Abstract list

TWIMS 2018

October 2018

Keynote Lecture

Suncica Canic

Mathematical Problems in Fluids

Abstract:
This talk will give an overview of certain current developments in mathematical methods for fluids. Of particular interest are problems arising in biological fluids, and in the design of new active materials. We will talk about problems arising in the modeling of the human circulatory system in health and disease, and in the modeling of the first implantable bioartificial pancreas, which does not require immunosuppressant medication, and can be implanted in an arm of a type 1 diabetes patient. Mathematical models, and the related mathematical analysis and numerical simulations will be discussed. The mathematical methods rely on the study of nonlinear partial differential equations defined on moving domains. The computational methods rely on the development of Finite Element Method- based fluid-structure interaction algorithms at the macro scale, and Smoothed Particle Hydrodynamics approaches at the micro scale. Examples of real-life applications will be shown.
This talk is a result of an interdisciplinary research performed with a collaborative team consisting of mathematicians (Profs. M. Bukac (Notre Dame), B. Muha (Zagreb), R. Glowinski (UH), J. Tambaca (Zagreb) , A. Quaini (UH), postdoc Y. Wang (Berkeley)) and biomedical specialists (Dr. D. Paniagua (THI), and Profs. T. Desai and S. Roy (UCSF Bioengineering)).

Anna Vershynina
Title: How fast can entanglement be generated in quantum systems?
Abstract:
I will give a gentle introduction to quantum information theory and, in particular, will talk about entanglement - a quantum phenomena that puzzled many bright minds. I investigate the maximal rate at which entanglement can be generated in a quantum system. The goal is to upper bound this rate. All previous results in closed systems considered entanglement entropy as a measure of entanglement. I will present recent results, where entanglement measure can be chosen from a large class of measures. The result is derived from a general bound on the trace-norm of a commutator, and can, for example, be applied to bound the entanglement rate for Renyi and Tsallis entanglement entropies. At the end I will quickly review the generalization of the problem to the open systems.

Annalisa Quaini
Title: A computational study of lateral phase separation in biological membranes
Abstract:
We consider conservative and non-conservative phase-field models for the numerical simulation of lateral phase separation and coarsening in biological membranes. An unfitted finite element method is devised for these models to allow for a flexible treatment of complex shapes in the absence of an explicit surface parametrization. For a set of biologically relevant shapes and parameter values, we compare the dynamic coarsening produced by conservative and non-conservative numerical models, its dependence on certain geometric characteristics and convergence to the final equilibrium.

Anyu Zhang

Title: Partitioning Data Using Monomial Bases to Improve Network Inference in Systems Biology

Abstract:

Network inference in systems biology is plagued by too few input data and too many candidate models which fit the data. When the data are discrete, models can be written as a linear combination of finitely many monomials. The problem of selecting a model can be reduced to selecting an appropriate monomial basis. Recently affine transformations were used to partition input data into equivalence classes with the same basis. We wrote a Python package to build the equivalence classes for small networks. We propose a "standard position" for data sets and developed a metric to measure how far a set is from being in standard position. We used this metric to define the representative of an equivalence class. The implication of this work is guidance for systems biologists in designing experiments to collect data that result in a unique model (set of predictions), thereby reducing ambiguity in modeling and improving predictions.

Bheemaiah Veena Shankara Narayana Rao

Title: Efficacy of Marine Protected Areas (MPAs) under multiple fishing zones.

Abstract:

Structured population models have been used to model density of individuals over time and other factors such as age, mass, developmental stage and space. Mass is a particularly useful measure of condition of a population. For example, large individuals tend to reproduce more offspring and survive better than smaller ones. Our approach to modeling mass dependent population dynamics introduces mass as a dependent variable. We developed a spatiotemporal population dynamics model to track density and average mass of the population at location x and time t and the model will be called as density and mass model. Our model provides an insight into how mobility of species affects the yield and Efficacy of MPAs under multiple fishing zones.

Brandy Doleshal

Title: The genus 2 Goeritz group

Abstract:

The genus g Goeritz group is the group of isotopy classes of orientation preserving homeomorphisms of the 3-sphere that fix the standard genus g Heegaard splitting. In this talk, we will begin to understand the genus 2 Goeritz group and its uses in understanding knot theoretic questions.

Christy Sue Langley
Title: Using games to broaden mathematical knowledge
Abstract:
I will share how I use games across a gamut of educational interactions with many different outcomes in mind. Games are an amazing way to introduce mathematical concepts, reinforce mathematical skills, and expand a persons knowledge of different types of mathematics. I will share how I use games in my freshman seminar, my pre-service math education courses, and in professional development of in-service teachers.

Aleksandra Sobieska
Title: Minimal Free Resolutions over Rational Normal Scrolls
Abstract:
Free resolutions of monomial ideals over the polynomial ring are well-studied and reasonably well-understood, though they are still an active area of research in commutative algebra. However, resolutions over quotients of the polynomial ring are much more mysterious, and even simple examples can violate the nicer properties that the polynomial ring provides. Starting in the 1990's, there is some work on resolutions over toric rings, a particular (and well-behaved) quotient of the polynomial ring. In this talk, we will present a minimal free resolution of the ground field over a specific toric ring that arises from rational normal scrolls. We also provide a computation of the Betti numbers for the resolution of the ground field for all rational normal k-scrolls.

Hayley Boynton

Title: On the Classification of Graphs Based on Their Rank Numbers

Abstract:

A k-ranking of a graph G is a function $f : V(G) \to \{1, 2, \dots, k\}$ such that if $f(u) = f(v)$ then every uv simple path contains a vertex w such that $f(w) > f(u)$. The rank number of G, denoted $\chi_r(G)$, is the minimum k such that a k-ranking exists for G. Rank number is a variant of graph colorings. It is known that given a graph G and a positive integer t the question of whether $\chi_r(G) \leq t$ is NP-complete. In this paper we completely characterize n-vertex graphs whose rank number is equal to $n-1$ or $n-2$. Also, we establish rank numbers of some dense subgraphs of complete graphs, some dense subgraphs of complete bipartite graphs, and complements of trees. In addition, we completely characterize the rank number of subdivided star graphs and establish the rank number of all trees that contain a complete binary tree of the same height.

Janet Sossamon

Title: Surgical Performance Monitoring Using an Optimal Statistic

Abstract:

Performance monitoring is used to ensure that surgeons' success rates are acceptable for quality control purposes in the healthcare system given that hospital-based care is the greatest proportion of costs, for monetary and non-monetary alike. Sometimes a surgeon may experience a temporary lag in performance level simply because of random, unavoidable fluctuations. The challenge is to distinguish doctors who are truly underperforming from doctors who are experiencing a temporary lag in performance as soon as possible so corrective measures can be implemented. In this paper, we show that a previously used method, known as Variable Life Adjustment Display (VLAD) charting, is inferior from the statistical point of view.

We also show that using a log likelihood statistic can identify genuine substandard performance much more effectively by proving that it results in the smallest possible missed detection rate for any given false alarm rate. We use computer simulations to confirm the superiority of our theoretical results.

Jen Berg
Title: Rational solutions to polynomial equations and geometry
Abstract:
Which integers can be expressed as the sum of three cubes? Does there exist a box such that the distance between any two of its corners is a rational number? These questions and many others can be reframed as Diophantine problems, that is, questions of existence of rational solutions to polynomial equations. Each such Diophantine problem has a geometric manifestation called an algebraic variety whose properties often shed light on why these questions do not have elementary answers. In this talk I will give a gentle introduction to the guiding principle that geometry influences arithmetic, and briefly describe recent work on obstructions to rational solutions to equations of the form $w^2 = f(x, y, z)$, which defines a $K3$ surface (a 2-dimensional analogue of an elliptic curve).

Joanna Furno
Title: Dynamics of Rational Maps and Exponentials in the Limit
Abstract:
In joint work with Lorelei Koss, we examine the complex dynamics of families of rational maps that converge to families of exponential maps. In particular, this talk will focus on the limiting behavior in the parameter spaces.

Lale Asik

Title: Dynamics of a Stoichiometric Producer-Grazer System with Seasonal Effects on Light Level

Abstract:

Many population systems are subject to seasonally varying environments. As a result, many species exhibit seasonal changes in their life-history parameters. It is quite natural to try to understand how seasonal forcing affects population dynamics subject to stoichiometric constraints, such as nutrient/light availability and food quality. Here, we use a variation of a stoichiometric Lotka-Volterra type model, known as the LKE model, as a case study, focusing on seasonal variation in the producer's light-dependent carrying capacity. Positivity and boundedness of model solutions are studied, as well as numerical explorations and bifurcations analyses. In the absence of seasonal effects, the LKE model suggests that the dynamics are either stable equilibrium or limit cycles. However, through bifurcation analysis we observe that seasonal forcing can lead to complicated population dynamics, including periodic and quasi-periodic solutions.

Mary Flagg

Title: Zero Forcing: From Linear Algebra to the Power Grid

Abstract:

Zero forcing is a coloring game on a simple graph introduced in the linear algebra community as an upper bound on the maximum nullity of a symmetric matrix whose off–diagonal pattern of zeros is determined by the edges of the graph. Zero forcing was independently introduced by physicists studying control of quantum systems. Zero forcing is related to power domination, a graph theory model of the PMU placement problem, the engineering challenge of placing the optimal number of phasor measurement units in the power grid to monitor the whole grid at minimal cost. My research collaboration has been studying the connections between zero forcing and power domination. In this talk I will share some of our results on the connections between power domination and zero forcing and current directions of research.

Meagan Carney

Title: Modeling Extremes in Dynamics under Stationary and Nonstationary Assumptions

Abstract:

An extreme value law concerns the distributional convergence of the maxima by the extremal index parameter typically under certain stationary assumptions. In this talk we discuss extreme value statistics for Sinai dispersing billiards and investigate how the geometry of the map relates to maximization of the observable at a periodic or generic point where the extremal index differs in each case. We also introduce a model for real world summer temperature recordings throughout Texas 1941-2017. In this case the Generalized Extreme Value distribution model needs to be adapted to account for nonstationarity in the time series.

Natasha Astudillo

Title: Comparative introduction to mathematical theory of the Fluorescence Correlation Spectroscopy for a diffusion process: Classical approach vs simplified approach

Abstract:

Since its introduction in the 1970s, Fluorescence Correlation Spectroscopy (FCS) has become a standard physical chemistry tool to investigate diffusion processes in living cells complementing other fluorescence microscopy techniques including but not limited to Fluorescence Recovery after Photobleaching (FRAP) and Single Particle Tracking (SPT). For diffusion FCS analysis, an autocorrelation curve of fluorescence fluctuation data is compared with a theoretical autocorrelation function or FCS equation for a diffusion coefficient. Additionally, FCS is now being applied not only to a diffusion process but also to a broad range of biochemical processes including binding kinetics and anomalous diffusion. Since the derivation of FCS equations for many biochemical processes shares many common derivation steps with the diffusion FCS equation, it is important to understand mathematical theory behind the diffusion FCS equation. However, because the derivation of FCS equations requires advanced Fourier Transform and inverse Fourier Transform involving intermediate to advance level mathematical techniques, which most biologists and bioengineers are not familiar with, it is often treated as a black box in the classroom. In this work, we first provide a simple and straightforward derivation of FCS equation for free diffusion based on calculus-level mathematics without the knowledge of Fourier transform and inverse Fourier transform, so that FCS equations and its applications are accessible to a broad audience. Additionally, we present the classical Fourier transform based derivation of the diffusion FCS equation and compare it with our new simplified approach.

Priyanga Ganesan

Title: Quantum Majorisation

Abstract:

In this talk, I will show that given a non-compact operator T on l^p, $(1 < p < \infty)$, there exist bounded linear maps A, B on l^p such that $B \circ T \circ A$ is equal to the identity map. If time permits, I will also talk about a variant of this factorization problem in L^p spaces.

Rebecca Woods

Title: Preliminary Results of Topological Symmetries of a 3-rung Möbius Ladder Embedded on a Torus

Abstract:

In 1985, Jon Simon proved the embedded graph on S^3 of a Möbius ladder with 3 rungs cannot be deformed into its mirror image such that rungs go to rungs and sides go to sides. This proof is important to chemists like Walba, Richards, and Haltiwanger who, years earlier, synthesized a molecule of this structure made from a polyether chain with three rungs that are carbon-carbon double bonds. Flapan and Lawrence went on to find the topological symmetry groups of all possible embeddings of the family of Möbius ladders in the 3-sphere. This talk will focus on classifying the topological symmetry groups of a Möbius ladder embedded on the torus. To do this, we examine the correspondence of the homeomorphisms of the torus and the elements of the general linear group, $GL_2(Z)$.

Rita Stanaityte

Title: ILU preconditioners for non-symmetric saddle point matrices with application to incompressible Navier-Stokes equation.

Abstract:

This presentation concerns numerical properties of incomplete LU factorizations applied to the discrete linearized incompressible Navier-Stokes problem. Stabilized and unstabilized finite element method that was used for the Navier-Stokes problem leads to the system of algebraic equations of a saddle point type which has a 2 2-block structure. Numerical experiments for a model problems of a driven cavity flow, and flow over a backward-facing step illustrate the performance of the two-parameter ILU factorization as a preconditioner.

Sara Shirinkam

Title: n-generalized quasi-Baer annihilator conditions

Abstract:

A near ring is a generalization of a ring that the commutativity of addition is not required and just one of the distributive laws is postulated. In this paper we define n-generalized quasi-Baer annihilator conditions in the class of near-rings. We investigate polynomial near-rings and we prove that a near-Armendariz polynomial ring with unity is equivalent to a Baer ring. Also, we generalize the matrix near-ring of a quasi-Baer near-ring.

Sarah Boon
Title: Analysis of the Trojan Y Chromosome Eradication Strategy
Abstract:
The Trojan Y-Chromosome (TYC) strategy is a proposed method to eradicate an invasive species. The strategy consists of introducing sex-reversed males containing two Y chromosomes into a habitat to skew the sex ratio of subsequent generations toward an increasing number of males. A new mathematical model that incorporates both a strong Allee effect and intraspecies competition between supermales and wild-type males for females mates is provided. The efficacy of the strategy is examined through the mathematical model. The influence of the frequency and amplitude of introduction on the strategy effectiveness will also be discussed.

Simona Hodis
Title: Topological description of hemodynamics inside brain aneurysms
Abstract:
Ruptured aneurysms are known to have complex flow patterns and concentrated inflow jet, but a quantifiable measure of the degree of complexity in patient-specific geometries has not been established.
The purpose of this study is to provide an analytic solution for calculating the flow complexity parameter based on the curvature and torsion of the flow field. Analyzing the flow complexity parameter in the jet and non-jet regions inside the aneurysm dome, we found that a ruptured aneurysm has more than four times more concentrated inflow jet and more than three times more complex flow patterns in non-jet region than an unruptured aneurysm. This newly implemented kinematic parameter provides a measurable degree of complexity of flow patters in cerebral aneurysms that can better assess aneurysm rupture risk.