillation $BMOA$ is of vanishing mean oscillation if and only if its rotations converge in norm to the original function as the angle of the rotation tends to zero. In a series of two papers [1, 2], Blasco et al. have raised the problem of characterizing all semigroups of holomorphic functions $(\varphi_t)_{t\geq 0}$ that can replace the semigroup of rotations in Sarason's theorem. In this talk we will give a complete answer to this question, in terms of a logarithmic vanishing oscillation condition on the infinitesimal generator of the semigroup $(\varphi_t)_{t\geq 0}$. In addition, we confirm the conjecture of Blasco et al. that all such semigroups are elliptic. We also investigate the analogous question for the Bloch and the little Bloch spaces, and surprisingly enough, we find that the semigroups for which the Bloch version of Sarason's theorem holds are exactly the same as in the BMOA case. This is a joint work with Vassilis Daskalogiannis [3].

References

[1] O. Blasco, M.D. Contreras, S. Díaz-Madrigal, J. Martínez, M. Papadimitrakis, and A.G. Siskakis. Semigroups of composition operators and integral operators in spaces of analytic functions. *Ann. Acad. Sci. Fenn. Math.*, 38(1):67–89, 2013. doi:10.5186/aasfm.2013.3806.

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A Berkson–Porta type theorem on Banach spaces of Dirichlet series

Carlos Gómez-Cabello

Universidad del Paìs Vasco
carlos.gomezca@ehu.eus

Tuesday
13:45
CR 3C

Abstract. The theory of strongly continuous semigroups of bounded operators on Banach spaces has proven fruitful in many areas in Analysis. A classical result related to this topic is Berkson and Porta's Theorem. This result establishes a one-to-one correspondence between continuous semigroups of analytic functions in the unit disc and strongly continuous semigroups of composition operators on the H^p spaces of the unit disc. In this talk we shall discuss about a similar correspondence in the less known setting of Banach spaces of Dirichlet series such as the $\mathcal{H}^p$ spaces, the space $\mathcal{H}^\infty$, or the algebra of Dirichlet series $\mathcal{A}(\mathbb{C}_+)$. Since the boundedness of composition operators in these spaces is, in general, a delicate topic, we shall also present some results related to the existence of continuous semigroups of symbols in terms of its infinitesimal generator.

Most of the results in this talk are extracted from the works [1] and [2]; both in collaboration with Professor Manuel D. Contreras and Professor Luis Rodríguez-Piazza.

References

[1] M.D. Contreras, C. Gómez-Cabello, and L. Rodríguez-Piazza. Semigroups of composition operators on Hardy spaces of Dirichlet series. *J. Func. Anal.*, 285(9): 36 pages, 2023. doi:10.1016/j.jfa.2023.110089.

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Cesàro–Hardy operators on $L^p[0,1]$: Fine spectrum, weighted Koopman semigroups and invariant subspaces

Luciano Abadias

University of Zaragoza
labadias@unizar.es

Tuesday
14:15
CR 3C

Abstract. In this talk we study boundedness and detailed spectral properties for the Cesàro–Hardy operator and some generalizations in $L^p[0,1]$. The study employs C_0-semigroup theory, expressing the Cesàro–Hardy operators and their dual operators through subordination with C_0-semigroups $T(t)$ and

$S(t)$, respectively. The spectral properties of the semigroup's infinitesimal generators are transferred to the Cesàro–Hardy operators using functional calculus methods. Additionally, some implications for the Invariant Subspace Problem are explored by demonstrating the universality of certain translations related to the semigroup $T(t)$, and providing results on the invariant subspaces of these operators. This is a joint work with A. Mahillo and P.J. Miana.

Weighted composition operators on the Schwartz class

Vicente Asensio

Universitat Politècnica de València

viaslo@mat.upv.es

Tuesday
14:45
CR 3C

Abstract. In this talk, we study the weighted composition operators $C_{\psi,\varphi}$ with weight $\psi : \mathbb{R}^d \to \mathbb{C}$ and symbol $\varphi : \mathbb{R}^d \to \mathbb{R}^d$ which act on the Schwartz class $\mathcal{S}(\mathbb{R}^d)$. We also characterize the power boundedness and related properties of these operators, and we discuss it when the symbol is a polynomial. Moreover, we provide an example of power bounded weighted composition operator $C_{\psi,\varphi}$ for which neither the corresponding multiplication operator M_ψ nor the composition operator C_φ is well defined.

This is based on a collaboration [2] with Enrique Jordá (Universitat Politècnica de València) and Thomas Kalmes (Chemnitz University of Technology).

References

[1] A.A. Albanese and C. Mele. Spectra and ergodic properties of multiplication and convolution operators on the space $\mathcal{S}(\mathbb{R})$. *Rev. Mat. Complut.*, 35(3):739–762, 2022. doi:10.1007/s13163-021-00403-0.

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Ergodic multipliers on some Banach algebras

Enrique Jordá

Universitat Politècnica de València

ejorda@mat.upv.es

Tuesday
16:00
CR 3C

Abstract. Let G be a locally compact group, let μ be a Radon probability measure on G and let ϕ be a positive definite function on G with $\phi(e) =$

1. We study uniform ergodicity and quasicompactness of the operators $\lambda_1(\mu)\colon L_1(G) \to L_1(G)$, $f \mapsto \mu * f$ and $M_\phi\colon A(G) \to A(G)$, $f \mapsto \phi f$. When G is abelian both operators can be identified via Fourier transform. Uniform ergodicity and quasicompactness of these operators is equivalent to that of the restriction of the operators to the invariant subspaces $L_1^0(G) = \{f \in L_1(G) : \int f dm_G = 0\}$ and $A^0(G) = \{u \in A(G) : u(e) = 0\}$, linking then our work to classic research on ergodic walks. We report on recent work with J. Galindo and A. Rodríguez-Arenas.

References

[1] J. Galindo, E. Jordá, and A. Rodríguez-Arenas. Uniformly ergodic probability measures. *Publ. Mat.*, 68(2):593–613, 2024. doi:10.5565/PUBLMAT6822410.

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Operator ergodic properties through matrices

Pablo Sevilla

Universitat Politècnica de València
psevilla@mat.upv.es

Tuesday
16:30
CR 3C

Abstract. We propose an approach to some classical notions, such as *power boundedness, Cesàro boundedness* and *mean ergodicity* through matrices. Given a lower-triangular matrix A, we define A-bounded and A-ergodic operators. Choosing convenient matrices, we recover the aforementioned classical definitions. For a pair of matrices A and B, we will give conditions that relate A and B-boundedness and A and B-ergodicity. We will use this to show new properties of Cesàro bounded and mean ergodic operators.

This contribution is co-authored by Daniel Santacreu.

Invariant measures for Fréchet-space operators

Antoni López-Martínez

Universitat Politècnica de València
alopezmartinez@mat.upv.es

Tuesday
17:00
CR 3C

Abstract. The existence of invariant measures for a given dynamical system is an important topic in Ergodic Theory. In this talk we will survey the recent results obtained in [1] and [2] on the existence of invariant measures when the underlying dynamical system is a continuous linear operator $T\colon X \longrightarrow X$ acting on a Fréchet space X. The main results that we will expose involve the new notion of "locally bounded orbit", which will be properly introduced but also used to leave some open problems at the end of the talk.

References

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Construction of the log-convex minorant of a multi-sequence

David Jornet

Universitat Politècnica de València
djornet@mat.upv.es

Tuesday
17:30
CR 3C

Abstract. For a sequence $\{M_p\}_{p\in\mathbb{N}_0}$ of real positive numbers, its *associated function* is defined by

$$\omega_M(t) \coloneqq \sup_{p\in\mathbb{N}_0} \log \frac{t^p}{M_p}, \qquad t > 0.$$

Mandelbrojt proved in [3, Chap. I] (see also [2]) that if $\lim_{p\to+\infty} M_p^{1/p} = +\infty$ then

$$M_p = \sup_{t>0} \frac{t^p}{\exp \omega_M(t)}, \qquad p \in \mathbb{N}_0, \tag{1}$$

if and only if $\{M_p\}_{p\in\mathbb{N}_0}$ is logarithmically convex, i.e.

$$M_p^2 \leq M_{p-1}M_{p+1}, \qquad p \in \mathbb{N}.$$

However, this condition has never been generalized to the multi-dimensional case, and the reason is that the classical coordinate-wise logarithmic convexity condition for a sequence $\{M_\alpha\}_{\alpha\in\mathbb{N}_0^d}$, $d > 1$, is not sufficient to obtain the analogon of (1) for M_α. We impose a stronger condition on the multi-sequence to obtain the analogon of (1) to the multi-dimensional case. To this aim we construct the optimal log-convex minorant of the multi-sequence $\{M_\alpha\}_{\alpha\in\mathbb{N}_0^d}$. As a consequence, we compare different classes of ultradifferentiable functions defined by (even anisotropic) multi-sequences. In fact, we characterise when the *inclusion operator* between different spaces of ultradifferentiable functions defined by multi-sequences is well defined and continuous.

This contribution [1] is co-authored by Chiara Boiti, Alessandro Oliaro, and Gerhard Schindl.

References

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The harmonic oscillator on the Moyal–Groenewold plane

Christoph Kriegler

University Clermont Auvergne

christoph.kriegler@uca.fr

Thursday
13:15
CR 3C

Abstract. Let $A = -\Delta + |x|^2$ be the harmonic oscillator which generates a submarkovian semigroup on $L^p(\mathbb{R}^d)$. It is well-known that its spectral multipliers $m(A)$ are bounded on L^p, $1 < p < \infty$, provided that $m : (0,\infty) \to \mathbb{C}$ is $\lfloor \frac{d}{2} \rfloor + 1$ times differentiable with a certain L^2 type control on its derivatives (Hörmander functional calculus).

On the other hand, A can be written as a square sum

$$A = \sum_{k=1}^{d} (i\partial_k)^2 + \sum_{l=1}^{d} x_l^2$$

where the operators $iA_k = -\partial_k$ and $iB_l = ix_l$ generate bounded (translation and modulation) C_0-groups on L^p, that obey simple, so-called canonical, commutation relations (CCR).

Recently, van Neerven, Portal and Sharma showed in a series of papers via a transference technique and square function estimates, that square sum operators (as A above) for quite general bounded C_0-groups with CCR inherit the Hörmander functional calculus from A.

We show that this also holds for C_0-groups acting on noncommutative L^p-spaces. Along the way of proof, an important step is a new method to generate square function estimates on noncommutative L^p.

An application are L^p bounded Hörmander spectral multipliers of the harmonic oscillator on the Moyal plane (also called quantum euclidean space), which are particular noncommutative pseudo-differential operators studied by González-Pérez, Junge and Parcet.

This is joint work with Cédric Arhancet (Albi, France), Lukas Hagedorn (Kiel, Germany), and Pierre Portal (Canberra, Australia) [1].

References

[1] C. Arhancet, L. Hagedorn, C. Kriegler, and P. Portal. The harmonic oscillator on the Moyal-Groenewold plane: an approach via Lie groups and twisted Weyl tuples, 2025. arXiv:2312.06143.

Functional calculus for the Laplacian on weighted Sobolev spaces

Floris Roodenburg

Delft University of Technology
f.b.roodenburg@tudelft.nl

Thursday
13:45
CR 3C

Abstract. We consider the Laplace operator with Dirichlet and Neumann boundary conditions on the half-space and on bounded $C^{1,\lambda}$-domains with $\lambda \in [0,1]$. We study these operators on Sobolev spaces with power weights measuring the distance to the boundary. These weights play an important role in the study of (stochastic) partial differential equations on domains. It is found that the Laplace operators admit a bounded H^∞-calculus on weighted Sobolev spaces where the weight depends on the regularity of the domain. As a consequence, we derive new maximal regularity results for the heat equation on weighted Sobolev spaces. In case of the half-space we additionally study the heat semigroups and we show that these semigroups, in contrast to the L^p-case, have polynomial growth. This is joint work with Nick Lindemulder, Emiel Lorist, and Mark Veraar [1].

References

[1] N. Lindemulder, E. Lorist, F. Roodenburg, and M. Veraar. Functional calculus on weighted Sobolev spaces for the Laplacian on the half-space. *J. Funct. Anal.*, 289(8): 69 pages, 2025. doi:10.1016/j.jfa.2025.110985.

Maximal regularity estimates for abstract Cauchy problems

Jarosław Sarnowski

Nicolaus Copernicus University in Toruń
jsarnowski@doktorant.umk.pl

Thursday
14:15
CR 3C

Abstract. In this talk, we will study L^1-maximal regularity estimates for sectorial operators acting on interpolation spaces, extending the Da Prato–Grisvard result in several directions. We will also characterize weighted L^1-maximal regularity and establish relations with the unweighted one. Several results concerning global-in-time estimates for non-invertible generators will be presented.

References

[1] S. Król, M. Mastyło, and J. Sarnowski. Maximal regularity estimates for the abstract Cauchy problems, 2025. arXiv:2502.16521.

Approximation of semilinear hyperbolic stochastic evolution equations

Katharina Klioba

Delft University of Technology
k.klioba-1@tudelft.nl

Thursday
14:45
CR 3C

Abstract. When approximating the mild solution of a semilinear stochastic evolution equation, several challenges arise due to the lack of temporal regularity caused by Gaussian noise. In this talk, optimal convergence rates in time are presented for such problems, where the leading operator A is the generator of a C_0-contraction semigroup $(S(t))_{t\geq 0}$ on a Hilbert space X, focusing on non-parabolic problems. The main result are optimal bounds for the *uniform strong error*

$$\mathrm{E}_k^\infty := \Big(\mathbb{E} \sup_{j\in\{0,\dots,N_k\}} \|U(t_j) - U^j\|^p\Big)^{1/p},$$

where $p \in [2,\infty)$, U is the mild solution, U^j is the temporal discretisation, $k \in (0,T]$ is the step size, and $N_k = T/k$. Under conditions on the nonlinearity and the multiplicative noise, we show

$$\mathrm{E}_k^\infty \lesssim \sqrt{k}\sqrt{\log(T/k)}$$

for a large class of time discretisation schemes. Improved rates up to 1 are achieved for wave equations and additive noise. For equations such as Maxwell's or Schrödinger, our results improve several existing results with a unified method using semigroup theory rather than C_0-groups and provide the first results known for rational approximations of $(S(t))_{t\geq 0}$.

We give an outlook on possible extensions of the framework to superlinearly growing nonlinearities and noise, concerning both local and global well-posedness as well as convergence rates.

This is joint work with Mark Veraar (Delft University of Technology) based on [1] and ongoing work.

References

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An abstract periodic boundary condition

Sascha Trostorff

CAU Kiel
trostorff@math.uni-kiel.de

Thursday
16:00
CR 3C

Abstract. Given two densely defined closed operators A and B between two Hilbert spaces such that $A \subseteq -B^*$, we introduce a certain extension

$A^{\#} \subseteq -B^*$ of A, which in case of differential operators can be interpreted as imposing an abstract periodic boundary condition. We inspect some properties of $A^{\#}$, like computing the adjoint or compact embedding of its domain. These operators naturally occur when dealing with so-called Beltrami fields in the theory of Electro-Magnetics.

The talk is based on a joint work with Rainer Picard (TU Dresden, Germany).

References

[1] R. Picard and S. Trostorff. A Note on Some Non-Local Boundary Conditions and their Use in Connection with Beltrami Fields. In F.L. Schwenninger and M. Waurick, editors, *Systems Theory and PDEs. WOSTAP 2022*, Trends Math., pp. 25–41, Birkhäuser, Cham, 2024. doi:10.1007/978-3-031-64991-2_2.

Nonlocal homogenization limits of local coefficients

Andreas Buchinger

Hamburg University of Technology
andreas.buchinger@tuhh.de

Thursday
16:30
CR 3C

Abstract. In this talk, we will revisit classical elliptic homogenization theory for local coefficients, i.e., L_∞-multiplication operators (H-convergence by Murat and Tartar) and compare it with a modern abstract operator-theory approach that readily allows for nonlocal coefficients, i.e., general bounded operators, and the treatment of a vast class of (time-dependent) problems (Schur-topology by Waurick). We will show that both concepts coincide for local coefficients, and we will discuss the term "local" in this setting.

This is partially joint work with Marcus Waurick.

Polynomial stability of wind turbine tower models

Mohamed Fkirine

Tampere University
Mohamed.fkirine@tuni.fi

Thursday
17:00
CR 3C

Abstract. In this talk, we study the stabilization of selected mathematical models describing the structural dynamics of monopile wind turbine towers, modeled using the NASA Spacecraft Control Laboratory Experiment (SCOLE) system. Our main results establish *polynomial stability* and provide an explicit decay rate for the energy of classical solutions to these models. This analysis can be used as a basis for control design aimed at reducing vibrations in the wind turbine towers.

This is joint work with Lassi Paunonen.

References

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On bi-continuous cosine families

Christian Budde

University of the Free State

BuddeCJ@ufs.ac.za

Thursday
17:30
CR 3C

Abstract. We introduce and investigate bi-continuous cosine families. Those are inspired by the theory of bi-continuous semigroups [2, 3] which had an impact in the area of evolution equations in the last decades as well as the work of Sova [4]. The idea here is again that we equip the underlying Banach space with an additional locally convex topology. We will analyze both the general behavior as well as generators and resolvents of bi-continuous cosine families. We will also give an outlook on forthcoming projects. This talk is based on [1].

References

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Similarity to contractive C_0-semigroups

Jesús Oliva-Maza

University of Zaragoza

joliva@unizar.es

Friday
10:45
CR 3C

Abstract. Let $(T(t))_{t\geq 0}$ be a semigroup of bounded operators on a Hilbert space H. We say that this semigroup is *similar* to a contraction semigroup

if there exists an equivalent Hilbert space norm $\|\cdot\|_{\mathrm{eq}}$ on H such that $\|T(t)\|_{\mathrm{op}} \leq 1$ for all $t \geq 0$, where $\|\cdot\|_{\mathrm{op}}$ is the operator norm on $L(H)$ induced by $\|\cdot\|_{\mathrm{eq}}$. In this talk, we discuss our recent joint work with Y. Tomilov, which uncovers new structural insights into such semigroups. Specifically, we establish that a semigroup $\mathcal{T} = (T(t))_{t\geq 0}$ is similar to a contraction semigroup if and only if it is similar to a quasi-contraction C_0-semigroup and there exists some $t > 0$ such that $T(t)$ is similar to a contraction. Moreover, our approach provides explicit estimates for the similarity constants, offering a deeper understanding of their significance in the similarity framework. This perspective leads to significant applications in control theory, including characterizations of systems that are exactly controllable or exactly observable in terms of their similarity to (quasi-) contraction semigroups.

Finally, we prove the existence of new counterexamples within the theory, such as a (quasi-)nilpotent semigroup that is not similar to a contraction semigroup.

Regularity preserving perturbations of operator semigroups

Sahiba Arora
Leibniz University Hannover
sahiba.arora@math.uni-hannover.de

Friday
11:15
CR 3C

Abstract. In this talk, we investigate the robustness of ultracontractivity of semigroups under relatively bounded perturbations. Specifically, we consider a C_0-semigroup $(T(t))_{t\geq 0}$ on a Banach space X with a smoothing property:

$$T(t)X \subseteq V \quad \text{and} \quad \|T(t)\|_{X\to V} \leq Ct^{-\alpha}, \qquad t \in (0,1];$$

where $\alpha, C > 0$ are constants and V is a subspace of X. Ultracontractivity is a key feature of semigroups arising from diffusion equations and has found recent applications in the theory of *eventually positive semigroups*. Our focus is to identify a class of (unbounded) perturbations B of the generator A such that the semigroup generated by $A + B$ retains the smoothing property.

This is joint work with Jonathan Mui (Wuppertal) [1].

References

[1] S. Arora and J. Mui. Smoothing of operator semigroups under relatively bounded perturbations, 2025. arXiv:2501.18556.

Exploring p-admissibility by means of concrete example systems

Philip Preußler

University of Twente
p.n.preusler@utwente.nl

Friday
11:45
CR 3C

Abstract. The property of p-admissibility—and crucially, the optimal range of such p—can be difficult to verify for many infinite-dimensional control systems. In particular, these difficulties can be seen by considering systems arising from partial differential equations with boundary control. Our aim is to give an overview of the problem of checking p-admissibility in the context of selected specific example systems which display different types of behavior with respect to p-admissibility.

This contribution is a collaboration with Felix L. Schwenninger.

On controllability and observability of the heat equation on discrete graphs

Christian Seifert

Hamburg University of Technology
christian.seifert@tuhh.de

Friday
12:15
CR 3C

Abstract. In this talk, we will first review the notions of α-controllability (for $\alpha \geq 0$) and weak observability estimates for evolution equations in abstract Banach and Hilbert spaces and explain the inherent duality of the two notions. Moreover, we provide sufficient conditions for weak observability and thus, in turn, for α-controllability. The main aim is to apply these conditions to heat equations on discrete graphs and explain differences between the discrete and the continuum setting.

This contribution is co-authored by Florentin Münch (Leipzig), Peter Stollmann (Chemnitz), and Martin Tautenhahn (Leipzig).

S14: Operator theory and hypercomplex analysis

Organizers: Antonino de Martino, Milton Ferreira, Dmitrii Legatiuk.

S-resolvent estimates for the Dirac operator on hyperbolic and spherical spaces

Irene Sabadini

Politecnico di Milano
irene.sabadini@polimi.it

Tuesday
13:15
CR 3A

Abstract. This talk explains the beginning of our investigation into on the spectral theory based on S-spectrum applied to the Dirac operator on manifolds. Specifically, we examine in detail the cases of the Dirac operator $\mathcal{D}_H$ on hyperbolic space and the Dirac operator $\mathcal{D}_S$ on the spherical space, where these operators, and their squares $\mathcal{D}_H^2$ and $\mathcal{D}_S^2$, can be written in a very explicit form. This fact is very important for the application of the spectral theory on the S-spectrum. In fact, let T denote a (right) linear Clifford operator, the S-spectrum is associated with a second-order polynomial in the operator T, specifically the operator defined as $Q_s(T) := T^2 - 2s_0T + |s|^2$. This allows us to associate to the Dirac operator boundary conditions that can be of Dirichlet type but also of Robin-like type. Moreover, our theory is not limited to Hilbert modules; it is applicable to Banach modules as well.

Joint work with I. Beschastnyi, F. Colombo, S. Lucas

Q^2-Clifford Algebras

Swanhild Bernstein

TU Bergakademie Freiberg
swanhild.bernstein@math.tu-freiberg.de

Tuesday
13:45
CR 3A

Abstract. A real Clifford algebra is typically generated by n elements that satisfy the relation $e_ie_j + e_je_i = -2\delta_{i,j}$. In the case of $2n$ real generating elements, it is possible to construct a so-called Witt basis, which fulfills a Grassmann relation, the duality relation, and isotropy conditions. This basis can be identified with fermionic raising and lowering operators that adhere to the canonical anticommutation relations [1].

In [2], the twisted canonical anticommutation relations are described within a formalism for second quantization based on the pseudogroup $SU_q(n)$ where $0 < q < 1$.

We utilize the fermionic raising and lowering operators derived from this framework to define the Q^2-Clifford algebras and examine some properties related to the q-deformed Dirac operator in the context of q-commuting variables.

References

[1] P. Woit. Quantum Theory, Groups and Representations. *Springer*, 2017. doi:10.1007/978-3-319-64612-1.

[2] W. Pusz. Twisted Canonical Anticommutation Relations. *Reports on Mathematical Physics*, 27(3):349–360, 1989. doi:10.1016/0034-4877(89)90017-7.

Clifford splines and bandpass spaces

Jeffrey Hogan

University of Newcastle, Australia
jeff.hogan@newcastle.edu.au

Tuesday
14:15
CR 3A

Abstract. We review recent constructions of Clifford generalisations of the classical B-splines on the real line. These depend on Clifford translation and modulation operators (τ_t and M_t, $t \in \mathbb{R}$), the properties of which we will explore. Defined on $\mathbb{R}^n$, the Clifford B-splines take values in the Clifford algebra $\mathbb{C}_n$ and enjoy many of the properties of the one-dimensional B-splines, including compact support, an elegant representation in Fourier space and self-similarity. We show that under Clifford translation the Clifford B-splines fail to act as Riesz bases for their span and we give necessary and sufficient conditions for a function ϕ to generate an orthonormal system $\{\tau_n \phi\}_{n=-\infty}^{\infty}$ in a certain Clifford-Sobolev space. This work extends that found in [2].
We also consider the application of Clifford translations and modulations to the construction of natural bases for the space of Clifford-valued *bandpass* functions on $\mathbb{R}^n$ whose Fourier transforms are supported on an annulus centred at the origin. These constructions involve Clifford translations of Clifford-Legendre polynomials and explicit formulae for these functions are given [1].
This is joint work with Peter Massopust (Munich) and Joseph Lakey (Las Cruces).

References

[1] J.A. Hogan and J.D. Lakey. Pseudo Clifford bandpass prolates *Proceedings of SampTA2023* doi:10.1007/s11785-019-00943-w

[2] J.A. Hogan and P. Massopust. Quaternionic fundamental cardinal splines: interpolation and sampling *Complex Analysis and Operator Theory*, 13:1173-3403 (2019). https://ieeexplore.ieee.org/document/10301199

On a Proportional Fractional Holomorphic Functions of Two Complex Variables

Baruch Schneider

University of Ostrava
baruch.schneider@osu.cz

Tuesday
14:45
CR 3A

Abstract. The aim of this talk is to present a novel work related to a notion of proportional fractional holomorphic function on two complex variables with respect to another function as a structural extension of the classical theory of holomorphic functions on two complex variables.

The talk is based on a joint work with J. O. González-Cervantes and J. Bory-Reyes.

Reproducing Kernel Hilbert Spaces Involving Touchard Polynomials and Hypergeometric Functions

Kamal Diki

Ghent University
kamal.diki@ugent.be

Tuesday
16:00
CR 3A

Abstract. In this talk, I will introduce two reproducing kernel Hilbert spaces (RKHSs) that arise from analyzing the images of the Schwartz space $\mathcal{S}$ and its dual $\mathcal{S}'$(the space of tempered distributions) under the Segal-Bargmann transform. The reproducing kernels of these spaces are expressed in terms of Touchard polynomials and hypergeometric functions. This talk is based on recent joint work with Daniel Alpay and Antonino De Martino.

Sufficient Conditions for Reproducing Bergman Kernels in Octonion Analysis

Milton Ferreira

School of Technology and Management, Polytechnic of Leiria
Morro do Lena - Alto do Vieiro, 2411-901, Leiria, Portugal.
milton.ferreira@ipleiria.pt

Tuesday
16:30
CR 3A

Abstract. Given the harmonic Green's function of a domain, the hypercomplex reproducing Bergman kernel for the class of monogenic functions can be obtained by applying the appropriate differential Cauchy–Riemann (or Dirac) operators from both the left and right to the Green's function. Following

this approach, we derive sufficient conditions on the intrinsic weight factor ω and on the sum of two associators to ensure the reproducing property of the Bergman kernel in the weighted space $\mathcal{B}_2(\Omega, \omega, \mathbb{O})$ of square-integrable, octonion-valued analytic functions in an arbitrary bounded domain Ω. These results allow us to explicitly construct the reproducing Bergman kernel in domains such as balls and annuli in the octonionic setting.

Joint work with R.S. Kraußhar, from University of Erfurt, Germany.

Discrete octonionic analysis: a unified approach

Dmitrii Legatiuk

University of Erfurt, Germany
dmitrii.legatiuk@uni-erfurt.de

Tuesday
17:00
CR 3A

Abstract. In recent years, several approaches to introduce a discrete counterpart of the continuous octonionic analysis have been proposed. In particular, the approaches based on a direct discretisation of partial derivatives in the continuous octonionic Cauchy-Riemann operator and Weyl calculus have been studied. Looking at various problems of mathematical physics, it is evident that not only the classical octonions, but also split-octonions are often used as a mathematical structure, which underpins the eight-dimensional nature of these problems. Therefore, it is also interesting to address the split-octonions in the discrete setting. However, to avoid a simple repetition of the results developed for octonions, we discuss in this talk a general umbrella to cover all different discrete octonionic settings in one unified approach that also encompasses the different eight-dimensional algebraic structures.

This is a joint work with Sören Kraußhar and Anastasiia Legatiuk.

References

[1] R.S. Kraußhar, D. Legatiuk. Cauchy formulae and Hardy spaces in discrete octonionic analysis. *Complex Analysis and Operator Theory*, 18:23, 2024. doi.org:10.1007/s11785-023-01461-6.

[2] R.S. Kraußhar, A. Legatiuk, D. Legatiuk. The discrete octonionic Stokes' formula revisited. *Research Perspectives: Ghent Analysis and PDE Center*, 2024.

[3] R.S. Kraußhar, A. Legatiuk, D. Legatiuk. Application of the Weyl calculus perspective on discrete octonionic analysis in bounded domains. *Complex Analysis and Operator Theory*, 19:26, 2025. doi.org:10.1007/s11785-024-01653-8.

[4] R.S. Kraußhar, A. Legatiuk, D. Legatiuk. Discrete octonionic analysis: a unified approach to the split-octonionic and classical settings. *Trends in Mathematics*, accepted for publication, 2025.

Unitary rational functions: the scaled quaternion case

Daniel Alpay
Chapman University, Orange (CA), USA
alpay@chapman.edu

Tuesday
17:30
CR 3A

Abstract. We develop the theory of minimal realizations and factorizations of rational functions where the coefficient space is a ring of the type introduced in our previous work, the scaled quaternions, which includes as special cases the quaternions and the split quaternions. The methods involved are not a direct generalization of the complex or quaternionic settings, and in particular, the adjoint is not the classical adjoint and we use properties of real Hilbert spaces. This adjoint allows to define the counterpart of unitarity for matrix-rational functions, and we develop the corresponding theories of realizations and unitary factorizations. We also begin a theory of matrices in the underlying rings.

This is joint work with Ilwoo Cho (St-Ambrose University) and Mihaela Vajiac (Chapman University).

Quadratic estimates for the H^∞-functional calculus

Peter Schlosser
TU Graz
pschlosser@math.tugraz.at

Wednesday
10:30
CR 3A

Abstract. For unbounded, sectorial operators T one defines the *ω-functional calculus*

$$f(T) \coloneqq \frac{1}{2\pi} \int_{\partial U \cap \mathbb{C}_J} S_L^{-1}(s,T) ds_J f(s). \tag{1}$$

Here f is a slice hyperholomorphic function which decays at $s = 0$ and $s = \infty$ fast enough, such that the above integral exists. Although the operator T is unbounded, the decay of f leads to a bounded operator $f(T) \in \mathcal{B}(V)$.

Moreover, for functions f which are (polynomially) growing at $s = 0$ and $s = \infty$, one can generalize (1) to the so called *H^∞-functional calculus*

$$f(T) \coloneqq e(T)^{-1}(ef)(T), \tag{2}$$

where e is a certain regularizer function. Due to the growth of the function f, this definition now leads to unbounded, closed operators $f(T)$.

The main question addressed in this talk will be: In which cases does the H^∞-functional calculus (2) give a bounded operator? I will give a necessary and sufficient condition on the operator T, called *Quadratic estimates*, such that $f(T) \in \mathcal{B}(V)$ and

$$\|f(T)\| \leq C \|f\|_\infty,$$

for every bounded holomorphic function f.

New Taylor and Laurent series of axially harmonic functions

Antonino De Martino
Politecnico di Milano
antonino.demartino@polimi.it

Wednesday
11:00
CR 3A

Abstract. The Fueter-Sce mapping theorem stands as one of the most profound outcomes in complex and hypercomplex analysis, producing hypercomplex generalizations of holomorphic functions. In recent years, delving into the factorization of the second operator appearing in the Fueter-Sce mapping theorem has uncovered its potential to generate novel classes of functions and their respective functional calculi. The sets of functions obtained from this factorization and the associated functional calculi define the so-called *fine structures on the S-spectrum*. In this talk I discuss the function theories for the fine structures of Dirac type in the quaternionic framework, presenting new series expansions for axially harmonic functions. These series expansions are highly nontrivial. In fact, when considering the hypercomplex realm, specifically the quaternionic or the Clifford setting, extending the concept of complex power series expansion is not immediate, and different Taylor and Laurent expansions appear with different sets of convergence.

Joint work with F.Colombo and I.Sabadini.

Fine structures on the S-spectrum in the Cifford Algebra setting

Stefano Pinton
Politecnico di Milano
stefano.pinton@polimi.it

Wednesday
11:30
CR 3A

Abstract. The main object of this talk is the spectral theory on the S-spectrum originated as a precise mathematical foundation for quaternionic quantum mechanics and as a spectral theory for linear operators in vector analysis. This theory has been extended to fully Clifford operators and It has revealed unexpected connections with the spectral theory based on the monogenic spectrum, developed over forty years ago by A. McIntosh and collaborators. In recent years, we have combined slice hyperholomorphic function theory with the Fueter-Sce extension theorem to broaden the class of functions and operators to which the theory can be applied. This generalization has led to the definition of what we call the fine structures

on the S-spectrum, consisting of classes of functions that admit an integral representation and their associated functional calculi. In this talk I will give an overview of these functional calculi explaining their main properties. This talk is based on joint works with F. Colombo, A. De Martino, P. Schlosser and I. Sabadini.

Dirac meets Riesz and Hilbert

Nelson Faustino

University of Aveiro, Portugal
nfaust@ua.pt

Wednesday
12:00
CR 3A

Abstract. The relationship between Dirac operators and Riesz-Hilbert transforms has remained largely unexplored, despite the considerable attention each has received over the past century. This talk attempts to bridge this gap by exploring their connections and implications.

We present new approaches in hypercomplex function theory inspired by classical Euclidean methods, but refined by novel constructions in discrete and fractional contexts. Recent advances using pseudo-differential calculus and semigroup theory have led to a faithful formulation of these operators.

Our discussion will cover generalizations of conjugate harmonics, solutions to initial value problems in upper and lower half spaces, and extensions of Hardy spaces. In addition, we will present recent results and contextualize them within the broader framework of open questions in the field.

The spectral theorem for a normal operator on an arbitrary Clifford module

David Kimsey
Newcastle University
david.kimsey@newcastle.ac.uk

Thursday
13:15
CR 3A

Abstract. In this talk we will consider the problem of generating a spectral resolution for a normal operator on a Clifford module over a Clifford algebra which is arbitrary, in the sense that we will allow units to square to be +1. We will see a spectral resolution holds in this setting, which is highly analogous to an expression that the speaker and F Colombo recently established for Clifford modules over Clifford algebras which only has units which square to be -1.

Fractional Polyanalyticity

Arran Fernandez

Eastern Mediterranean University, Northern Cyprus
arran.fernandez@emu.edu.tr

Thursday
13:45
CR 3A

Abstract. Analyticity can be understood via the kernel of the d-bar derivative operator: a function is analytic if and only if its d-bar derivative equals zero. Polyanalyticity extends this concept to repeated d-bar derivative operators: a function is n-polyanalytic if and only if its nth-order d-bar derivative equals zero. Since d-bar derivatives of fractional (non-integer) orders have recently been defined [1], it now makes sense to extend the concept of polyanalyticity to fractional orders. We provide a complete description of fractionally polyanalytic functions in terms of an Almansi-type decomposition, in both Riemann–Liouville and Caputo cases.

Joint work with: Walaa Yasin.

References

[1] A. Fernandez, C. Bouzouina. Fractionalisation of complex d-bar derivatives. *Complex Var. Elliptic Equ.*, 66(3):437–475, 2021. doi:10.1080/17476933.2020.1722114.

On the Free Metaplectic Transform for Clifford-Valued Functions and Applications

Youssef El Haoui

Moulay Ismail University, Meknès, Morocco
y.elhaoui@umi.ac.ma

Thursday
14:15
CR 3A

Abstract.

The free metaplectic transform (FMT), an extension of the linear canonical transform (LCT), has proven to be a powerful tool in areas such as signal analysis, radar imaging, and mathematical physics. In this presentation, we propose a new hypercomplex extension of the FMT, called the Clifford free metaplectic transform (CFMT), developed within the setting of real Clifford algebras. We establish key properties of the CFMT, including linearity, shift, modulation, inversion formula, Plancherel's theorem, Parseval's identity, the sharp Hausdorff–Young inequality, and partial derivatives. Additionally, leveraging the connection between the Clifford–Fourier transform (CFT) and the CFMT, we derive the Heisenberg–Pauli–Weyl uncertainty principle. We conclude by illustrating the CFMT's application to partial differential equations, particularly the Clifford free metaplectic heat equation and a constant-coefficient non-homogeneous linear equation.

References

[1] M. Zayed and Y. El Haoui. Quaternionic free metaplectic transformation. *Math. Methods Appl. Sci.*, 48(4):4740–4756, 2024. doi:10.1002/mma.10573.

The Mittag-Leffler Bargmann transform, and its extension to the quaternionic setting

Natanael Alpay

University of California Irvine
nalpay@uci.edu

Thursday
14:45
CR 3A

Abstract. In this talk we introduce a Segal-Bargmann type transform associated to the Mittag Leffler Fock space introduced in [1] First, we study some basic properties of this operator and investigate how this can be connected to the classical Fourier transform. Then, we discuss the counterpart of the creation and annihilation operators in this setting. Finally, we present an extension of these results in the case of quaternions, in particular in the noncommutative setting: the slice hyperholomorphic theory and the Fueter regular theory.

This work is based on a joint work with Kamal Diki and Antonino De Martino.

References

[1] Rosenfeld, Joel A., Benjamin Russo, and Warren E. Dixon. The Mittag Leffler reproducing kernel Hilbert spaces of entire and analytic functions. *Journal of Mathematical Analysis and Applications* 463.2 (2018): 576-592. doi:10.1016/j.jmaa.2018.03.036

Hypertwined Regularity in Quantum Physics

Adrian Vajiac

Chapman University
avajiac@chapman.edu

Thursday
16:00
CR 3A

Abstract. Hypertwined analysis is a refinement of the general hypercomplex theory of partial differential operators, hypertwined regular functions being in the kernel of certain systems of partial differential operators, and admitting a decomposition in a hypertwined sum of regular functions in certain subalgebras. As examples, I briefly introduce the notion of hypertwined regularity for quaternionic, biquaternionic, and split-quaternionic spaces. The hypertwined quaternionic regularity lies in between slice regularity and the modified Cauchy–Fueter theories, and proves to have a direct impact on reformulations of quaternionic and spacetime algebra quantum theories.

In the same context, I discuss several applications of hypertwined analysis in Quantum Mechanics (QM) and Quantum Field Theory (QFT). Particular QFTs of interest in this study are Topological QFTs such as supersymmetric Yang–Mills theories on a four–manifold, which are deeply related with Donaldson and Seiberg–Witten invariants.

Fueter-type variables on the space of split quaternions

Mihaela Vajiac

Chapman University
mbvajiac@chapman.edu

Thursday
16:30
CR 3A

Abstract. In this talk I will present recent results on the space of split quaternions, as well as an associated global operator. I will also introduce new Fueter-type variables on this space, in the kernel of this operator. This talk is based on recent work with Daniel Alpay.

The Laplace Equation and some Related Results in the Bicomplex Context

María Elena Luna-Elizarrarás

Holon Institute of Technology, Holon, Israel
lunae@hit.ac.il

Thursday
17:00
CR 3A

Abstract. It is well known that the structure of bicomplex numbers $\mathbb{BC}$ is quite versatile, since it contains copies of the real, complex and hyperbolic numbers. Due to this versatility, some authors have explored different options to propose operators that will define a "good Laplacian" and then, define in the bicomplex context harmonic functions and different problems related with them.

In this talk I will present a second–order differential operator that is also a "good" Laplacian, in such a way that, with the harmonic functions induced by it, the Dirichlet problem and Poisson's theorem can be solved without losing geometric meaning by using hyperbolic curves and other hyperbolic geometric objects.

S15: Operator theory on function spaces I

Organizers: Jani Virtanen, Carlo Bellavita.

Exchanging Essential Norm and Integration

David Norrbo

University of Reading
d.norrbo@reading.ac.uk

Tuesday
13:15
CR 3B

Abstract. Let X be a Banach space and let $\{S_t : t \in]0,1[\}$ be a family of bounded operators on X. Assume the integral operator

$$\int_0^1 S_t\,dt\colon f \mapsto \int_0^1 S_t f\,dt$$

is well defined. What type of families $\{S_t\}$ satisfies

$$\left\| \int_0^1 S_t\,dt \right\|_e = \int_0^1 \|S_t\|_e\,dt?$$

In this talk, we will consider $\{S_t\}$ being certain multiplication operators acting on the reflexive Bergman spaces $A^p, p > 1$. The presentation will outline some of the methods used in the more general case of $\{S_t\}$ being certain weighted composition operators acting on the weighted Bergman spaces $A^p_\alpha, p > 1, \alpha \geq 0$ [1].

References

[1] Norrbo, D.; Essential norm and integration of a family of weighted composition operators. arXiv:2505.21268 [math.FA], http://arxiv.org/abs/2505.21268.

Commutants of Complex Symmetric Weighted Composition Operators on Hilbert Spaces of Analytic Functions

Ching-on LO

College of Professional and Continuing Education,
The Hong Kong Polytechnic University
co.lo@cpce-polyu.edu.hk

Tuesday
13:45
CR 3B

Abstract. We characterize all weighted composition operators vC_ψ that commute with a J_μ-symmetric weighted composition operator uC_φ on the reproducing kernel of Hilbert space H_γ of analytic functions on the unit

disk $\mathbb{D}$. It turns out such operators vC_ψ are also necessarily J_μ-symmetric. Furthermore, we provide simple characterizations for vC_ψ to be self-adjoint, normal and unitary.

Compact Difference of Fejér-Riesz Composition Operators

Boo Rim Choe

Korea University
cbr@korea.ac.kr

Tuesday
14:15
CR 3B

Abstract. We introduce the *Fejér-Riesz composition operator* F_φ induced by a holomorphic self-map φ of the unit disk $\mathbf{D}$, and defined on the space of holomorphic functions on $\mathbf{D}$ by $F_\varphi f = \chi_{(-1,1)} f \circ \varphi$. Denote by A^p_α the standard weighted Bergman space of holomorphic functions on $\mathbf{D}$ and denote the Hardy space H^p by A^p_{-1}. We study the operators $F_\varphi : A^p_\alpha \to L^p(m_\alpha)$, where m_α is the weighted Lebesgue measure $dm_\alpha(x) = (1-x^2)^{\alpha+1}dx$, $x \in (-1,1)$. For $0 < p < \infty$ and $\alpha \geq -1$, every such F_φ is bounded, which in the case $\alpha = -1$ is related to the classical Fejér-Riesz Inequality. We provide characterizations for when F_φ is compact and for when $F_\varphi - F_\psi$ is compact. Our characterizations reveal a new phenomenon which is not the case for ordinary composition operators.

This presentation is based on a recent joint work with Hyungwoon Koo and Wayne Smith.

Universality of Composition Operators and Applications to Complex Dynamics

Clifford Gilmore

Université Clermont Auvergne
clifford.gilmore@uca.fr

Tuesday
14:45
CR 3B

Abstract. We consider universality properties of composition operators $C_f \colon g \mapsto g \circ f$, acting on spaces of holomorphic functions, where the symbol f is given by a transcendental entire function restricted to parts of its Fatou set $F(f)$. The investigation of this topic was initiated by Jung [2], and it lies at the interface of complex dynamics and operator theory.

In the spirit of [2], we will discuss new results on the universality of C_f when the symbol f is restricted to certain Baker and wandering domains. We will also consider the more general class of weighted composition operators, $W_{\omega,f} \colon g \mapsto \omega \cdot (g \circ f)$, in this context. We uncover analogous universality results for this larger class, which permits us to further extend applications of the theory to the domain of complex dynamics [1].

This is joint work with V. Evdoridou (The Open University) and M. Manolaki (University College Dublin).

References

[1] Evdoridou, V.; Gilmore, C.; Manolaki, M.; *Interactions between Universal Composition Operators and Complex Dynamics*. ArXiv:2409.16260, 2024. DOI: https://doi.org/10.48550/arXiv.2409.16260

[2] Jung, A.; Universality of composition operators and applications to holomorphic dynamics. *Journal d'Analyse Mathématique*, 137, 2, 845-874, 2019.

Differences of Composition Operators on Small Weighted Bergman Spaces

Fanglei Wu

University of Eastern Finland
fanglei.wu@uef.fi

Tuesday
16:00
CR 3B

Abstract. Let $\widehat{\mathcal{D}}$ denote the class of radial weights ω on the unit disc satisfying the doubling property: $\sup_{0\le r<1} \frac{\int_r^1 \omega(s)\,ds}{\int_{\frac{1+r}{2}}^1 \omega(s)ds} < \infty$. In this talk, when $1 \le p < \infty$ and $\omega \in \widehat{\mathcal{D}}$, we characterize the compact differences of composition operators on A^p_ω, which therefore solves an unsettled case in [1]. Using some novel methods that differ from those in [2], we also provide a general characterization of Hilbert-Schmidt differences of composition operators on A^2_ω. This is a joint work with J. Chen, X. Guo, Y. Shi and M. Wang.

References

[1] Liu, B.; Rättyä, J.; Wu, F.; Compact differences of composition operators on Bergman spaces induced by doubling weight. *The Journal of Geometric Analysis*, 31, 12485-12500, 2021.

[2] Choe, B.; Hosokawa, T.; Koo, H. Hilbert-Schmidt differences of composition operators on the Bergman spaces. *Mathematische Zeitschrift* , 269, 751-775, 2011.

Bergman Projection induced by Radial Weight Acting on Growth Spaces

Álvaro Miguel Moreno López

University of Málaga
alvarommorenolopez@uma.es

Tuesday
16:30
CR 3B

Abstract. Let ω be a radial weight on the unit disc of the complex plane $\mathbb{D}$ and denote by $\widehat{\omega}(r) = \int_r^1 \omega(s)\,ds$ the tail integrals. A radial weight ω

belongs to the class $\widehat{\mathcal{D}}$ if satisfies the upper doubling condition

$$\sup_{0<r<1} \frac{\widehat{\omega}(r)}{\widehat{\omega}\left(\frac{1+r}{2}\right)} < \infty.$$

If ν or ω belongs to $\widehat{\mathcal{D}}$, we describe the boundedness of the Bergman projection P_ω induced by ω on the growth space

$$L^\infty_{\widehat{\nu}} = \{f : \|f\|_{\infty,v} = \operatorname{ess\,sup}_{z\in\mathbb{D}} |f(z)|\widehat{\nu}(z) < \infty\}$$

in terms of neat conditions on the moments and/or the tail integrals of ω and ν. Moreover, we solve the analogous problem for P_ω from $L^\infty_{\widehat{\nu}}$ to the Bloch type space $\mathcal{B}^\infty_{\widehat{\nu}} = \{f \text{ analytic in } \mathbb{D} : \|f\|_{\mathcal{B}^\infty_{\widehat{\nu}}} = \sup_{z\in\mathbb{D}}(1-|z|)\widehat{\nu}(z)|f'(z)| < \infty\}$. Similar questions for exponentially decreasing radial weights will also be studied.

This is a joint work with José Ángel Peláez and Jari Taskinen.

Two-weight Fractional Derivative on Bloch and Bergman Spaces

Siyu Wang

Fudan University

siyuwang@fudan.edu.cn

Tuesday
17:00
CR 3B

Abstract. In this talk, we will show that the classical Bloch space and the Bergman space A^p_η, induced by a radial doubling weight η, can be characterized by using the fractional derivative

$$f \mapsto R_{\nu,\omega}(f)(z) = \sum_{k=0}^{\infty} \frac{\nu_{2k+1}}{\omega_{2k+1}} \widehat{f}(k) z^k, \quad z \in \mathbb{D},$$

induced by two radial weights admitting certain doubling conditions. Here

$$\omega_{2k+1} = \int_0^1 r^{2k+1}\omega(r)\, dr$$

are the odd moments of ω, and $\widehat{f}(k)$ stands for the Maclaurin coefficient of the analytic function f in the unit disc $\mathbb{D}$.

The arguments employed here rely on the natural integral representation

$$R_{\nu,\omega}(f)(z) = \int_{\mathbb{D}} f(\zeta)\overline{B^\omega_z(\zeta)}\nu(\zeta)\, dA(\zeta), \quad z \in \mathbb{D}, \quad f \in L^1_\nu$$

via the Bergman reproducing kernels B^ω_z of the Hilbert space A^2_ω. On the path to our main result, we also study the boundedness of fractional

derivative $R_{\nu,\omega}$ as an integral operator from weighted L^∞ to weighted Bloch spaces. This is a joint work with A. Perälä and J. Rättyä.

Tent-Carleson Measures for some Holomorphic Function Spaces

Xiaofen Lv

Department of Mathematics, Huzhou University, Huzhou 313000, China
lvxf@zjhu.edu.cn

Tuesday
17:30
CR 3B

Abstract. In this talk, we introduce the definition of tent-Carleson measures and characterize the positive Borel measures μ such that the embedding is bounded or compact from some holomorphic function spaces to tent spaces, including the Hardy space, Bergman space, $\mathcal{Q}_p$...

Paired Operators and Scalar-type Kernels of Block Toeplitz Operators

M. Cristina Câmara

Centre for Mathematical Analysis, Geometry, and Dynamical Systems Instituto Superior Técnico, University of Lisbon
cristina.camara@tecnico.ulisboa.pt

Wednesday
10:30
CR 3B

Abstract. The kernels of paired operators, together with their analytic projections, which are generalisations of Toeplitz kernels, are studied. We consider in particular inclusion relations between those spaces and apply them to describing the kernels of certain classes of Toeplitz operators and asymmetric truncated Toeplitz operators.

This talk is based on joint work with Jonathan R. Partington.

Symmetry of Hankel and Truncated Hankel Operators

Marek Ptak

University of Agriculture in Krakow
rmptak@cyf-kr.edu.pl

Wednesday
11:00
CR 3B

Abstract. A symmetry of Hankel operators with respect to some conjugation (anti-linear isometric involution) is shown. Inner functions θ such that all truncated Hankel operators on the model space K^2_θ are symmetric with some

conjugation are fully characterized. In such a case, the conjugation is unique, and we give the formula for the conjugation.

Joint work with Piotr Dymek and Artur Płaneta

Hypercyclicity of Toeplitz Operators

Maeva Ostermann

CNRS & Université de Lille

maeva.ostermann@univ-lille.fr

Wednesday
11:30
CR 3B

Abstract. The study of Toeplitz operators from the point of view of linear dynamics began with a seminal work by Godefroy and Shapiro, in which they characterized when a Toeplitz operator on the Hardy space with anti-analytic symbol is hypercyclic (i.e., has a dense orbit). Shkarin later characterized the hypercyclicity of tridiagonal Toeplitz operators, and his result was extended first by Baranov and Lishanskii, and later by Abakumov, Baranov, Charpentier, and Lishanskii.

In this talk, I will discuss a new characterization of the hypercyclicity of Toeplitz operators that we obtained using a model theory developed by Yakubovich in the 1990s. This is a joint work with E. Fricain and S. Grivaux.

References

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Toeplitz Operators on Large Vector-Valued Fock Spaces

Ghazaleh Asghari

University of Reading

g.asgharikhonakdari@pgr.reading.ac.uk

Wednesday
12:00
CR 3B

Abstract. Let $\mathcal{H}$ be a separable Hilbert space. We denote by $L^2_\phi(\mathcal{H})$ the space of all measurable $\mathcal{H}$-valued functions on $\mathbb{C}^n$ for which

$$\|f\|^2_{2,\phi} = \int_{\mathbb{C}^n} \|f(z)\|^2_{\mathcal{H}}\, e^{-2\phi(z)}\, dA(z) < \infty,$$

where dA is the Lebesgue measure on $\mathbb{C}^n$ and ϕ is an *admissible weight* introduced in [1], generalizing doubling weights to $\mathbb{C}^n$. The large vector-valued Fock space $F^2_\phi(\mathcal{H})$ is the space of holomorphic $\mathcal{H}$-valued functions in $L^2_\phi(\mathcal{H})$. We show that $F^2_\phi(\mathcal{H})$ is a vector-valued reproducing kernel Hilbert space, by generalizing the concept of scalar reproducing kernels which are elements of the scalar Fock space to those maps of the form

$K^{\mathcal{H}}\colon \mathbb{C}^n \times \mathbb{C}^n \to \mathcal{H} \otimes \mathcal{H}^*$. Let $G\colon \mathbb{C}^n \to \mathcal{L}(\mathcal{H})$ be such that $G(z)$ is a positive operator for every $z \in \mathbb{C}^n$. The *vectorial Toeplitz operator* T_G is defined by $T_G f(z) = P(Gf)$, where $P\colon L^2_\phi(\mathcal{H}) \to F^2_\phi(\mathcal{H})$ is the orthogonal projection.

We characterize boundedness and compactness of T_G in terms of generalized Berezin transforms, averaging functions, and Carleson measures. To determine Schatten class Toeplitz operators, we introduce the operator-valued Berezin transform and averaging functions.

References

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[2] Arroussi, H.; He, H; Li, J.; Tong, C.; Toeplitz operators between large Fock spaces. *Banach Journal of Mathematical Analysis*, 16, 2, 32, 2022. doi: 10.1007/s43037-022-00187-5.

Boundedness, Compactness and Schatten Class for Rhaly Matrices

Eugenio Dellepiane

Politecnico di Torino

eugenio.dellepiane@polito.it

Thursday
13:45
CR 3B

Abstract. In this talk, we discuss the *Rhaly operator* R_α, that acts on ℓ^2 as the infinite matrix

$$R_\alpha = \begin{pmatrix} \alpha_0 & 0 & 0 & 0 & 0 & \cdots \\ \alpha_1 & \alpha_1 & 0 & 0 & 0 & \cdots \\ \alpha_2 & \alpha_2 & \alpha_2 & 0 & 0 & \cdots \\ \alpha_3 & \alpha_3 & \alpha_3 & \alpha_3 & 0 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots \end{pmatrix}.$$

Rhaly matrices arise as the natural generalization of the classical Cesàro operator: choosing

$$\alpha_k = \frac{1}{k+1}, \qquad k \in \mathbb{N},$$

then R_α coincides with the classical Cesàro operator $\mathcal{C}$, that assigns to each $f \in \ell^2$ the averages

$$\mathcal{C}f(k) = \frac{1}{k+1} \sum_{j=0}^{k} f(j), \qquad k \in \mathbb{N}.$$

We provide new characterizations of the boundedness and compactness of R_α on ℓ^2, and we completely characterize its membership in the p-Schatten

class $\mathcal{S}^p(\ell^2)$, for $1 < p < \infty$. This talk is based on a joint project with Carlo Bellavita and Giorgos Stylogiannis, that has recently appeared on ArXiv [1].

References

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Linear Functionals on Banach Spaces

Giorgi Tutberidze

The University of Georgia
g.tutberidze@ug.edu.ge

Thursday
14:15
CR 3B

Abstract. S. Banach [1] demonstrated that strong differentiability conditions on a function do not necessarily ensure the almost everywhere (a.e.) convergence of its Fourier series concerning arbitrary orthonormal systems (ONS). Conversely, it is well established that the Menshov-Rademacher Theorem provides a sufficient criterion for the a.e. convergence of an orthonormal series.

The main aim of this paper is to investigate the convergence of the general Fourier series $Lip\alpha$, when $0 < \alpha < 1$. In particular, we studied the conditions on the functions φ_n of an ONS (φ_n) under which the variational Fourier series (with respect to general orthonormal systems) of functions from class BV be convergent a.e. on $[0, 1]$. We also found special conditions for functions of the orthonormal system, for which the Fourier series of functions of class $Lip\alpha$ converges. It is established that the resulting conditions are the best possible in a certain sense. These findings not only enhance our understanding of the convergence behavior of Fourier series but also provide valuable insights into the interplay between various function classes and orthonormal systems.

References

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[2] Persson, L.-E.; Tsagareishvili, V.; Tutberidze, G.; Properties of sequence of linear functionals on BV with applications. *Nonlinear Studies*, 30, 4, 2023.

[3] Tsagareishvili, V.; Tutberidze, G.; Cagareishvili, G.; Unconditional convergence of general Fourier series. *Publicationes Mathematicae Debrecen*, to appear.

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Sharp Strong Convergence Result of the Two-dimensional Walsh-Fourier Series in Martingale Hardy Spaces

George Tephnadze

Viktor Kupradze Institute of Mathematics, The University of Georgia, Tbilisi, Georgia

g.tephnadze@ug.edu.ge

Thursday
14:45
CR 3B

Abstract. Unlike the classical theory of Fourier series which deals with decomposition of a function into sinusoidal waves the Walsh functions are rectangular waves. Some important steps in early development can be found in the book by F. Schipp, W. R. Wade, P. Simon and J. Pál [1] from 1990. The research continued intensively also after this. Some of the most important steps in these developments are presented in the recent book by L. E. Persson, G. Tephnadze and F. Weisz [2] from 2022.

In [4] Weisz investigated strong convergence of partial sums $S_{m,n}$ of the two-dimensional Walsh-Fourier series in the martingale Hardy spaces, but under the condition when $2^{-\alpha} < m/n \leq 2^{\alpha}$. This talk is devoted to investigate strong convergence of the two-dimensional Walsh-Fourier series in the martingale Hardy spaces $H_p^{\square}\left(G^2\right)$ for $0 < p < 1$, without any restriction on the indices (for details see [4]) . Moreover, sharpness of this result is also showed.

References

[1] Persson, L. E.; Tephnadze, G.; Weisz, F.; Martingale Hardy Spaces and Summability of Vilenkin-Fourier Series. Birkhäuser/Springer, 2022.

[2] Schipp, F.; Wade, W.; Simon, P.; Pál, J.; Walsh series, An Introduction to Dyadic Harmonic Analysis. Adam-Hilger, Ltd. Bristol, 1990.

[3] Tephnadze, G.; Sharp strong convergence result of the two-dimensional Walsh-Fourier series in martingale Hardy spaces. *Analysis and Mathematical Physics*, 15, 3, 78, 23 pp, 2025.

[4] Weisz, F.; Strong convergence theorems for two-parameter Walsh-Fourier and trigonometric-Fourier series. *Studia Mathematica*, 117, 2, 173-194, 1996.

Some Geometric Properties of Spaces of Vector-Valued Functions

Ranjana Jain

University of Delhi, India

rjain@maths.du.ac.in

Thursday
16:00
CR 3B

Abstract. Birkhoff-James orthogonality plays an important role in the geometry of Banach spaces. In this study, we exploit Birkhoff-James orthogonality to identify the smooth points of $L^1(\mu, X)$ and $C_0(K, X)$, K

being locally compact Hausdorff space and X being a Banach space. We further provide some necessary, and sufficient conditions for the left and right symmetry of points with respect to Birkhoff-James orthogonality in $L^p(\mu, X), 1 \leq p < \infty$, and in $C(K, X)$ where μ is any complete positive measure, X is a Banach space and K is a compact space. This study is based on the joint works with Mohit (see, [1] and [2]).

References

[1] Mohit and R. Jain. Some geometric properties of spaces of vector-valued integrable functions (2024). https://arxiv.org/abs/2411.03798.

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The Stone-Weierstrass Theorem on Algebras of weighted vector-valued continuous functions

Lourdes Palacios

Universidad Autónoma Metropolitana Iztapalapa, MEXICO

pafa@xanum.uam.mx

Thursday
16:30
CR 3B

Abstract. A very well known theorem in Analysis is the classical Stone-Weierstrass Theorem (1948). Since its first appearance, a great amount of generalizations and applications of this result have been given in several directions. Here we give a special version of this theorem in the following context of algebras of weighted vector-valued continuous functions.

Let X be a completely regular Hausdorff space, V a Nachbin family defined in X, and A a locally convex algebra. Let $CV_0(X, A)$ be the space of all weighted vector-valued continuous functions defined in X with values in A and consider on it the topology given by the family of uniform seminorms induced by V. These spaces can be viewed as spaces of vector-valued continuous functions equipped with different topologies, according to the special Nachbin family V. Under certain circumstances, they actually are locally convex algebras.

In this talk we establish a Stone-Weierstrass Theorem for $CV_0(X, A)$ and give some applications of this theorem. Several useful examples related with Function Algebras and Operator Theory will be provided.

p-nuclear operators on spaces of continuous functions

Juliusz Stochmal

Kazimierz Wielki University in Bydgoszcz, Poland

j.stochmal@ukw.edu.pl

Thursday
17:00
CR 3B

Abstract. Let K be a compact Hausdorff space and let E denote a Banach

space. Let $C(K, E)$ stand for the Banach space of all E-valued continuous functions on K.

Different classes of operators on $C(K, E)$ have been characterized in terms of their representing measures. In particular, this problem for nuclear operators, absolutely summing operators and p-absolutely summing operators $(1 < p < \infty)$ has been studied in [3], [4], [1], [2].

The aim of this talk is to obtain the relationship between p-nuclear operators on $C(K, E)$ and properties of their representing operator-valued Borel measures. We also show that a bounded linear operator on the space of scalar-valued continuous functions with the representing measure that has an appropriate Pettis integrable derivative is p-nuclear.

References

[1] D. Popa. (r, p)-absolutely summing operators on the space $C(T, X)$ and applications. *Abstr. Appl. Anal.*, 6(5): 309–315, 2001.

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[3] P. Saab and B. Smith. Nuclear operators on spaces of continuous vector-valued functions. *Glasgow Math. J.*, 33(2): 223–230, 1994.

[4] C. Swartz. Absolutely summing and dominated operators on spaces of vector-valued continuous functions. *Trans. Amer. Math. Soc.*, 179: 123–131, 1973.

Superposition operators in various spaces of functions of bounded variation

Daria Bugajewska

Adam Mickiewicz University, Poznań

dbw@amu.edu.pl

Thursday
17:30
CR 3B

Abstract. It is well known that superposition operators (both autonomous and nonautonomous) play a very important role in many areas of nonlinear analysis. The basic problem of this theory concerns describing of necessary and sufficient conditions on generating functions under which the superposition operator acts between given spaces. Next two problems concern boundedness and continuity of such operators. During this talk I am going to focus on the above mentioned problems in various spaces of functions of bounded variation.

In particular, in the theory of autonomous superposition operators in the space of functions of bounded variation in the sense of Jordan a central place occupies the Josephy theorem, which states that the autonomous superposition operator maps the space of functions of bounded variation in the sense of Jordan into itself if and only if its generator satisfies the local Lipschitz condition. Among others, I will present some new generalizations of this theorem coming from the paper [2].

References

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[2] D. Bugajewska and P. Kasprzak Josephy's Theorem, Revisited. *Results in Mathematics*, 79(6):1-11, 2024. doi:10.1007/s00025-024-02265-6.

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S16: Operator theory on function spaces II, in honour of Nikolai Vasilevski

Organizers: Jani Virtanen, Carlo Bellavita.

Liftings and Invariant Subspaces of Hankel Operators

Jaydeb Sarkar

Indian Statistical Institute

jaydeb@gmail.com; jay@isibang.ac.in

Thursday
13:15
CR 3B

Abstract. We discuss a Hankel-variant of the commutant lifting theorem and present a complete structure theorem for Beurling-type reducing and invariant subspaces of Hankel operators. We also share some new developments related to Hilbert's Hankel matrix. The kernel spaces of Hankel operators emerge as a key component in this study.

This talk is based on joint work with Sneha B., Neeru Bala, and Samir Panja.

Fredholm theory of Toeplitz operators with piecewise continuous symbols

Jani Virtanen

University of Eastern Finland, University of Reading, and University of Helsinki

jani.virtanen@uef.fi;
j.a.virtanen@reading.ac.uk;
jani.virtanen@helsinki.fi

Friday
10:45
Waaier 3

Abstract. I will discuss Fredholm theory of Toeplitz operators, where Vasilevski made significant contributions, in particular when these operators act on the Bergman space and the symbols are piecewise continuous. Vasilevski's description of the essential spectra is in the setting of the Hilbert space and the question of what happens in the Banach space setting remains open.

Fourier Description of the Space of Polyanalytic Functions of Infinite Order

Julio Eduardo Enciso-Molina

Departamento de Matemáticas, CINVESTAV

jeenciso@math.cinvestav.mx

Friday
11:15
Waaier 3

Abstract. Let $\mathcal{SF}(\mathbb{C})$ be the polyanalytic Fock space of infinite order,

introduced in [1]. Our goal is to make a description of this space in terms of the Fourier transform. To this end, we connect $\mathcal{SF}(\mathbb{C})$ with another reproducing kernel Hilbert space $\mathcal{E}(\mathbb{C})$, with reproducing kernel

$$K(z,w) = e^{-|z-w|^2}.$$

We show that $\mathcal{E}(\mathbb{C})$ can be seen as the image of the space $L^2(\mathbb{R}^2, W)$ under the Fourier transform, where $W(s,t) = \frac{1}{\pi} e^{\pi^2(s^2+t^2)}$. This allows us to define an isometric integral transform between the spaces $L^2(\mathbb{R}^2)$ and $\mathcal{SF}(\mathbb{C})$. This relationship enables the study of "horizontal translation operators" in these spaces and the von Neumann algebra of the operators that commute with such translations.

This is a joint work with Egor Maximenko and Maribel Loaiza. This research has been partially supported by SECIHTI (Mexico) project 'Ciencia de Frontera' FORDECYT-PRONACES/61517/2020.

References

[1] Alpay, D.; Colombo, F.; Diki, K.; Sabadini, I. Reproducing kernel Hilbert spaces of polyanalytic functions of infinite order. *Integral Equations Operator Theory*, 94, 35, 2022. doi:10.1007/s00020-022-02713-4

Convolution equations on the submonoid $\mathrm{M} = [0,1)$

Roland Duduchava

V. Kupradze Institute of Mathematics, University of Georgia

roldud@gmail.com

Friday
11:45
Waaier 3

Abstract. The interval $\mathrm{G} = (-1,1)$ turns into a Lie group under the group operation $x \circ y := (x+y)(1+xy)^{-1}, \quad x, y \in \mathrm{G}$, the Fourier transformation $\mathcal{F}_{\mathrm{G}}$ and the invariant Haar measure $d\mu_{\mathrm{G}} := \dfrac{dt}{1-t^2}$. Then $\mathrm{M} = [0,1)$ is a submonoid of G (has the same binary operation $x \circ y$) and we can induce the invariant Haar measure $d\mu_{\mathrm{M}}$ and the Fourier transformation $\mathcal{F}_{\mathrm{M}}$ from G to M. The main object of the investigation is the Fourier convolution operator $W_{\mathrm{M},a} := r_+ W^0_{\mathrm{G},a} \ell_+$, which represents the restriction of the convolution $W^0_{\mathrm{G},a} := \mathcal{F}_{\mathrm{G}}^{-1} a \mathcal{F}_{\mathrm{G}}$ from G.

An example of such convolution integro-differential equation on the submonoid $\mathrm{M} = [0,1)$ is

$$\sum_{j=0}^{n} \left[a_j \mathfrak{D}^{m_j} u(t) - b_j \mathfrak{D}^{n_j} \int_0^1 k_j \left(\frac{t-\tau}{1-t\tau} \right) \frac{\mathfrak{D}^{\ell_j} u(\tau) d\tau}{1-\tau^2} \right] = f(t), \qquad t \in \mathrm{M},$$

where $a_j, b_j \in \mathbb{C}$, $m_j, n_j, \ell_j \in \mathbb{N}$, $j = 1, \dots, n$, $k_j \in \mathbb{L}_1(\mathrm{G}, d\mu_{\mathrm{G}})$, $\mathfrak{D}u(x) := -(1-x^2)\dfrac{d}{dx}u(x)$ is the generic differential operator, which is a convolution operator and $(\mathcal{F}_{\mathrm{G}}\mathfrak{D}) = -i\xi$, $\xi \in \mathbb{R}$.

Theory of convolution opertators $W_{\mathrm{M},a}$ on the submonoid M is much more complicated, but more rich and important in applications (example of Wiener-Hopf equations on submonoid $\mathrm{M} = [0, \infty)$ of the Lie group $\mathrm{G} = (-\infty, \infty)$ is a good example). Convolution equation $W_{\mathrm{M},s}\varphi = f$ in the Generic Bessel potential space setting $f \in \mathbb{GH}_p^{s-r}(\mathrm{M}, d\mu_{\mathrm{M}})$, $\varphi \in \mathbb{GH}_p^s(\mathrm{M}, d\mu_{\mathrm{M}})$, $1 < p < \infty$, $s, r \in \mathbb{R}$, has non-trivial Fredholm index and the Fredholmity and solvability conditions for discontinuous symbols $a(\xi)$ depend on the parameters of the spaces. We expose full theory of such convolution integro-differential equations: Fredholm property and solvability criteria, index formula. Formula for solutions are available through the factorization of the symbol.

It is worth to mention that the celebrated equations of Prandtl, Tricomi and Lavrentjev-Bitsadze belong to the class of convolution equations on the Lie group $\mathrm{G} = (-1, 1)$.

The Heisenberg Group and a Bargmann type Transform

Raul Quiroga-Barranco

Centro de Investigacion en Matematicas (Cimat), Mexico

quiroga@cimat.mx

Friday
12:15
Waaier 3

Abstract. Among the most important analytic function spaces one finds the (Segal-Bargmann-)Fock spaces $\mathcal{F}^2_\xi(\mathbb{C}^n)$ and the Bergman spaces $\mathcal{A}^2_\lambda(D_{n+1})$, where these are considered in their weighted realizations. Both of these spaces admit natural unitary actions of the Heisenberg group $\mathbb{H}_n$. On the other hand, Toeplitz operators on Fock and Bergman spaces are fundamental as well. We have proved in [1] that the Toeplitz operators on $\mathcal{A}^2_\lambda(D_{n+1})$ with $\mathbb{H}_n$-invariant symbols generate a commutative C^*-algebra. This was achieved by constructing a Bargmann type transform that related $\mathcal{A}^2_\lambda(D_{n+1})$ to a direct integral of Fock spaces $\mathcal{F}^2_\xi(\mathbb{C}^n)$. We will discuss further properties of this Bargmann type transform, its implications to the structure of analytic function spaces, its relationship to the actions of the Heisenberg group and applications to more general operators that intertwine such actions.

This is joint work with Julio A. Barrera-Reyes.

References

[1] Barrera-Reyes, J. A.; Quiroga-Barranco, R.; The Heisenberg group action on the Siegel domain and the structure of Bergman spaces. *Integral Equations Operator Theory*, 96, 3, 24, 2024.

S17: Positivity and dynamical systems

Organizers: Onno van Gaans, Sahiba Arora.

Automatic continuity of positive matrix semigroups

Jochen Glück

University of Wuppertal
glueck@uni-wuppertal.de

Tuesday
13:15
HB 2A

Abstract. It is a classical result that a function $T\colon [0,\infty) \to \mathbb{R} \setminus \{0\}$ that satisfies the functional equation $T(s+t) = T(s)T(t)$ for all $s, t \geq 0$ and is bounded close to 0, is actually an exponential function, i.e., $T(t) = e^{at}$ for a number $a \in \mathbb{R}$ and all $t \geq 0$. This is no longer true if T is matrix-valued or, more generally, operator-valued.

Yet, we will show in this talk that the result remains true if T is matrix-valued and satisfies the additional positivity condition $T(t) \geq 0$ for all $t \geq 0$, where the inequality is meant entrywise. Note that this condition is automatically satisfied in the $\mathbb{R}$-valued case. We will also discuss a generalization to the case where the $T(t)$ are operators on a sequence space.

Diffusions with exotic boundary conditions

Jonathan Mui

University of Wuppertal
jomui@uni-wuppertal.de

Tuesday
13:45
HB 2A

Abstract. This talk concerns second-order uniformly elliptic differential operators acting on a Lipschitz domain, equipped with so-called *non-local Wentzell-Robin* boundary conditions. Non-locality in this context means that the dynamics on the boundary of the domain interact with the dynamics in the interior. Under quite general assumptions, such operators generate analytic C_0-semigroups. However, in contrast to the classical setting of diffusion equations, the semigroup is not positive in general. Nevertheless, we are able to provide characterisations of positivity and (sub-)Markovianity of the semigroup. In the non-positive case, we also study the more subtle notion of eventual positivity, which requires a detailed investigation of spectral properties of the differential operator.

This is joint work with Markus Kunze (Konstanz) and David Ploß (Karlsruhe).

Eventual positivity of fourth-order elliptic operators with Wentzell boundary conditions

David Ploß

Karlsruhe Institute of Technology
david.ploss@kit.edu

Tuesday
14:15
HB 2A

Abstract. For bounded domains Ω with Lipschitz boundary Γ, we investigate boundary value problems for elliptic operators with variable coefficients of fourth order subject to Wentzell (or dynamic) boundary conditions. Using two nested quadratic forms, we begin by showing general results for an even wider class of operators of type

$$\mathcal{A} = \begin{pmatrix} B^*B & 0 \\ -\mathcal{N}^{\mathfrak{b}}B & 0 \end{pmatrix},$$

where B is associated to a quadratic form $\mathfrak{b}$ and $\mathcal{N}^{\mathfrak{b}}$ an abstractly defined co-normal Neumann trace. Even in this general setting, we prove generation of an analytic semigroup $(\mathcal{T}(t))_{t\geq 0}$ on the product space $\mathcal{H} := L^2(\Omega) \times L^2(\Gamma)$.

Using recent results concerning weak co-normal traces, we apply our abstract theory to the elliptic fourth-order case and are able to fully characterize the domain in terms of Sobolev regularity for operators in divergence form $B = -\mathrm{Div} Q\nabla$ with $Q \in C^{1,1}(\overline{\Omega}, \mathbb{R}^{d\times d})$, also obtaining results on stability, asymptotic behavior, and Hölder-regularity of solutions. This regularity is the key to obtain eventual positivity for $(\mathcal{T}(t))_{t\geq 0}$. As $\mathcal{A}$ is of order 4, this results in a large class of examples of semigroups that are eventually positive, but not positive.

References

[1] D. Ploss. Elliptic fourth-order operators with Wentzell boundary conditions on Lipschitz domains. *J. Evol. Equ. 24*, 86 (2024). doi:10.3934/10.1007/s00028-024-01015-z.

Entropy Decay Rates for Quantum Markov Semigroups

Melchior Wirth

Leipzig University
melchior.wirth@uni-leipzig.de

Tuesday
14:45
HB 2A

Abstract. Relative entropy is a measure for the distinguishability of (quantum) states. An early breakthrough result in quantum information theory was the data processing inequality, which states that the relative entropy between quantum states cannot increase under physical operations. This

talk concerns the question when the data processing inequality can be tightened to have (exponential) decay of relative entropy for a Markovian open quantum system.

For classical diffusions, it was long known that exponential decay of relative entropy is equivalent to a logarithmic Sobolev inequality. For finite-dimensional quantum systems subject to certain symmetry conditions, analogous characterizations have been established in the last 15 years, but a rigorous proof for infinite-dimensional systems has been missing. In this talk we present the equivalence between a (modified) logarithmic Sobolev inequality and exponential decay of relative entropy for infinite-dimensional quantum Markov semigroups under rather general conditions. Key steps in the proof are a noncommutative deBruijn identity and a formula for the entropy production in general von Neumann algebras.

Positive commutators on Banach lattices

Roman Drnovšek

Faculty of Mathematics and Physics, University of Ljubljana, Slovenia
roman.drnovsek@fmf.uni-lj.si

Tuesday
16:00
HB 2A

Abstract. We will present several results on positive commutators of positive operators on Banach lattices. We will start with the following finite-dimensional theorem. Let A and B be non-negative matrices such that the commutator $C = AB - BA$ is non-negative as well. Then, up to similarity with a permutation matrix, C is a strictly upper triangular matrix, and so it is nilpotent.

We will continue with the following infinite-dimensional analogue. Let A and B be bounded operators on a Banach lattice E such that the commutator $C = AB - BA$ and the product BA are positive operators. If the product AB is a power-compact operator, then C is a quasi-nilpotent operator having a triangularizing chain of closed ideals of E. If the resolvent set of the operator C is connected, then C is not invertible. Some related results will be also discussed.

Extension of positive multilinear operators and an application to orthosymmetric maps

Janko Stennder

TU Dresden
janko.stennder@tu-dresden.de

Tuesday
16:30
HB 2A

Abstract. The well-known Kantorovich extension theorem states that positive operators on majorizing subspaces of ordered vector spaces can be

extended positively if the range space is Dedekind complete. We show that a similar statement for multilinear positive operators does not hold in general and exhibit an example why the "naive" approach using tensor products fails. However, we give conditions under which an extension is still possible and use this result to show a representation for orthosymmetric maps on spaces of continuous functions.

A Radon-Nikodým theorem for completely positive maps on Hilbert pro-C^*-modules

Bhumi Amin

IIT Hyderabad

ma20resch11008@iith.ac.in

Tuesday
17:00
HB 2A

Abstract. We first state a Stinespring-like representation theorem for completely positive (CP) maps between two Hilbert pro-C^*-modules. Next, we introduce an equivalence relation on the set of all CP maps between Hilbert pro-C^*-modules and analyze the Stinespring's construction for equivalent completely positive maps. Finally, we define a pre-order relation on the collection of all CP maps between Hilbert pro-C^*-modules and obtain a Radon-Nikodým type theorem.

Decomposing Completely Positive Maps

Chaitanya J. Kulkarni

Postdoctoral Research Associate, Indian Institute of Science Education and Research Mohali, India

chaitanyakulkarni58@gmail.com

Tuesday
17:30
HB 2A

Abstract. For a given separable C*-algebra A and a state $\omega\colon A \to \mathbb{C}$ with the GNS-representation π_ω, Effros established a connection between the decomposition of ω and the disintegration of π_ω, using a special class of measures called *orthogonal* measures.

In this talk, we take this approach to unital completely positive (UCP) maps. We consider a UCP map $\phi\colon A \to B(H)$ with the minimal Stinespring dilation $V^*\pi V$. We connect the decomposition of ϕ and the disintegration of π, by introducing a special class of measures called *generalized orthogonal* measures. A decomposition of ϕ obtained by using a generalized orthogonal measure is called as an orthogonal decomposition of ϕ. This decomposition of a UCP map mainly uses the theory of direct integral of Hilbert spaces. This part of the talk is based on the work in [1].

Next, we introduce an ergodic decomposition of a UCP map which is defined on a C*-algebra A by considering an action of a group G on A. This

uses the theory of orthogonal decomposition of a UCP map. To complete the picture of an ergodic decomposition of a UCP map, we characterize the set of all ergodic UCP maps. This part of the talk is based on the work in [2].

References

[1] C. J. Kukarni; A. Bhattacharya, Generalized orthogonal measures on the space of unital completely positive maps *Forum Mathematicum*, 36 (2024), no. 6, 1483-1497. doi:10.1515/forum-2023-0330.

[2] C. J. Kukarni; A. Bhattacharya, Ergodic decomposition in the space of unital completely positive maps *Infi. Dimen. Anal. Quantum Probab. and Relat. Top.*, (2024), (appeared online). doi:10.1142/S0219025724500127.

An order-theoretic characterization of JB-algebras

Samuel Tiersma

Universiteit Leiden

s.j.tiersma@math.leidenuniv.nl

Wednesday
10:30
HB 2A

Abstract. JB-algebras are an important class of nonassociative, complete normed algebras, the prototypical example being the hermitian elements in a C*-algebra equipped with the Jordan product $\frac{1}{2}(xy + yx)$. There is a natural partial order on a JB-algebra in which the positive elements are precisely the squares.

Let Ω be an open cone in a finite dimensional vector space V. The celebrated Koecher–Vinberg theorem asserts that Ω is the cone of invertible squares in a JB-algebra if and only if Ω is symmetric, that is, homogeneous and self-dual. Walsh has provided an elegant alternative characterization, in terms of the existence of an order-reversing bijection $\Phi : \Omega \to \Omega$ that is homogeneous of degree -1. This talk will outline how the following extension of Walsh's result to infinite dimensions has been obtained.

Theorem. *Let Ω be the open cone of a complete order unit space V. Then Ω is the set of invertible squares of a JB-algebra if and only if there exists a homogeneous order-anti-isomorphism $\Phi : \Omega \to \Omega$ of degree -1.*

Based on joint work with Mark Roelands.

Inequalities on the joint and generalized spectral radius and their essential versions for Hadamard weighted geometric means

Aljoša Peperko

University of Ljubljana and IMFM, Ljubljana, Slovenia
aljosa.peperko@fs.uni-lj.si

Wednesday
11:00
HB 2A

Abstract. We will present several inequalities for the generalized and the joint spectral radius and their essential versions of Hadamard (Schur) weighted geometric means of bounded sets of infinite nonnegative matrices that define operators on suitable Banach sequence spaces and of bounded sets of positive kernel operators on suitable Banach function spaces.

The recently published presented work is joint work with B. Lins and with K. Bogdanovic.

References

[1] B. Lins and A. Peperko. Inequalities on the essential joint and essential generalized spectral radius. *Journal of Mathematical Inequalities*, 18(4): 1489–1514, 2024 https://jmi.ele-math.com/18-85/Inequalities-on-the-essential-joint-and-essential-generalized-spectral-radius

[2] K. Bogdanovic and A. Peperko. Inequalities and equalities for the generalized and joint spectral radius and their essential versions of positive kernel operators. *Lin. Mult. Algebra*, 2839–2857, 2023

[3] A. Peperko. Inequalities on the joint and generalized spectral and essential spectral radius of the Hadamard geometric mean of bounded sets of positive kernel operators. *Lin. Mult. Algebra*, 2159–2172, 2019

On Structured Perturbations of Positive Semigroups

Alessio Barbieri

Università degli Studi dell'Aquila
alessio.barbieri@graduate.univaq.it

Wednesday
11:30
HB 2A

Abstract. It is well-known that an evolution problem that can be described by an Abstract Cauchy Problem

$$\begin{cases} \dot{x}(t) = Gx(t), & t > 0 \\ x(0) = x_0, \end{cases} \tag{1}$$

on a Banach space X for a linear (e.g., differential) operator $G : D(G) \subset X \to X$ is well-posed if and only if G generates a C_0-semigroup on X. One

of the most effective strategies to verify the generator property of G is to split it as the sum $G = A + P$, where A is a well-known generator and P is a *perturbation*, and then to use some abstract perturbation result.

In the papers [1] and [2] the authors showed in this way that well-posedness of (1) can be verified via quite simple spectral conditions involving only P and the resolvent $R(\lambda, A)$, provided P is positive and A generates a positive semigroup on an AL- or an AM-space X, respectively.

In the recent paper [3], we proved some generalizations of these results. In particular, the state space X can be an arbitrary Banach lattice if the perturbation can be factorized appropriately as $P = BC$. To show the great advantage of our approach over [1, 2] we give applications to a perturbation of the first derivative.

Using the same approach we proved a Weiss–Staffans type perturbation result (cf. [4] and [5]) for generators of positive C_0–semigroups on Banach lattices for finite–rank perturbations $P = BC$ (cf. [6]). We present this result alongside an application to rank-one perturbations of the first derivative.

References

[1] J. Voigt. On resolvent positive operators and positive C_0-semigroups on AL-spaces. *Semigroup Forum*, 38(2):263–266, 1989. doi:10.1007/BF02573236.

[2] A. Bátkai, B. Jacob, J. Voigt and J. Wintermayr. Perturbations of positive semigroups on AM-spaces. *Semigroup Forum*, 96(2):333–347, 2018. doi:10.1007/s00233-017-9879-0.

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Disjointness preserving operators on partially ordered vector spaces

Onno van Gaans

Leiden University

vangaans@math.leidenuniv.nl

Wednesday
12:00
HB 2A

Abstract. The generator of a strongly continuous semigroup of disjointness preserving operators on a Banach lattice is a local operator (Arendt, 1986).

The definition of disjointness in general partially ordered vector spaces (Kalauch–vG, 2006) has led to a study of corresponding disjointness preserving operators. Such operators have mainly been considered on pre-Riesz spaces, which are the partially ordered vector spaces that can be embedded order densely in vector lattices. Each directed Archimedean partially ordered vector space is a pre-Riesz space. We will give a survey of the theory of disjointness preserving operators on pre-Riesz spaces. In particular, we will consider semigroups of disjointness preserving operators.

S18: Quantum information theory

Organizers: Jurij Volčič, Marc-Olivier Renou.

Second order cone relaxations for quantum Max Cut

Felix Huber
U. Gdánsk
felix.huber@ug.edu.pl

Thursday
13:15
CR 2G

Abstract. Quantum Max Cut (QMC), also known as the quantum antiferromagnetic Heisenberg model, is a QMA-complete problem relevant to quantum many-body physics and computer science. Semidefinite programming relaxations have been fruitful in designing theoretical approximation algorithms for QMC, but are computationally expensive for systems beyond tens of qubits. We give a second-order cone relaxation for QMC, which optimizes over the set of locally compatible three-qubit reduced density matrices. In combination with level-1 of the Pauli moment-SoS hierarchy, the relaxation achieves an approximation ratio of 0.526 to the ground state energy. This overcomes the 0.498 approximation ratio derived from the first level of the Pauli moment-SoS hierarchy, without relying on the second level. Our relaxation is solvable on random graphs with hundreds of qubits and provides computationally efficient lower and upper bounds on the ground state energy of large-scale quantum spin systems. This talk is based on joint work with Kevin Thompson, Ojas Parekh, and Sevag Gharibian [1].

References

[1] F. Huber, K. Thompson, O. Parekh, and S. Gharibian, Second order cone relaxations for quantum Max Cut, arxiv:2411.04120

Real Nullstellensatz for 2-step nilpotent Lie algebras

Matthias Schötz
Univerza v Ljubljani
matthiasschoetz@gmx.de

Thursday
13:45
CR 2G

Abstract. Methods of real algebraic geometry have proven to be useful tools in QIT, e.g. the NPA hierarchie can be seen as a non-commutative analog of the Lasserre hierarchie in polynomial optimization. Roughly speaking, the duality between commutative algebras and varieties translates into the duality between observables and states in quantum physics. More generally, noncommutative real algebraic geometry can be seen as a abstraction of the

theory of *-algebras of operators on a Hilbert space – the language in which quantum physics is formulated – extending the theory of C^*-algebras to the realms of unbounded operators. In my talk, which is based on [1], I present a further step into this direction, a real Nullstellensatz for 2-step nilpotent Lie algebras $\mathfrak{g}$: A quotient $\mathcal{A}$ of the universal enveloping *-algebra of $\mathfrak{g}$ has a faithful *-representation (which turns out to simply be a direct sum of Schrödinger representations) if and only if $\mathcal{A}$ is formally real.

References

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Tracial joint spectral measures

Otte Heinävaara

Caltech

oeh@caltech.edu

Thursday
14:15
CR 2G

Abstract. Given two Hermitian matrices, A and B, we introduce a new type of spectral measure, a *tracial joint spectral measure* $\mu_{A,B}$ on the plane. Existence of this measure implies large number of trace inequalities, including the following two results: 1) any two-dimensional subspace of the Schatten-p class is isometric to a subspace of L_p, and 2) if $f : \mathbb{R} \to \mathbb{R}$ has non-negative kth derivative and A and B are Hermitian matrices with A positive semidefinite, then $t \mapsto \operatorname{tr} f(tA + B)$ has non-negative kth derivative. We also give an explicit expression for the measure $\mu_{A,B}$, and consider possible extensions of the theory.

References

[1] O. Heinävaara. Tracial joint spectral measures. *Inventiones mathematicae*, 239(2):505–526, 2025. doi:10.1007/s00222-024-01309-6.

Semidefinite hierarchies for separable diagonal unitary invariant quantum states

Jonas Britz

CWI Amsterdam

jonas.britz@cwi.nl

Thursday
14:45
CR 2G

Abstract. We analyze the DPS hierarchy, a hierarchy of conic approximations for the separable cone introduced in [1], under additional assumptions on the initial bipartite quantum state. States that are invariant under multiplication with diagonal unitary matrices are called CLDUI (conjugate

local diagonal unitary invariant) and they admit a sparsity pattern, which allows for separability to be captured efficiently by the cone of pairwise completely positive matrices ([2],[3]). We show that the CLDUI sparsity pattern can be extended to any level of the DPS hierarchy. This allows to test membership in the DPS hierarchy more efficiently for CLDUI quantum states. In addition, we show further complexity reduction by reformulating the relaxations in the polynomial optimization framework (following [4]). These techniques can be also be used to test membership for general states.

Based on joint work with Monique Laurent.

References

[1] A. Doherty, P. Parrilo, F. Spedalieri. Complete family of separability criteria. *Phys. Rev.*, A 69, 022308, 2004. doi:10.1103/physreva.69.022308.

[2] N. Johnston and O. MacLean. Pairwise Completely Positive Matrices and Conjugate Local Diagonal Unitary Invariant Quantum States. *Electronic Journal of Linear Algebra*, 35:156–180, 2019. doi:10.13001/1081-3810.3842.

[3] S. Singh and I. Nechita Diagonal unitary and orthogonal symmetries in quantum theory. *Quantum*, 5:519, 2021. doi:10.22331/q-2021-08-09-519.

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Quantitative Soundness of Compiled Bell Games at Finite Security via Sequential NPA Hierarchy

Xiangling Xu

Inria Saclay

xu.xiangling@inria.fr

Thursday
16:00
CR 2G

Abstract. Compiled Bell games probe quantum non-locality with a *single* untrusted device by replacing physical separation with *quantum homomorphic encryption* (QHE)—an encryption scheme that lets a prover run a quantum circuit on encrypted data without ever decrypting. While Kalai et al. [1] showed the compilation preserves the quantum-vs-classical gap, the stronger notion of *quantum soundness*—that a dishonest quantum prover cannot exceed the original Bell score—was known only for specific games. Kulpe et al. [2] recently settled the question qualitatively for all bipartite games under infinitely secure QHE; the quantitative, finite-security case remains open.

This work establishes the first *quantitative quantum soundness bound* for all bipartite compiled Bell games $\mathcal{G}_{\text{comp}}$ at finite security λ. In particular, for every quantum polynomial time (QPT) strategy S (i.e. implementable

with poly(λ) quantum gates) we prove that the compiled score $\omega_\lambda(\mathcal{G}_{\text{comp}}, S)$ is upper bounded by

$$\omega_\lambda(\mathcal{G}_{\text{comp}}, S) \leq \omega_{qc}(\mathcal{G}) + \epsilon(\log(\lambda)) + \text{negl}(\lambda), \tag{1}$$

where $\epsilon(\log(\lambda))$ arises from the convergence rate of our novel *sequential* Navascués–Pironio–Acín hierarchy and $\text{negl}(\lambda)$ is some function, dependent of the QHE scheme and QPT strategy, that vanishes faster than λ^{-k} for every fixed k.

We further argue for the necessity of knowing the convergence rate $\epsilon(\log(\lambda))$, highlighting an open challenge in QHE correctness for "weakly commuting" registers. Our techniques, involving operator algebras and noncommutative polynomial optimization, also introduce and characterize this sequential NPA hierarchy and its conic dual, potentially of independent interest.

References

[1] Y. Kalai, A. Lombardi, V. Vaikuntanathan, and L. Yang. Quantum advantage from any non-local game. In *Proceedings of the 55th Annual ACM Symposium on Theory of Computing (STOC)*, pages 1617–1628. ACM, 2023. doi:10.1145/3564246.3585164.

[2] A. Kulpe, G. Malavolta, C. Paddock, S. Schmidt, and M. Walter. A bound on the quantum value of all compiled nonlocal games. *arXiv preprint* arXiv:2408.06711.

Bounding the asymptotic quantum value of all multipartite compiled nonlocal games

Matilde Baroni

Sorbonne Université, CNRS, LIP6, F-75005 Paris, France

matilde.baroni@lip6.fr

Thursday
16:30
CR 2G

Abstract. Nonlocal games are a powerful tools to distinguish between correlations possible in classical and quantum worlds. Kalai *et al.* (STOC'23) proposed a compiler that converts multipartite nonlocal games into interactive protocols with a single prover, relying on cryptographic tools to remove the assumption of physical separation of the players. While quantum completeness and classical soundness of the construction have been established for all multipartite games, quantum soundness is known only in the special case of bipartite games.

In this paper, we prove that Kalai's compiler indeed achieves quantum soundness for all multipartite compiled nonlocal games, by showing that any correlations that can be generated in the asymptotic case correspond to quantum commuting strategies.

Our proof uses techniques from the theory of operator algebras, and relies on a characterisation of sequential operationally no-signalling strategies as quantum commuting operator strategies in the multipartite case, thereby generalising several previous results. On the way, we prove a new chain rule for Radon-Nikodym derivatives of completely positive maps on C^*-algebras which may be of independent interest.

The Feige game

Simon Schmidt

Ruhr University Bochum
s.schmidt@rub.de

Thursday
17:00
CR 2G

Abstract. In this talk, we investigate a nonlocal game introduced by Feige in [1], which has the property that its classical value does not decrease when it is played twice in parallel. We will show that the quantum value for this game is higher than the classical value. In addition, we discuss some interesting properties of the game, including parallel repetition, synchronicity and its relation to "or"-games in the quantum setting.

References

[1] U. Feige. On the success probability of the two provers in one-round proof systems. *Proceedings of the Sixth Annual Structure in Complexity Theory Conference*, 1991. doi:10.1109/SCT.1991.160251.

Quantum waterfalls can be parallelized

J. William Helton

UC San Diego
helton@ucsd.edu

Friday
10:45
CR 2G

Abstract. Many classical computer algorithms can be paralyzed efficiently; what about quantum computers? An algorithm can be described as having layers, one composed with another, with the depth n of the circuit being the number of layers. An algorithm might be presented as having n simple layers, but if we are able to build more complicated layers, can we construct an equivalent algorithm with a few layers? This is an issue, which goes back to the early days when people became enthusiastic about the possibility of quantum computers.

One of the most straightforward test cases is called the quantum waterfall or quantum staircase. It is a tensor product analog of a matrix of 2×2 blocks supported on the diagonal and the first diagonal below it. It was conjectured in the late 90s that an n layer quantum waterfall cannot be produced with an algorithm having fewer than n layers.

This conjecture turns out to be way too pessimistic and the talk describes recent work in progress with to Adam Bene Watts, Joe Slote, Charlie Chen on a theorem constructing a parallelization of any n layer quantum waterfall which yields (asymptomatically) $\log n$ layers. Gratifying to our IWOTA crowd is that a substantial ingredient is a theorem originating with Chandler Davis.

Measurement algebras in Bell non-locality

Máté Farkas

Department of Mathematics, University of York, Heslington, York, YO10 5DD, United Kingdom
mate.farkas@york.ac.uk

Friday
11:15
CR 2G

Abstract. In this talk I will revisit some results in Bell non-locality that make use of measurement algebras. These are algebras generated by certain relations that a collection of measurement operators satisfy. The paradigmatic example is the algebra generated by two projections, the irreducible representations of which are at most two-dimensional. This property is essentially what is known as Jordan's lemma, and it vastly simplifies the analysis of Bell non-locality with two binary measurements per party.

While similar general results do not exist for more complex Bell scenarios, the maximal violation of certain Bell inequalities are often given by a (somewhat) unique representation of a measurement algebra. These algebras give rise to generalised ("device-independent") notions of well-known classes of measurements, such as mutually unbiased bases or symmetric informationally complete (SIC) POVMs [1].

I will introduce some of these measurement algebras, as well as a new algebra we call "balanced informationally complete" (BIC), whose smallest representations we call BIC-POVMs. I will then show how these measurement algebras appear in Bell non-locality, and how the uniqueness and algebraic properties allow us to prove cryptographic security of protocols using these measurements [2, 3].

References

[1] A. Tavakoli, M. Farkas, D. Rosset, J. D. Bancal, J. Kaniewski, Mutually unbiased bases and symmetric informationally complete measurements in Bell experiments. *Sci. Advances* 7(7), eabc3847, 2021.

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Quantum field theory can be more contextual than non-relativistic quantum theory

Victoria J Wright

Quantinuum
victoria.wright@quantinuum.com

Friday
11:45
CR 2G

Abstract. Quantum theory allows for correlations between spacelike separated experiments that go beyond the set of local realist correlations of classical physics. However, since the resolution of Tsirelson's conjecture we know that the set of quantum commuting correlations—that is identified by the mathematical framework of algebraic quantum field theory (AQFT)—is strictly larger than the (closure of the) set of quantum spatial correlations—that are allowed in non-relativistic quantum theory (NRQT). An experiment observing correlations beyond the quantum spatial set would greatly impact our understanding of nature. Currently, these correlations are difficult to identify and it is not known whether any have a physical realisation. Both the theoretical and technological challenges to deciding these problems are great.

In this presentation, I will consider the sets of correlations identified by the AQFT and NRQT formalisms for a different type of experiment: prepare-and-measure experiments known as (generalised) contextuality scenarios. One may initially expect that the relative simplicity of a prepare-and-measure experiment would not allow us to probe the distinction between AQFT and NRQT. Nonetheless, using the non-local case [1] and a result about steering in C*-algebras [2, 3], I will demonstrate that the set of potential AQFT correlations for contextuality scenarios is strictly larger than that of NRQFT. The simplicity of contextuality scenarios comes at the cost of requiring more assumptions about the experiment. However, this simplified setting may provide a more feasible testing ground for probing the difference in the predictions of AQFTs and NRQT both theoretically and experimentally.

References

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Zero-error communication under completely positive maps

Mizanur Rahaman

Chalmers University of Technology
mizanurr@chalmers.se

Friday
12:15
CR 2G

Abstract. Motivated by Shannon's theory of zero-error communication, we study the quantum channel (trace preserving completely positive map) version of the zero-error capacity problem which can be thought as a non-commutative version of Shannon's paradigm. More specifically, we investigate how do the various information capacities behave over time, that is, under repeated applications of a quantum channel. We show that in the limit of infinite time, the capacities are characterized by efficiently computable properties of the peripheral eigenspace of the quantum channel. This talk is based on two joint works, one (https://arxiv.org/abs/2402.18703) with Nilanjana Datta (University of Cambridge) and Satvik Singh (University of Cambridge), and the other (https://arxiv.org/abs/2408.00116) is with Omar Fawzi (ENS de Lyon) and Mostafa Taheri (ENS de Lyon).

S19: Session in honour of Harry Dym

Organizers: Bill Helton, David Kimsey.

A family persective

Nadav Dym

Technion - Israel Institute of Technology
nadavdym@technion.ac.il

Wednesday
10:30
Waaier 3

Abstract.

Between East and West: Harry Dym's contributions to Mathematical System Theory

Patrick Dewilde

TUM-IAS and TU Delft
p.dewilde@me.com

Wednesday
10:40
Waaier 3

Abstract. Harry Dym, who passed away July 15th, 2024 as an em. Professor of the Weizmann Institute in Rehovot, Israel, has been a major contributor connecting East and West in the area of Mathematical System and Circuit Theory, more specifically, connecting Operator Theory as practiced in the West with the key ideas generated in the wake of the seminal work of M.G. Krein, his students and collaborators (in particular D. Arov and I. Gohberg), thereby making substantial contributions not only to mathematics but also to its application in System and Circuit Theory.

I shall briefly illuminate this statement using several examples starting with Harry Dym's seminal book with McKean, followed with an account of various results in inverse scattering theory and the movement towards generalizations covering an ever larger class of systems (multi-variable, time-variant).

Harry Dym had the knack of bringing people together and making his (interestingly and invitingly messy) office in the Weizmann Institute a great place for discussion and communication. He was an excellent teacher and great coach for eminent Ph.D. students, exposing them not only to his own ideas, but also those of other mathematicians and engineers in East and West, many of whom were his frequent visitors.

Personally, I have been a fortunate beneficiary of Harry's hospitality, erudition and friendship over at least 45 years, and am missing his humor, wisdom, good cheer and sympathy very much.

References

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[3] P. Dewilde and H. Dym. Lossless chain scattering matrices and optimum linear prediction: The vector case. *Circuit Theory and Appl.*, 9:135–175, 1981.

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Recollections of Harry

Bill Helton

UC San Diego
helton@ucsd.edu

Wednesday
10:50
Waaier 3

Abstract. The talk will have a few pictures of and words regarding Harry Dym, my good friend for many decades, and frequent collaborator.

Factorization of generalized J-inner matrix-valued functions

Volodymyr Derkach

Vasyl Stus Donetsk National University, Ukraine
derkach.v@gmail.com

Wednesday
11:00
Waaier 3

Abstract. We recall Kreĭn-Langer factorization formula for generalized Schur matrix-valued function and write the noncancellation conditions as the Francis identity. This identity plays a crucial role in proving the factorization formulas for generalized J-inner matrix-valued function W and in describing the excluded parameters for the linear-fractional transformation generated by W. The results are based on joint work with Harry Dym [1].

References

[1] V. Derkach and H. Dym, On linear fractional transformations associated with generalized J–inner matrix functions, Integ. Eq. Oper. Th., 65 (2009), 1-50 10.1007/s00020-009-1709-7

Indefinite de Branges–Rovnyak spaces on compact real Riemann surfaces

Victor Vinnikov

Dept. of Mathematics, Ben Gurion University of the Negev, Beer Sheva, Israel
vinnikov@math.bgu.ac.il

Wednesday
11:10
Waaier 3

Abstract. I will state a result from a joint work with Daniel Alpay and Ariel Pinhas [1] that gives a complete characterization of reproducing kernel Pontryagin spaces on a compact real Riemann surface that are invariant under a pair of generalized difference quotient operators and satisfy an appropriate version of de Branges structure identity. The result and its proof bring together several themes that were omnipresent in Harry Dym's work over decades influencing me, like many other operator theorists, a great deal, both directly and indirectly: reproducing kernel spaces; indefiteness, both in the guise of Pontryagin (and Krein) spaces and in the study of J-contractive matrix functions; and the many faces of de Branges spaces.

References

[1] D. Alpay, A. Pinhas, and V. Vinnikov. Commuting operators over Pontryagin spaces with applications to system theory. *J. Funct. Anal.* 284 (2023), article 10986.

CMV matrices, a matrix version of Baxter's theorem, scattering and de Branges spaces

David Kimsey

Newcastle University
david.kimsey@newcastle.ac.uk

Wednesday
11:20
Waaier 3

Abstract. In this talk we establish bijective correspondences between five classes of objects: (1) Matricial Schur parameters which are summable; (2) A spectral density belonging to a matricial Wiener algebra; (3) certain CMV matrices; (4) scattering matrices belonging to a matricial Wiener algebra; (5) a class of solutions of a certain Nehari problem. de Branges spaces of vector-valued polynomials are used to ease certain computations.

This talk is based on joint work with Harry Dym.

From de Branges Matrices to de Branges Operators: Towards a Functional Model

Santanu Sarkar

Indian Institute of Technology Ropar
santanu@iitrpr.ac.in

Wednesday
11:30
Waaier 3

Abstract. The theory of de Branges matrices, the corresponding de Branges spaces of vector-valued entire functions with matrix-valued reproducing kernels, and their applications has been extensively developed by D. Arov and H. Dym. In this talk, we intend to observe the transition of the theory of de Branges spaces based on matrix valued reproducing kernels to operator valued reproducing kernels. To this end, we introduce the de Branges operators $\mathfrak{E} = (E_-, E_+)$ analogous to de Branges matrices, which are based on pairs of Fredholm operator-valued entire functions. The notion of entire operators dates back to M. G. Krein's work on several classical problems in analysis and differential equations. Finally, we present a functional model for entire operators with infinite deficiency indices, realized in a vector-valued de Branges space based on a de Branges operator. This is part of joint work with Subhankar Mahapatra and Bharti Garg.

References

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A Noncommutative Szegő-Type Theorem

Connor Gauntlett

Newcastle University
c.gauntlett@newcastle.ac.uk

Wednesday
11:40
Waaier 3

Abstract. Building on work of Constantinescu and Johnson, we introduce notions of Verblunsky coefficients (or Schur parameters) and orthogonal

polynomials to the free noncommutative setting via Jury and Martin's noncommutative measures, and we apply these notions to generalise a number of equalities surrounding the weak Szegő limit theorem. A crucial tool in this analysis is the Christoffel function associated to a noncommutative measure.

This talk is based on joint work with David Kimsey.

Open Microphone

Wednesday
11:50
Waaier 3

Abstract. All participants are invited to contribute to the session in honour of Harry Dym.

S20: Spaces of analytic functions

Organizers: Nikolaos Chalmoukis, Michael Hartz.

Determinants of Random Unitary Pencils

Michael Jury
University of Florida
mjury@ufl.edu

Wednesday
10:30
CR 2H

Abstract. By a *random unitary pencil* we mean an expression of the form

$$L_X(U) \coloneqq I_k \otimes I_d + \sum_{j=1}^{g} X_j \otimes U_j$$

where $X = (X_1, \dots, X_g)$ is a fixed g-tuple of $k \times k$ matrices, and we consider the U_j to be unitary matrices sampled independently with respect to Haar measure on the $d \times d$ unitary group $\mathcal{U}(d)$. Motivated by the rich theory that exists in the case of a single variable ($g = 1$) we describe a conjecture in the multivariate case ($g > 1$), about the limiting behavior of the covariances $\mathbb{E}[\det(L_X(U))\overline{\det(L_Y(U))}]$ for contractive g-tuples X and Y, as $d \to \infty$. The conjecture is true at least in the case of upper triangular X and Y, which leads to an interesting (but still poorly understood) connection between random matrix theory and the Drury-Arveson space. This is joint work with George Roman.

Interpolation in de Branges-Rovnyak spaces

Giuseppe Lamberti
Institut de Mathématiques de Bordeaux
giuseppe.lamberti@math.u-bordeaux.fr

Wednesday
11:00
CR 2H

Abstract. We provide a characterization of universal and multiplier interpolating sequences for de Branges-Rovnyak spaces where the defining function is a non-extreme, rational function. Previous work on this topic examined interpolation in de Branges-Rovnyak spaces specifically in cases where the space coincides with a local Dirichlet space under norm equivalence. Our results carry over to recently introduced higher order local Dirichlet spaces [1] and thus generalize previously known results. In this general framework, we prove the equivalence of universal and multiplier interpolating sequences and establish explicit, verifiable conditions for their characterization. We also explore random interpolation through the use of Steinhaus sequences,

where the sequence of the radii is fixed, while the arguments are independent and uniformly distributed on $[0, 2\pi]$.

This is a joint work with Andreas Hartmann.

References

[1] S. Luo, C. Gu and S. Richter. Higher order local Dirichlet integrals and de Branges–Rovnyak spaces. *Adv. Math.*, **385** (2021), Paper No. 107748, 47 pp. doi:10.1016/j.aim.2021.107748.

Characterization of boundary conformality of holomorphic self-maps via hyperbolic geometry

Pavel Gumenyuk

Politecnico di Milano

pavel.gumenyuk@polimi.it

Wednesday
11:30
CR 2H

Abstract. This talk is based on the joint paper [1]. We deal with two classical notions of boundary conformality for holomorphic self-maps $\varphi : \mathbb{D} \to \mathbb{D}$ of the unit disk $\mathbb{D} := \{z \in \mathbb{C} : |z| < 1\}$:

($\mathrm{C_w}$) The non-tangential conformality, in the sense of angle preservation, at a boundary point $\sigma \in \partial\mathbb{D}$:

$$\angle \lim_{z\to\sigma} \varphi(z) =: \varphi(\sigma) \in \partial\mathbb{D}, \quad \angle \lim_{z\to\sigma} \arg \frac{\varphi(z) - \varphi(\sigma)}{z - \sigma} = \arg \frac{\varphi(\sigma)}{\sigma};$$

($\mathrm{C_s}$) The existence of a finite angular derivative at a boundary point $\sigma \in \partial\mathbb{D}$ in the sense of Carathéodory:

$$\angle \lim_{z\to\sigma} \varphi(z) =: \varphi(\sigma) \in \partial\mathbb{D}, \quad \angle \lim_{z\to\sigma} \frac{\varphi(z) - \varphi(\sigma)}{z - \sigma} =: \varphi'(\sigma) \in \mathbb{C}.$$

We show that the above versions of the boundary conformality correspond exactly to two certain natural cases of non-tangential asymptotic equality in the invariant Schwarz lemma. Namely, we prove that the weaker version ($\mathrm{C_w}$) of boundary conformality is equivalent to any of the following two conditions:

$$\angle \lim_{z,w\to\sigma} \frac{\mathrm{k}_{\mathbb{D}}\big(\varphi(z), \varphi(w)\big)}{\mathrm{k}_{\mathbb{D}}\big(z, w\big)} = 1 \quad \text{and} \quad \angle \lim_{z\to\sigma} \mathrm{D}_h\, \varphi(z) = 1,$$

where $\mathrm{k}_{\mathbb{D}}(\cdot, \cdot)$ stands for the Poincaré distance in $\mathbb{D}$ and

$$\mathrm{D}_h\, \varphi(z) := \lim_{w\to z} \frac{\mathrm{k}_{\mathbb{D}}\big(\varphi(z), \varphi(w)\big)}{\mathrm{k}_{\mathbb{D}}\big(z, w\big)} = \frac{(1 - |z|^2)\, |\varphi'(z)|}{1 - |\varphi(z)|^2}.$$

We also show that the stronger version ($\mathrm{C_s}$) of boundary conformality is equivalent to $\angle\lim_{z,w\to\sigma}\Big(\mathrm{k}_{\mathbb{D}}\big(\varphi(z),\varphi(w)\big)-\mathrm{k}_{\mathbb{D}}(z,w)\Big)=0$ and to

$$I(\sigma)\coloneqq\int_0^1\big(1-\mathrm{D}_h\,\varphi(r\sigma)\big)\,\frac{\mathrm{d}r}{1-r^2}\;<\;+\infty.$$

We also characterize ($\mathrm{C_s}$) in operator-theoretic terms as a case of non-tangential asymptotic equality in the Cauchy – Bunyakovsky – Schwarz inequality

$$\frac{\langle k_z^\varphi,k_w^\varphi\rangle_\varphi}{\|k_z^\varphi\|_\varphi\,\|k_w^\varphi\|_\varphi}\leqslant 1,$$

where k_z^φ, $\langle\cdot,\cdot\rangle_\varphi$, and $\|\cdot\|_\varphi$ stand for the reproducing kernel, the inner product, and the norm in the de Banges – Rovnyak space $\mathcal{H}(\varphi)$ associated to φ.

Equivalence between ($\mathrm{C_s}$) and convergence of the integral $I(\sigma)$ was independently proved in [2]. Some qualitative aspects of this equivalence are studied in [3] and [4].

References

[1] P. Gumenyuk, M. Kourou, A. Moucha, O. Roth. Hyperbolic distortion and conformality at the boundary. *Adv. Math.*, **470** (2025) paper 110251. doi:10.1016/j.aim.2025.110251.

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Generalization of Foguel-Hankel Operators with Multiplication Operators

Giovanni Marano

Università degli Studi Milano-Bicocca
g.marano7@campus.unimib.it

Wednesday
12:00
CR 2H

Abstract. Foguel-Hankel type operators are defined as

$$\Gamma_f=\begin{pmatrix}S^* & H_f\\ 0 & S\end{pmatrix}$$

where S is the shift operator, i.e., the operator that multiplies by the holomorphic function z and H_f is the Hankel operator with symbol f.

The idea of our work is to study a more general version of such operators. Given φ a holomorphic function from the disk to the disk, we define the generalized Foguel-Hankel operator as

$$\Gamma_{f,\varphi} := \begin{pmatrix} JM^*_{\widetilde{\varphi}}J & H_f \\ 0 & M_\varphi \end{pmatrix}$$

where J is the flip operator and $\widetilde{\varphi}$ denotes the function obtained from φ by taking the complex conjugate of its power series coefficients.

This generalization preserves many properties of the classical operator: it is a linear and bounded operator, and it satisfies the Kreiss condition if f' belongs to the Bloch space. Another property we want to investigate is whether such an operator, with the symbol f' in the Bloch space, is not only Kreiss but also power bounded.

This work leads to an interesting open question: while it is known that the power bounded condition implies the Kreiss condition and in general there exist counter examples for the converse implication, we do not know if for generalized Foguel Hankel operators the two conditions are equivalent. We want to analyze whether it is possible to modify the conditions on the symbols f and φ to construct a potential counterexample.

Point-evaluation and related extremal problems

Sarah May Instanes

Norwegian University of Science and Technology (NTNU)

sarah.m.instanes@ntnu.no

Thursday
13:15
HB 2A

Abstract. We study the constant $\mathcal{C}_p$ defined as the smallest constant C such that $|f(0)|^p \leq C\|f\|_p^p$ holds for every function f in the Paley–Wiener space PW^p. Brevig, Chirre, Ortega-Cerdà, and Seip have shown that $\mathcal{C}_p < p/2$ for all $p > 2$. We improve this bound for $2 < p \leq 5$ by solving an optimization problem. We also see how similar techniques can be used to give some upper bounds for the related problem of determining the constant $\mathcal{K}_{d,p}$ defined to be the smallest constant K such that $|P(1)|^p \leq K\|P\|_p^p$, for any polynomial P of degree d.

Bounded Point Derivations on a Space of Analytic Functions

Stephen Deterding

Marshall University

deterding@marshall.edu

Thursday
13:45
HB 2A

Abstract. A *bounded point derivation* is an operator that generalizes the process of taking the derivative of a function and evaluating it at a point,

even in contexts where classical differentiation may not apply. Notably exhibiting the existence of a bounded point derivation at a boundary point is one way to show that the elements of a function space possess a greater degree of analyticity at the boundary than would otherwise be expected. An important and widely studied class of analytic functions is the space of *analytic Lipschitz functions* – functions that are analytic on a domain and satisfy a global Lipschitz condition. We explore how bounded point derivations reveal enhanced smoothness on the boundary in this setting, investigate related conditions that imply similar smoothness, and highlight key distinctions between them. Our results demonstrate the different ways that analyticity can extend to the boundary of a domain.

On the spectrum of the infinitesimal generator for certain C_0-semigroups

Maria Kourou
Julius-Maximilians Universität Würzburg
maria.kourou@uni-wuerzburg.de

Thursday
14:15
HB 2A

Abstract. Let $(\varphi_t)_{t\geq 0}$ be a parabolic one-parameter semigroup of holomorphic self-maps of the unit disk $\mathbb{D}$ and let $(T_t)_{t\geq 0}$ denote the strongly continuous semigroup of composition operators induced by $(\varphi_t)_{t\geq 0}$ on the classical Hardy space H^p, $p \geq 1$. In this talk, we investigate the point spectrum of the infinitesimal generator of (T_t). Namely, we establish an inclusion relation for the point spectrum when the associated Koenigs domain of (φ_t) asymptotically contains a sector of a prescribed angle opening. Furthermore, we discuss examples illustrating cases of both strict inclusion and equality, depending on the geometric properties of the corresponding Koenigs domain. The results presented are based on a joint work with E. Theodosiadis and K. Zarvalis.

Carleson measures and interpolating sequences in the polydisc

Alberto Dayan
Saarland University
dayan@math.uni-sb.de

Thursday
14:45
HB 2A

Abstract. Interpolating sequences for $H^p(\mathbb{D})$ and their connections to Carleson measures are very well understood since the seminal works of Carleson and Shapiro & Shields. On the other hand, a description of interpolating sequences and Carleson measures for Hardy spaces on the

polydisc has yet to emerge, despite the efforts that have been made in this direction in the last few decades.

One question that we will consider in this talk is the following: does any interpolating sequence for $H^p(\mathbb{D}^d)$ generate a Carleson measure? In dimension $d = 1$, the answer is yes for all p, due to a theorem of Shapiro & Shields. We show that, for $d \geq 2$, the answer is yes only for p large enough.

This talk is mostly based on a joint work with Nikolaos Chalmoukis.

Zeros of optimal polynomial approximants

Myrto Manolaki

University College Dublin
myrto.manolaki@ucd.ie

Thursday
16:00
HB 2A

Abstract. The notion of optimal polynomial approximants arises naturally from classical problems in function theory. Such polynomials approximate, in some optimal sense, reciprocals of functions in certain function spaces on the unit disc. In this talk, we will focus on the behaviour of zeros of optimal polynomial approximants for the setting of Hardy spaces H^p. (Based on a joint project with C. Bénéteau, R. Cheng, C. Felder, D. Khavinson and K. Maronikolakis.)

Thermal states on Mittag Leffler Fock space of the slitted plane

Nathanael Alpay

University of California Irvine
nalpay@uci.edu

Thursday
16:30
HB 2A

Abstract. Number states and thermal states form an important class of physical states in quantum theory. A mathematical framework for studying these states is that of a Fock space over an appropriate Hilbert space. Several generalizations of the usual Bosonic Fock space have appeared recently due to their importance in many areas of mathematics and other scientific domains. One of the most prominent generalization of Fock spaces is the Mittag-Leffler (ML) Fock space of the slitted plane. Natural generalizations of the basic operators of quantum theory can be obtained on ML Fock spaces. Following the construction of the creation and annihilation operators in the Mittag-Leffler Fock space of the slitted plane by Rosenfeld, Russo, and Dixon, (J. Math. Anal. Appl. 463, 2, 2018). We construct and study the number states and thermal states on the ML Fock space of the slitted plane. Thermal states on usual Fock space form an important subclass of the so called quantum gaussian states, an analogous theory of more general quantum states (like

squeezed states and Bell states) on ML Fock spaces is an area open for further exploration.

Logarithmic integrability, but locally

Bartosz Malman

Mälardalen University
bartosz.malman@mdu.se

Thursday
17:00
HB 2A

Abstract. If an L^1 function f on the circle has Fourier coefficients $(\widehat{f}(n))_n$ that vanish for all sufficiently large positive n, then $\log|f|$ will be L^1 also. This fact is known to some operator theorists as *Jensen's inequality*. A problem which came up in my study of spaces of analytic functions is related to this, but instead asks to infer from $(\widehat{f}(n))_n$ if $\log|f|$ is integrable over some short arc on the circle. In my talk, I will explain what I know about such *local* Jensen-type inequalities.

On log-integrability of Radon–Nikodym derivatives

Rob Martin

University of Manitoba
Robert.Martin@umanitoba.ca

Thursday
17:30
HB 2A

Abstract. We apply functional analytic and reproducing kernel techniques to study finite and positive Baire measures on the complex unit circle. In particular, we will show that if μ is such a measure, then $\mu = f \cdot m$ has log-integrable Radon–Nikodym derivative, f, with respect to normalized Lebesgue measure, m, if and only if $H^2(\mu) := \mathbb{C}[\zeta]^{-\|\cdot\|_{L^2(\mu)}}$, is a reproducing kernel Hilbert space of holomorphic functions in the unit disk. Moreover, in this case, $H^2(\mu) = \mathcal{R}(g^{-1})$ is the *operator–range space*, in the sense of de Branges and Rovnyak, of a closed and generally unbounded multiplication operator, M_g^{-1}, with dense domain in the Hardy space, $H^2 = H^2(m)$. Here, $g \in H^2$ is the outer function determined uniquely by $\frac{1}{2}\log f$ and the Riesz exponential integral formula for outer functions.

We further provide a new functional analytic proof and extension of a classical result of Grenander and Szegö, which computes the inverse of the log-integrable Radon–Nikodym derivative of μ using orthogonal polynomials.

References

[1] R.T.W. Martin On log-integrability of Radon–Nikodym derivatives. in *Operator Theory*, Springer, 2025.

S21: Spectral theory, in honour of Heinz Langer

Organizers: Christiane Tretter, Carsten Trunk.

The Kreĭn formula and its Weyl families

Henk de Snoo

University of Groningen
h.s.v.de.snoo@rug.nl

Tuesday
13:15
Waaier 3

Abstract. In 1977 Langer and Textorius formulated Krein's formula in the context of linear relations for exit space extensions of symmetric relations. The parameters in this formula will be discussed in terms of Weyl functions of boundary triplets and Weyl families for boundary relations.

Analytic continuation of time in Brownian motion. Stochastic distributions approach

Daniel Alpay

Chapman University, Orange (CA), USA
alpay@chapman.edu

Tuesday
13:45
Waaier 3

Abstract. With the use of Hida's white noise space theory space theory and spaces of stochastic distributions, we present a detailed analytic continuation theory for classes of Gaussian processes, with focus here on Brownian motion. For the latter, we prove and make use a priori bounds, in the complex plane, for the Hermite functions; as well as a new approach to stochastic distributions. This in turn allows us to present an explicit formula for an analytically continued white noise process, realized this way in complex domain. With the use of the Wick product, we then apply our complex white noise analysis in a derivation of a new realization of Hilbert space-valued stochastic integrals.

This is joint work with Luis Daniel Abreu (University of Vienna), Tryphon Georgiou (University of California at Irvine) and Palle Jorgensen (University of Iowa).

Spectral Theory of Infinite Dimensional Dissipative Hamiltonian Systems

Volker Mehrmann

Technische Universität Berlin, Germany
mehrmann@math.tu-berlin.de

Tuesday
14:15
Waaier 3

Abstract. The spectral theory for operator pencils and operator differential-algebraic equations is studied. Special focus is laid on singular operator pencils and three different concepts of singularity of operator pencils are introduced. The concepts are analyzed in detail and examples are presented that illustrate the subtle differences. It is investigated how these concepts are related to uniqueness of the underlying algebraic-differential operator equation, showing that, in general, classical results known from the finite dimensional case of matrix pencils and differential-algebraic equations do not prevail. The results are then studied in the setting of structured operator pencils arising in dissipative differential-algebraic equations. Here, unlike to the general infinite-dimensional case, the uniqueness of solutions to dissipative differential-algebraic operator equations is closely related to the singularity of the pencil.
(Joint work with Christian Mehl und Michal Wojtylak)

Spectral analysis of Klein-Gordon problems

Christiane Tretter

University of Bern, CH
tretter@math.unibe.ch

Tuesday
14:45
Waaier 3

Abstract. This talk will give an overview of two Krein space approaches to abstract Klein-Gordon problems and the results obtained for the corresponding spectra. The results will be applied to the physical case of the Klein-Gordon equation

$$\left(-\left(-\mathrm{i}\hbar\frac{\partial}{\partial t}-e\varphi\right)^2+c^2\left(-\mathrm{i}\hbar\nabla-\frac{e}{c}\vec{A}\right)^2+m^2c^4\right)U=0$$

in $L_2(\mathbb{R}^n)$, describing the motion of a relativistic particle of mass m and charge e in an electrostatic field with scalar potential φ and vector potential $\vec{A}$; here c is the speed of light and $\hbar$ is the Planck constant. In addition, for this case, new results on the solvability complexity index (SCI) of computing the spectrum of the Klein-Gordon equation in $L_2(\mathbb{R}^n)$ will be presented.
(Joint work with Heinz Langer† and Branko Najman†, and with Frank Rösler)

On the structure of expansive matrices in indefinite inner product spaces

A.C.M. Ran

Vrije Universiteit, Amsterdam, The Netherlands and North-West University, Potchefstroom, South Africa

a.c.m.ran@vu.nl

Tuesday
16:00
Waaier 3

Abstract. Let $H = H^*$ be an invertible matrix. A matrix A is called *H-expansive* if $A^*HA - H = D \geq 0$. We shall say that a pair (A_2, H_2) is a *unitary compression* of (A, H) if there is an H-nondegenerate subspace K and an H-neutral subspace M such that with respect to the decomposition $\mathbb{C}^n = M \dot{+} K \dot{+} ((HK)^\perp \ominus M)$ we have

$$A = \begin{bmatrix} A_1 & A_{12} & A_{13} \\ 0 & A_2 & A_{23} \\ 0 & 0 & A_3 \end{bmatrix}, \qquad H = \begin{bmatrix} 0 & 0 & H_{13} \\ 0 & H_2 & 0 \\ H_{13}^* & 0 & H_{33} \end{bmatrix},$$

and $A^*HA - H = \left[\begin{smallmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \widetilde{D} \end{smallmatrix}\right]$ for some positive semidefinite $\widetilde{D}$.

If in addition the subspace K is A-invariant (and so $A_{12} = 0$) then we shall say that the pair (A_2, H_2) is a *unitary part* of (A, H).

In the talk we present a result on the structure of expansive matrices which exhibits the largest unitary compression of the matrix. The result is closely related to a decomposition for selfadjoint operators in an indefinite inner product space which the author learned from Heinz Langer.

Localisation of the essential spectrum

Marko Lindner

Hamburg University of Technology

lindner@tuhh.de

Tuesday
16:30
Waaier 3

Abstract. After the spectrum and the pseudospectrum, we now also derive inclusion sets and approximations to the essential spectrum of banded, bounded and non-normal operators on ℓ^2.

Our inclusion sets come as unions of pseudospectra of certain submatrices of chosen size. Via this choice, we can balance accuracy against numerical cost. The philosophy is to split one global spectral problem into several local problems of moderate size.

This is joint work with Simon Chandler-Wilde (Reading).

Eigenvalues of parametric rank-one perturbations of matrix pencils

Hannes Gernandt

University of Wuppertal
gernandt@uni-wuppertal.de

Tuesday
17:00
Waaier 3

Abstract. Motivated by matrix perturbation results [2, 3] and structured perturbation results [4], we study the behavior of eigenvalues of regular matrix pencils $sE - A$, $E, A \in \mathbb{C}^{n\times n}$ under parameter-dependent rank-one perturbations of the form

$$sF_\tau - G_\tau := \tau(as - b)uv^*, \quad \tau \in \mathbb{C},$$

where $a, b \in \mathbb{C}$ and $u, v \in \mathbb{C}^n$ are fixed and only τ is allowed to vary. In particular, we address the change in algebraic multiplicities, the change in eigenvalues for small parameter variations, and the asymptotic behavior of eigenvalues as the parameter τ tends to infinity. In addition to that, an interlacing result for rank-one perturbations of matrix pencils is obtained. Finally, we apply the result to a redesign problem for electrical circuits. The talk is based on the joint work [1] with Carsten Trunk (TU Ilmenau).

References

[1] H. Gernandt and C. Trunk. Eigenvalues of parametric rank-one perturbations of matrix pencils. *Linear Algebra Appl.*, 708:429–457, 2025. doi.org/10.1016/j.laa.2024.12.012.

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[4] C. Mehl, V. Mehrmann, and M. Wojtylak. Parameter-dependent rank-one perturbations of singular Hermitian or symmetric pencils. *SIAM J. Matrix Anal. Appl.*, 38:72–95, 2017. doi.org/10.1137/16M1060352.

On the relation between the spectra of linear pencils and linear relations

Carsten Trunk

TU Ilmenau, Germany
carsten.trunk@tu-ilmenau.de

Tuesday
17:30
Waaier 3

Abstract. The relation between the spectra of operator pencils with unbounded coefficients and of associated linear relations is investigated.

It turns out that various types of spectrum coincide and the same is true for the Weyr characteristics. This characteristic describes how many independent Jordan chains up to a certain length exist.

Linear relations are just subspaces of the cartesian product $X \times X$ of a normed Banach space X. They allow a rich spectral theory. Here we associate with an operator pencil

$$\lambda E - A$$

the two subspaces

$$\ker[A, -E] \quad \text{and} \quad \operatorname{ran}\left[\begin{smallmatrix} E \\ A \end{smallmatrix}\right],$$

which are called, for obvious reasons, the *kernel* and the *range representation*. The spectrum and the Weyr characteristic of the operator pencil coincides with the spectrum and the Weyr characteristic for the range and the kernel representation. Furthermore, we consider Hermitian pencils and their correspondig range and kernel representations.

The talk is based on a joint collaboration with T. Reis and H. Winkler, both from TU Ilmenau.

S22: Open session: Operator Theory and its Applications

Organizers: Philip Preußler, Jens de Vries, Hans Zwart.

Invariant subspaces and related topics in some Banach spaces of analytic functions

Ramiz Tapdigoglu, Mehmet Gürdal, Mubariz T. Garayev and Saime Kolanci

Suleyman Demirel University
saimekolanci@sdu.edu.tr;
gurdalmehmet@sdu.edu.tr

Tuesday
13:15
HB 2D

Abstract. We study a local algebra structure of some Banach spaces of analytic functions including Hardy spaces $H^p(\mathbb{D})$, $1 \leqslant p < +\infty$, and $\ell^p_A(\mathbb{D})$, $1 \leqslant p < +\infty$, where $\mathbb{D} = \{z \in \mathbb{C} : |z| < 1\}$ is the unit disk. Namely, we prove that the spaces under consideration are Banach algebras with respect to the classical Duhamel product [3, 4]. This result implies, in particular, the uniallularity of the Volterra integration operator V, $Vf(z) = \int_0^z f(t)\,dt$. We also give applications to the Volterra integral operator on this space. We also discuss Katznelsson-Tzafriritype results [2] in $\ell^p_A(\mathbb{D})$. Moreover, we characterize the so-called extended eigenvalues and extended eigenvectors of the operator V [1]. We prove some existence theorems for invariant subspaces of operators.

References

[1] A. Biswas, A. Lambert, S. Petrovic. Extended eigenvalues and the Volterra operator. *Glasgow Math. J.*, 44(3):521–534, 2002. doi:10.1017/S0017089502030015X.

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General solution of corona problem

Marek Kosiek, Krzysztof Rudol

Jagiellonian University, Kraków, AGH University of Science and Technology, Kraków

Marek.Kosiek@im.uj.edu.pl;
grrudol@cyfronet.pl

Tuesday
13:45
HB 2D

Abstract. Our main result is a description of the spectrum of bidual algebra A^{**} of a uniform algebra A. This allows us to obtain abstract corona theorem for certain uniform algebras, asserting density of a specific Gleason part in the spectrum of an H^∞ – type subalgebra of A^{**}. There is an isometric isomorphism of the latter subalgebra with $H^\infty(G)$ for a wide class of domains $G \subset \mathbb{C}^d$. Using abstract corona theorem we show the density of the canonical image of G in the spectrum of $H^\infty(G)$, solving positively corona problem for this class (which in particular includes balls and polydisks).

Quantitative approach to weak amenability of Banach algebras

Krzysztof Koczorowski

Adam Mickiewicz University in Poznań, Poland

krzkoc@amu.edu.pl

Tuesday
14:15
HB 2D

Abstract. The definition of an amenable Banach algebra was introduced after Johnson's theorem (1972) which provides an equivalent condition for amenability of locally compact groups in terms of convolution Banach algebras and derivations. In this talk we will show amenability properties of vector-valued sequence algebras, namely the relation between amenability properties of a Banach algebra A and those of $\ell_p(A)$, where $1 \leq p < \infty$.

Recall that in [8] it is shown that for a compact Hausdorff space K and a Banach algebra A, Banach algebra $C(K, A)$ (A-valued continuous functions on K) is (weakly) amenable if and only if so is A (weak amenability proved only for commutative A). In case when A is a C^*-algebra (thus weakly amenable by [2, Corollary 4.2]), weak amenability of $\ell_1(A)$ was implicitly proved in [5] and [6]. Also characterization of amenable $\ell_\infty(A)$ was given in [4, Theorem 2.5] for C^*-algebras A. It is also known that if A is a Banach algebra then $c_0(A)$ is amenable if and only if A is amenable.

This research directs us to more general theorem (and main result) providing an equivalent definition of weakly amenable Banach algebras A in terms of existence of a constant, which raises a definition of *weak amenability constant* $\mathrm{WAM}(A)$, analogue to amenability constant $\mathrm{AM}(A)$ defined in [7, Definition 2.2.7]. We will show some properties of $\mathrm{WAM}(A)$ and present its

values for non-commutative Banach algebras of some 2×2 complex matrices with different norms.

The talk is based on a joint work [3] and ongoing project.

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General composition of formal power series - towards Fréchet-Lie group-like formalism

Dawid Bugajewski

University of Warsaw

d.bugajewski@student.uw.edu.pl

Tuesday
14:45
HB 2D

Abstract. Fréchet-Lie groups (or, more generally, Lie groups modelled on locally convex spaces) are a natural infinite-dimensional extension of classical Lie groups, an important tool in modern theoretical physics. Such structures have been found useful in the description of the so called *substitution group* $\xi(\mathbb{K})$ – the group of nonunit formal power series (i.e. $f = a_1 z + a_2 z^2 + ...$, $a_n \in \mathbb{K} = \mathbb{R}$ or $\mathbb{C}$) satisfying $a_1 = 1$, with formal superposition $\circ$ as the group action (see e.g. [1]). This group can be also easily extended by imposing the condition $a_1 \neq 0$ instead of $a_1 = 1$, which corresponds to the semi-direct product $\xi(\mathbb{K}) \rtimes \mathbb{K}^\times$ ($\mathbb{K}^\times := \mathbb{K} \setminus \{0\}$ with multiplication). However, it is well-known that composition of formal power series $g = \sum_{n=0}^{\infty} b_n z^n$ and

$f = \sum_{n=0}^{\infty} a_n z^n$ can be also defined if $a_0 \neq 0$ and in 2002, a necessary and sufficient condition for existence of $g \circ f$ in this case was established in the paper [2].

In this talk, we will consider the general composition of formal power series (that is we do not impose any nonunitness conditions) in a topological and geometrical context. In particular, we provide a necessary and sufficient condition of invertibility of such operation, as well as a thorough analysis of its continuity and smoothness as a mapping between infinite-dimensional Fréchet manifolds. It constitutes a necessary step towards possibility of exploiting elements of the Fréchet Lie theory in formal analysis in a more general context. If time allows, we will also mention some further results, regarding infinite dimensional Lie group structures on the spaces of generalized Riordan arrays. Our talk will be mainly based on the paper [3].

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Mean-Field limit of the Bose-Hubbard Model in High Dimension

Denis Périce

Constructor University Bremen

dperice@constructor.university

Tuesday
16:00
HB 2D

Abstract. The Bose-Hubbard model effectively describes bosons on a lattice with on-site interactions and nearest-neighbour hopping, serving as a foundational framework for understanding strong particle interactions and the superfluid to Mott-insulator transition. In the physics literature, the mean field theory for this model is known to provide qualitatively accurate results in three or more dimensions. This talk will present a result that establishes the validity of the mean-field approximation for bosonic quantum systems in high dimensions. Unlike the conventional many-body mean-field limit, the high-dimensional mean-field theory exhibits a phase transition and remains compatible with strongly interacting particles.

Linear Structures in Orlicz Spaces Equipped with the s-Norms

Badik Hüseyin Uysal
İstanbul University
huseyinuysal@istanbul.edu.tr

Tuesday
16:30
HB 2D

Abstract. Let (X, Σ, μ) be a σ-finite, non-atomic, complete measure space and let Φ be an Orlicz function. We investigate the Orlicz spaces $L^{\Phi}(X, \Sigma, \mu)$ equipped with the s-norms. We characterize conditions the inclusion properties of Orlicz spaces in relation to other spaces, and systematically characterize how the geometric and order structures lead to behavior. Our approach unifies and extends previously known results for the Orlicz, Luxemburg and p-Amemiya norms. By utilizing the framework of the s-norms defined via outer functions. This study provides a deeper insight into the interaction between functional properties and norm structures in Orlicz spaces

This presentation is based on joint work with Serap Öztop.

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Exploring Quantum Instruments Through the Lens of C^*- Convexity: A Foundational Perspective

Arghya Chongdar
ISI Bangalore, India
chongdararghya@gmail.com

Tuesday
17:00
HB 2D

Abstract. Completely positive instruments, more specifically CP map valued measures, were introduced to describe the conditional state change during a quantum process. We view it as non-commutative analogue of joint probability measures. This work explores the set of C^*-extreme points of instruments, deriving insights from their marginals, and revisits classical results on the extremity of joint distributions in the quantum context. This talk is based on ongoing work with my advisor B. V. Rajarama Bhat and Sruthy Murali.

Optimization of Robin Laplacian eigenvalue with indefinite weight in spherical shell

Yifan Zhang
University of Ostrava
yifan.zhang.s01@osu.cz

Tuesday
17:30
HB 2D

Abstract. We investigate an eigenvalue problem involving an indefinite weight function under Robin boundary conditions, arising naturally in models

of population dynamics. The problem is approached through the lens of shape optimization, using the known bang-bang structure of the optimal weight distribution to recast the original formulation. While the one-dimensional case has been thoroughly studied, the analysis in higher dimensions remains largely unresolved. In this work, we focus on domains in the form of spherical shells across arbitrary dimensions. By applying appropriate changes of variables and leveraging the symmetry of the domain, we derive insights into the structure of optimal configurations. Our results contribute to the broader understanding of spectral optimization problems in complex geometries. This talk is based on joint work with B. Schneider and D. Schneiderová.

A study of multiplicative maps on Reproducing Kernel Hilbert spaces (RKHS)

Mohana Rahul Nandan

Indian Institute of Technology Hyderabad
ma20resch11003@iith.ac.in

Wednesday
10:30
HB 2D

Abstract. The study of multiplicative linear functionals and maps is a well-explored area in Banach algebras. Recently, Cheng Chu, Michael Hartz, Javad Mashreghi, and Thomas Ransford studied the multiplicative linear functionals in reproducing kernel Hilbert space (RKHS) with normalized complete Nevanlinna-Pick kernel (NCP). In this talk, we will define and study the multiplicative linear maps between two RKHS. We will also see when such maps are continuous. In addition, we will show that any unital cyclicity-preserving linear map in RKHS with NCP kernel is multiplicative. Conversely, we also characterise when such multiplicative linear maps are unital cyclicity preserving. Composition operators are examples of multiplicative linear maps on RKHS. We will show that every continuous multiplicative linear operator can be realised as a composition operator on various analytic Hilbert spaces over the unit disc $\mathbb{D}$.

Reproducing kernel Hilbert space with the Gaussian kernel and its description in terms of the Fourier transform

Jesús Alberto Flores Hinostrosa

Instituto Politécnico Nacional
jfloreshinostrosa@gmail.com

Wednesday
11:00
HB 2D

Abstract. This talk is based on a joint work with Maribel Loaiza Leyva and Egor Maximenko.

We denote by H be the space associated with Gaussian kernel (RBF kernel) and let η denote the weighted Lebesgue measure with"anti-Gaussian" weight:

$$d\eta(x) = e^{\pi\|x\|^2}\, d\mu_n(x).$$

We show that H is the image of the space $L^2(\mathbb{R}^n, \eta)$ under the Fourier transform. In a similar way, the image of $L^2(\mathbb{R}^n, \eta)$ under the complex extension of Fourier transform is the Steinwart–Hush–Scovel space S, introduced in [1], with reproducing kernel

$$K_{\mathcal{S}}(z, w) = \exp\left(2\pi \sum_{j=1}^{n} (z_j - \overline{w_j})^2\right), \quad z, w \in \mathbb{C}^n.$$

We show that the correspondences between the spaces $L^2(\mathbb{R}^n, \eta)$, H and S are isometric isomorphims. We also describe connections with Fock space, with the usual $L^2(\mathbb{R}^n, \mu_n)$ space, and with Bargmann transform.

Using this description, we study translation-invariant operators that act on H.

The speaker has been partially supported by Proyecto SECIHTI "Ciencia de Frontera" FORDECYT-PRONACES/61517/2020, by SECIHTI (Mexico) scholarship, and by IPN-SIP project 20253632 (Instituto Politécnico Nacional, Mexico).

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Convexity of the Berezin range on functional Hilbert spaces

Athul Augustine

Cochin University of Science and Technology, India

athulaugus@gmail.com

Wednesday
11:30
HB 2D

Abstract. We discuss the convexity of the range of the Berezin transform. Berezin range of a bounded linear operator T acting on a reproducing kernel Hilbert space $\mathcal{H}$ is the set $Ber(T) := \{\langle T\hat{k}_x, \hat{k}_x\rangle_{\mathcal{H}} : x \in X\}$, where $\hat{k}_x$ is the normalized reproducing kernel for $\mathcal{H}$ at $x \in X$. The *numerical range* of a bounded linear operator T on a Hilbert space $\mathcal{H}$ is defined as $W(A) := \{\langle Tu, u\rangle : \|u\| = 1\}$. By Toeplitz-Hausdorff theorem, the numerical

range of a linear operator on a Hilbert space is always convex. It is easy to observe that the Berezin range of an operator T is always a subset its numerical range. In general, the Berezin range of an operator is not convex. Here, we focus on characterizing convexity of the Berezin range for classes of composition operators acting on some functional Hilbert spaces.

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The Lifting Property for Frame Multipliers and Toeplitz Operators

Peter Balazs

Acoustics Research Institute @ Austrian Academy of Sciences; Acoustics, Analysis and AI @ Interdisciplinary Transformation University Austria

peter.balazs@oeaw.ac.at

Wednesday
12:00
HB 2D

Abstract. Frame multipliers are an abstract version of Toeplitz operators in frame theory and consist of a composition of a multiplication operator with the analysis and synthesis operators. Let $\Psi = \{\psi_k\} \subseteq \mathcal{H}_1$ be a frame in the Hilbert space $\mathcal{H}$. For a given sequence $\mu = (\mu_k)_{k\in K} \in \mathbb{C}^K$, the frame multiplier [1] with symbol μ is the operator $M_{\mu,\Psi} : \mathcal{H} \to \mathcal{H}$ defined by

$$M_{\mu,\Psi} f = \sum_{k\in K} \mu_k \langle f, \psi_k \rangle \psi_k. \tag{1}$$

We consider Banach spaces associated to a frame, so-called coorbit spaces $\mathcal{H}_m^p$, which are defined by the coefficents being in a weighted sequence space ℓ_m^p. Whereas the boundedness properties of frame multipliers are well understood, their invertibility is much more difficult. We show that frame multipliers with a positive symbol are Banach space isomorphisms between

the corresponding coorbit spaces. To offer a flavor of our result, we state an inexact version here.

Result. *Under suitable conditions on the frame Ψ and the weights m and μ, the frame multiplier $M_{\mu,\Psi}$ is a Banach space isomorphism between $\mathcal{H}^p_{m\sqrt{\mu}}$ and $\mathcal{H}^p_{m/\sqrt{\mu}}$, and for some constants $m, M > 0$ one has the norm equivalence*

$$m\|f\|_{\mathcal{H}^p_{m\sqrt{\mu}}} \leq \|M_{\mu,\Psi} f\|_{\mathcal{H}^p_{m/\sqrt{\mu}}} \leq M\|f\|_{\mathcal{H}^p_{m\sqrt{\mu}}}.$$

The main techniques are the theory of localized frames [3] and existence of inverse-closed matrix algebras.

The precise formulation resembles the lifting theorems in the theory of Besov spaces and modulation spaces. Indeed, the application of the abstract lifting theorem to Gabor frames yields a new lifting theorem between modulation spaces. A second application to Fock spaces yields isomorphisms between weighted Fock spaces.

This is joint work with K. Gröchenig [2].

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On some nonlinear operators in spaces of almost periodic functions

Dariusz Bugajewski

Adam Mickiewicz University, Poznań
ddbb@amu.edu.pl

Thursday
13:15
HB 2D

Abstract. The theory of almost periodic functions was initiated by Harald Bohr about a hundred years ago. As a very essential application of that theory one can indicate a mathematical description of quasicrystal structures as almost periodic patterns which correspond to almost periodic measures.

There are many various classes of almost periodic functions. In this talk we are going to focus mainly on almost periodic functions in view of the Lebesgue measure (briefly μ-a.p. functions).

In the first part of the talk we are planning to discuss some properties of μ-a.p. functions, especially their behavior under convolutions while in the second part we are going to deal with autonomous superposition

operators acting in the space of μ-a.p. functions. In particular, we will indicate necessary and sufficient conditions under which the autonomous superposition operator maps the space under consideration into itself as well as conditions under which it is continuous. We also indicate when the autonomous superposition operator defined on that space is a bijection. We will analyze the situation when the composition of a μ-a.p. function with a continuous function or with a homeomorphism gives a Stepanov almost periodic function, as well.

Depending on time, as an application of our results we are planning to present some theorems concerning μ-a.p. solutions to linear differential equations of the first order. The results presented in this talk come mainly from the papers [1] and [2].

References

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Inverse problem for the L-operator in the Lax Pair of Boussinesq's equation on the circle

Andrey Badanin

Harbin Institute of Technology, China

an.badanin@gmail.com

Thursday
13:45
HB 2D

Abstract. We consider the third-order non-self-adjoint operator $y''' + (py)' + py' + qy$ in $L^2(\mathbb{R})$, with real periodic coefficients p, q. This is an L-operator in the Lax pair for Boussinesq's equation $p_{tt} = -\frac{1}{3}(p_{xxxx} + 4(p^2)_{xx})$, $q_x = p_t$, on the circle, see [1]. We construct a mapping from the set of operator coefficients p, q to the set of spectral data. Our mapping is similar to the corresponding mapping for the Hill operator, constructed by E. Korotyaev [2], [3]. We prove that in a neighborhood of zero our mapping is analytic and one-to-one.

The work was carried out jointly with E. Korotyaev.

References

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Measures on General Co-dimensional Surfaces in Infinite Dimensions and Stokes Type Theorems

Jiayang Yu

Sichuan University
jiayangyu@scu.edu.cn

Thursday
14:15
HB 2D

Abstract. In this talk, we construct explicitly measures on general co-dimensional surfaces in ℓ^2 which is, in some sense, the simplest infinite-dimensional space, closest to Euclidean spaces, but the construction of related surface measures is a longstanding unsolved problem. Our surface measures are naturally induced from the usual Gaussian measures on ℓ^2, based on which we introduce the notion of differential forms and establish the corresponding Stokes type theorems.

Estimates of approximation numbers of a singular operator generated by the linear part of the Korteweg-de Vries operator

Madi Muratbekov

L.N. Gumilyov Eurasian National University and
M.Kh. Dulaty Taraz University
madimm@list.ru

Thursday
14:45
HB 2D

Abstract. Consider the differential operator

$$(L+\mu I)\,u=\frac{\partial u}{\partial t}+\frac{\partial^3 u}{\partial x^3}+q\,(x)\,u+\mu\,u, \tag{1}$$

initially defined on $C^{\infty}_{0,\,\pi}\left(\overline{\Omega}\right)$, where

$$\overline{\Omega}=\{(t,x):\ -\pi\le t\le\pi,\ \ -\infty<x<\infty\},\quad \mu\ge 0.$$

$C^{\infty}_{0,\,\pi}$ is a set of infinitely differentiable functions satisfying the condition

$$u\,(-\pi,\ x)=u\,(\pi,\ x)\,. \tag{2}$$

and compactly supported with respect to the variable x.

Further, we assume that the coefficient $q\,(x)$ satisfies the conditions:

i) $q\,(x)\ge\delta_0>0$ is a continuous function in $\mathbb{R}$;

ii) $c_0=\sup\limits_{|x-y|\le 1}\frac{q(x)}{q(y)}<\infty$.

Note here that $q(x)$ can be an unbounded function at infinity.

As you know, the third order partial differential equations are one of the basic equations of wave theory. For example, in particular, linearized Korteweg-de Vries type equations with variable coefficients model ion-acoustic waves into plasma and acoustic waves on a crystal lattice [1, 2]. In contrast to those interesting papers, in this paper the operator generated by the linear part of the Korteweg-de Vries operator is considered in the space $L_2(\Omega)$. For this operator in an unbounded domain with an unbounded coefficient, the following questions will be studied:

- the existence of the resolvent;
- separability (maximum regularity of solutions);
- compactness of the resolvent;
- estimates of singular (s-numbers) numbers.

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Restriction Theorems for the p-analog of the Fourier-Stieltjes algebra

Arvish Dabra

Indian Institute of Technology Delhi, India
arvishdabra3@gmail.com

Thursday
16:00
HB 2D

Abstract. For a locally compact group G and $1 < p < \infty$, let $B_p(G)$ denote the p-analog of the Fourier-Stieltjes algebra $B(G)$ (or $B_2(G)$). Let $r : B_p(G) \to B_p(H)$ be the restriction map given by $r(u) = u|_H$ for any closed subgroup H of G. In this article, we prove that the restriction map r is a surjective isometry for any open subgroup H of G. Further, we characterise the closure of the range space of map r for a compact normal subgroup N of G and prove that $\overline{B_p(G)|_N} = \{v \in B_p(N) : \|v^g - v\|_N \to 0 \text{ as } g \to e\}$ where $v^g(n) := v(g^{-1}ng)$ for $n \in N$. Moreover, we show that the range of the map r is dense in $B_p(H)$ for a compact subgroup H of an $[\mathrm{SIN}]_H$-group.

This work is based on the following article:

Dabra, A., and Shravan Kumar, N. Restriction Theorems for the p-Analog of the Fourier-Stieltjes Algebra. *Results Math. 79*, 6 (2024), Paper No. 232.

Interpolation of Banach spaces related to decreasing functions

Tomasz Kiwerski
Poznań University of Technology
tomasz.kiwerski@gmail.com

Thursday
16:30
HB 2D

Abstract. Our considerations are devoted to the study of interpolation structure of a certain class of Banach function spaces that we will collectively refer to as *spaces related to decreasing functions*. Technicalities apart, these are Banach function spaces defined using the least decreasing majorant construction and Köthe duality. We will show that there is, so to speak, a bijective correspondence between the interpolation scales generated by the couples of spaces related to decreasing functions and the associated scale generated by the couple of Banach function spaces upon which they are built. This will allow us, among other things, to describe the Calderón–Mityagin couples of spaces belonging to the mentioned class. Nevertheless, we will also provide new examples of Banach couples that do not form Calderón–Mityagin couples. At the heart of these results lies the general variant of Grosse–Erdmann's *blocking technique* from [1] whose main ingredient is a certain *discretization procedure* that goes back to the work of Kalton [3].

This talk is based on a joint paper [2] with Jakub Tomaszewski from Poznań University of Technology.

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Pointwise multipliers of Calderón–Lozanovskiĭ spaces

Jakub Tomaszewski
Poznań University of Technology
jakubtomaszewski@put.poznan.pl

Thursday
17:00
HB 2D

Abstract. We will provide a complete description of the space $M(X_F, X_G)$ of pointwise multipliers between two Calderón–Lozanovskiĭ spaces X_F and X_G built upon a rearrangement invariant space X and two Young functions F and G. Meeting natural expectations, the space $M(X_F, X_G)$ turns out

to be another Calderón–Lozanovskiĭ space $X_{G\ominus F}$ with $G \ominus F$ being the appropriately understood generalized Young conjugate of G with respect to F. Furthermore, as an example to illustrate applications, we will solve the factorization problem for Calderón–Lozanovskiĭ spaces.

The talk is based on joint work [1] with Tomasz Kiwerski from Poznań University of Technology.

References

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Spectral properties of the indefinite Kirchhoff Laplacian on a star graph

Mitsuru Wilson

Technische Universität Ilmenau
mitsuru.wilson@tu-ilmenau.de

Thursday
17:30
HB 2D

Abstract. We study the spectral properties of an *indefinite Kirchhoff Laplacian* on a star graph G. The operator acts as $-\sigma_e \frac{d^2}{dx^2}$ on each edge e, where

$$\sigma_e = \begin{cases} 1, & e = 1, \dots, k, \\ -1, & e = k+1, \dots, n. \end{cases}$$

The system is equipped with Dirichlet boundary conditions at the outer vertices and a Kirchhoff-type coupling condition at the central vertex. We show that the resulting indefinite Laplace operator is similar to a self-adjoint operator in the Hilbert space $L^2(G)$. Furthermore, the eigenfunctions form a Riesz basis, and the associated Weyl function provides a complete characterization of the point spectrum.

The Friedrichs extension of a class of discrete symplectic systems

Petr Zemánek

Masaryk University
zemanekp@math.muni.cz

Friday
10:45
HB 2D

Abstract. Self-adjointness is a fundamental concept in functional analysis. Since the pioneering work of von Neumann, it has been known that every densely defined symmetric linear operator with equal and nonzero deficiency indices admits multiple self-adjoint extensions, which can be characterized

in various ways. A natural question arises: can they be ordered? In general, only partially – some of them are incomparable. The situation is considerably better in the case when the operator is, in addition, non-negative, as all self-adjoint extensions then remain non-negative, and the existence of the smallest and largest self-adjoint extensions can be established. In particular, special attention has been devoted to the characterization of the latter extension, which is known as the Friedrichs extension, originally introduced in the seminal work [1].

In this talk, we present a very recent result concerning the Friedrichs extension for a class of discrete symplectic systems established in [2]. It is worth noticing that, unlike classical cases involving differential expressions, we employ the more general framework of linear relations rather than operators, due to the non-dense domain of the associated operator. This approach enables us to extend the theory to settings that are inaccessible via standard operator methods.

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Maximal regularity and approximation properties of differential equations

Kordan Ospanov and Myrzagali Ospanov

L.N. Gumilyov Eurasian National University, Astana, Kazakhstan

kordan.ospanov@gmail.com; myrzan66@mail.ru

Friday
11:15
HB 2D

Abstract. We consider the following second order differential equation

$$Ly = -\left(\rho(x)y'\right)' + r\left(x\right)y' + q\left(x\right)y = f(x), \tag{1}$$

where $x \in R = (-\infty, +\infty)$, and ρ, r and q are smooth functions, and $f \in L_p(R)$, $1 < p < \infty$.

We discuss some conditions for coefficients sufficient for the correct solvability of equation (1). Moreover, we present the maximal regularity estimate for a solution. Then we apply this inequality for the estimate of approximation numbers of the resolvent L^{-1}. It is known that the estimate of approximate numbers gives the corresponding estimate of the best approximation of the solution of (1) by elements of k - dimensional subspaces in $L_p(R)$. The novelty of this work is that the above questions are

solved in a new case of the singular differential equation (1), when the leading coefficient ρ is variable, and the right-hand side f lies in a non-Hilbert space $f \in L_p(R)$ $(1 < p < \infty)$.

The question on correct solvability of (1) and maximal regularity of its solution has been studied previously in the case $\rho = 1$ in [1]. In [2] such problems were investigated for one third order differential equation in $L_2(R)$.

References

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Periodic eigenvalue problem for the third-order differential operator with a repulsive δ-interaction

Hiroaki Niikuni

Maebashi Institute of Technology

niikuni@maebashi-it.ac.jp

Friday
11:45
HB 2D

Abstract. In this talk, we discuss the eigenvalue problem for the operator

$$H = \left(-i\frac{d}{dx}\right)^3 + \alpha\delta(x)$$

in $L^2(-1/2, 1/2)$ with the periodic boundary condition $y^{(j)}(1/2) = y^{(j)}(-1/2)$ for $j = 0, 1, 2$ and $\alpha \in \mathbb{R} \setminus \{0\}$. Here, $\delta(\cdot)$ is the Dirac's delta function supported at the origin. The precise definition of the operator H is given as follows:

$$(Hy)(x) = iy'''(x), \quad x \in I := (-1/2, 0) \cup (0, 1/2).$$

The domain of H consists of functions $y \in H^3(I)$ satisfying

$$y(+0) = y(-0), \quad y'(+0) = y'(-0), \quad y''(+0) = y''(-0) + i\alpha y(0),$$
$$y(1/2) = y(-1/2), \quad y'(1/2) = y'(-1/2), \quad y''(1/2) = y''(-1/2).$$

Our operator H is related to the class of all self-adjoint extensions for the operator $T := (-i\frac{d}{dx})^3|_{C_0^\infty(\mathbb{R}\setminus\{0\})}$. Put

$$J = \begin{pmatrix} 0 & 0 & 1 \\ 0 & -1 & 0 \\ 1 & 0 & 0 \end{pmatrix} \quad \text{and} \quad A_1 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ i\alpha & 0 & 1 \end{pmatrix}.$$

For $\theta \in \mathbb{R}$ and $A \in SU(3,J) = \{A \in SL(3,\mathbb{C}) \,|\, A^*JA = J\}$, we define the operator $L_{\theta,A}$ in the Hilbert space $L^2(\mathbb{R})$ as

$$(L_{\theta,A}y)(x) = iu'''(x), \quad x \in \mathbb{R} \setminus \{0\},$$
$$\mathrm{dom}(L_{\theta,A}) = \left\{ u \in H^3(\mathbb{R}\setminus\{0\}) \;\middle|\; \begin{pmatrix} u(+0) \\ u'(+0) \\ u''(+0) \end{pmatrix} = e^{i\theta} A \begin{pmatrix} u(-0) \\ u'(-0) \\ u''(-0) \end{pmatrix} \right\}.$$

Then, almost all self-adjoint extensions for T are given by $\{L_{\theta,A} \,|\, \theta \in \mathbb{R}, A \in SU(3,J)\}$ with respect to the Haar measure of $U(3)$. In particular, we have $L_{0,A_1} = \left(-i\frac{d}{dx}\right)^3 + \alpha\delta(x)$ in $L^2(\mathbb{R})$. Our main result is the following:

Theorem. Assume that $\alpha > 0$. Then, we have $\sigma(H) = \sigma_d(H)$. In particular, H has exactly one eigenvalue λ_n in $I_n := ((2n\pi)^3, (2(n+1)\pi)^3)$ for each $n \in \mathbb{Z}$.

The speaker is planning to upload the presentation slide of the talk to the following webpage about one week before the talk: http://www.maebashi-it.ac.jp/~niikuni/slide/202507.pdf

On spectral analysis of some Sturm–Liouville operators

Grzegorz Świderski
Wrocław University of Science and Technology
grzegorz.swiderski@pwr.edu.pl

Friday
12:15
HB 2D

Abstract. We introduce a new class of Sturm-Liouville operators with periodically modulated parameters. Their spectral properties depend on the monodromy matrix of the underlying periodic problem computed for the spectral parameter equal to 0. Under some assumptions, by studying the asymptotics of Christoffel functions and density of states, we are able to prove that the spectral density is a continuous function positive everywhere on the real line. This is a joint work with Bartosz Trojan (Wrocław University of Science and Technology).

Arithmetic Bohr radius of bounded linear operators

Subhadip Pal
Indian Institute of Technology Bhubaneswar
subhadippal33@gmail.com;
s21ma09006@iitbbs.ac.in

Friday
14:00
CR 2M

Abstract. The main aim of this talk is to discuss on arithmetic Bohr radius which an interesting version of classical multidimensional Bohr radius

introduced by Defant, Maestre, and Prengel [5]. In 2012, Defant, Maestre, and Schwarting [6] studied the multidimensional Bohr radius for bounded linear operators. We discuss the arithmetic Bohr radius of bounded linear operators between arbitrary complex Banach spaces. We establish the close connection between the classical Bohr radius and the arithmetic Bohr radius of bounded linear operators. Further, we present the asymptotic estimates of arithmetic Bohr radius for identity operator on infinite dimensional complex Banach spaces. In addition, we give the correct asymptotic behavior of Bohr radii of operators between sequence spaces.
This is a joint work with Vasudevarao Allu.

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[5] A. Defant, M. Maestre, and C. Prengel. The arithmetic Bohr radius. *Q. J. Math.*, 59(2):189–205, 2008. doi:10.1093/qmath/ham028.

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Dynamics of weighted shifts on certain analytic function spaces

Bibhash Kumar Das

IIT Bhubaneswar
bkd11@iitbbs.ac.in

Friday
14:30
CR 2M

Abstract. We introduce the Banach space $\ell^p_{a,b}$ of analytic functions on the unit disc, having normalized Schauder bases consisting of polynomials of the form $f_n(z) = (a_n + b_n z)z^n, \quad n \geq 0$, where $\{f_n\}$ is assumed to be equivalent to the standard basis in ℓ^p. We study the weighted backward and forward shift operators B_w and F_w on this space, and obtain sufficient conditions for B_w and F_w to be bounded, and prove that, under some mild assumptions on $\{a_n\}$ and $\{b_n\}$, the operator B_w is similar to a compact perturbation of a weighted backward shift on the sequence space ℓ^p. Further, we study the hypercyclicity, mixing, and chaos of B_w and adjoint of F_w. Finally, it is proved that the adjoint of F_w on the dual of $\ell^p_{a,b}$ can have non-trivial

periodic vectors, without being even hypercyclic. Also, the zero-one law of orbital limit points fails for F_w^*.

References

[1] B.K. Das and A. Mundayadan. Dynamics of weighted backward shifts on certain analytic function spaces. *Results Math.*, 242(2024). doi:10.1007/s00025-024-02279-0.

[2] B.K. Das and A. Mundayadan. Weighted shift operators on spaces of analytic functions over an annulus. arXiv:2412.05509.

[3] K.-G. Grosse-Erdmann and A. Peris. Linear Chaos, *Springer Universitext,* 2011. doi:10.1007/978-1-4471-2170-1.

Joint and Outer Spectral radius

Prajakta Sahasrabuddhe

Indian Statistical Institute, Bangalore, India

prajuiitb@gmail.com

Friday
15:00
CR 2M

Abstract.

S23: Advanced matrix techniques in the numerical solution of differential equations

Organizers: Matania Ben-Artzi, Paola Boito, Yuli Eidelman.

Numerical tensor methods for few-body Schrödinger equation

M. Melgaard

University of Sussex
m.melgaard@sussex.ac.uk

Thursday
13:15
HB 2B

Abstract. We report on the recent development of pioneering, unified, all-particle calculations of the ground state energies of a quantum mechanical, three-body atomic system, an exotic system and a molecular system using two different numerical tensor methods (NTM), namely the Lagrange-mesh NTM [3, 1], and the (Pekeris type) Laguerre NTM [3, 1], both utilizing explicitly correlated wave functions. It is shown that energies of at least nano-Hartree accuracy can be obtained with very low computational cost. The Schrödinger equation in perimetric coordinates is recast in a canonical tensor format. It is shown that the Schrödinger equation can be solved in this full tensor format but that by using a low-rank tensor decomposition, in particular the tensor train and quantised tensor train formats, energies accurate to at least the nano-Hartree can be obtained for the He atom (where the mass of the uniquely charged particle is much greater than the other two particles), the positronium negative ion Ps^- (where all the masses are equal) and the non-Born-Oppenheimer H_2^+ molecule (where the mass of the uniquely charged particle is much smaller than the other two particles. The talk will focus on the mathematical aspects of the numerical methods.

References

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[3] M. Melgaard. *Numerical tensor methods with explicitly correlated wave functions for bound-state stability of Coulomb three-body systems.* In "Theoretical Methods, Algorithms and Applications of Quantum Systems in Chemistry, Physics and Biology (QSCP)" (Ed. S. Pal *et al*). Proceedings of the 26th QSCP, Jaipur (2023), Progress in Theoretical Chemistry and Physics, Springer Nature, 2025, to appear.

Splines, biharmonic operator and approximate eigenvalues

Matania Ben-Artzi

Institute of Mathematics, The Hebrew University, Jerusalem

mbartzi@math.huji.ac.il

Thursday
13:45
HB 2B

Abstract. The biharmonic operator plays a central role in a wide array of physical models, such as elasticity theory and the streamfunction formulation of the Navier-Stokes equations. Its spectral theory has been extensively studied. In particular the one-dimensional case (over an interval) constitutes the basic model of a high order Sturm-Liouville problem. The need for corresponding numerical simulations has led to numerous works. In this talk we present a discrete biharmonic calculus. The primary object of this calculus is a high-order compact discrete biharmonic operator (DBO). The DBO is constructed in terms of the discrete Hermitian derivative. However, the underlying reason for its accuracy has surprising aspects. We discuss the strong connection between cubic spline functions (on an interval) and the DBO. The first observation is that the (scaled) fourth-order distributional derivative of the cubic spline is identical to the action of the DBO on grid functions. It is shown that the kernel of the inverse of the discrete operator is (up to scaling) equal to the grid evaluation of the kernel of $\left[\left(\frac{d}{dx}\right)^4\right]^{-1}$, and explicit expressions are presented for both kernels. As an important application, the relation between the (infinite) set of eigenvalues of the fourth-order Sturm-Liouville problem and the finite set of eigenvalues of the discrete biharmonic operator is studied. The discrete eigenvalues are proved to converge (at an "optimal" $O(h^4)$ rate) to the continuous ones. Another consequence is the validity of a *comparison principle.* It is well known that there is no maximum principle for the fourth-order equation. However, a positivity result is derived, both for the continuous and the discrete biharmonic equation, showing that in both cases the kernels are order preserving.

Based on joint work with Guy Katriel.

A compact scheme for the Munk boundary-layer equation in one dimension

Dalia Fishelov

Afeka College of Engineering, Tel Aviv

daliaf@afeka.ac.il

Thursday
14:15
HB 2B

Abstract. We consider here Munk equation $-\beta u' - \mu u'' + \varepsilon u^{(4)} = f(x)$, where $\beta > 0$, $\mu \geq 0$ and $\varepsilon > 0$ are parameters. This equation is a model for

closed ocean circulation with a sharp boundary layer on the west coast. In this study we show that high order compact schemes previously introduced in other contexts (see [1]) are applicable and yield very good results.

Here the main difficulty involves the accuracy of the results as the parameters lead to singularities, namely, $\beta \to +\infty$, $\varepsilon \to 0$. It is then impossible to use a uniform grid on the whole domain. We show that it is possible to define a multiscale version of the scheme at transmission nodes, which preserve the high order accuracy. Numerical results are presented. Convergence proofs are provided just in the case of a uniform grid, using discrete functional analysis or matrix algebra tools. The test cases are taken from [2], see also [3].

This is joint work with Matania Ben-Artzi and Jean-Pierre Croisille.

References

[1] M. Ben-Artzi, J.-P. Croisille and D. Fishelov. *Navier-Stokes Equations in Planar Domains.* Imperial College Press, 2013.

[2] M. D. Chekroun, Y. Hong and R. M. Temam. Enriched numerical scheme for singularly perturbed barotropic Quasi-Geostrophic equations. *J. Comput. Phys.*, 416 (2020).

[3] M. Ben-Artzi, J.-P. Croisille and D. Fishelov. A Compact Scheme for the Munk Boundary-Layer Equation in One Dimension. *Journal of Computational and Applied Mathematics*, 2025.

Eigenstructure of matrices of a higher order of quasiseparability

Iulian Haimovici

Open University, Israel

iulianh@zahav.net.il

Thursday
14:45
HB 2B

Abstract. We study the bisection eigenvalue method for the matrices involved in boundary value problems for the biharmonic equations (which are quasiseparable of order 2), the Hermitian matrix $U + U^*$ where U is unitary Hessenberg (as a main step in finding the eigenvalues of U), Toeplitz symmetric band matrices, and some other cases. For all of them we also find eigenvectors, but only in the Toeplitz case we obtain orthogonal eigenvectors for huge matrices too, since they have many entries of 1 and 0 in the generator small matrices with which we multiply a lot. We use a more general algorithm published previously, but we prescribe it for each of these particular cases, in order to further improve its efficiency.

We introduce here a divide and conquer method for Hermitian quasiseparable matrices of higher order and we study the above classes and more. With this method we also find orthogonal eigenvectors for any matrix size, at the same time. We solve the biharmonic matrix case as a pentadiagonal matrix.

This is a joint work with Yuli Eidelman.

Numerical solution of parabolic equations with using quasiseparable representation of matrices

Yuli Eidelman

Tel Aviv University
eideyu@tauex.tau.ac.il

Thursday
16:00
HB 2B

Abstract. We consider differential equations of the form

$$\frac{dv}{dt} = Av + f(t),\ 0 < t < T \tag{1}$$

in functional spaces. Here A is a matrix or an unbounded operator, $f(t)$ is a continuous vector valued function. We study the problems to determine solutions of such equations under different boundary conditions.

The first one is the equation (1) with the initial condition

$$v(0) = v_0, \tag{2}$$

i.e., the Cauchy problem.

The second case is the differential equation with the nonlocal boundary value condition

$$\frac{1}{T}\int_0^T v(t)\,dt = g, \tag{3}$$

where g is an element of the functional space, i.e., the Cauchy problem.

In the discretization step of the numerical solution of the boundary value problem for each case we obtain a matrix analogue of the operator A which turns out to be a rank structured matrix with a quasiseparable of small order representation. Based on such representations we obtain fast algorithms to compute numerical solutions of the considered boundary value problems.

Numerical solution of differential problems with integral boundary conditions

Paola Boito

Department of Mathematics, University of Pisa
paola.boito@unipi.it

Thursday
16:30
HB 2B

Abstract. We consider a class of differential problems set in a Banach space, with integral boundary conditions:

$$\frac{dv}{dt} = Av, \qquad 0 < t < T, \qquad \frac{1}{T}\int_0^T v(t)dt = f. \tag{1}$$

Here A is a linear, closed, possibly unbounded operator (e.g., second derivative in space).

We prove the existence and uniqueness of the solution $v(t)$ of (1) and characterize it via a family of mixed polynomial-rational expansions w.r.t. the operator A. From this result we design a general numerical procedure for computing an approximation of $v(t)$ up to a given tolerance.

An interesting feature of this approach is the fact that successive rational terms can be computed independently: this allows us to fine-tune the accuracy of the approximation by adding further terms as needed, without having to recompute the whole approximation.

Numerical tests focus on a model problem involving a parabolic equation, either using finite-difference semidiscretization or via a symbolic-numeric approach.

This is joint work with Yuli Eidelman and Luca Gemignani [1].

References

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