Patrick Bardsley - University of Utah
Title: Imaging with power controlled source pairs
Abstract: We image scatterers in a homogeneous medium by sending correlated wave signals from two different locations and measuring the intensity of the echoes at a single receiver location. By altering the positions of the source pairs we form a linear system that we solve in the least squares sense to recover full waveform data. We can image with this data using classic techniques such as Kirchhoff migration which gives known resolution estimates. The same source pair strategy can be used when we probe the medium with correlated sources of noise (Gaussian processes) and measure autocorrelations at a single location.

Sougata Dhar - Northern Illinois University
Title: Lyapunov-type inequalities for third-order linear differential equations
Abstract: In this talk, we present new Lyapunov-type inequalities for the third-order linear differential equation $x''' + q(t)x = 0$. Our work provides the sharpest results in the literature. Based on the above, we further establish new Lyapunov-type inequalities for more general third-order linear differential equations. Moreover, by combining these inequalities with the “uniqueness implies existence” theorems by several authors, we establish the uniqueness and hence existence-uniqueness for several classes of boundary value problems for third-order linear equations.

Ngoc Do - Texas A&M University
Title: Quantum graph model of a graphyne and graphyne nanotubes
Abstract: Graphynes, which are non-honeycomb monolayers of carbon allotropes, are expected to be sometimes even better than graphene in terms of electronics properties. Nanotube, although appeared much earlier than graphene, can be viewed as sheets of graphene rolled onto a cylinder. It is thus natural to look at the nanotubes obtained by folding a sheet of a graphyne. In this talk, we will present a study of spectra of Schrödinger operator on a particular graphyne structure and its nanotubes.
Yekaterina Epshteyn - The University of Utah

Title: Grain boundary character distribution and mass transport paradigm

Abstract: Cellular networks are ubiquitous in nature. Most technologically useful materials arise as polycrystalline microstructures, composed of a myriad of small crystallites, or grains, separated by interfaces, or grain boundaries. The energetics and connectivity of the grain boundaries network plays a crucial role in determining the properties of a material across a wide range of scales. Coarsening, or growth process is influenced mainly by the effort of the system to decrease the interfacial energy subject to spatial constraints. The recently discovered Grain Boundary Character Distribution (GBCD) indicates that the boundary network of a cellular structure, and, more generally, material texture has a natural order.

Grain Boundary Character Distribution (GBCD) is a new characterization of the texture which is found to be strongly correlated to the interfacial energy. In this talk GBCD is introduced and investigated by the use of a large scale simulations and mathematical analysis. We present the simplified critical event model and discuss an entropy based theory based on mass transport and a Kantorovich-Rubinstein-Wasserstein metric to suggest that, to first approximation, the GBCD behaves like the solution to a Fokker-Planck Equation. This is joint work with K. Barmak, P. Bardsley, E. Eggeling, M. Emelianenko, D.Kinderlehrer, R. Sharp, and S. Ta’asan.

Jarod Hart - University of Kansas

Title: Hardy Space Estimates for Bilinear Calderón-Zygmund Operators

Abstract: In this joint work with Guozhen Lu, we find sufficient conditions for bilinear Calderón-Zygmund operators to be bounded on Hardy spaces. For a bilinear operator $T(f_1, f_2)$, we give sufficient regularity and cancellation conditions for $T$ to be bounded from $H^{p_1} \times H^{p_2}$ into $H^p$ for $0 < p_1, p_2, p \leq 1$. The product structure of bilinear Calderón-Zygmund operators severely complicates analysis of $H^{p_1} \times H^{p_2} \to H^p$ boundedness when $0 < p \leq 1$, which stems from difficulties in understanding the oscillatory behavior of products of functions. The fundamental difficulty that arises with the bilinear Hardy spaces estimates, which is not present in the linear setting, can be observed in the fact that $f_1, f_2 \in H^1$ does not imply $f_1 \cdot f_2 \in H^{1/2}$, i.e. the pointwise product operator $(f_1, f_2) \mapsto f_1(x) f_2(x)$ does not map from $H^1 \times H^1$ into $H^{1/2}$ (hence, it is certainly not bounded from $H^1 \times H^1$ into $H^{1/2}$). Some Hardy space paraproduct boundedness properties for bilinear operators will also be discussed. In particular, we will introduce a paraproduct $\Pi(f_1, f_2)$ that maps (and is bounded) from $H^{p_1} \times H^{p_2}$ into $H^p$ and resembles the product operator, $\Pi(f_1, f_2)(x) \approx f_1(x) f_2(x)$, in the appropriate sense.
Lotfi Hermi - University of Arizona
Title: Isoperimetric inequalities for wedge-like membranes
Abstract: Inspired by an old result of Pólya and Szegő, we introduce new geometric factors which lend themselves to the Payne interpretation in Weinstein fractional space to prove new isoperimetric inequalities which complement those of Payne-Weinberger and Saint-Venant, and which offer a new upper bound for the fundamental mode of vibration of a wedge-like membrane and a new lower bound for its relative torsional rigidity. We show how to use this procedure to improve the bounds for certain triangles. [Joint work with A. Hasnaoui.]

Yash Jhaveri - University of Texas
Title: Lipschitz Changes of Variables between Perturbations of Log-Concave Measures
Abstract: In 2000, Caffarelli showed that given a Gaussian distribution $\gamma$ on $\mathbb{R}^n$ and a log-concave perturbation of that Gaussian distribution $e^{-U}\gamma$ with $U$ convex, the optimal transport (for quadratic cost) that takes $\gamma$ to $e^{-U}\gamma$ is at most 1-Lipschitz. Inspired by his result, we leverage the relationship between optimal transportation and the Monge-Ampère equation to investigate conditions under which one can find Lipschitz changes of variables between log-concave measures, the natural generalizations of Gaussian measures, and perturbations of these measures. This is joint work with Maria Colombo and Alessio Figalli.

Minh Kha - Texas A&M University
Title: Greens function asymptotics near the internal edges of spectra of periodic elliptic operators. Spectral gap interior.
Abstract: Precise asymptotics known for the Green function of the Laplacian have found their analogs for bounded below periodic elliptic operators of the second-order below the bottom of the spectrum. Due to the band-gap structure of the spectra of such operators, the question arises whether similar results can be obtained near the edges of spectral gaps. In this talk, we will discuss the Greens function asymptotics for generic periodic elliptic operators of second-order in dimension $d \geq 2$, when the gap edge occurs at a symmetry point of the Brillouin zone. This talk is based on joint work with P. Kuchment (Texas AM) and A. Raich (University of Arkansas).
**David Kinderlehrer** - Carnegie Mellon University  
**Title:** Lecture 1: Introducing mass transport  
Lecture 2: Evolution of material microstructure and the discovery of the grain boundary character distribution  

**Abstract:** This first talk will be an introduction to Mass Transport. Mass Transport is a very active area that has experienced phenomenal growth since the early nineties. Many prominent mathematicians have contributed; a bibliography will be provided on site. An area of particular interest is the use of mass transport methods, based in particular on the so-called Wasserstein metric, to solve PDEs and systems of PDEs and to understand gradient flows. After outlining basic features of Mass Transport, our goal is to look at these methods, the difficulties they present and what can be learned from them.

Can ideas of mass transport be employed to identify observed flows? In this second talk our concern is the problem of microstructural evolution, one of the central issues in materials science. We discuss a bit of history which leads us to the question of texture for a polycrystal or a cellular network. We shall explore the route to the discovery of the grain boundary character distribution (GBCD), a statistic of a configuration during the coarsening process. Why should a statistic be the solution of a PDE? Here we seek to invert the first lecture by deriving a theory which up scales the local microscopic description cellular evolution to the GBCD. The talk will be coordinated with Prof. Epshteyns.

**Sergiy Koshkin** - University of Houston  
**Title:** Positive semigroups and algebraic Riccati equations in Banach spaces  

**Abstract:** We generalize Wonham’s theorem on solvability of algebraic operator Riccati equations to Banach spaces, namely there is a unique stabilizing solution to $A^*P+PA-PBB^*P+C^*C=0$ when $(A,B)$ is exponentially stabilizable and $(C,A)$ is exponentially detectable. The proof is based on a new approach that treats the linear part of the equation as the generator of a positive semigroup on the space of symmetric operators from a Banach space to its dual, and the quadratic part as an order concave map. A direct analog of global Newton’s iteration for concave functions is then used to approximate the solution, the approximations converge in the strong operator topology, and the convergence is monotone. The linearized equations are the well-known Lyapunov equations of the form $A^*P+PA=-Q$, and semigroup stability criterion in terms of them is also generalized.
**Nguyen Lam** - University of Pittsburgh  
**Title:** Existence and nonexistence of maximizers for the Sobolev embeddings in the limiting case  
**Abstract:** In this talk, we will discuss the existence and nonexistence of extremal functions for the Sobolev embeddings in the border line case, namely, the Trudinger-Moser inequalities. We will first prove the equivalence of the sharp subcritical and critical Trudinger-Moser inequalities. Then we will propose a new approach to the study of the maximizers for the subcritical Trudinger-Moser inequalities. This is joint work with Guozhen Lu and Lu Zhang.

**Phi Le** - University of Missouri, Columbia  
**Title:** Quasi-linear PDEs and uniform rectifiability  
**Abstract:** Let $E \subset \mathbb{R}^{n+1}$, $n \geq 2$, be an Ahlfors-David regular set of dimension $n$. If we assume additionally that $\mathbb{R}^{n+1} \setminus E$ has some “nice” properties then whenever the harmonic measure belongs weak-$A_\infty$ with respect to $H^n|E$ we have $E$ is uniformly rectifiable (i.e. $E$ is locally flat). For more details, the reader may check recent works by Steve Hofmann, José María Martell and their collaborators. In this project, we were interested in the similar result for $p$-harmonic measure. More precisely, let $E$ be as above and let $p$, $1 < p < \infty$, be given, let $u$ be a non-negative $p$-harmonic function in $\Omega := \mathbb{R}^{n+1} \setminus E$ which vanishes continuously on $E$, and let $\mu$ be its associated $p$-harmonic measure supported on $E$. We prove that the weak-$A_\infty$ property of $p$-harmonic measure, weak-$A_\infty$ with respect to $H^n|E$, implies uniform rectifiability of $E$. This result is new already in the case of harmonic measure ($p = 2$).  
(joint work with Steve Hofmann, Kaj Nyström and José María Martell.)

**Robert McCann** - University of Toronto  
**Title:** The intrinsic dynamics of optimal transport  
**Abstract:** The question of which costs admit unique optimizers in the Monge-Kantorovich problem of optimal transportation between arbitrary probability densities is investigated. For smooth costs and densities on compact manifolds, the only known examples for which the optimal solution is always unique require at least one of the two underlying spaces to be homeomorphic to a sphere. We introduce a (multivalued) dynamics which the transportation cost induces between the target and source space, for which the presence or absence of a sufficiently large set of periodic trajectories plays a role in determining whether or not optimal transport is necessarily unique. This insight allows us to construct smooth costs on a pair of compact manifolds with arbitrary topology, so that the optimal transportation between any pair of probability densities is unique.
**Cornelia Mihaila** - University of Texas at Austin

**Title:** On the Shape of Capillarity Droplets in a Container

**Abstract:** The traditional capillarity droplet problem focuses on minimizing the Gauss free energy of a set, that is, the sum of surface and potential energies. We work in the case where the set has a specified volume constraint, is in the small mass regime, and is restricted to being inside a container. We describe the expected shape of the minimizer and properties of its regularity. The results are obtained in collaboration with Francesco Maggi.

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**Tayyab Nawaz** - University Of Illinois at Urbana-Champaign

**Title:** Non-normal asymptotics of the mean-field XY model

**Abstract:** I will discuss the XY spin model of superconductors, with spins in the circle. I will discuss work with Kay Kirkpatrick on the mean-field XY model and its non-normal behavior at the phase transition. There is more to learn about related spin models; I will mention our current work on generalizing these models for higher spin dimensions such as the Toy model of the Higgs sector in particle physics.

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**Robin Neumayer** - University of Texas at Austin

**Title:** Gradient stability for the Sobolev inequality when $p \geq 2$

**Abstract:** The sharp Sobolev inequality in $\mathbb{R}^n$ gives control of the $L^{p^*}$ norm of a function, $p^* = np/(n - p)$, in terms of the $L^p$ norm of the gradient. Equality is achieved by the $(n + 2)$-dimensional family of Talenti functions. In this talk, we show that, in the case $p \geq 2$, functions which almost attain equality in the Sobolev inequality are quantitatively close to Talenti functions at the level of gradients. To the furthest degree possible, we extend the Hilbert space methods employed in Bianchi and Egnell’s proof of the analogous result for $p = 2$ (despite the fact that $L^p$ is not a Hilbert space for $p > 2$), and then use an interpolation argument to reduce to a weaker stability result already shown by Cianchi, Fusco, Maggi and Pratelli.
**Enrique Pereira-Batista** - Universidad de Puerto Rico  
**Title:** Numerical approximation to solutions of linear and nonlinear Schrödinger equation  
**Abstract:** Schrödinger equation describes the behavior of the wave function of a physical system in time. Analytical solutions for Linear (LSE) and Nonlinear Schrödinger Equation (NLSE) have been obtained for certain parameters, but for more general cases it is very complicated to get an explicit solution. Numerical strategies are necessary in order to approximate non-explicit solutions. Results are achieved using pseudospectral and finite difference methods for one dimensional case giving reasonable solutions related to the analytical cases.

**Todd Harry Reeb** - The University of Utah  
**Title:** Dirichlet eigenvalues via $\Gamma$-convergence and optimal transportation  
**Abstract:** Recently, Nicolás García Trillos and Dejan Slepčev have shown that under certain assumptions, if we randomly sample points from a subset $D$ in $\mathbb{R}^n$ and construct a weighted graph in a prescribed manner, then, with probability one, as the number of points goes to infinity, the spectra of the graph Laplacians will converge to that of the Laplacian on $D$ with Neumann boundary condition. In this talk, we’ll discuss how they used optimal transportation theory for a key step, showing the $\Gamma$-convergence of the Dirichlet energies of the graphs to that of the original domain, and then extend their results to the Dirichlet boundary condition. This is joint work with Braxton Osting.

**Maciej Rzeszut** - University of Warsaw  
**Title:** New class of idempotent Fourier multipliers on $H^1(\mathbb{T} \times \mathbb{T})$  
**Abstract:** We construct a new idempotent Fourier multiplier on the Hardy space on bidisc, which could not be obtained by applying known one dimensional results. The main tool is a new $L^1$ equivalent of the Stein martingale inequality which holds for special filtration of periodic subsets of $\mathbb{T}$ with some restrictions on the functions involved.
Pablo Raúl Stinga - Iowa State University
Title: Regularity theory for fractional equations
Abstract: The fractional Laplacian is a classical object in Harmonic and Functional Analysis. Nevertheless, some fine tools needed in the study of PDEs like Harnack inequalities and Schauder regularity estimates are not available from such a general theory. L. Caffarelli and L. Silvestre introduced the nowadays-famous extension problem for the fractional Laplacian. This turned out to be a powerful technique for the theory of fractional equations.

We will explain a novel point of view to handle fractional operators: the semigroup language approach. The method was introduced in my PhD thesis (2010). With this we can understand what a fractional operator is and we can generalize the Caffarelli-Silvestre extension problem to a large class of fractional operators. Applications to Hölder regularity estimates for fractional divergence form elliptic operators will be shown. The latter results were obtained in collaboration with Luis A. Caffarelli.

Alejandro Velez-Santiago - University of California, Riverside
Title: Ambrosetti–Prodi-type problems for quasi-linear elliptic equations with nonlocal boundary conditions
Abstract: Let $\Omega \subseteq \mathbb{R}^N$ be a bounded Lipschitz domain, for $N \geq 2$. We investigate the solvability of the Ambrosetti–Prodi problem for the $p$-Laplace operator $\Delta_p$, with nonlocal Neumann, or Wentzell boundary conditions
\[
|\nabla u|^{p-2}\frac{\partial u}{\partial \nu} - \beta \Delta_{p,v} u + \Theta_p u = 0 \quad \text{on} \quad \Gamma := \partial \Omega,
\]
for $\beta \geq 0$ a constant, where $\Delta_{p,v} u := \text{div}(|\nabla v u|^{p-2} \nabla u)$ denotes the $p$-Laplace-Beltrami operator, for $\nabla v$ the tangential gradient at $\Gamma := \partial \Omega$, and $\Theta_p$ is a nonlocal Besov operator from the trace space of $W^{1,p}(\Omega)$ into its dual. Using a priori estimates, regularity theory, a sub-supersolution method, and the Leray-Shauder degree theory, we obtain a necessary condition for the non-existence of solutions (in the weak sense), the existence of at least one minimal solution, and the existence of at least two distinct solutions. Moreover, when the boundary value problem is solvable, we prove that the weak solutions are Hölder continuous over $\overline{\Omega}$. 
**Xinfeng Wu** - The University of Kansas  
**Title:** An atomic decomposition characterization of flag Hardy spaces  
**Abstract:** We give an atomic decomposition characterization of flag Hardy spaces. A remarkable feature of atoms of such flag Hardy spaces is that these atoms have only partial cancellation conditions.

**Samantha Xu** - University of Illinois at Urbana Champaign (UIUC)  
**Title:** Diffusion processes and invariant Gibbs Measures  
**Abstract:** In this talk, we discuss the connection between various diffusion processes and Gibbs measures for Hamiltonian PDEs. We analyze various examples of this connection, and discuss some recent results.

**Kazuo Yamazaki** - Washington State University  
**Title:** 3-D stochastic micropolar and magneto-micropolar fluid systems with non-Lipschitz multiplicative noise  
**Abstract:** We discuss mathematical analysis tools on stochastic partial differential equations in fluid mechanics. The equations to be discussed include micropolar and magneto-micropolar fluid models, the Boussinesq system and nonhomogeneous magnetohydrodynamics system, all of which include the Navier-Stokes equations as a special case. The type of results to be discussed will be the well-posedness, namely the existence of a martingale solution and its path-wise uniqueness if possible. If time permits, we also discuss other type of results such as the existence of an invariant measure and large deviation principle.

**Shuangjian Zhang** - University of Toronto  
**Title:** Optimal strategy for a principal facing risk-averse agent  
**Abstract:** A monopolist wishes to maximize her profit by finding an optimal price policy. After publishing her price list of products, each agent will choose to buy the product which maximizes his own utility, where the given utility function is strictly decreasing in price. Then the principal will calculate her profit by summing up the benefit each product sold. Note that the distribution of products sold is based on the choices of agents, and thus fundamentally depends on distribution of agents and also price policy. In this paper, we provide an existence result for this optimization, by using convex analysis argument, which is a generalizer of convexity from the quasilinear case.