

OPERATOR THEORY ON ANALYTIC FUNCTION SPACES 1 (S21)

MARIBEL LOAIZA-LEYVA (CENTRO DE INVESTIGACION Y DE ESTUDIOS AVANZADOS DEL IPN, MEXICO), RAUL QUIROGA BARRANCO (CIMAT, GUANAJUATO), ARMANDO SANCHEZ-NUNGARAY (UNIVERSIDAD VERACRUZANA), KEHE ZHU (STATE UNIVERSITY OF NEW YORK AT ALBANY)

Monday 14:00-16:00

(PLT1) chair: Maribel Loaiza-Leyva

- 14:00-14:25 Nina Zorboska
Measure induced Hankel and Toeplitz type operators on weighted Dirichlet spaces
- 14:30-14:55 Ghazaleh Asghari
Schatten class Hankel operators on doubling Fock spaces and the Berger-Coburn phenomenon
- 15:00-15:25 Cezhong Tong
A new class of Carleson embeddings
- 15:30-15:55 Zengjian Lou
Carleson embedding on Bergman spaces with applications

Monday 16:30-19:00

(PLT1) chair: Raul Quiroga-Barranco

- 16:30-16:55 Wolfram Bauer
Operators in the Fock-Toeplitz Algebra
- 17:00-17:25 Robert Fulsche
A Wiener algebra on the Fock space
- 17:30-17:55 Egor Maximenko
Horizontal Fourier transform of the polyanalytic Fock kernel
- 18:00-18:25 Stephen Sontz
Non-commutative Toeplitz Quantization of Euclidean Planes
- 18:30-18:55 Pindoli Mohan
Von Neumann algebras of analytic functions on the unit ball

Tuesday 14:00-16:00

(PLT1) chair: Armando Sanchez-Nungaray

- 14:00-14:25 Jari Taskinen
Bergman projection induced by radial weight acting on growth spaces
- 14:30-14:55 Maribel Loaiza-Leyva
On C^ -algebras generated by Toeplitz operators and projections*
- 15:00-15:25 Shubham Rameshsingh Bais
Integral representation of angular operators on the Bergman space over the upper half-plane
- 15:30-15:55 Miron Bekker
On Generators of the Hardy and the Bergman Spaces

Tuesday 16:30-19:00

(PLT1) chair: Maribel Loaiza-Leyva

- 16:30-16:55 Jani Virtanen
Asymptotics of determinants for structured matrices
- 17:00-17:25 Željko Čučković
A geometric condition for the invertibility of Toeplitz operators on the Bergman space
- 17:30-17:55 Hyungwoon Koo
Local Hopf lemma for degenerate elliptic operator
- 18:00-18:25 Hicham Arroussi
Generalized Volterra type integral operators on large Bergman spaces

Wednesday 11:40-12:40

(PLT1) chair: Raul Quiroga-Barranco

- 11:40-12:05 David Norrbo
Asymptotic Toeplitzness of weighted composition operators on Abstract Hardy spaces
- 12:10-12:35 Armando Sanchez-Nungaray
Toeplitz Operators with symbols invariant under the action of a subgroup of the nilpotent group on the Siegel Domain D_2

Thursday 14:00-16:00

(PLT1) chair: Armando Sanchez-Nungaray

- 14:00-14:25 Ching-on Lo
Complex Symmetric Weighted Composition-Differentiation Operators on Weighted Hardy Spaces
- 14:30-14:55 Marek Ptak
Invariant Subspaces for conjugations with special behavior with respect to given unitary operator
- 15:00-15:25 Anusree Sreedharan
Multiresolution Analysis on the Weighted Bergman spaces

Abstracts.

Hicham Arroussi, University of Reading and Helsinki

Generalized Volterra type integral operators on large Bergman spaces

Abstract. : Let ϕ be an analytic self-map of the open unit disk \mathbb{D} and g analytic in \mathbb{D} . We characterize boundedness and compactness of generalized Volterra type integral operators

$$GI_{(\phi,g)}f(z) = \int_0^z f'(\phi(\xi))g(\xi) d\xi$$

and

$$GV_{(\phi,g)}f(z) = \int_0^z f(\phi(\xi))g(\xi) d\xi,$$

acting between large Bergman spaces A_{ω}^p and A_{ω}^q for $0 < p, q \leq \infty$. To prove our characterizations, which involve Berezin type integral transforms, we use the Littlewood-Paley formula of Constantin and Peláez and establish corresponding embedding theorems, which are also of independent interest. When $\phi(z) = z$, our results for $GV_{(\phi,g)}$ complement the descriptions of Pau and Peláez.

Ghazaleh Asghari, University of Reading

Schatten class Hankel operators on doubling Fock spaces and the Berger-Coburn phenomenon

Abstract. Using the notion of integral distance to analytic functions, we give a characterization of Schatten class Hankel operators acting on doubling Fock spaces on the complex plane and use it to show that for $f \in L^\infty$, if H_f is Hilbert-Schmidt, then so is $H_{\bar{f}}$. This property is known as the Berger-Coburn phenomenon. When $0 < p \leq 1$, we show that the Berger-Coburn phenomenon fails for a large class of doubling Fock spaces. Along the way, we illustrate our results for the canonical weights $|z|^m$ when $m > 0$.

References

[1] G. Asghari, Z. Hu, J. A. Virtanen, Schatten class Hankel operators on doubling Fock spaces and the Berger-Coburn phenomenon, *J. Math. Anal. Appl.* **540**, (2024).

Shubham R. Bais, The Institute of Mathematical Sciences

Integral representation of angular operators on the Bergman space over the upper half-plane

Abstract. Let Π denote the upper half-plane and $\mathcal{A}^2(\Pi)$ be the Bergman space over the upper half-plane. In this talk, we define a class of integral operators on the space $\mathcal{A}^2(\Pi)$. We characterize the integral kernels so that the operators are bounded. We show that this class coincides with the class of angular operators on $\mathcal{A}^2(\Pi)$. As a consequence, we discuss various operator theoretic properties of angular operators, and a C^* -subalgebra generated by Toeplitz operators with special symbols. This is based on the joint work with D. Venku Naidu [1].

References

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Wolfram Bauer, Leibniz Universität Hannover

Operators in the Fock-Toeplitz Algebra

Abstract. We consider various classes of bounded operators on the Fock space of Gaussian square integrable entire functions over the complex plane. These include Toeplitz (type) operators, weighted composition operators, singular integral operators, Volterra-type operators and Hausdorff operators. As a leading problem and closely linked to well-known compactness or boundedness characterizations we pursue the question of when these operators are contained in the Toeplitz algebra. Some new proofs from the perspective of quantum harmonic analysis will be explained. This is joint work with Robert Fulsche and Miguel A. Rodriguez Rodriguez.

Miron Bekker, University of Pittsburgh at Johnstown

On Generators of the Hardy and the Bergman Spaces

Abstract. A function φ which is analytic and bounded in the unit disk \mathbb{D} is called a generator for the Hardy space $H^2(\mathbb{D})$ or the Bergman space $A^2(\mathbb{D})$ if polynomials in φ are dense in the corresponding space. We characterize generators in terms of φ -invariant subspaces which are also z -invariant and study wandering properties of such subspaces. Density of bounded analytic functions in the φ -invariant subspaces is also investigated.

References

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Željko Čučković, University of Toledo, USA

A geometric condition for the invertibility of Toeplitz operators on the Bergman space

Abstract. Invertibility of Toeplitz operators on the Bergman space and the related Douglas problem are long standing open problems. In this paper we study the invertibility problem under the novel geometric condition on the image of the symbols, which relaxes the standard positivity condition. We show that under our geometric assumption, the Toeplitz operator T_φ is invertible if and only if the Berezin transform of $|\varphi|$ is invertible in L^∞ . It is well known that the Douglas problem is still open for harmonic functions. We study a class of rather general

harmonic polynomials and characterize the invertibility of the corresponding Toeplitz operators. We also give a number of related results and examples. (Joint work with Jari Taskinen)

Robert Fulsche, Leibniz Universität Hannover

A Wiener algebra on the Fock space

Abstract. In the operator theory of Hardy spaces H^p , it is well known that the spectrum of the Toeplitz operator T_f can depend on the precise Hardy space on which the operator is considered, i.e., the spectrum can depend on the choice of the parameter p . In the present talk, we will demonstrate that for Toeplitz operators on the Fock space such behaviour is impossible. More precisely, we will introduce an algebra of integral operators \mathcal{W}_t (called the *Wiener algebra*), which act boundedly on each of the Fock spaces F_t^p , $1 \leq p \leq \infty$, and contains all Toeplitz operators with bounded symbols. As the main results, we show that the spectrum, the essential spectrum, and the Fredholm index of an operator from \mathcal{W}_t do not depend on the choice of the parameter p .

Hyungwoon Koo, Korea University

Local Hopf lemma for degenerate elliptic operator

Abstract. We prove that the local Hopf lemma of Baouendi-Rothschild for harmonic functions continues to hold for the degenerate elliptic operator, $\mathcal{L}_\alpha = x^\alpha \partial_x^2 + \sum_{j=1}^n \partial_{y_j}^2$, on the half-space when the degeneracy exponent α is less than 2. We provide examples of degenerate elliptic operators with the degeneracy exponent greater or equals to 2 for which the local Hopf lemma fail.

References

- [1] E. Hopf, A remark on linear elliptic differential equations of second order, *Proc. Amer. Math. Soc.* **3**, (1952), 791–793.
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- [4] H. Koo and S. Li, Local Hopf lemma for certain degenerate elliptic operators on the half-space *Complex Analysis and Operator Theory*, (2023), 17:67.

Ching-on LO, College of Professional and Continuing Education, The Hong Kong Polytechnic University

Complex Symmetric Weighted Composition-Differentiation Operators on Weighted Hardy Spaces

Abstract. Complex symmetric weighted composition-differentiation operators on the weighted Hardy spaces $H^2(\beta)$ with respect to the standard conjugation are investigated. Our results partially answer a question from a paper of Lim and Khoi (2018) [1] and subsume several existing ones in the literature. We also study the classes of self-adjoint, normal, co-isometric, unitary weighted composition-differentiation operators on $H^2(\beta)$ and their relations with the property of complex symmetry. The talk is based on joint work with Anthony Wai-keung LOH.

References

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Maribel Loaiza-Leyva, Centro de investigación y de estudios avanzados del IPN

On C^ -algebras generated by Toeplitz operators and projections*

Abstract. The C^* -algebra generated by Toeplitz operators, acting on the poly-Bergman space of order n , with bounded vertical symbols (and with finite limits at the points 0 and ∞), is isomorphic and isometric to the algebra $\{M(x) \in M_n(\mathbb{C}) \otimes C[0, +\infty] : M(0), M(\infty) \in \mathbb{C}I\}$. Then this algebra looks close to the C^* -algebra generated by n orthogonal projections. This implies that, inside the algebra of all bounded operators acting on the Poly-Bergman space of order n , there are n orthogonal projections that generate a C^* -algebra close related to the C^* -algebra generated by all Toeplitz operators with vertical symbols. In this talk we construct a family of projections with these characteristics. One of them is in terms of Toeplitz operators. Besides, we study the C^* -algebra \mathcal{A} generated by a single Toeplitz operator and the orthogonal projections P_1, \dots, P_n , where P_k is the orthogonal projection from the n -poly-Bergman space onto the true poly-Bergman space of order k . It turns out that, if the vertical symbol of the Toeplitz operator is a characteristic function, the C^* -algebra \mathcal{A} is isomorphic and isometric to the algebra

$$\mathcal{D}_n := \{M \in M_n(\mathbb{C}) \otimes C[0, \infty] : M(0), M(\infty) \text{ are diagonal matrices}\}.$$

In particular, this C^* -algebra contains (isometrically) the C^* -algebra generated by all Toeplitz operators with vertical symbols under the conditions given above.

References

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Zengjian Lou, Shantou University

Carleson embedding on Bergman spaces with applications

Abstract. In this talk, we consider Carleson embedding and its applications. We will introduce the recent development of absolutely summing Carleson embedding on Bergman spaces with applications on composition operators (Based on joint work with B. He (FDU), J. Jreis and P. Lefèvre (Université d'Artois, France))

I would like to thank NNSF of China and Li Ka Shing Foundation for their support.

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Egor Maximenko, Instituto Politécnico Nacional (Mexico)

Horizontal Fourier transform of the polyanalytic Fock kernel

Abstract. This is a joint work with Erick Lee-Guzmán, Gerardo Ramos-Vazquez, and Armando Sánchez-Nungaray.

Let $\mathcal{F} = \mathcal{F}_m(\mathbb{C}^n)$ be the space of m -analytic functions on \mathbb{C}^n square integrable with the Gaussian weight. Its reproducing kernel was recently computed by Youssfi [1]:

$$K_{\mathcal{F}}(w, z) = e^{\langle w, z \rangle} L_{m-1}^{(n)}(|w - z|^2).$$

We construct a new RKHS \mathcal{H} multiplying all elements of \mathcal{F} by the weight

$$2^{\frac{n}{2}} e^{-\frac{1}{2}|w|^2 - i\langle \operatorname{Re}(w), \operatorname{Im}(w) \rangle}.$$

\mathcal{H} is invariant under the usual translations in the horizontal direction. The reproducing kernel of \mathcal{H} is

$$K_{\mathcal{H}}(w, z) = 2^n e^{-\frac{1}{2}|w-z|^2 - i\langle \operatorname{Re}(w-z), \operatorname{Im}(w+z) \rangle} L_{m-1}^{(n)}(|w - z|^2).$$

Then, we compute the Fourier transform of $K_{\mathcal{H}}$ in the horizontal direction. It decomposes into a sum of products of Hermite functions:

$$\begin{aligned} & \frac{1}{(2\pi)^{\frac{n}{2}}} \int_{\mathbb{R}^n} K_{\mathcal{H}}(u + iv, iy) e^{-i\langle u, \xi \rangle} du_1 \cdots du_n \\ &= 2^n \pi^{\frac{n}{2}} \sum_{k_1 + \dots + k_n = m-1} \prod_{r=1}^n \psi_{k_r} \left(\frac{\xi_r + 2v_r}{\sqrt{2}} \right) \psi_{k_r} \left(\frac{\xi_r + 2y_r}{\sqrt{2}} \right). \end{aligned}$$

The number of summands is $d = \binom{m+n-1}{n}$. As the main application, we construct an isometric isomorphism $R: \mathcal{F} \rightarrow L^2(\mathbb{R}^n)^d$ that intertwines Weyl translation operators with multiplication operators by characters of \mathbb{R}^n . Using [2] we show that the corresponding centralizer (i.e., the von Neumann algebra of “vertical” operators in \mathcal{F}) is isometrically isomorphic to $L^2(\mathbb{R})^{d \times d}$.

The speaker has been supported by CONAHCYT (Mexico) project “Ciencia de Frontera” FORDECYT-PRONACES/61517/2020 and by IPN-SIP projects.

References

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Pinlodi Mohan, Indian Institute of Technology Hyderabad, India

Von Neumann algebras of analytic functions on the unit ball

Abstract. This talk answers the challenge posed by Ma and Zhu in [1]. We provide examples of von Neumann algebras of analytic functions over the unit disc as well as over the unit ball. Also, we introduce a novel multiplication operation on the set of all analytic functions over the unit disc, ensuring that this collection forms a $*$ -algebra of analytic functions over \mathbb{D} .

References

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David Norrbo, University of Reading

Asymptotic Toeplitzness of weighted composition operators on Abstract Hardy spaces

Abstract. How closely related are weighted composition operators to Toeplitz operators? This talk will provide an answer in terms of asymptotic Toeplitzness of weighted composition operators on abstract Hardy spaces on the disk. This class of spaces include the reflexive Hardy spaces and many Hardy-Lorentz and Orlicz spaces.

Marek Ptak, University of Agriculture in Kraków, Poland

Invariant Subspaces for conjugations with special behavior with respect to given unitary operator

Abstract. For a given unitary operator U we consider conjugation C (antilinear, isometric, involution) such that U is C -symmetric i.e. $CUC = U^*$. The subspaces which are invariant for all such conjugations are characterized. It turns out that it is all subspaces which are hyperinvariant for the given unitary operator U . Next, conjugations commuting with a given unitary operator are investigated. The necessary and sufficient condition when such conjugation exists is given. The description of subspaces which are invariant for all commuting conjugation is much complicated. The examples of specific unitary operators are pointed out.

Joint work with J. Mashreghi, W. Ross.

Armando Sánchez Nungaray, Universidad Veracruzana

Toeplitz Operators with symbols invariant under the action of a subgroup of the nilpotent group on the Siegel Domain D_2

Abstract. In this talk, we consider two types of subgroups of the Nilpotent group of the Siegel Domain of dimension two D_2 . For each of these two subgroups we construct a Bargman-type transform adapted to the action of that subgroup over D_2 , moreover using these Bargman-type transforme, we characterized the Toeplitz operators with invariant symbols under the action of these subgroups. I would like to thank the Harry Potter Foundation for their generous support.

This is a joint work with Nikolai Vasilevski (RIP).

Stephen Bruce Sontz, CIMAT, Guanajuato, Mexico

Non-commutative Toeplitz Quantization of Euclidean Planes

Abstract. We present a way of constructing Hilbert spaces from an algebraic representation of the Euclidean plane. If a certain Harmony condition is satisfied, this is a reproducing kernel Hilbert space of holomorphic functions. Then, together with a symbol space which is a non-commutative algebra and another Harmony condition, we can define Toeplitz operators and the corresponding quantization, which generalize greatly our previous research on this topic. In collaboration with Micho Durdevich.

References

Various eprints on arxiv.

Anusree Sreedharan, Cochin University of Science and Technology, India

Multiresolution Analysis on the Weighted Bergman spaces

Abstract. We examine rational Blaschke functions that are capable to formulate a Multiresolution on the weighted Bergman space of the open unit disc $A_\alpha^2(\mathbb{D})$. We construct a rational orthogonal wavelet system that generates the levels of the multiresolution. The levels of the multiresolution are finite dimensional, which makes it easier to find a basis on each level. We can approximate any $f \in A_\alpha^2(\mathbb{D})$ by the projection operator on the n^{th} resolution level. The projection will be an interpolation operator and whose coefficients can be computed through the evaluation of f on a given set of points in the unit disc. We extend the results to weighted Bergman space of upper half plane also.

References

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- [3] Pap, M. Hyperbolic wavelets and multiresolution in $H^2(\mathbb{T})$. J. Fourier Anal. Appl. 17(5), 755 - 776 (2011).
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Jari Taskinen, University of Helsinki

Bergman projection induced by radial weight acting on growth spaces

Abstract. A radial weight ω on the unit disc \mathbb{D} of the complex plane is said to belong to the class $\widehat{\mathcal{D}}$, if satisfies the upper doubling condition

$$\sup_{0 < r < 1} \frac{\widehat{\omega}(r)}{\widehat{\omega}\left(\frac{1+r}{2}\right)} < \infty,$$

where $\widehat{\omega}(r) = \int_r^1 \omega(s) ds$ denotes the tail integral. Given a weight ω , let P_ω be the Bergman projection in the space L_ω^2 , endowed with the ω -weighted area measure. For a weight ν , denote $L_\nu^\infty = \{f : \|f\|_{\infty, \nu} = \text{ess sup}_{z \in \mathbb{D}} |f(z)| \widehat{\nu}(z) < \infty\}$.

Under the general assumption that either ω or ν belongs to $\widehat{\mathcal{D}}$, we give several characterizations of pairs (ω, ν) such that P_ω is a bounded operator from L_ν^∞ onto its closed subspace H_ν^∞ consisting of analytic functions. The characterizations involve natural conditions on the moments and/or the tail integrals of ω and ν . Moreover, we solve the analogous problems for the boundedness of P_ω from L_ν^∞ onto the corresponding weighted Bloch type spaces and also study similar questions for exponentially decreasing radial weights.

This is a report on a joint work with Álvaro Miguel Moreno and José Ángel Peláez, Universidad de Málaga.

Cezhong Tong, Hebei University of Technology

A new class of Carleson embeddings

Abstract. In this talk I will introduce a new class of Carleson embeddings for Bergman-type spaces. This extends the embedding of a single derivative to the embedding of a combination of finite derivatives of different orders. As applications, we can use these new Carleson embeddings to characterize the generalized Volterra-type operators on Bergman-type spaces, and to characterize the boundedness and compactness of sums of weighted composition-differentiation operators of different orders.

Jani Virtanen, University of Reading*Asymptotics of determinants for structured matrices*

Abstract. I discuss the determinant asymptotics for structured matrices with focus on Toeplitz and Toeplitz plus Hankel matrices, and also finite sections of Toeplitz operators, generated by matrix-valued symbols that may be smooth or possess singularities. Most of our results have been proved using operator theory but we also compare the operator-theoretic approach with the use of Riemann-Hilbert problems. Some applications to random matrix theory and mathematical physics are also mentioned.

References

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- [2] E. Basor, T. Ehrhardt, J. A. Virtanen, A survey of asymptotics of determinants for structured matrices, (preprint to be posted on arXiv).

Nina Zorboska, University of Manitoba*Measure induced Hankel and Toeplitz type operators on weighted Dirichlet spaces*

Abstract. I will talk about the boundedness of measure induced Hankel and Toeplitz type operators on weighted Dirichlet spaces, extending the known results for the case of the classical Hardy and Dirichlet spaces. The approach relies on recent results on weak products of complete Nevanlinna-Pick reproducing kernel Hilbert spaces.