BOOK OF ABSTRACTS

FUNCTION THEORY ON INFINITE DIMENSIONAL SPACES XVI

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PLENARY TALKS

Quantitative and qualitative estimates on the norm of product of polynomials

Gustavo Araújo. Universidade Estadual da Paraíba, Brazil.

`Abstract.` When for the first time, in 1987, a Banach space X and a bounded operator $T : X \to X$ with no trivial invariant subspaces was constructed, two of the many tools used by P.H. Enflo was the "concentration of polynomials at low degrees" and a series of estimates on the norm of products of polynomials. The concept of concentration of polynomials at low degrees has been adapted to other norms and one of these adaptations falls within the case of sets with gaps or missing portions (the so-called lacunary sets). Here we deepen into the study of these two concepts and, among other things, we present a result on estimates of lacunary norms of product of polynomials.

This is a joint work with P.H. Enflo, G.A. Muñoz-Fernández, D.L. Rodríguez-Vidanes and J.B. Seoane-Sepúlveda.

Reflexivity and norm attaining operators on Banach Spaces and their Applications

Richard Aron. Kent State University, USA

`Abstract.` Let X and Y be Banach spaces, and let $T, K : X \to Y$ be bounded, resp. compact linear operators. We investigate the relation between the reflexivity of X and Y and the question of whether the inequality $\|T\| < \|T + K\|$ implies that $T + K$ attains its norm. This is related to the following: A pair of Banach spaces (X, Y) is said to have the *weak maximizing property* if for any bounded linear operator $T : X \to T$, the existence of a non-weakly null maximizing sequence for T implies that T attains its norm.

If time permits we will also describe related questions for homogeneous polynomials.

This is joint work with Domingo García, Daniel Pellegrino, and Eduardo Teixeira (Proc. AMS, to appear).

Large algebraic structures in families of holomorphic functions and of sequences of functions

Luis Bernal González. University of Sevilla, Spain.

Abstract. Quite frequently, a family of mathematical objects that present strange properties is far from being linear but, paradoxically, may contain rather large linear or algebraic structures. This property can be measured by using the concept of lineability, introduced by Gurariy at the beginning of this millenium: a subset A of a vector space X is called *lineable* whenever there is a vector space M with $\dim(M) = \infty$ such that $M \subset A \cup \{0\}$. Since then, several stronger properties, as for instance *dense lineability, spaceability* and *algebrability*, have been defined and studied by several mathematicians.

In the last two decades there has been a great advance in this line of research. In this expository talk, we present some recent discoveries in the topic, with special emphasis on families of holomorphic functions in infinite dimensional spaces, and on families of sequences of functions. Moreover, we introduce some results about the notions of S-lineability and convex lineability, also coined by Gurariy but unpublished until recently.

Differentiability versus continuity: Restriction and extension theorems and monstrous examples

Krzysztof Chris Ciesielski. West Virginia University, United States

Abstract. This talk is based on the first part of a 2019 BAMS survey, with the same title, written with Juan B. Seoane–Sepúlveda. Its aim is to revisit the centuries old discussion on the interrelations between continuous and differentiable functions from $\mathbb{R}$ to $\mathbb{R}$. The new angle of this presentation is influenced by a series of very recent results in this research area.

This is presented in an narrative that answers two classical questions: (1) *To what extend a continuous function must be differentiable?* and (2) *How strong is the assumption of differentiability of a function?*

Question (2) will be interpreted as: *To what extent the derivative F' of an $F\colon \mathbb{R} \to \mathbb{R}$ must be continuous?* Here we recall some well known properties of the derivatives (large set of points of continuity, Darboux property) as well as newer (e.g., a finite composition of derivatives from $I = [0, 1]$ to I has fixed point property). We will also provide a very easy new construction of *everywhere differentiable nowhere monotone map.*

Concerning question (1): we indicate a simple new proof that *for every continuous $f\colon \mathbb{R} \to \mathbb{R}$ there is a perfect set $Q \subset \mathbb{R}$ such that $f \restriction Q$ is differentiable*; discuss Jarník and Whitney differentiable extension theorems;

deduce that *for every continuous* $f\colon \mathbb{R} \to \mathbb{R}$ *there is a* C^1 *map* $g\colon \mathbb{R} \to \mathbb{R}$ *such that* $f \cap g$ *is uncountable.* We will also present a new seemingly paradoxical example a differentiable function $F\colon \mathbb{R} \to \mathbb{R}$ (which can be nowhere monotone) and of compact perfect $\mathfrak{X} \subset \mathbb{R}$ such that $F'(x) = 0$ for all $x \in \mathfrak{X}$ while $F[\mathfrak{X}] = \mathfrak{X}$; thus, the map $\mathfrak{f} = F \upharpoonright \mathfrak{X}$ is shrinking at every point while, paradoxically, not globally.

Lipschitz continuous functions and criticality

Aris Daniilidis. Universidad de Chile, Chile

`Abstract.` In this talk I will discuss theoretical results concerning the size of Clarke critical values for special subclasses of Lipschitz continuous functions, as well as the phenomenon of generic trivialization due to the saturation of the Clarke subdifferential. I will comment on the (non-)efficiency (in the general case) of standard first-order iteration methods to detect critical points.

Smooth and Lipschitz approximation of functions defined on metric measure spaces

Rafael Espínola García. Universidad de Sevilla, Spain

`Abstract.` In this talk we will revise some of the classical results on smooth and Lipschitz approximation of functions defined on $\mathbb{R}^n$ and Banach spaces and will provide a first approach to the problem when the domain of the function is a metric measure space endowed with a measure differentiable structure (MDS). In particular, we explore density of differentiable functions defined from a metric measure space with a MDS into a Banach space.

New results here presented are part of a joint work with Luis Sánchez González.

The sets of monomial convergence for polynomials and holomorphic functions

Domingo García Rodríguez. Universidad de Valencia, Spain

`Abstract.` There are two possible ways to approach holomorphy: the Cauchy way through differentiability and the Weierstrass way through analyticity. These approaches coincide for functions of several complex variables but in infinite many dimensions they are different.

We are interested in functions on the open unit ball B_{c_0} of the Banach space c_0 of the null sequences. Here for each holomorphic function f we have a unique family of coefficients $(c_\alpha(f))_{\alpha\in\mathbb{N}_0^{(\mathbb{N})}}$ such that the formal monomial series $\sum_{\alpha\in\mathbb{N}_0^{(\mathbb{N})}} c_\alpha(f)z^\alpha$ equals $f(z)$ for all finite sequences $z \in B_{c_0}$.

Thus it is natural to define the set of monomial convergence of the space $H_\infty(B_{c_0})$ of all bounded holomorphic functions on B_{c_0}

$$\mathrm{mon}H_\infty(B_{c_0}) := \{z \in \mathbb{C}^{\mathbb{N}} : \sum_{\alpha\in\mathbb{N}_0^{(\mathbb{N})}} |c_\alpha(f)z^\alpha| < \infty \ \text{ for all } \ f \in H_\infty(B_{c_0})\},$$

and similarly for the space $\mathcal{P}_m(c_0)$ of all m-homogeneous continuous polynomials on c_0.

In this talk we are going to study these sets giving a complete description in the case of the m-homogeneous polynomials. We also extend this study to more general situations. We describe the sets of monomial convergence in Banach sequence spaces X for the cases of bounded holomorphic functions on the open unit ball of X and m-homogeneous polynomials on X, being of particular interest the spaces ℓ_p, for $1 \leq p < \infty$. But we go further giving a rather accurate lower bound for $\mathrm{mon}H(R)$, where R is an arbitrary Reinhardt domain in an arbitrary Banach sequence space. This cycle of ideas is related with Bohr's original absolute convergence problem, as well as Bohr radius and unconditionality for spaces of homogeneous polynomials.

The content of this talk is part of the book *Dirichlet Series and Holomorphic Functions in High Dimensions,* New Mathematical Monographs 37. Cambrigde University Press (2019) by A. Defant, M. Maestre, P. Sevilla-Peris and myself.

A three-point inequality for convex functions

Pablo Jiménez Rodríguez. Universidad de Valladolid, Spain

Abstract. We will focus our attention on a property that real convex functions verify, in the form of an inequality. We will show some consequences in properties that real numbers satisfy.

Universality and Dirichlet series

Manuel Maestre Vera. Universidad de Valencia, Spain

Abstract. The pourpose of this talk is to show the existence of a Dirichlet series $\sum_{n=1}^{\infty} \frac{a_n}{n^s}$ such that $\sum_{n=1}^{\infty} \frac{|a_n|}{n^\sigma}$ is convergent for every $\sigma > 0$ and satisfying the following "**universal property**":

Given $K \subset \{z \in \mathbb{C} : \mathrm{Re} z \leq 0\}$ a compact set with connected complement and given $g : K \to \mathbb{C}$ a function continuous function on K and holomorphic on its interior, there exists a subsequence (S_{N_j}) of $S_N = \sum_{n=1}^{N} \frac{a_n}{n^s}$ such that (S_{N_j}) converges uniformly to g on K.

Previously, we will survey on the concept of Universality that originally was associated to the behaviour of partial sums of the Taylor series expansion of an holomorphic function defined on the unit disk.

This is a joint work with R.M. Aron, F. Bayart, P. Gauthier and V. Nestoridis.

Bourbaki-completeness spaces and Samuel realcompactification

Ana Meroño. Universidad Complutense de Madrid, Spain

Abstract. *Bourbaki-completeness* is a completeness-like property of uniform spaces (X, μ) introduced by Garrido and Meroño in [1]. It is defined by means of a certain family of filters called *Bourbaki-Cauchy filters*. It turns out, that the Bourbaki-completeness property is equivalent to the the completeness of the uniform space $(X, s_f\mu)$ where $s_f\mu$ is the *star-finite modification* of μ, that is, the compatible uniformity on X induced by all the star-finite uniform coves from μ (see [2]).

On the other hand, Bourbaki-completeness is strongly related to the *Samuel realcompactification* of a uniform space. This is defined as the smallest realcompactification such that every real-valued uniformly continuous function can be continuously extended to it, or equivalently, as the completion of $(X, wU_\mu(X))$ where $wU_\mu(X)$ is the weak uniformity on X induced by all the real-valued uniformly continuous function $U_\mu(X)$ on (X, μ).

In this talk we will explain all the above notion and we will see, following the reference [3], how Bourbaki-completeness characterize *Samuel realcompact space*, that is, those uniform spaces (X, μ) such that $(X, wU_\mu(X))$ is complete.

References

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Global geometry and C^1 convex extensions of jets

Carlos Mudarra. Aalto University, Finland

Abstract. Given $E \subset \mathbb{R}^n$ arbitrary, and two functions $f : E \to \mathbb{R}$, $G : E \to \mathbb{R}^n$, it is natural to look for necessary and sufficient conditions on f, G for the existence of a $C^1(\mathbb{R}^n)$ convex extension F of f with $\nabla F = G$ on E. When E is bounded, the solution to this problem is given by two simple (and natural) conditions and the extension can be taken to be Lipschitz and coercive. However, if E is unbounded these two conditions are no longer sufficient and the problem is much more complicated due to some geometrical aspects of differentiable convex functions (jets) and, in particular, to the presence of *corners at infinity*. The purpose of this talk is to understand the global geometry of convex functions (jets) of class C^1 and to show the solution to the extension problem in full generality. Also, we will see that if G is bounded, F can be taken so that $\mathrm{Lip}(F) \lesssim \|G\|_\infty$. As an application, we solve a similar problem about finding C^1 convex hypersurfaces with prescribed normals at the points of an arbitrary subset of $\mathbb{R}^n$. This is a joint work with Daniel Azagra.

On coarse-Lipschitz embeddings of c_0 into dual Banach spaces

Antonín Procházka. Université Bourgogne Franche-Comté, France

Abstract. The space c_0 is known to embed badly into separable dual spaces. This is certainly true for linear embeddings, where Bessaga and Pełczyński teach us that $c_0 \subset X^*$ implies that ℓ_1 is complemented in X (and so X^* is non-separable). This is also true for Lipschitz embeddings since Heinrich and Mankiewicz can transform them very well into linear ones by differentiation. Relaxing further the conditions we impose on our embedding, we enter the domain of open problems but, thanks to Kalton, the following is known: if c_0 embeds coarsely into X, then some iterated dual $X^{(n)}$ is non-separable. It is not known whether n could be taken equal to 2 in this result. Tightening a bit the conditions we impose on the embedding, we can show the following.

Theorem. 1. *If c_0 coarse-Lipschitz embeds into X^* then the Szlenk index of X is at least ω^2.*

This is still a far cry from the desired result that in this case X^* should be non-separable (which would be, in terms of the Szlenk index, $Sz(X) = \omega_1$). So we tighten a bit again:

Theorem. 2. *If c_0 embeds coarse-Lipschitz into X^* with distortion strictly less than $\frac{3}{2}$, then $\ell_1 \subset X$ (and so X^* is non-separable).*

In order to prove Theorem 1 we use the so called Kalton's graphs. A striking application of the pre-duality theory of Lipschitz-free spaces by García Lirola, Petitjean, Rueda Zoca and the author shows that the method of Kalton's graphs cannot go beyond $Sz(X) = \omega^2$. Conversely, we will also discuss some applications of (the proof) of Theorem 2 to the pre-duality theory of Lipschitz free spaces.

These results are coming from a joint work with B. Braga, G. Lancien and C. Petitjean.

Renorming with generalized types and cotypes

Matías Raja. Universidad de Murcia, Spain

Abstract. The classic notions of type and cotype have been proved of great utility in many chapters of Banach space theory, including non-linear theory. Indeed, these notions can be formulated in purely metric terms and

thus extended to metric spaces (Enflo, Mendel-Naor). However, the classic type and cotype live in a linear scale whereas the complexity of Banach spaces cannot.

We retrieve the quite unnoticed notions of generalized type and cotype in relation with the possibility of improving, by renorming, beyond the linear scale the moduli of convexity and smoothness of super-reflexive spaces. Building on the pioneering work of Figiel we prove that a UMD space can be renormed to have a modulus of convexity not worse than a given generalized cotype.

The limitations for the existence of an optimal modulus of smoothness or convexity are essentially the same that for the existence of best type or cotype. We discuss the properties of the boundary functions and its relation to ordinal indices. This is part of a joint work with Luis C. García-Lirola.

Polynomial Properties of Spaces with Cotype

Pablo Sevilla Peris. Universitat Politècnica de València, Spain

`Abstract.` The Bohnenblust-Hille inequality, by now classical, bounds the $\frac{2m}{m+1}$-norm of the coefficients of any scalar-valued polynomial of n variables and degree m by a constant that only depends on m multiplied by the supremum of the polynomial on the n-dimensional polydisc. Having a good control of the growth of the constant with the degree is very important for certain applications. It is known that these constants grow at most exponentially with the degree.

The notion of cotype appears in a natural way when trying to get an analogous inequality for polynomials taking values on a Banach space. In this case, however, so far the constants were known to grow exponentially only in some especial cases. In general only constants with very fast growth were known.

We show that in fact for every Banach space with finite cotype, an inequality with constants growing exponentially can be obtained.

More precisely, we show that if X has cotype q, then there is a constant C so that the q-norm of the coefficients of every polynomial of n variables and degree m is bounded by C^m multiplied by the integral of the polynomial on the n-dimensional torus. Some applications will be given.

This is a joint work with Daniel Carando and Felipe Marceca (Universidad de Buenos Aires, Argentina).

Asymptotic behavior of BV functions and sets of finite perimeter in metric measure spaces

Nageswari Shanmugalingam. University of Cincinnati, USA

Abstract. We will describe the asymptotic behavior of functions of bounded variation. The setting is that of a complete metric measure space equipped with a doubling measure supporting a 1-Poincare inequality with respect to the upper gradient structure. The tools used include pointed measured Gromov-Hausdorff limits of measures, and tangent cones. The results discussed here are based on joint work with Sylvester Eriksson-Bique, James T. Gill, and Panu Lahti.

Recent Results within Nash-Moser-Ekeland Theory

Nadia Zlateva. Sofia University, Bulgaria

Abstract. Nash-Moser Theorem is an inverse function theorem in Fréchet spaces, see [5]. It is used in problems with infinitely smooth data and loss of derivatives. Its proof uses Newton type method.

In its seminal work [1] Ekeland shows that certain surjectivity can be proved for functions which are only Gâteaux differentiable.

The results in this talk are set out in three common works with Milen Ivanov that further Nash-Moser-Ekeland Theory.

In [2] we prove surjectivity result for a multivalued map. However, when translated to a function, it requires *strong* directional derivatives.

The spaces, which are interesting for applications, e.g. spaces of infinitely differentiable functions, have Heine-Borel property. This can be used to prove in a straightforward way surjectivity using the standard definition of differentiability. Namely, we have the following result.

Theorem. *Let $X = \cap_0^\infty (X_n, \|\cdot\|_n)$ and $Y = \cap_0^\infty (Y_n, |\cdot|_n)$ be Fréchet spaces with Heine-Borel property. Let $f : X \to Y$ be continuous, Gâteaux differentiable and such that $f(0) = 0$.*

Assume that there are $c_n > 0$ and $d \in \{0\} \cup \mathbb{N}$, such that for each $x \in X$ and $v \in Y$

$$\exists u \in X : \ f'(x)u = v \text{ and } \|u\|_n \le c_n |v|_{n+d}, \quad \forall n \ge 0.$$

Then for each $y \in Y$ there is $x \in X$ such that

$$f(x) = y \text{ and } \|x\|_n \le c_n |y|_{n+d}, \quad \forall n \ge 0.$$

In [4] we combine some ideas from [2] and [3] to generalize the main result of [5].

References

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SHORT TALKS

Lipschitz-free spaces that embed into ℓ_1

Ramón Aliaga. Universitat Politècnica de València, Spain.

Abstract. It is known that if a Lipschitz-free space $\mathcal{F}(M)$ embeds isometrically into ℓ_1, then the underlying metric space M must embed isometrically into a separable $\mathbb{R}$-tree and its canonical measure must be zero. Moreover, if M is compact then the converse is also true. We investigate the validity of the converse in the general case, and give the following partial answer: for any such M, the space $\mathcal{F}(M)$ embeds isomorphically into ℓ_1 with distortion $1+\varepsilon$ for any $\varepsilon > 0$. This is a joint work with C. Petitjean and A. Procházka.

Operator Inequalities. Agler models and Ergodicity

Luciano Abadias, Glenier Bello-Burguet and Dmitry Yakubovich.
Universidad de Zaragoza, Universidad Autónoma de Madrid and
ICMAT, Universidad Autónoma de Madrid and ICMAT, Spain

Abstract. We discuss a kind of spectral theory for bounded linear operators T on a Hilbert space H satisfying

$$\alpha(T^*,T) := \sum_{n=0}^{\infty} \alpha_n T^{*n} T^n \geq 0 \quad \text{(convergence in SOT)}, \tag{1}$$

where $\alpha(t) = \sum \alpha_n t^n$ is an analytic function with $\alpha_n \in \mathbb{R}$ and $\alpha_0 = 1$. This type of conditions has been extensively analysed, starting from pioneering work by Agler in the 80's. There are also many papers on tuples of commuting operators. Put $k(t) = 1/\alpha(t) = \sum k_n t^n$. In 2018, Bickel, Clouâtre, Hartz and McCarthy proved (even for tuples of commuting operators) that if $\alpha_n < 0$ for every $n \geq 1$ and the quotients k_{n+1}/k_n tend to 1 then (1) holds if and only if T extends to $(B_k \otimes I_{\mathcal{R}}) \oplus S$, where B_k is a backward shift on the RKHS of analytic functions associated to k, $\mathcal{R}$ is an auxiliary Hilbert space and S is an isometry. As a complement of this result, we show that (V_D, W) provides a *minimal model* of T, where V_D is a contraction given by

$$V_D x(z) := D(I - zT)^{-1}x, \quad D := (\alpha(T^*,T))^{1/2}$$

and $W := (I_H - V_D^* V_D)^{1/2}$. So D plays the role of the defect operator of T. Let $\mathcal{A}_T$ be the set of analytic functions α with summable Taylor coefficients

such that $\sum |\alpha_n| T^{*n} T^n$ converges in SOT and let $\mathcal{A}_T^0$ be the closure of the polynomials in $\mathcal{A}_T$. Define

$$\mathcal{C}_\alpha^w := \{T \in L(H) \,:\, \alpha \in \mathcal{A}_T, \alpha(T^*, T) \geq 0\}.$$

Using Gelfand Theory and a factorization lemma for polynomials, we prove the following result. Let $T \in L(H)$ with $\sigma(T) \subset \overline{\mathbb{D}}$. Suppose that $(1-t)^a \in \mathcal{A}_T$, where $a > 0$, and let $\beta \in \mathcal{A}_T^0$ satisfy that $\beta(t) > 0$ for every $t \in [0, 1]$. If

$$\alpha(t) = (1-t)^a \beta(t)$$

and $T \in \mathcal{C}_\alpha^w$, then T is similar to an operator in $\mathcal{C}_{(1-t)^a}^w$.

This result applies to many functions α such that $k(t)$ has negative coefficients and Agler's techniques do not work. We will give some consequences for Ergodic Theory. In particular, we show that any operator in $\mathcal{C}_a^w$ is *quadratically* (C, b)*-bounded* for any $b > 1 - a$.

On a conjecture of A. L. Shields about Kreiss bounded operators

Antonio Bonilla. Universidad de La Laguna, Spain.

`Abstract.` We Let X be a Banach space and $T : X \to X$ a continuous operator with $\sigma(T)$ contained in the closed unit disc. T is said Kreiss bounded iff

$$\|(\lambda I - T)^{-1}\| \leq \frac{C}{|\lambda| - 1} \quad \text{for all } |\lambda| > 1.$$

If T is Kreiss bounded operator in a Banach space, then $\|T^n\| = O(n)$ for all $n \in \mathbb{N}$. However, forty years ago Shields conjecture that in Hilbert spaces, $\|T^n\| = O(\sqrt{n})$. We will show that this conjecture is no true, although there is a small improvement to the general estimation in Hilbert spaces, $\|T^n\| = o(n)$.

Joint work with T. Bermúdez and V. Müller.

Vector valued Sobolev spaces and Sobolev-Reshetnyak spaces

Iván Caamaño. Universidad Complutense de Madrid, Spain

`Abstract.` We study Sobolev-type spaces of vector-valued functions. First, given an open set $\Omega \subset \mathbb{R}^n$, we will talk about the well-known Sobolev spaces $W^{1,p}(\Omega, V)$ of functions with domain in Ω mapping into a Banach space V and then we will introduce the space $R^{1,p}(\Omega, V)$ of Sobolev-Reshetnyak functions, which have a certain weak differentiation property involving the

vectors in the dual space of V. Our goal is to compare these spaces and establish a characterization for both spaces coinciding. Joint work with J.A. Jaramillo, A. Prieto and A. Torregrosa.

Study of several polynomial norms and the topologies induced by them

Hernán Javier Cabana Méndez. Universidad Complutense de Madrid, Spain

Abstract. In this talk we study several norms in the space $\mathcal{P}$ of the polynomials of arbitrary degree in the complex plane. In particular we consider the sup norm on the disk $\mathbb{D}_r := \{z \in \mathbb{C} : |z| \leq r\}$, namely $\|\cdot\|_{D_r}$, and the ℓ_1-norm of the coefficients, $\|\cdot\|_1$. As a result of the study we derive the relationship existing among the topologies induced by those norms for several choices of r. This research has been conducted jointly with Luis Bernal González, Gustavo A. Muñoz Fernández and Juan B. Seoane Sepúlveda.

On the Mazur–Ulam property for continuous functions spaces

María Cueto-Avellaneda and Antonio M. Peralta Pereira
Universidad de Almería*, Spain

Abstract. A Banach space X satisfies the *Mazur–Ulam property* if for any Banach space Y, every surjective isometry $\Delta : S(X) \to S(Y)$ admits an extension to a surjective real linear isometry from X onto Y, where $S(X)$ and $S(Y)$ denote the unit spheres of X and Y, respectively. An equivalent reformulation tells that X satisfies the Mazur–Ulam property if the so-called Tingley's problem admits a positive solution for every surjective isometry from $S(X)$ onto the unit sphere of any Banach space Y. We shall make in this talk a brief incursion into the origin of the quoted extension problems and provide a new positive answer to them. Concretely, let K be a compact Hausdorff space and let H be a real or complex Hilbert space with $\dim(H_{\mathbb{R}}) \geq 2$. We shall show that the space $C(K, H)$ of all H-valued continuous functions on K, equipped with the supremum norm, satisfies the Mazur–Ulam property.

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Approximating continuous functions with smooth ones without critical points

Daniel Azagra, Tadeusz Dobrowolski and Miguel García-Bravo.
Universidad Complutense de Madrid, Spain, Pittsburgh State University, USA and Universidad Autónoma de Madrid/ICMAT, Spain

Abstract. The Morse-Sard theorem states that if $f : \mathbb{R}^n \to \mathbb{R}^m$ is of class C^k, $k = n - m + 1$ then the set of critical values of f has Lebesgue measure zero in $\mathbb{R}^m$. This theorem fails in infinite dimension, although S. Smale proved a version of the theorem for differentibale functions whose derivatives were Fredholm operators. This is a very strong hypothesis that restrics the range of applications drastically. However in many cases it is not important if a function has the Morse-Sard property or not but if it can be approximated by smooth functions with the Morse-Sard property.

In 2004 Azagra and Cepedllo proved that every continous function from l_2 to $\mathbb{R}^m$ can be approximated by a C^∞-function without any critical point. In 2007 Azagra and Jimńez-Sevilla proved the same for continuous $f : E \to \mathbb{R}$ where E is a Banach space with separable dual. In this talk we will extend these results to show that the same is true for continuous $f : E \to F$ where E is a Banach space from a large class (including all classcial Banach spaces) and the target space F is a quotient of E.

Theorem. *Let E be one of the classical Banach spaces c_0, ℓ_p or L^p, $1 < p < \infty$. Let F be a Banach space, and assume that there exists a bounded linear operator from E onto F. Then, for every continuous mapping $f : E \to F$ and every continuous function $\varepsilon : E \to (0, \infty)$ there exists a C^k mapping $g : E \to F$ such that $\|f(x) - g(x)\| \leq \varepsilon(x)$ and $Dg(x) : E \to F$ is a surjective linear operator for every $x \in E$. (Here k denotes the order of smoothness of the space E).*

The proof will rely in part on a new result about extractibility of subsets from the space E. Namely that given a closed subset X in E that is locally contained in graphs of continuous functions defined in subspaces of infinite codimension in E (and taking values in their orthonal complements), given an open set U with $X \subseteq U$ and given an open cover $\mathcal{G}$, then there exists a C^∞-diffeomorphism from $E \setminus X$ onto E which is the identity outside U and refines $\mathcal{G}$.

Counterexamples of M-Weierstrass' Theorem

Pablo José Gerlach Mena. Universidad de Sevilla, Spain

Abstract. We all know the M-Weierstrass' Theorem which guarantees the absolute and uniform convergence of a series of functions that is dominated by a convergent series. In this talk we are going to focus our attention on the algebraic structure of those series that do not fulfill the hypothesis of M-Weierstrass' Theorem although they are absolute and uniformly convergent.

Orthogonally additive polynomials on non-commutative L^p-spaces

María Luisa C. Godoy. Universidad de Granada, Spain

Abstract. Let $\mathcal{M}$ be a von Neumann algebra with a normal semifinite faithful trace τ. We prove that every continuous m-homogeneous polynomial P from $L^p(\mathcal{M}, \tau)$, with $0 < p < \infty$, into each topological linear space X with the property that $P(x + y) = P(x) + P(y)$ whenever x and y are mutually orthogonal positive elements of $L^p(\mathcal{M}, \tau)$ can be represented in the form $P(x) = \Phi(x^m)$ $(x \in L^p(\mathcal{M}, \tau))$ for some continuous linear map Φ from $L^{p/m}(\mathcal{M}, \tau)$ into X.

This result is an extension of the result published by Sundaresan in 1991, which gave a representation for polynomials on $L^p[0, 1]$ or ℓ^p, with $1 \leq p < \infty$. Our result is much more general since we not only ensure representation in non-commutative L^p-spaces, but we also contemplate the cases in which the spaces are not Banach spaces.

This is a joint work with J. Alaminos and A. R. Villena.

Riesz representatable multilinear mappings

Raffaella Cilia and Joaquín M. Gutiérrez. Università di Catania, Italy and Universidad Politécnica de Madrid, Spain

Abstract. We introduce the Riesz representable multilinear mappings on products of $L_1(\mu)$ spaces and prove a Grothendieck type theorem for compositions with the canonical inclusions Ł$_\infty \to L_1$ and $C(K) \to L_1$.

Bogovski estimates and solenoidal difference quotients

Martin Křepela and Michael Růžička. University of Freiburg, Germany

Abstract. The Bogovski operator provides a solution to the divergence equation with a particular estimate of its gradient. In the talk, additional properties of the Bogovski solution will be presented, namely an estimate concerning difference quotients of the gradient. This information enables a construction of specific test functions with solenoidal (divergence-free) difference quotients. As an application, one gets a new way to prove interior regularity of the solution to the p-Stokes system. The used proof method relies particularly on the theory of singular integral operators and extrapolation.

Dual and bidual octahedral norms in Lipschitz-free spaces

Johann Langemets. University of Tartu, Estonia

Abstract. We continue with the study of octahedral norms in the context of spaces of Lipschitz functions and in their duals. First, we prove that the norm of $\mathcal{F}(M)^{**}$ is octahedral as soon as M is unbounded or is not uniformly discrete. Further, we prove that a concrete sequence of uniformly discrete and bounded metric spaces (K_m) satisfies that the norm of $\mathcal{F}(K_m)^{**}$ is octahedral for every m. Finally, we prove that if X is an arbitrary Banach space and the norm of $\mathrm{Lip}_0(M)$ is octahedral, then the norm of $L(X, \mathrm{Lip}_0(M))$ is octahedral. These results solve several open problems from the literature. The talk is based on a joint work with Abraham Rueda Zoca.

Equivalence between Markushevich semi-greedy and almost greedy bases

Silvia Lassalle. Universidad de San Andrés and IMAS–CONICET, Argentina

Abstract. Greedy bases allow us to represent elements of a Banach space with a series, built on a given system, whose coefficients are ordered (in absolute value) in decreasing form. The approximation with greedy bases

(best m-approximant) is of nonlinear nature and it is linked to the notion of unconditionality. In order to work with more flexible structures, variants of the greedy concept arise, such as *semi-greedy Schauder bases*, *almost greedy Schauder bases* and more recently that of *branch greedy bases*. For example, the Haar Schauder basis of $L_1([0,1])$ is not unconditional and therefore not greedy but it turns out to be branch greedy convergent.

The concepts of semi-greedy and almost greedy bases, which were independently introduced, are closely related. Semi-greedy Schauder bases were introduced by S.J. Dilworth, N.J. Kalton and D. Kutzarova (2003). In their article, the authors show that every almost greedy Schauder basis is semi-greedy, and prove the converse for spaces with finite cotype. This implication was proved without the cotype restriction by P. Berná (2019), who, after noting that the proof of the implication (almost greedy $\Longrightarrow$ semi-greedy) given in 2003 is also valid in the general context of Markushevich bases, asks whether the converse also holds for such bases.

In this talk, based on a joint work with Miguel Berasategui, the goal is to present these concepts, reaching an affirmative answer to this last problem.

The Takagi-Van der Waerden function and its infinite derivatives

Jesús Llorente. Universidad Complutense de Madrid, Spain

Abstract. Let $r \geq 2$. The Takagi-Van der Waerden function $f_r : [0,1] \to \mathbb{R}$ is defined as follows

$$f_r(x) = \sum_{n=0}^{\infty} \frac{1}{r^n} \phi(r^n x)$$

where $\phi(x)$ denotes the distance from the point x to the nearest integer. These functions are an immediate generalization of the Takagi function and they constitute a family of continuous nowhere differentiable functions. We characterize the set of points where the lateral derivatives of the Takagi-Van der Waerden function are infinite. Furthermore, we determine the Hausdorff dimension and the Lebesgue measure of this set. This is a joint work with J. Ferrera and J. Gómez Gil.

Norm estimates for vector valued Dirichlet series

Daniel Carando, Felipe Marceca and Pablo Sevilla-Peris. IMAS UBA-CONICET, Argentina, IMAS UBA-CONICET, Argentina and IUMPA Universidad Politécnica de Valencia, Spain

Abstract. Analytic results for vector valued functions often depend on the geometry of the Banach space. The goal of this talk is to provide estimates of the p-norm of a Dirichlet series with values in a Banach space X in terms of the coefficients of the series. These estimates are determined by geometric properties of X, specially the concepts of type and cotype.

The Mackey-Arens Theorem in the context of topological abelian groups

Elena Martín-Peinador. Universidad Complutense de Mardrid, Spain

Abstract. The locally quasi-convex groups were defined by Vilenkin in the 50's of the last century. They are an important class of topological abelian groups which encloses as a subclass the locally convex topological vector spaces. Thus, central results of Functional Analysis might have extended versions for locally quasi-convex groups. This is not a straightforward process, and usually the obstructions which appear make the theory reacher. In order to deal with local quasi-convexity several authors have developed techniques based on Numerical Analysis, and there has been a great activity in this field in the last 25 years.

The Mackey-Arens Theorem -a relevant result of linear Functional Analysis- asserts that for a real topological vector space (X, τ), the set $\mathrm{LCT}(X, \tau)$ of all compatible locally convex topologies on X has a maximum, subsequently called the Mackey topology. In [1] the Mackey-Arens Theorem was studied within the category of abelian topological groups. The main problem left open in the mentioned paper was the existence of the analogue to the Mackey topology for abelian groups. Explicitly, if (G, τ) is an abelian topological group, is there a maximum in the family $\mathrm{LQC}(G, \tau)$ of all the locally quasi-convex topologies compatible with τ? The existence of the Mackey topology for a broad class of topological groups, including the locally compact and the complete metrizable abelian groups, was already established in [1].

Finally, in 2018 the question has been solved in the negative. Außenhofer and Gabriyelyan (simultaneously) provided an example of a topological group which does not admit a Mackey topology: namely the free abelian

topological group on a convergent sequence. Some other examples have just appeared.

In this lecture the Mackey theory for groups will be presented, stressing the similarities and differences with the classical Mackey theory for locally convex spaces.

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Describing multiplicative convex functions

Elena Martínez Gómez. Universidad Complutense de Madrid, Spain

`Abstract.` The theory of convex functions keeps playing a central role in operator theory, in real analysis and in some realms of applied mathematics, such as management science or optimization theory. Since the beginning of their study by Jensen, they have been thoroughly described and many of their properties have been unveiled.

The study of convex functions has extended to the consideration of other inequalities. In this direction, Niculescu proposed the definition of **multiplicative convex functions** (see [1]), since they are supposed to substitute the arithmetic mean in the inequality that defines the convex functions by the geometric mean. Yet, the definition of the multiplicative convex functions could be regarded as a way of upgrading the operations that take part in the definition of convex functions. In this direction, we propose the following variation for the definition of multiplicative convex functions:

Definition 1. *Let $f : (0,\infty) \to [0,\infty)$ be such that $f(1) = 1$. We will say that f is* **multiplicative convex** *if, for every $\mu > 0$ and $x, y \geq 0$ we have*

$$f(x^\mu y^{1/\mu}) \leq f(x)^\mu f(y)^{1/\mu}. \tag{2}$$

In [2] we study the resulting functions and a characterization is also provided.

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Principal ideals in algebras of Lorch analytic mappings

Guilherme V. S. Mauro and Luiza A. Moraes. Universidade Federal da Integração Latino-Americana (UNILA), Brazil and Universidade Federal do Rio de Janeiro (UFRJ), Brazil

Abstract. If E is a commutative complex Banach algebra with unit and U is an open (non empty) connected subset of E, a mapping $f : U \to E$ is analytic in U in the sense of Lorch if given any $a \in U$ there exists $\rho > 0$ and there exist unique elements $a_n \in E$, such that $B_\rho(a) \subset U$ and $f(z) = \sum_{n=0}^{\infty} a_n(z-a)^n$, for all $z \in E$ satisfying $\|z - a\| < \rho$.

The definition of Lorch analytic mapping extends to unitary commutative complex Banach algebras the classical definition of analytic function on $\mathbb{C}$ in a very natural way and a considerable portion of the classical theory of analytic functions carries over to the Lorch analytic mappings.

Let $\mathcal{H}_L(U, E)$ denote the set of all $f : E \to E$ that are Lorch analytic in U, considered as a subalgebra of the algebra $C(U, E)$ of continuous mappings from U into E.

We endow the algebra $\mathcal{H}_L(U, E)$ with a convenient topology τ_d which coincides with the topology τ_b when $U = E$ or $U = B_r(z_0) = \{z \in E; \|z - z_0\| < r\}$ $(z_0 \in E, r > 0)$.

An interesting result of the classical theory of analytic functions states that the closed ideals in $(\mathcal{H}(G), \tau_0)$ (where G is an open connected subset of $\mathbb{C}$) are precisely the principal ideals.

As $(\mathcal{H}_L(U, E), \tau_d) = (\mathcal{H}(U), \tau_0)$ when $E = \mathbb{C}$ and U is an open connected subset of E, it is natural to ask how the closed ideals and the principal ideals of $(\mathcal{H}_L(U, E), \tau_d)$ are related.

In this talk we will be concerned with this question.

Monomial expansions on sequence spaces

Daniel Galicer, Martín Mansilla, Santiago Muro and Pablo Sevilla-Peris. Universidad de Buenos Aires, Argentina, Universidad de Buenos Aires, Argentina CIFASIS-CONICET, Rosario, Argentina and Universidad Politécnica de Valencia, Spain

`Abstract.` For each entire function f on n complex variables, there is a series of monomials, the monomial expansion of f, such that

$$f(z) = \sum_{\alpha} a_\alpha z^\alpha,$$

for every z and the convergence is uniform on each compact set. If f is a holomorphic function on an infinite dimensional sequence space X, then it also has a monomial expansion, but in this case, the series does not necessarily converge for every $z \in X$.

There has been some effort to characterize the subset of X where the monomial expansion of every holomorphic function on $\mathcal{F}$ converge, where $\mathcal{F}$ is a family of polynomials or of holomorphic functions on c_0 or ℓ_p. This set is called the *set of monomial convergence* of $\mathcal{F}$. The only case where set of monomial convergence has been completely characterized is when $X = \ell_1$, or $\mathcal{F} = \mathcal{P}(^m c_0)$.

In this talk we will describe the set of monomial convergence for the space $H_b(\ell_r)$ of entire functions of bounded type on ℓ_r, for $1 < r \leq 2$, and show that it is exactly a Marcinkiewicz sequence space.

We will also talk about the set of monomial convergence for $\mathcal{P}(^m\ell_r)$, the space of m-homogeneous polynomials on ℓ_r, and for the space $H^\infty(B_{\ell_r})$ of bounded holomorphic on the unit ball of ℓ_r, $1 < r \leq 2$.

The talk is based on a joint work with Daniel Galicer (Universidad de Buenos Aires), Martín Mansilla (Universidad de Buenos Aires) and Pablo Sevilla-Peris (Universidad Politécnica de Valencia).

Embeddings of Kalton's interlaced graphs into dual Banach spaces

Colin Petitjean. Université Paris-Est Marne-la-Vallée (UPEM), France

`Abstract.` The work we will present concerns the non-linear geometry of Banach spaces. One goal in this theory is to classify Banach spaces with the help of some non linear maps (Lipschitz, coarse-Lipschitz, etc). In other words, given two Banach spaces X and Y, one tries to determine

whether they are equivalent with respect to a certain category. Sometimes we try to determine if X is equivalent to a subset of Y; when it is true we say that X embeds into Y. A natural and powerful approach to classify mathematical objects is to discover properties that are invariant with respect to isomorphisms or embeddings.

In a fundamental paper on the coarse geometry of Banach spaces (published in 2007), N. Kalton introduced a property that he named property $\mathcal{Q}$. In particular, it is a coarse-invariant and serves as an obstruction to coarse embeddability into reflexive spaces. This property is related to the behavior of Lipschitz maps defined on a particular family of metric graphs: the Kalton interlaced graphs.

In this talk we pursue the study of property $\mathcal{Q}$ and of the interlaced graphs in the particular case of dual Banach spaces X^*. Specifically, we establish some links with the Szlenk index of X and give concrete examples. We also study a weaker version of property $\mathcal{Q}$ which as an application permits us to rule out the classification of some Banach spaces (e.g.ℓ_p spaces and the James spaces $\mathcal{J}_p$).

Numerical index with respect to an operator

Alicia Quero. Universidad de Granada, Spain

Abstract. The concept of numerical index was introduced by G. Lumer in 1968 in the context of the study and the classification of operator algebras. This is a constant of a Banach space relating the behaviour of the numerical range with that of the usual norm on the Banach algebra of all bounded linear operators on the space. Recently, Ardalani introduced new concepts of numerical range and numerical radius of one operator with respect to another one, which generalize in a natural way the classical concepts of numerical range and numerical radius. Therefore, it is possible to define a concept of numerical index with respect to an operator which relates the numerical radius with respect to the operators with the operator norm. The main objective is to study basic properties of this new numerical index, present some examples and provide results on the stability with respect some natural operations and results on the set $\mathcal{N}(\mathcal{L}(X,Y))$ of the values of the numerical indices with respect to all norm-one operators on $\mathcal{L}(X,Y)$.

This is joint work with V. Kadets, M. Martín, M. Merí and A. Pérez.

The Fremlin tensor product and holomorphic functions on complex Banach lattices

Ray Ryan. National University of Ireland, Ireland

Abstract. Just as the projective tensor product linearizes the bounded bilinear forms on a product of Banach spaces, so the Fremlin tensor product (1974) for Banach lattices linearizes the regular bilinear forms. Bu and Buskes (2012) extended this to a symmetric n-fold tensor product that linearizes the regular n-homogeneous polynomials on a Banach lattice. We examine Fremlina's construcion and we show how it can be used to identify some geometric properties of the domain of convergence of a power series on a complex Banach lattice.

(Joint work with Chris Boyd and Nina Snigireva.)

Completeness in the Mackey topology

José Rodríguez-Ruiz. Universidad de Murcia, Spain

Abstract. A Banach space X is said to be universally Mackey complete if $(X, \mu(X, Y))$ is complete for every norming and norm-closed subspace $Y \subset X^*$, where $\mu(X, Y)$ is the Mackey topology on X associated to the dual pair $\langle X, Y \rangle$. This class of Banach spaces was studied by Bonet and Cascales [1], and Guirao, Montesinos and Zizler [3]. In this talk we will review their main results on universally Mackey complete spaces, and we will present some improvements obtained recently in a joint work with Guirao and Martínez-Cervantes [2]. Some related open problems will be discussed as well. Research supported by Agencia Estatal de Investigación/FEDER (MTM2017-86182-P) and Fundación Séneca (20797/PI/18).

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Lineability of Darboux-like functions

Daniel L. Rodríguez-Vidanes. Universidad Complutense de Madrid, Spain

Abstract. The class Ext of all extendable functions from $\mathbb{R}$ to $\mathbb{R}$ is the smallest among all Darboux-like classes of functions, which constitute different natural generalizations of the class of usual continuous functions. In 2013, T. Natkaniec asked whether or not Ext is maximal algebrable, that is, there is an algebra of functions contained in Ext such that the set of generators of such algebra has cardinality $2^{\mathfrak{c}}$ (where $\mathfrak{c}$ is the cardinality of the continuum). In this talk we present a positive answer in a recent published paper where the authors use a new technique in this field.

Joint work with Krzysztof C. Ciesielski and Juan B. Seoane-Sepúlveda.

Mean ergodic composition operators in spaces of homogeneous polynomials

Daniel Santacreu. Universitat Politècnica de València, Spain

Abstract. We study some dynamical properties of composition operators defined on the space $\mathcal{P}(^m X)$ of m-homogeneous polynomials on a Banach space X when $\mathcal{P}(^m X)$ is endowed with two different topologies: the one of uniform convergence on compact sets and the one defined by the usual norm. The situation is quite different for both topologies: while in the case of uniform convergence on compact sets every power bounded composition operator is uniformly mean ergodic, for the topology of the norm there is no relation between the latter properties. Several examples are given.

Joint work with David Jornet and Pablo Sevilla.

Synnatzschke's Theorem for Polynomials

Nina Snigireva. University College Dublin, Ireland

Abstract. For a regular linear operator, T, on a Banach lattice, Synnatzschke's Theorem addresses the question of when $|T'| = |T|'$. In this talk we will consider a non-linear version of Synnatzschke's Theorem. Namely, we will show that for a regular polynomial on a Banach lattice, under certain conditions, absolute value commutes with the Aron-Berner extension.

This will allow us to determine when the regular norm for polynomials is preserved by the Aron-Berner extension. (This is joint work with C. Boyd, University College Dublin, and R. Ryan, National University of Ireland Galway.)

Compact and Limited operators

Mohammed Bachir, Gonzalo Flores and Sebastián Tapia-García.
Université Paris 1, France, Universidad de Chile, Chile and
Universidad de Chile, Chile

Abstract. Let $T : Y \to X$ be a bounded linear operator between two normed spaces. We characterize compactness of T in terms of differentiability of the Lipschitz functions defined on X with values in another normed space Z. Furthermore, using a similar technique we can also characterize finite rank operators in terms of differentiability of a wider class of functions but still with Lipschitz flavour. As an application we obtain a Banach-Stone-like theorem. On the other hand, we give an extension of a result of Bourgain and Diestel related to limited operators and cosingularity.

The semi-Lipschitz free space of a quasi-metric space

Francisco Venegas. Universidad de Chile, Chile

Abstract. In this work we present a generalization of Lipschitz free spaces to spaces allowing asymmetries on the distance function, known as quasi-metric spaces. Given a quasi-metric space (X, d), and making use of the theory of normed cones and asymmetric normed spaces, we construct an asymmetric normed space $\mathcal{F}_a(X, d)$, which contains a canonic isometric copy of (X, d), and such that its dual cone is isometrically isomorphic to $\mathrm{SLip}_0(X)$, the cone of real valued semi-Lipschitz functions banishing at a given base point. If the quasi-metric space is in fact a metric space, the usual Lipschitz free space is recovered. We also present examples of this construction for a finite quasi-metric space, $\mathbb{N}$ and $\mathbb{R}$ (endowed with suitable quasi-metrics).

A remark on Defant-Floret-Lima-Oja's conjecture

Ju Myung Kim and Keun Young Lee. Sejong University, Republic of Korea

Abstract. Let $\lambda \geq 1$. We prove that the λ-bounded approximation property and the weak λ-bounded approximation property are equivalent for every Banach space if they are equivalent for every separable Banach space.