MWAA 2017
IUPUI, October 6–8th

Friday

15:00–15:30	**Refreshments**	
15:30–16:30	**S. Koch**	Roots of polynomials and parameter spaces

Saturday

09:00–09:40	**Coffee**	
09:40–10:20	**Irina Holmes**	Weighted inequalities for commutators with Calderón-Zygmund operators
10:30–11:10	**Giusy Mazzone**	Stability and long-time behavior of a heavy rigid body with a cavity completely filled with a viscous liquid
11:20–12:00	**Ming Xiao**	Embeddability of real hypersurfaces into hyperquadrics and spheres
12:00–14:00	**Lunch**	
14:00–14:40	**E. Miña Diaz**	Method of series expansions for orthogonal polynomials
14:50–15:30	**G. Silva**	Random matrices and zeros of polynomials
15:30–16:00	**Break**	
16:00–16:40	**K. Driver**	Zeros of ultraspherical and pseudo-ultraspherical polynomials
16:50–17:30	**L. Baratchart**	Rational approximants to analytic functions with polar singular set and finitely many branchpoints

Sunday

09:00–09:50	**Coffee and Posters**	
10:00–10:40	**N. Shcherbina**	Cores of domains: An overview of some recent results
10:50–11:30	**M. van der Walt**	Signal decomposition via SuperEMD
11:40–12:20	**A. Powell**	Sharp Balian-Low theorems and Fourier multipliers

Plenary Talks

Laurent Baratchart
INRIA, Sophia Antipolis, France

Rational approximants to analytic functions with polar singular set and finitely many branchpoints

Joint work with M. Yattselev and the late H. Stahl

We consider the problem of approximating a function f of one complex variable, analytic except over a polar subset of $\mathbb{C}$ comprising only finitely many branchpoints all of which are algebraic, by a rational or meromorphic function with at most n poles, uniformly on a compact subset K of the domain of analyticity of f. In [3] it was proven that there exists a (essentially) unique compact set S outside of which f is single valued, to minimize the condenser capacity $C(S, K)$. Subsequently, the optimal n-th root rate of approximation to f o K was shown in [1] to be $\exp\{-2/C(K, S)\}$. We explain in this talk that the normalized counting measure of the poles of a sequence of best approximants converges weak-* to the condenser equilibrium distribution on S, and more generally that any sequence of optimal approximants in the n-th root sense has this property. The same results holds for best meromorphic (i.e. AAK) approximants. We dwell on the solution to the Gonchar conjecture on the degree of approximation [2], combined with some AAK theory and logarithmic potential theory.

References

[1] A.A. Gonchar and E.A. Rakhmanov. Equilibrium distributions and the degree of rational approximation of analytic functions. *Mat. Sb.*, 134(176)(3):306–352, 1987. English transl. in *Math. USSR Sbornik* 62(2):305–348, 1989.

[2] O.G. Parfenov. Estimates of the singular numbers of a Carleson operator. *Mat. Sb.*, 131(171):501–518, 1986. English. transl. in *Math. USSR Sb.* 59:497–514, 1988.

[3] H. Stahl. Extremal domains associated with an analytic function. I, II, Complex Variables Theory Appl. 4:311–324, 325–338, 1985.

Kathy Driver
University of Cape Town

Zeros of ultraspherical and pseudo-ultraspherical polynomials

The pseudo-ultraspherical polynomial of degree n is defined by $\tilde{C}_n^{(\lambda)}(x) = (-i)^n C_n^{(\lambda)}(ix)$ where $C_n^{(\lambda)}(x)$ is the ultraspherical polynomial. We discuss the orthogonality of finite sequences of pseudo-ultraspherical polynomials $\{\tilde{C}_n^{(\lambda)}\}_{n=0}^N$ for different values of N that depend on λ. We discuss applications of Wendroff's Theorem and use an identity linking the zeros of the pseudo-ultraspherical polynomial $\tilde{C}_n^{(\lambda)}$ with the zeros of the ultraspherical polynomial $C_n^{(\lambda')}$ where $\lambda' = \frac{1}{2} - \lambda - n$ to prove that when $1 - n < \lambda < 2 - n$, two (symmetric) zeros of $\tilde{C}_n^{(\lambda)}$ lie on the imaginary axis.

Irina Holmes
Michigan State University
Weighted inequalities for commutators with Calderón-Zygmund operators

This talk summarizes some recent results in the weighted theory of commutators of multiplication with Calderón-Zygmund operators T. The prototypical such operator is the Hilbert transform in dimension 1, and the Riesz transforms in higher dimensions. We are looking at operators of the form $[b,T]f = bTf - T(bf)$. It is a famous theorem of Coifman, Rochberg and Weiss that this operator is bounded in $L^p(\mathbb{R}^n)$ if b is in $BMO(\mathbb{R}^n)$ (and conversely, if the commutator with the Riesz/Hilbert transforms is bounded, then b is in BMO). It is also known that this same result holds if we work with $L^p(\mathbb{R}^n, w)$, where w is a Muckenhoupt A_p weight. We discuss recent extensions of this result to the case where the commutator acts between two different weighted spaces, so $[b,T] : L^p(\mu) \to L^p(\lambda)$, where μ and λ are A_p weights.

Sarah Koch
University of Michigan
Roots of polynomials and parameter spaces

Parts of this talk are joint work with D. Calegari and A. Walker, and parts of this talk are joint work with X. Buff and A. Epstein

In William Thurston's last paper, *Entropy in Dimension One*, there is a spectacular image associated to entropy values of quadratic polynomials on the very first page. This set displays some amazing fractal structure which can be (somewhat) understood when viewed as a subset of parameter space for a particular family of iterated function systems (IFS). In this talk, we compare this with the parameter space discussion of the family $z \mapsto z^2 + c$, and investigate the associated connectedness locus in parameter space for the IFS. If time permits, we study another subset arising in the dynamical realm which displays similar structure; this set is also associated to postcritically finite quadratic polynomials.

Giusy Mazzone
Vanderbilt University
Stability and long-time behavior of a heavy rigid body with a cavity completely filled with a viscous liquid

We consider the motion of the coupled system constituted by a heavy rigid body with an interior cavity completely filled by a viscous liquid. We study the stability of the steady-state configurations and the long-time dynamics of the coupled system. In particular, we show that after an initial interval of time, whose length depends on the initial data as well as on the relevant physical parameters involved, every Leray-Hopf solution to the equations of motion, corresponding to a "large" set of initial data (with finite total energy), approaches to a (stable) steady-state at an exponentially fast rate.

Erwin Miña Diaz
University of Mississippi
Method of series expansions for orthogonal polynomials

In this talk I will explain a method that allows, in certain settings, to derive series expansions (and hence asymptotics) of a sequence of orthonormal polynomials $P_n(z)$, $n = 0, 1, \ldots$. The important idea I want to convey is that everything is encoded in the reproducing kernel $\sum_{n=0}^{\infty} P_n(z)\overline{P_n(\zeta)}$, and once this kernel is known, there is a rather direct way to extricate the asymptotic behavior of the polynomials. I will illustrate how the method works in the case of orthogonal polynomials over circular multiply connected domains.

Alex Powell
Vanderbilt University
Sharp Balian-Low theorems and Fourier multipliers

Joint work with Shahaf Nitzan and Michael Northington

The classical Balian-Low theorem is a strong form of the uncertainty principle that constrains the time-frequency localization of Gabor systems that form orthonormal bases. We discuss a generalization of the Balian-Low theorem that provides a sharp scale of constraints on the time-frequency localization of Gabor systems under a weaker form of spanning structure associated with so-called exact C_q systems. Admissibility conditions on Fourier multipliers play an important role in the proofs and, as an additional application, yield sharp Balian-Low type theorems in the setting of shift-invariant spaces.

Nikolay Shcherbina
Bergische Universität Wuppertal, Germany
Cores of domains: An overview of some recent results

Let G be a domain in a complex manifold M of dimension n. The core $c(G)$ of G is defined to be the set of all points P in G such that the rank of the Levi form of F at P is less than n for every smooth bounded above plurisubharmonic function F in G. In this talk we make an overview of some recent results and some open questions related to this notion.

Guilherme Silva

University of Michigan

Random matrices and zeros of polynomials

Joint work with Pavel Bleher

Random matrices appeared for the first time in the works of Wishart, back in the 1920's, but came into spotlight after the studies of Dyson in the 1950's related to high energy physics. In the past thirty or so years, the theory of random matrices has attracted a lot of activity, partially in virtue of its connection to several areas of physics and mathematics, as for instance statistical mechanics, number theory, approximation theory, telecommunications, algebraic geometry and integrable systems, to mention only a few.

In this talk, we plan to discuss the relation between eigenvalues of large random matrices and zeros of orthogonal polynomials of high degree. As we will discuss at the beginning of our talk, when the matrix model is hermitian, it is now well-understood that the eigenvalue distribution and the distribution of zeros, in the appropriate limit, coincide and are described in terms of a weighted equilibrium problem.

However, when the random matrices under consideration are normal, the connection between eigenvalues and the zeros is given in terms of the so-called motherbody problem, and the dynamical evolution of them can be described in terms of the Laplacian growth.

Maria van der Walt

Westmont College

Signal decomposition via SuperEMD

Joint work with Charles Chui and Hrushikesh Mhaskar

Decomposition of signals into finitely many primary building blocks, called *atoms*, is a fundamental problem in signal analysis, especially when the instantaneous frequencies of the atoms are close together. In this talk, we describe a novel data-driven, local method to address this problem, called *SuperEMD*, which is in essence a clever adaptation and combination of the popular empirical mode decomposition (EMD) and the signal separation operator (SSO). The highlights of our discussion include a natural formulation of the data-driven atoms, a modified sifting process for EMD for real-time implementation with specific reference to handling boundary artifacts, motivation of the SSO, the description of our SuperEMD, and experimental results.

Ming Xiao
University of California San Diego

Embeddability of real hypersurfaces into hyperquadrics and spheres

Joint work with Kossovskiy, Huang, and Li

We will discuss the embeddability problems of real hypersurfaces into hyperquadrics and spheres. In particular, we present a negative answer to a question concerning the embeddability of compact strongly pseudoconvex real algebraic hypersurfaces into spheres.

Poster Presentations

Stephen Deterding
University of Kentucky

Bounded point derivations on $R^p(X)$

Let X be a compact subset of the complex plane. The space $R^p(X)$ is the closure of rational functions with poles off X in the L^p norm. $R^p(X)$ admits a bounded point derivation at a point x_0 if the map $f \to f'(x_0)$ extends from the rational functions with poles off X to $R^p(X)$. A bounded point derivation provides a way to define derivatives for functions in $R^p(X)$ which may not be differentiable in the usual sense. Suppose that $R^p(X)$ admits a bounded point derivation at x_0. We consider the question of how close the functions in $R^p(X)$ must come to being differentiable in the usual sense.

Bingying Lu
University of Michigan

The semi-classical sine-Gordon equation, universality at phase transition and the gradient catastrophe

Joint work with Peter Miller

We will present in the poster the universal behaviors of the semi-classical limit of the sine-Gordon equation. We consider a class of solutions with pure impulse initial data below critical value such that within small time only librational-type waves are generated and the solutions should decay when $|x| \to \infty$ [1]. We are particularly interested in a neighborhood of a certain gradient catastrophe point that contains both modulated plane waves and localized structures or "spikes". We aim to describe the solutions using special functions. Besides the gradient catastrophe point (we think of it as a more degenerate point than other generic locations of phase transition), we are also interested in describing phase transition in space-time as a boundary curve and the behaviors of the solutions nearby. These phase transitions exhibit universality in the sense that the solutions behave locally the same way in the asymptotic limit for different initial data chosen from the class we consider; it is only the space-time location of the transition that depends on the initial data. We use the Deift-Zhou steepest descent method related to an approach of Bertola and Tovbis [2] to universality for the focusing nonlinear Schrödinger equation.

REFERENCES

[1] Robert J. Buckingham and Peter D. Miller, The Sine-Gordon Equation in the Semi-classical Limit: Dynamics of Fluxon Condensates, *Memoirs of the American Mathematical Society*, **225**, (2013)

[2] Marco Bertola and Alexander Tovbis, Universality for the Focusing Nonlinear Schr?dinger Equation at the Gradient Catastrophe Point: Rational Breathers and Poles of the Tritronqu?e Solution to Painlevé I, *Communications on Pure and Applied Mathematics*, **LXVI**, (2013), 0678-0752

Margaret Stawiska-Friedland

Mathematical Reviews

On Lagrange polynomials in approximating planar sets by Julia sets

Joint work with Leokadia Bialas-Ciez and Marta Kosek

We present an application of Lagrange polynomials to the problem of approximating subsets of $\mathbb{C}$ in Hausdorff and Klimek metrics. We revisit a recent result of K. Lindsey and M. Younsi that a nonempty compact set $E \subset \mathbb{C}$ can be approximated arbitrarily close by filled-in Julia sets of polynomials iff it is polynomially convex and improve the convergence rate. We show that taking the interpolation nodes with subexponential growth of Lebesgue constants is sufficient for better approximation. Along the way we establish subexponential growth of Lebesgue constants for some pseudo Leja sequences. For some classes of sets we estimate the rate of approximation by Julia sets more precisely.