Abstracts of talks by Invited Speakers

Cecilia Diniz Behn (Colorado School of Mines)
Oral Minimal Model protocol duration affects estimates of insulin sensitivity in obese adolescent girls

Abstract: Insulin sensitivity (SI) decreases during adolescence and is prevalent in obese adolescent girls. In order to study SI under physiological conditions, researchers have developed a method using glucose and insulin concentrations obtained from an oral glucose tolerance test (OGTT) in conjunction with the Oral Minimal Model (OMM), a differential-equations based mathematical model of glucose-insulin dynamics that estimates SI. To assess SI in adolescents, we administered a frequently sampled OGTT to a cohort of 75 obese adolescent girls in the 95th percentile or higher body mass index (BMI) with an average age of 16 years. The OMM-based method for estimating SI was developed in adults where glucose and insulin levels typically return to baseline within two or three hours following ingestion of the drink. In our highly insulin resistant adolescent population, it was necessary to extend the standard two hour OGTT protocol up to six hours to allow participants' glucose and insulin concentrations to return to baseline. To investigate how measures of SI change with protocol duration, we compared SI values computed using an OMM fit to six hour OGTT data to SI values computed using OMMs fit to data collected over shorter durations. Specifically, we considered two, three and four hour implementations of OMMs. We found that although SI estimates are correlated across protocols, shorter protocols produce SI values that may overestimate SI as computed with a six hour protocol with a bias up to -73.5%. Our results suggest that OGTT-OMM protocol duration affects SI estimates. Future work may exploit these insights to establish methodologies to reliably estimate SI in adolescents from shorter OGTT protocols that are less time and resource intensive. These methodologies will facilitate characterization of SI in individual patients as well as in different disease conditions, such as diabetes and metabolic syndrome, and may support the development of targeted therapeutic approaches.

Ana Berrizbeitia (Colorado Mesa University)
Invariants Of Hopf Actions On Path Algebras Of Quivers

Abstract: Invariant theory has its roots in groups acting on algebraic varieties, where the goal is to describe the polynomial functions that are fixed by the group action. A classic question in the study of group actions is whether the invariant ring is finitely generated, and if so, can we find a nice description for a minimal set of generators. Actions, however, are not limited to group actions, and in this talk, we will show under which circumstances a Hopf Algebra, namely a Taft Algebra, can act on the path algebra of a quiver, extending the work of Kinser and Walton published in 2016. Furthermore, given an action where the group like element $g \in T(n)$ acts transitively on Q_0, we provide a description of the invariant ring of the action.

Janet Best (Ohio State University)
Biological variation stimulates new questions in dynamical systems

Abstract: Biological variation creates the need to study families of dynamical systems in which the coefficients have large variation. The study of such systems has revealed special mechanisms that keep certain important biological variables homeostatic, and understanding such mechanisms has stimulated new research in bifurcation theory. Large biological variation means that experiments on cells and animals often produce a wide variety of responses to external stimulation. A difficult fundamental problem is how to use that variety of responses to gain information about the internal biological mechanisms.

Victoria Booth (University of Michigan)
Mapping the circadian modulation of sleep-wake dynamics

Abstract: The timing of human sleep is strongly modulated by the 24-hour circadian rhythm, and desynchronization of sleep-wake cycles from the circadian rhythm can negatively impact health. We have developed a physiologically-based mathematical model for the neurotransmitter-mediated interactions of sleep-promoting, wake-promoting and circadian rhythm-generating neuronal populations that govern sleep-wake behavior in humans. To investigate the dynamics of circadian modulation of sleep patterns and of entrainment of the sleep-wake cycle with the circadian rhythm, we have reduced the dynamics of the sleep-wake regulatory network model to a one-dimensional map. The map dictates the phase of the circadian cycle at which sleep onset occurs on day $n+1$ as a function of the circadian phase of sleep onset on day n. The map is piecewise continuous with discontinuities caused by circadian modulation of the duration of sleep and wake episodes and the occurrence of rapid eye movement (REM) sleep episodes. Analysis of map structure reveals changes in sleep patterning, including REM sleep behavior, as sleep occurs over different circadian phases. In this way, the map provides a portrait of the circadian modulation of sleep-wake behavior and its effects on REM sleep patterning. Using the map, we are analyzing effects of sleep deprivation and bifurcations of the sleep-wake regulatory network model to understand how variations in the homeostatic sleep drive affect human sleep patterning over development.

Ranthony Edmonds (Ohio State University)
Factorization in Polynomial Rings with Zero Divisors

Abstract: Factorization theory is concerned with the decomposition of mathematical objects. One of the earliest and most significant results involving factorization is the Fundamental Theorem of Arithmetic, which states that every integer can be written uniquely as the product of primes. Thus we can think of prime numbers as the atoms of the integers. We can generalize this idea of unique factorization into atoms to a commutative ring R called a unique factorization domain.

One important result about unique factorization is that if a ring R is a unique factorization domain, then the polynomial ring $R[X]$ is also a unique factorization domain and vice versa. However, if R satisfies the unique factorization property but is not an integral domain, $R[X]$ does not have to be a unique factorization ring. This example highlights the general bad behavior of factorization properties with respect to the polynomial ring extension $R[X]$ when R is an arbitrary commutative ring with zero divisors. In this talk we discuss how factorization in an arbitrary commutative ring R with zero divisors differs from when R is an integral domain, and frame that conversation in the context of polynomial rings. Along the way we focus on some of the challenges in factorization that arise when working with zero divisors, and give a characterization of when a polynomial ring over an arbitrary commutative ring has unique factorization.

Diana Hubbard (Brooklyn College, CUNY)
The braid index of highly twisted braid closures

Abstract: The braid index of a knot is the least number of strands necessary to represent it as the closure of a braid. If we view a braid as an element of the mapping class group of the punctured disk, its fractional Dehn twist coefficient measures, informally, the amount of twisting it exerts about the boundary. In this talk I will discuss joint work with Peter Feller showing that if an n-braid has fractional Dehn twist coefficient greater than $n-1$, then its closure is of minimal braid index, which draws a connection between braids as topological and geometric objects.

Mihaela Ifrim (University of Wisconsin, Madison)
Dispersive decay of small data solutions for the KdV equation

Abstract: We consider the Korteweg-de Vries (KdV) equation, and prove that small localized data yields solutions which have dispersive decay on a quartic time-scale. This result is optimal, in view of the emergence of solitons at quartic time, as predicted by inverse scattering theory.

Katelyn J. Plaisier Leisman (University of Illinois at Urbana-Champaign)
Stability of Traveling Wave Solutions of Nonlinear Schrödinger-Type Equations

Abstract: The cubic Nonlinear Schrödinger Equation (NLS) is a well studied integrable (analytically solvable) nonlinear equation. Here we analyze the stability of periodic solutions to quasi-periodic perturbations of NLS-type equations (with varied nonlinear terms) that are not necessarily integrable. We perturb traveling wave solutions and study the eigenvalues of the linearization around this perturbation (instability will occur if these eigenvalues have a nonzero real part). When the boundary conditions are periodic, the linearization has eigenvalues that equal zero. However, when the periodicity of the boundary conditions is perturbed, these zero eigenvalues will become nonzero, potentially indicating instability. Using matrix perturbations, we compute these eigenvalues near the origin in the complex plane and find them to be in agreement with results based on the integrability of the cubic NLS. This is particularly useful, because our method can be used for NLS-type equations that are not integrable, such as the 1D quintic NLS.

Caitlin Leverson (Georgia Tech)
Ruling Polynomials and the Colored HOMFLY-PT Polynomial

Abstract: Given a Legendrian knot Λ in $\mathbb{R}^3$ with the standard contact structure, Rutherford showed that the ruling polynomial of Λ appears as a specialization of the HOMFLY-PT polynomial of its topological knot type. We will extend the definition of the ruling polynomial to define the colored ruling polynomial of a Legendrian knot, analogously to how the definition of the colored HOMFLY-PT polynomial is an extension of the HOMFLY-PT polynomial, and show that the colored ruling polynomial of Λ also appears as a specialization of the colored HOMFLY-PT polynomial of Λ's topological knot type.

Rachael Norton (Northwestern)
A guide to generalized Nevanlinna-Pick theorems

Since the original proof of the Nevanlinna-Pick theorem in 1915, there have been a variety of generalizations to operator theory, most of which can be recovered by Muhly-Solel's result from 2004. Muhly and Solel think of Nevanlinna-Pick interpolation as an instance of commutant lifting. Constantinescu-Johnson, on the other hand, use the displacement equation to prove a result which is fundamentally different from Muhly-Solel's. In this talk, we address the differences and discuss circumstances under which the theorems are equivalent.

Camila Ramirez (Oakridge National Lab)
Finding a Solution: From Blackboards to Super Computers

Abstract: In this talk, I will share my experience of transitioning from life as a graduate student in pure mathematics to a new job as a post doctoral research fellow at the largest national laboratory in the US. I?ll discuss how I landed an internship at Oak Ridge National Lab as a graduate student,

and the challenges of navigating the online world of resume submissions in a new field. I will also cover my experience of flying back-and-forth, from the university to the lab, during the post-doc interview process while wrapping up my dissertation. Finally, I?ll dive into tips on breaking into an industry career and having a successful job interview.

Yangyang Wang (Ohio State University)
Bifurcations on Fully Inhomogeneous Networks

Abstract: Mathematically, network dynamics can be formalized as coupled cell systems, where each cell is a system of differential equations. Networks arise naturally in many areas of biology such as gene regulation, ecology and biochemistry. In these fields, networks are often fully inhomogeneous in the sense that all cells are distinct and all couplings are different. Motivated by this, we consider dynamics on fully inhomogeneous networks. Center manifold reduction is a standard technique in bifurcation theory, reducing the essential features of local bifurcations to equations in a small number of variables corresponding to critical eigenvalues. This method can be applied to admissible differential equations for a network, but it bears no obvious relation to the network structure. For fully inhomogeneous networks, however, there are general circumstances in which the center manifold reduced equations inherit a network structure of their own. This observation is used to analyze codimension one and two local bifurcations. For codimension one, only one critical component is involved and generic local bifurcations are saddle-node and standard Hopf. For codimension two, we focus on the case when one component is downstream from the other in the feedforward structure. Here the generic bifurcations, within the realm of network-admissible equations, differ significantly from generic codimension two bifurcations in a general dynamical system.

Ye Wang (Hunan University and University of Iowa)
Non-spectral problem for some self-similar measures

Abstract: In this talk, I will give a brief introduction of Fourier analysis on fractals. In particular, I will mention the results of the joint paper with Prof. Xin-Han Dong et al. In the paper, we focus on the non-spectral properties of one dimensional self-similar measures with consecutive digits and uniform weights. We consider the maximal cardinality of orthogonal set of exponential functions (OEF) in the square integrable functional space. We prove that the maximal cardinality of OEF will either depend on the cardinality of the digits or be arbitrarily finite.

Anna Weigandt (University of Michigan)
Bumpless Pipe Dreams and Alternating Sign Matrices

Abstract: Lam, Lee, and Shimozono introduced bumpless pipe dreams to study back stable Schubert calculus. In particular, Schubert polynomials can be expressed as a weighted sum over bumpless pipe dreams in a square grid. Working from a different perspective, Lascoux gave a formula for Grothendieck polynomials as a sum over alternating sign matrices. We explain the connection between these two formulae.

Rebecca Winarski (University of Michigan)
Polynomials, Dynamics, and Twisted Rabbits

Abstract: Motivated by problems in complex dynamics, we study branched covers from the sphere to itself. Thurston proves that branched self-cover of the sphere that satisfies certain finiteness conditions is either equivalent to a polynomial or it has a topological obstruction. We use topological techniques - adapting tools used to study mapping class groups - to produce an algorithm that determines which polynomial a topological branched cover is equivalent to. Our algorithm provides a new solution to Hubbard's twisted rabbit problem, a celebrated theorem from complex dynamics, and allows us to solve a generalization of the twisted rabbit problem. This is joint work with Jim Belk, Justin Lanier, and Dan Margalit.

Emily Witt (University of Kansas)
Connectedness and local cohomology

Abstract: Local cohomology modules are algebraic objects that encode important properties; e.g., the dimension of a ring, the depth of a ring on an ideal, and the number of equations needed to define a variety. The second vanishing theorem of local cohomology characterizes the connectedness of the punctured spectrum. In this talk, we seek to understand how local cohomology determines more refined connectedness properties, and introduce a "third vanishing theorem." This is joint work with Luis Núñez-Betancourt and Sandra Spiroff.

Sijue Wu (University of Michigan)
On the motion of water waves with angled crests

Abstract: A common phenomena in the ocean is waves with angled crests. In this talk, I will discuss some recent progress on the understanding of the motion of water waves that allows for angled crested type singularities in the interface.

Jue Yan (Iowa State University)
Positivity preserving high order direct discontinuous Galerkin method for Keller-Segel chemotaxis equations

Abstract: We develop a new direct discontinuous Galerkin (DDG) method to solve Keller-Segel Chemotaxis equations. One unique feature of our method is that we introduce no extra variables to approximate the gradient of the chemical concentration and solve the system directly with DDG method. We obtain optimal $(k + 1)$th order convergence with kth degree piecewise polynomials approximations, even on a random mesh. Furthermore, we prove the cell density solution is maintained positive at all time levels with at least third order of accuracy. Cell density blow up phenomena is captured well.