

Book of abstracts

abstracts and list of participants

The Real World is Complex

– an international symposium in honor of Christian Berg

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Abstracts

On Jain operators and their approximation properties

OCTAVIAN AGRATINI

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The talk is a stop in the complex world of the approximation processes. We will discuss about a class of linear positive operators of discrete type which in recent years have returned to the mathematical spotlight.

Starting from the following Poisson-type distribution

$$w_{\beta}(k, \alpha) = \alpha(\alpha + k\beta)^{k-1} e^{-(\alpha+k\beta)} / k!, \quad k \geq 0,$$

where $\alpha > 0$ and $|\beta| < 1$, in 1972 G.C. Jain constructed a class of linear and positive operators given by the formula

$$(P_n^{[\beta]} f)(x) = \sum_{k=0}^{\infty} w_{\beta}(k, nx) f\left(\frac{k}{n}\right), \quad f \in C(\mathbb{R}_+),$$

where β is a parameter belonging to the interval $[0, 1)$. We focus on the following aspects: the relationship between the local smoothness of function and the local approximation, the degree of approximation in terms of the moduli of smoothness, a complete asymptotic expansion for operators, the statistical convergence of the sequence. On the other hand, we identify functions for which these operators provide uniform approximation over unbounded intervals. In the final part an integral generalization of these operators is investigated.

For particular case $\beta = 0$ some previous results are recaptured.

Radii of convexity of some Lommel and Struve functions

ÁRPÁD BARICZ

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In this talk the radii of convexity of some Lommel and Struve functions of the first kind are presented. For both of Lommel and Struve functions three different normalizations are applied in such a way that the resulting functions are analytic in the unit disk of the complex plane. Some results on the zeros of the derivatives of some Lommel and Struve functions of the first kind are also deduced, which may be of independent interest. The talk is based on a joint work [[arXiv . 1410 . 5217](#)] with Nihat Yağmur.

On Hyperbolically Monotone Functions

LENNART BONDESSON

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A nonnegative function $f(x)$ on $(0, \infty)$ is called hyperbolically monotone of order k (HM_k) if for each $u > 0$ the function $h(w) = f(uv)f(u/v)$, where $w = v + v^{-1}$, is such that $(-1)^j h^{(j)}(w) \geq 0$ for $j = 1, 2, \dots, k$.

The HM_k class is closed with respect to (wrt) multiplication of functions. More remarkably, it is also closed wrt multiplicative convolution. For $k = 1$ and $k = \infty$ canonical representations of the HM_k functions are known since long. In these cases $f \in \text{HM}_k$ implies that $f^p \in \text{HM}_k$ for all $p > 0$ but this does not hold for $1 < k < \infty$. A recent review of the HM_k -functions is given in [1].

Here there is presented a representation of all functions f such that, for any integer $k \geq 2$, $f^p \in \text{HM}_k$ for all $p > 0$. Let $\psi(x) = -xf'(x)/f(x)$. It turns out that $f^p \in \text{HM}_k$ for all $p > 0$ if and only if

$$(-1)^{j-1} (x^{2j-1} \psi^{(j)}(x))^{(j-1)} \geq 0, \quad j = 1, 2, \dots, k.$$

Moreover, this holds if and only if

$$\psi'(x) = a + \frac{b}{x^2} + \int_{(0, \infty)} \phi'_k(x; \lambda) C(d\lambda),$$

where $a, b \geq 0$ and C is a nonnegative measure with density $c(\lambda)$ given by

$$c(\lambda) = (-1)^{k-1} (\lambda^{2k-1} \psi^{(k)}(\lambda))^{(k-1)},$$

and

$$\phi_k(x; \lambda) = \frac{(-1)^{k-1}}{(2k-2)!} \left(\frac{(x-\lambda)^{2k-2}}{\lambda^k x^{k-1}} \text{Heaviside}(x-\lambda) - P(x; \lambda) \right)$$

with $P(x; \lambda) = \text{Polynomial part of } (x-\lambda)^{2k-2}/(\lambda^k x^{k-1})$.

Examples of this novel result are presented. It can be seen as a integral representation for functions in a special convex cone. It has also connections to a classical characterization of the Stieltjes transform of a nonnegative measure.

Reference

[1] Behme, A., Bondesson, L. (2015). A class of scale mixtures of gamma(k)-distributions that are generalized gamma convolutions. Submitted.

Asymptotic values and analytic sets

ALICIA CANTÓN

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In the 30's, Mazurkiewicz observed that the set of asymptotic values of a function meromorphic in \mathbb{C} is an analytic set (in the sense of Suslin). Conversely, any analytic set on $\widehat{\mathbb{C}}$ can be realized as the set of asymptotic values of a meromorphic function (even with a prescribed finite order) or as the set of asymptotic values of a holomorphic function if the analytic set contains infinity.

Quasiregular maps are a generalization of holomorphic functions to dimensions $d \geq 3$, and in fact, they share many of their properties. In a joint work with Qu, it is shown that analytic sets that contain infinity also characterize the sets of asymptotic values of quasiregular maps defined in \mathbb{R}^d with finite order of growth. Our example is based on Drasin's version of a quasiregular sine.

Asymptotics of Chebyshev polynomials

JACOB S. CHRISTIANSEN

LUND UNIVERSITY, SWEDEN

In the talk, I'll consider Chebyshev polynomials $T_n(z)$ for infinite compact sets, E . These are the unique minimizers of the sup-norm on E among all monic degree n polynomials. The main result to be discussed deals with asymptotics of $T_n(z)$ when E is a finite gap set in \mathbb{R} and settles a 45 year old conjecture of Widom. The talk is based on joint work with B. Simon and M. Zinchenko.

On a new concept of conjugate Laplace series

ALBERTO CIALDEA

UNIVERSITÀ DELLA BASILICATA, ITALY

It is well known that the conjugate trigonometric series play an important role in the theory of Fourier series. In this talk I will present a definition of conjugate Laplace series on the $(n - 1)$ -dimensional sphere. For example, in the particular case $n = 3$, if

$$\sum_{h=0}^{\infty} \sum_{k=0}^{2h} a_{hk} Y_{hk}(\varphi, \theta) \quad (1)$$

is a spherical expansion, then its conjugate series - according to this definition - is given by

$$\sum_{h=1}^{\infty} \sum_{k=0}^{2h} \frac{a_{hk}}{h+1} \left[\frac{1}{\sin \varphi} \frac{\partial Y_{hk}}{\partial \theta} d\varphi - \sin \varphi \frac{\partial Y_{hk}}{\partial \varphi} d\theta \right]. \quad (2)$$

It must be remarked that this is not a series of scalar functions, but it is a series of differential forms on the sphere $\{x \in \mathbb{R}^3 : |x| = 1\}$.

I will show why (2) can be considered the conjugate series of (1) and I will give some related results. In particular I will describe some convergence results and a Brothers Riesz Theorem for such expansions.

q -polynomials. Orthogonality in the complex plane and more

ROBERTO S. COSTAS-SANTOS

UNIVERSIDAD DE ALCALA, SPAIN

In this short talk I will describe the orthogonality of some families of q -polynomials for almost all the values of their parameters. I also present the last result about generalizations of generating functions for these families.

When does a discrete differential perturbation of a sequence of orthonormal polynomials belong to ℓ^2 ?

ANTONIO J. DURÁN

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Let μ be a positive Borel measure on the real line having finite moments and infinite support. Such a measure μ is said to be determinate if no other positive measure has the same moments as those of μ ; otherwise, μ is said to be indeterminate. We denote by $(p_n)_n$ the sequence of orthonormal polynomials associated to the positive measure μ .

The aim of this talk is to show the solution of the following problem: for which discrete differential operators

$$T = \sum_{l=1}^N \sum_{j=0}^{k_l} a_{l,j} \delta_{z_l}^{(j)}, \quad z_l \in \mathbb{C}, z_l \neq z_m, l \neq m \quad (3)$$

does the complex sequence $(T(p_n))_n$ belong to ℓ^2 ?

From the works of Nevalinna and M. Riesz in the 1920's, the solution of the problem above was known for indeterminate measures. Indeed, if μ is an indeterminate measure then any discrete differential operator T of the form (3) satisfies $(T(p_n))_n \in \ell^2$. For determinate measures the problem was solved some 20 years ago, in a series of joint papers by prof. Berg and this speaker, using as the main tool the so-called index of determinacy. This index of determinacy checks the stability of determinacy under multiplication by even powers of $|t - z|$, where z is a given complex number (a similar index for Stieltjes moment problem and $z = 0$, was previously introduced by prof. C. Berg and his then PhD. student M. Thill in their paper in *Acta Mathematica* entitled *Rotation invariant moment problems* (1991)). We show in this talk a complete and very simple classification of determinate measures according to this index of determinacy. Then for a determinate measure μ , the problem above has non trivial solutions if and only if the measure μ has finite index of determinacy. In that case, we will display a complete characterization of the discrete differential operators T of the form (3) for which $(T(p_n))_n \in \ell^2$.

Indeterminate moment problems and Christian Berg

ERIK KOELINK

RADBOUD UNIVERSITY NIJMEGEN, THE NETHERLANDS

Indeterminate moment problems go back to the work of Thomas J. Stieltjes (1856-1894), and have been studied from various angles since Stieltjes. Moment problems are a continuous interest of Christian Berg and we discuss some highlights of his results. Some explicit cases and examples from the world of q are considered.

Approximation of solutions to multidimensional parabolic equations by Approximate Approximations

FLAVIA LANZARA

SAPIENZA UNIVERSITY, ITALY

In this talk we present a fast method for high order approximations of the solution of n -dimensional parabolic problems over hyper-rectangular domains:

$$\begin{aligned}\frac{\partial u}{\partial t} - \Delta_{\mathbf{x}}u + 2\mathbf{b} \cdot \nabla_{\mathbf{x}}u + cu &= f(\mathbf{x}, t), \\ u(\mathbf{x}, 0) &= g(\mathbf{x})\end{aligned}$$

for $(\mathbf{x}, t) \in \mathbb{R}^n \times \mathbb{R}_+$ with $\mathbb{R}_+ = [0, \infty)$, $\mathbf{b} \in \mathbb{C}^n$, $c \in \mathbb{C}$. We suppose that f and g are supported with respect to \mathbf{x} in a hyper-rectangle $[\mathbf{P}, \mathbf{Q}] = \{\mathbf{x} = (x_1, \dots, x_n) \in \mathbb{R}^n : P_j \leq x_j \leq Q_j, j = 1, \dots, n\}$, $\text{supp } f \subseteq [\mathbf{P}, \mathbf{Q}] \times \mathbb{R}_+$, $\text{supp } g \subseteq [\mathbf{P}, \mathbf{Q}]$.

Our method consists in approximating the functions f and g via the basis functions introduced in the method of approximate approximations, which are product of Gaussians and special polynomials, providing high order semi-analytic cubature formulas. This approach, combined with separated representations, makes our method effective also in high dimensions. We report on numerical results illustrating that our formulas are accurate and provide the predicted approximation rate in high dimensions. This talk is based on a joint work with Vladimir Maz'ya (Linköping University, Sweden & Liverpool University, UK) and Gunther Schmidt (WIAS, Berlin, Germany).

The Eneström–Kakeya theorem encounters the theory of orthogonal polynomials on the unit circle

ANDREAS LASAROW

LEIPZIG UNIVERSITY OF APPLIED SCIENCES, GERMANY

A classical result due to Eneström and Kakeya gives some bounds for the moduli of the zeros of polynomials having a monotone sequence of non-negative (real) coefficients. The main subject of the talk is a study of this fact with a view to the recurrence relations fulfilled by systems of orthogonal polynomials on the unit circle (of the complex plane). In particular, we will be interested in the special case, where the zeros of the polynomials in question are not located on the boundary of the estimate which occurs in the Eneström–Kakeya theorem. Among other things, we will give characterizations of this case in terms of orthogonal polynomials.

Approximation of semigroups generated by differential operators associated with Markov operators

VITA LEONESSA

UNIVERSITY OF BASILICATA, ITALY

The talk is concerned with a special differential operator W_T associated with a Markov operator T acting on the space $C(K)$ of all continuous functions defined on a convex compact subset K of \mathbb{R}^d ($d \geq 1$). The operator W_T has been carefully investigated in [1] and it is defined as

$$W_T(u) := \frac{1}{2} \sum_{i,j=1}^d \alpha_{ij} \frac{\partial^2 u}{\partial x_i \partial x_j} \quad (u \in C^2(K)), \quad (4)$$

$$\alpha_{ij} := T(pr_i pr_j) - pr_i pr_j \quad (i, j = 1, \dots, d),$$

pr_i being the i^{th} coordinate function on K . W_T is elliptic, it degenerates on a subset of K which contains the set of extreme points of K and, as we shall see, if T maps polynomials into polynomials of the same degree, then $(W_T, C^2(K))$ is closable in $C(K)$ and its closure generates a Markov semigroup on $C(K)$ which can be approximated by means of suitable iterates of the so-called Bernstein-Schnabl operators B_n ($n \geq 1$) associated with T .

All these new results are also contained into the recent monograph [2] which contains, among other things, a deeper and more accurate study of B_n 's.

References

- [1] Francesco Altomare, Mirella Cappelletti Montano, V. L., Ioan Raşa, *On differential operators associated with Markov operators*, J. Funct. Anal. 266 (2014) 3612-3631.
- [2] Francesco Altomare, Mirella Cappelletti Montano, V. L., Ioan Raşa, *Markov Operators, Positive Semigroups and Approximation Processes*, De Gruyter Studies in Mathematics, 61, 2014.

Extension of Wright type hypergeometric function

BHUMIKA MAHESHWARI

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Virchenko et al.[Virchenko N, Kalla SL, Al-Zamel A. Some results on a generalized hypergeometric function. *Integral Transforms Spec. Funct.* 2001;12(1):89-100] generalized Wright type hypergeometric function. In this talk, we extend Virchenko's version of Wright type hypergeometric function by using extended and generalized Pochhammer symbol by Srivastava [Srivastava R. Some generalizations of Pochhammers symbol and their associated families of hypergeometric functions and hypergeometric polynomials, *Appl. Math. Inform. Sci.* 2013;7(6):2195-2206]. Various properties in the form of integral representation, contiguous relations, differential relations, integral forms and recurrence formula are discussed.

Joint work with Ranjan Kumar Jana.

Regularization of some integral equations of the first kind in potential theory

ANGELICA MALASPINA

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Results concerning the regularization of some integral equations of the first kind involved in the study of boundary value problems for different partial differential equations in simply connected domains and in multiply connected domains are presented. Some papers, obtained in the last few years, are joint works with Alberto Cialdea, Emanuela Dolce and Vita Leonessa.

Zero distribution of Incomplete Padé and Hermite-Padé approximants

JUDIT MÍNGUEZ CENICEROS

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Incomplete Padé approximants have been recently introduced in [1] and [2]. They are defined in a similar manner as the Padé approximants except for the fact that the number of interpolating conditions may be fewer than the number of coefficients to be determined. Hence, type-Padé or Hermite Padé approximants are incomplete. We prove that a subsequence of the normalized zero counting measures of incomplete Padé approximants tend, as the degree of the numerators goes to infinity and that of the denominators remains bounded, to the uniform distribution on the largest circle centered at the origin inside of which the approximants converge in the sense of the Hausdorff content. As a consequence, a Jentzsch-Szegő type theorem for row sequences of Hermite-Padé approximants is given.

This is a joint work with B. de la Calle Ysern.

References

- [1] J. Cacoq, B. de la Calle Ysern, G. López Lagomasino, Incomplete Padé approximation and convergence of row sequences of Hermite-Padé approximants, *J. Approx. Theory* 170 (2013) 59–77.
- [2] J. Cacoq, B. de la Calle Ysern, G. López Lagomasino, Direct and inverse results on row sequences of Hermite-Padé approximants, *Constr. Approx.* 38 (2013) 133–160.

On Laguerre-Hahn affine Orthogonal Polynomials on the Unit Circle from matrix Sylvester equations

MARIA DAS NEVES REBOCHO

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Laguerre-Hahn affine orthogonal polynomials on the unit circle are related to Carathéodory functions, F , that satisfy first order differential equations with polynomial coefficients

$$zAF' = CF + D.$$

Well-known families of these polynomials include the semi-classical orthogonal polynomials on the unit circle as well as some of their perturbations.

In this talk it is derived recurrences for the reflection coefficients of Laguerre-Hahn affine orthogonal polynomials on the unit circle, including a form of the discrete Painlevé equations dP_V . The technique is based on the knowledge of the first order differential equation for the Carathéodory function, combined with a re-interpretation, in the formalism of matrix Sylvester equations, of compatibility conditions for the differential systems satisfied by the polynomials.

Higher order monotonicity: analytical and probabilistic aspects

PAUL RESSEL

CATHOLIC UNIVERSITY EICHSTÄTT-INGOLSTADT, GERMANY

Monotonicity is a fundamental notion in nearly every part of mathematics, in particular when dealing with real valued functions. For functions on an interval sharper notions of monotonicity seem to be natural, in- or decreasing increments over subintervals of equal length lead to the notion of a higher degree of monotonicity, for differentiable functions most easily expressible by the sign of their derivatives.

For functions of n variables another natural type of monotonicity exists, called “fully n -increasing”, the essential characterizing property of multivariate distribution functions, and there is a non-trivial link to univariate higher order monotonicity. Fully n -increasing functions can also be characterized by positive definiteness on certain idempotent (abelian) semigroups. Natural questions then lead to higher order monotonic functions of several variables. Suitably normalized, the set of these functions turns out to be a Bauer simplex, whose extreme points are precisely the tensor products of their univariate counterparts.

Among the applications we’ll discuss a spectral representation of classical mean values, a new characterization of so-called stable dependence functions (used in multivariate statistical analysis), and we introduce linearly order-symmetric distribution functions on $[0, 1]^n$, related to special copulas and to Marshall-Olkin distributions. Here in fact also higher order monotonic sequences play an important rôle.

Entire functions of exponential type represented by pseudo-random and random Taylor series

MIKHAIL SODIN

TEL AVIV UNIVERSITY, ISRAEL

We show that the distribution of zeroes of various classes of Taylor series with random and pseudo-random coefficients is governed by certain autocorrelations of in relative short windows. Using this guiding principle, we consider several examples of random and pseudo-random sequences and, in particular, answer some questions posed by Chen and Littlewood in 1967. As a by-product we show that if a spectral measure of a stationary random $\{0, 1\}$ -valued sequence has a gap in its support, then the sequence is periodic.

The talk is based on a joint work with Alexander Borichev and Alon Nishry.

On the horizontal monotonicity of the gamma function

G. K. SRINIVASAN

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The behaviour of the modulus of the gamma function along vertical lines in the right half plane is well understood owing to its importance in number theory. In contrast very little is available in the literature on the behaviour of the modulus of the gamma function along horizontal lines in the plane.

Writing $s = \sigma + it$ for a complex variable, it is proved that the modulus of the gamma function, $|\Gamma(s)|$, is strictly monotone increasing with respect to σ whenever $|t| > 5/4$. It is also shown that this result is false for $|t| \leq 1$. We obtain rather sharp bounds on the "ordinate of monotonicity". The work is a joint work with Professor Peter Zvengrowski at the University of Calgary.

Boundary estimates for Bergman polynomials in domains with corners

NIKOS STYLIANOPOULOS

UNIVERSITY OF CYPRUS, CYPRUS

Let G be a bounded simply-connected domain in the complex plane \mathbb{C} , whose boundary $\Gamma := \partial G$ is a Jordan curve, and let $\{p_n\}_{n=0}^{\infty}$ denote the sequence of Bergman polynomials of G . This is defined as the unique sequence of polynomials $\{p_n(z)\}_{n=0}^{\infty}$, with positive leading coefficient, that are orthonormal with respect to the area measure on G .

The asymptotic behaviour of $p_n(z)$ in the exterior of Γ , in cases when Γ is a piecewise analytic Jordan curve, has been recently established. The purpose of this talk is to present, for the same class of curves, definite results and a conjecture for the asymptotics of $p_n(z)$ on Γ .

Turán determinants in an unbounded setting

GRZEGORZ ŚWIDERSKI

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Let μ be a probability measure on the real line and $\{p_n\}_{n=0}^{\infty}$ be the corresponding sequence of orthonormal polynomials. It satisfies a recurrence relation

$$\begin{aligned} p_{-1}(x) &\equiv 0, \quad p_0(x) \equiv 1, \\ xp_n(x) &= a_{n-1}p_{n-1}(x) + b_n p_n(x) + a_n p_{n+1}(x) \quad (n \geq 0) \end{aligned}$$

for certain $a_n > 0, b_n \in \mathbb{R}$. Turán determinants are defined by

$$T_n(x) = p_n^2(x) - p_{n-1}(x)p_{n+1}(x).$$

A classical theorem of Nevai asserts that if sequences a_n and b_n are of bounded variation then $\{T_n\}$ is closely related to the density of μ . We are going to present an extension of this theorem to the case when the sequence a_n is divergent.

The order and the type of some indeterminate moment problems

RYSZARD SZWARC

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In a joint paper with Christian Berg (The order of indeterminate moment problems, *Advances in Mathematics* **250** (2014), 105-143) we studied the connection between the growth of the following quantities associated with indeterminate moment problem

- the order of the problem
- behaviour of the recurrence coefficients in the corresponding Jacobi matrix
- summability exponent of the corresponding orthogonal polynomials

The methods of the proofs required regular behaviour of the recurrence coefficients. For example we could not admit the asymptotically periodic case.

Motivated by a conjecture of G. Valent (Indeterminate moment problems and a conjecture on the growth of the entire functions in the Nevanlinna parametrization, *Applications and computation of orthogonal polynomials* (Oberwolfach, 1998), *Internat. Ser. Numer. Math.*, **131** (1999), 227-237) concerning certain birth and death processes, we developed new methods which can be applied to asymptotically two-periodic case.

In this way we reproved a recent result of Roman Romanov (Order problem for canonical systems and a conjecture of Valent, <http://arxiv.org/abs/1502.04402>), where the author proved the Valent conjecture concerning the order. Our method allow us, additionally, to get pretty precise information also on the type of the moment problem of Valent.

Polynomial inequalities on general sets

VILMOS TOTIK

UNIVERSITY OF SZEGED, HUNGARY AND UNIVERSITY OF SOUTH FLORIDA, TAMPA, USA

Recently some remarkable generalizations of classical polynomial inequalities have been proven on general sets by various authors. The talk will discuss some of these recent developments: the variants of the Bernstein and Markov inequalities on general compact subsets of the real line or on a system of Jordan curves and arcs. The formulation involves some basic potential theory, which will also be presented.

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