19th ANNUAL WORKSHOP

on

APPLICATIONS AND GENERALIZATIONS
OF COMPLEX ANALYSIS

Booklet of Abstracts

AVEIRO
March 23-24, 2018
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GENERAL INFORMATIONS
We welcome you all to the 19th Annual Workshop in Aveiro. The workshop will take place at room Sousa Pinto (second floor).

INTERNET ACCESS
Rooms are available for checking your e-mail through a computer terminal

Login: euro.cour@visit.uaveiro.eu
Password: Aveiro_2018

Alternatively, if you possess a personal Laptop with WLAN you can use either the above login or your personal EDUROAM access at your home university.

Important: please, do not change the password, as it is a multiple login.

COMPUTER TERMINALS
Computers terminal are available at rooms 11.2.7, 11.2.8, and 11.2.22, located in the 2nd floor. However, due to lecturing restrictions, please do confirm its availability before entering.

WHERE TO EAT?
Around the campus there exist several coffee bars where you can have also small meals such as sandwiches, snacks, fruits, ice creams, etc.

For lunch or dinner, there exist several possibilities:

- Refeitório de Crasto and Refeitório de Santiago, Monday to Friday, lunch 12h to 14h30 / dinner 18h30 to 20h30, Saturday and Sunday, lunch 13h to 14h30 / dinner 19h to 20h30. Prices: from 2,55 to 6,00 euros

- Edifício do Snack-bar and Self-Service (ground floor), Monday to Friday, lunch 12h to 14h30. Prices: from 2,55 to 6,00 euros

- Restaurante Universitário (1st floor), Monday to Friday, lunch 12h to 14h30. Prices: buffet service 7,00 euros (without dessert) or 8,00 euros (with dessert).

In addition, several restaurants can be found all around the campus.
E-MAIL CONTACT OF SPEAKERS

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SUPPORT

These events are supported by CIDMA, and the FCT - Portuguese Foundation for Science and Technology within project UID/MAT/04106/2013.

We wish you all a happy stay and a good and fruitful workshop.

Aveiro, March 20, 2018

The Organizers
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Milton Ferreira Universidade de Aveiro
Uwe Kähler Campus de Santiago
Nelson Vieira 3810-193 Aveiro, Portugal
ABSTRACTS - 23rd March

10:45 Opening Session

11:00-11:45 de Branges spaces and characteristic operator function: the quaternionic case

Daniel Alpay
Chapman University, U.S.A.

We first review the notion of characteristic operator function in the classical setting of operators in complex Hilbert spaces. We then review some recent results in quaternionic Schur analysis and discuss the characteristic operator function in this setting.

This is joint work with Fabrizio Colombo and Irene Sabadini (Polimi Milano)

11:50-12:10 Quasi-monogenic functions and their application to quasi-monogenic frames

Swanhild Bernstein, Sandra Schufmann
TU Bergakademie Freiberg, Germany

Quasi-monogenic functions are generalized monogenic functions which have the similar properties as monogenic functions. They are constructed in Fourier domain in the following way. The classical Dirac operator $D$ in $\mathbb{R}^n$ decomposes as $D = |D|H = F^{-1}\left(\frac{-i\omega}{|\omega|^2}\right)$, where $H$ is the Riesz-Hilbert transform and $F^{-1}$ the inverse Fourier transform. The Riesz-Hilbert transform is a singular integral integral operator, i.e. a Fourier multiplier in $L^p$, $1 < p < \infty$, and the Fourier transform is a homogeneous polynomial of degree zero. We generalize the Riesz-Hilbert operator to $H$ which is supposed to be a Fourier multiplier and it’s Fourier transform is a homogeneous polynomial of degree 0. Furthermore, the operator should be invertible and a Clifford vector. Then, the Dirac operator in $\mathbb{R}^n$ is generalized to $D = |D|R$ and a function $f$ in $G \subset \mathbb{R}^{n+1}$ is called quasi-monogenic iff $(\partial_{x_0} + D)f = 0$ in $G$. Hilbert, Riesz, and Riesz-Hilbert transforms have been widely used in image processing. For example to construct monogenic wavelet frames, Laplace-Riesz wavelets and for analyzing images. We will
demonstrate that the quasi-monogenic Riesz-Hilbert transform has similar properties and that the classical Riesz transforms and the linearized Riesz transforms are special cases. Especially, we construct quasi-monogenic frames which unify the construction of monogenic wavelets and monogenic shearlets.

12:15-12:35 Schatten-von Neumann Ideals for Integral operators

Julio Delgado
Imperial College London, U. K.

In this talk we establish sharp kernel conditions ensuring that the corresponding integral operators belong to Schatten-von Neumann classes. The conditions are given in terms of the spectral properties of operators acting on the kernel. As applications we establish several criteria in terms of different types of differential operators and their spectral asymptotics in different settings: compact manifolds, operators on lattices, domains in $\mathbb{R}^n$ of finite measure, and conditions for operators on $\mathbb{R}^n$ given in terms of anharmonic oscillators, among others.

This is a joint work with Michael Ruzhansky.

12:40-14:30 Lunch-break

14:30-14:50 Discrete Segal-Bargmann transform

Astrid Massé
Ghent University, Belgium

The classical Segal-Bargmann transform is a unitary map between the space of square integrable functions and the Fock space, which is of great interest in e.g. quantum mechanics. In this presentation, we try to define an analogue version of this transform in the discrete Hermitian Clifford analysis, where functions are defined on a grid rather than the continuous space. This is done based on the classical definition, in combination with a discrete version of the Gaussian function and discrete counterparts of the classical Hermite polynomials. Furthermore, a discrete Hilbert space with appropriate inner product is constructed, for which the discrete Hermite polynomials form a basis. In this setting, we also investigate the behaviour of discrete delta functions and delta distributions.

This is joint work with Frank Sommen and Hilde De Ridder.
14:55-15:15 Discrete potential and function theories on rectangular lattices and their applications

Klaus Gürlebeck†, Angela Hommel‡, Anastasiia Legatiuk† ‡
†Bauhaus Universität Weimar, Germany, ‡Westsächsische Hochschule Zwickau, Germany

Discrete potential and function theories are natural extensions of the continuous theories to functions defined on lattices. The idea of the discrete function theory is to work directly with discretized domains (lattices) and to transfer all important properties from the continuous case to the discrete level. In the field of boundary value problems it is more beneficial to work with rectangular lattices, i.e. allowing two different stepsizes. Thus, the aim of this presentation is to present the extension of the discrete potential and function theories to rectangular lattices. Particularly, we present the discrete analogue of the Borel-Pompeiu formula, and one real-world application related to the induction heating problem, where the mentioned theories can be used.

15:20-15:40 Differential Operators in Hypercomplex Analysis

Adrian Vajiac
Chapman University, U.S.A.

In this talk I introduce the analysis of general hypercomplex algebras, focusing on the differential operator theory that arises naturally in this context. As a main example, I will present the different types of differential operators that this hypercomplex analytic theory induces on the biquaternionic space.

This talk is based on collaborative work with D.C. Struppa and M.B. Vajiac.

15:45-16:05 Fourier analysis of Discrete Dirac operators on the $n$-torus $\mathbb{R}^n/\frac{2\pi}{k} \mathbb{Z}^n$

Nelson Faustino
Universidade Federal do ABC, Brazil

New developments concerning the theory of Discrete Dirac operators will be presented by means of Fourier series representations on the $n$-torus $\mathbb{R}^n/\frac{2\pi}{k} \mathbb{Z}^n$. The resulting approach will be applied to time-evolution problems of Klein-Gordon type.

16:10 Coffee-break
16:45-17:05 A realization theorem for ternary rational functions

Mihaela Vajiac
Chapman University, U.S.A.

We introduce a new class of analytic functions defined on the ternary algebra $\mathbb{T}$, a three-dimensional structure different from $\mathbb{C} \times \mathbb{R}$, i.e. a commutative algebra given by the linear span of \{1, $e$, $e^2$\}, where $e \notin \mathbb{C}$ is a generating unit. We define a theory of analytic functions on the basis of a single conjugation (akin to the quaternionic case). Using Fueter–type variables that arise in this context we show that a realization theorem for ternary rational functions holds true.

This is joint work with D. Alpay and A. Vajiac.

17:10-17:30 Singular integral operators and functional operators with non-Carleman shift

Rui Marreiros
University of Algarve, Portugal

We consider the singular integral operator with a non-Carleman shift $T = I - cU P_+: L^p_+^n(\mathbb{T}) \to L^p_+^n(\mathbb{T})$, $p \in (1, \infty)$, where $P_+$ is the Cauchy projector, $U$ is an isometric shift operator and $c(t)$ is a continuous matrix function on the unit circle $\mathbb{T}$. We obtain some estimates for the dimension of the kernel of the operator $T$; additionally we relate those estimates with the resolvent set of the functional operator $cU$.

19:30 Conference dinner - Restaurante Espeto do Sul
ABSTRACTS - 24th March

10:00-10:45 Time-frequency analysis of probability distributions associated with reproducing kernels

Luís Daniel Abreu
Austrian Academy of Sciences, Vienna, Austria

Abstract

10:50 Coffee-break

11:25-11:45 A local Hardy uncertainty principle for Wigner functions

João Nuno Prata
University of Lisbon, Portugal

I will present a Hardy-type uncertainty principle, where the concentration of a Wigner function in a small neighborhood of a point in phase-space is compared with that of Gaussian measures. The method also permits non-Gaussian estimates. As a by-product, I will show that many (perhaps all) Wigner functions can be determined entirely from their shape on a set of arbitrarily small measure.

The talk is based on joint work with N.C. Dias (GFM-University of Lisbon) and M. de Gosson (NuHAG-University of Vienna)

11:50-12:10 Phase space Feynman path integrals

Naoto Kumano-Go
Kogakuin University, Japan

We give a general set of functionals for which the phase space Feynman path integrals have a mathematically rigorous meaning. More precisely, for any functional belonging to the set, the time slicing approximation of the phase space path integral converges uniformly on compact subsets with
respect to the starting point of momentum paths and the endpoint of position paths. The set is closed under addition and multiplication. Therefore, we can produce many functionals which are phase space path integrable. Furthermore, though we need to pay attention for use, the interchange of the order with the integrals with respect to time, and the interchange of the order with some limits are valid in the phase space path integrals.

12:15-14:30 Lunch-break

14:30-15:15 The shearlet transform and coorbit spaces

Gerd Teschke
University of Applied Sciences, Neubrandenburg, Germany

Abstract

15:20-15:40 Edge detection, vanishing moments and the Euler function

Thomas Fink
Universität Passau, Germany

In numerous fields of image analysis, the determination of the precise geometry of occurring edges is a crucial task. Here, the edges’ curvature is a geometric feature of great practical relevance and hence part of many algorithms for object recognition. In this talk, we present the Taylorlet transform which is an extension of the continuous shearlet transform, but features a different structure and uses nonlinear shears. By locally representing an edge as the graph of a function $q : \mathbb{R} \to \mathbb{R}$, the Taylorlet transform can detect the Taylor coefficients of $q$ by observing the decay rate of this transform with respect to the dilation parameter. For this, the analyzing function $\tau$ has to fulfill vanishing moment conditions of higher order i.e., $\int_{\mathbb{R}} \tau(\pm x_1^k, x_2)x_1^m dx_1 = 0$ for all $x_2 \in \mathbb{R}$, where $k \in \mathbb{Z}^+$, $m \in \mathbb{Z}_0^+$. The goal of this talk is to find an analyzing function similar to the Meyer wavelet which is a Schwartz function with infinitely many vanishing moments, thus providing a robust detection of singularities. The construction of a Schwartz function with infinitely many vanishing moments of higher order is challenging as one cannot resort to a Fourier approach as for the construction of the Meyer wavelet. Hence, we present an approach based on q-calculus which reveals a surprising connection to combinatorics.
15:45-16:05 Application of quaternionic operator calculus to micropolar elasticity

Klaus Gürlebeck, Dmitrii Legatiuk
Bauhaus Universität Weimar, Germany

Micropolar elasticity is a refined version of the classical elasticity. Equations of micropolar elasticity are not given only by a single differential equation w.r.t. a vector field of displacement, but by a coupled system of differential equations connecting fields of displacements and rotations. However, construction of solution methods for boundary value problems of micropolar elasticity is still an open mathematical task, mostly due to the coupled nature of the resulting system of partial differential equations. Especially, only few results are available for spatial problems of micropolar elasticity. Therefore, in this talk, we present a quaternionic operator calculus-based approach to construct general solutions to three-dimensional problems of micropolar elasticity. Moreover, we prove solvability of the boundary value problem of micropolar elasticity, as well as we provide an explicit estimate for the difference between the classical elasticity and the micropolar model.

16:10 Coffee-break

16:45-17:05 On some Radon-type transforms for monogenic functions

Irene Sabadini
Politecnico di Milano, Italy

In this talk we discuss some Radon-type transforms of monogenic functions. We first define a version of the Radon transform based on Szegö kernels. We shall show how the transform is explicitely computed on axially monogenic functions of degree $k$. We also introduce a Szegö-Radon projection which may be abstractly defined as the orthogonal projection of a suitable Hilbert module of square integrable left monogenic functions onto the closed submodule of monogenic functions spanned by the monogenic plane waves.

We then discuss a Bargmann-Radon transform which is defined as the projection of the real Bargmann module on the closed submodule of monogenic functions spanned by the monogenic plane waves. This transform can be expressed in integral form using a suitable kernel.

If time permits, we shall introduce a version of the Szegö-Radon transform for a subclass of monogenic functions in the unit Lie ball in $\mathbb{C}^m$. 
17:10-17:30 Fractional operator calculus in hypercomplex Analysis

Sören Kraußhar
Universität Erfurt, Germany

In this talk we present the fundamentals for a fractional integral operator calculus in Clifford analysis. We introduce Dirac operators of fractional order by Riemann-Liouville and Caputo derivatives. We prove a generalized Stokes- and Borel Bonpeiu formula in which an interesting duality between Riemann-Liouville and Caputo derivatives appears. These tools in hand together with explicit representation formulas for the fundamental solution in terms of Mittag-Leffler series allow us to introduce generalizations of the Teodorescu and the Cauchy integral operator. Finally, we present a Hodge decomposition together with some applications to boundary value problems related to the fractional Laplacian.

This is joint work with M. Ferreira, M.M. Rodrigues, and N. Vieira of University of Aveiro.

17:35-17:55 On the Hilbert formulas for some singular integrals in unit circle

Baruch Schneider
Izmir University of Economics, Turkey

The classical Hilbert formulas describing the relation between the boundary values, in the unit circle, of a pair of conjugate harmonic functions is a well-known result in one-dimensional complex analysis. Various analogues of the Hilbert formulas on the unit sphere keep interest until our days. In this talk we give some analogues of the Hilbert formulas on the unit circle for \( \alpha \)-hyperholomorphic function theory when \( \alpha \) is a complex number. Such formulas relate a pair of components of the boundary value of an \( \alpha \)-hyperholomorphic function in the unit circle with the other one.

Talk based on joint works with J. Bory Reyes, R. Abreu Blaya, M. A. Pérez-de la Rosa.

18:00 Closing Session