Abstracts

Adina Ciomaga *Accurate Curvature Computation in Digital Images*

In processes of visual perception, it may be argued on neurological grounds that the human brain could not possibly use all the information provided by states of stimulation, but rather it strips away redundant information and encodes only important features. As such, when processing a visual image, the brain encodes the information along contours (i.e., regions where color changes abruptly), and furthermore those points on a contour at which its direction changes most rapidly (i.e., at angles or peaks of curvature). Yet, a direct computation of curvature on a raw image is impossible. I will explain in this talk how curvatures can be accurately estimated by a computation on level lines after their independent smoothing. The algorithm, entitled *Level Lines Shortening*, provides results coherent to our visual perception, and gives a new method of features computation and selection (e.g. cores and ridges for fingerprints), similar to the human brain activity.

Amie Wilkinson *Chaotic stability, stable chaos*

Viewed from various perspectives, the evolution of a dynamical system over time can appear both orderly and extremely disordered. I will describe some mechanisms behind chaos and stability in dynamics and how in certain contexts this intermixing of behaviors is to be expected.

Amy Buchmann *Why do Myxo cells cluster together?*

The bacteria, Myxococcus xanthus, is known to exhibit collective motion, but the details of their organized motility is not fully understood. Mathematical modeling can be used to understand complex biological processes such as bacteria swarming. I will present a parallel implementation of a subcellular element model of M. Xanthus. The parallelization of this model allows for thousands of bacteria cells to be modeled so questions pertaining to collective motion may now be studied. This model is used to analyze the clusters of bacteria that form when M. Xanthus swarm in a vegetative state. In particular, we investigate how a cells flexibility, adhesive properties, and reversal period contribute to cluster formation. These findings lead to predictions that can be tested experimentally.

Ana Caraiani *Local-global compatibility of Langlands correspondences*

The Langlands program is a network of conjectures linking together many areas of pure mathematics. It has been at the heart of some of the most exciting developments in number theory in recent years, such as the proof of Fermat's last theorem, and it can be thought of as a vast generalization of quadratic reciprocity. In this talk, I will focus on the compatibility between local and global Langlands correspondences for GL_n and explain how it relates to deep conjectures in other fields of mathematics, such as the Ramanujan conjecture in harmonic analysis and the weight-monodromy conjecture in arithmetic geometry.

Anne Shiu *Dynamics of reaction systems*

Chemical reaction networks are directed graphs in which each edge represents a chemical reaction. The most basic kinetics to assign to reaction networks are those of mass-action, first introduced nearly 150 years ago by Guldberg and Waage: the rate at which each reaction occurs is proportional to the product of the concentrations of its reactants. The systematic study of the resulting polynomial ordinary differential equations began in the 1970s, and in recent years, this area has seen renewed interest, due in part to applications to systems biology. This talk will discuss recent results on long-standing questions pertaining to the dynamics of reaction systems, using methods from combinatorics and polyhedral geometry.

Ellen Goldstein *Nilpotent Orbit Closures in the Symplectic and Orthogonal Groups*

Kraft and Procesi proved in their 1982 paper that for certain nilpotent elements in either the orthogonal or symplectic groups over a field of characteristic zero, the closure of the orbit of such an element is normal. In this talk I will discuss how to classify these nilpotent orbits using Young diagrams and the use of these diagrams in Kraft and Procesis paper. Time permitting, I will discuss some of the challenges in generalizing their results to prime characteristic.

Emily Peters *Proof by pictures*

Planar algebras – "proof by picture" – bring topological tools to bear on algebraic problems that arise in von Neummann algebras, and explain (or, at least, deepen) the connection between knot theory and subfactors. In this talk I will assume you know nothing about operator algebras and mostly talk about the Temperley-Lieb algebra, which is the most straightforward planar algebras, and is also universal as well as just plain cool.

Inna Zakharevich *Scissors congruence and K-theory*

Hilbert's third problem asks the following question: given any two polyhedra with the same volume, is it always possible to dissect them into finitely many pairwise congruent polyhedra? In 1901 Dehn showed that the answer was "no", by constructing a cutting invariant which is different for the cube and regular tetrahedron. In 1965, Sydler showed further that this invariant, together with the volume, completely classifies polyhedra up to finite dissection. For dimensions higher than four, however, this problem remains unsolved. In this talk we will describe two modern approaches to this problem, one through group homology and one through K-theory, and discuss the role of the Dehn invariant in both contexts.

Irina Bobkova *Resolutions of spheres*

Computing the stable homotopy groups of spheres is a long-standing problem in algebraic topology. We will explain the idea of chromatic homotopy theory and how it helps break down the problem into $K(n)-$local layers. Then we will

discuss what is known about the resolutions of $K(1)$ and $K(2)$-local spheres. The talk is based on recent research by Goerss-Henn-Mahowald-Rezk and work in progress.

Irina Nenciu

Jessica Dyer *Substitutions, Bratteli Diagrams, and Dynamics*

This will be an expository talk about substitution dynamical systems and their associated Bratteli diagrams.

Julia Knight *Describing groups*

I will say how to characterize certain groups, up to isomorphism, using infinitely long, but still comprehensible, sentences. Sela showed that all non-abelian free groups, with different numbers of generators, satisfy the same *elementary first order sentences*, where these are sentences of the usual kind– finitely long. In $L_{\omega_1\omega}$, we allow countably infinite disjunctions and conjunctions. Scott showed that for any countable structure $\mathcal{A}$, there is a sentence of $L_{\omega_1\omega}$ whose countable models are exactly the isomorphic copies of $\mathcal{A}$. This is called a Scott sentence for $\mathcal{A}$. Many computable structures have *computable* infinitary Scott sentences, in which the countable disjunctions and conjunctions are over computably enumerable sets.

Katherine Alexander Anders *An interesting family of polynomials in $\mathbb{Z}_2[x]$*

I describe a sequence of polynomials $p_n(x) \in \mathbb{Z}_2[x]$ such that the order of $p_n(x) = d_n$ and $p_n(x)q_n(x) = 1 + x^{d_n}$ with the property that the proportion of 1's among the coefficients of $q_n(x)$ goes to 1 as $n \to \infty$.

Mariana Smit Vega Garcia *The optimal regularity in the Signorini problem with Lipschitz variable coefficients*

We study the lower-dimensional obstacle problem for a uniformly elliptic divergence form operator $L = \mathrm{div}(A(x)\nabla)$ with Lipschitz continuous coefficients. When the obstacle is zero, similarly to what happens when $L = \Delta$, the variational solution has the optimal interior regularity $C^{1,\frac{1}{2}}_{loc}(\Omega_\pm \cup \mathcal{M})$, where $\mathcal{M}$ is the lower-dimensional manifold where the obstacle is supported. This is joint work with Professor Nicola Garofalo.

Olga Lukina *Hierarchy of graph matchbox manifolds*

We study a class of graph foliated spaces, or graph matchbox manifolds, initially constructed by Kenyon and Ghys. For graph foliated spaces we introduce a quantifier of dynamical complexity which we call its level. We develop the fusion construction, which allows us to associate to every two graph foliated spaces a third one which contains the former two in its closure. Although the underlying idea of the fusion is simple, it gives us a powerful tool to study graph foliated spaces. Using fusion, we prove that there is a hierarchy of graph foliated spaces at infinite levels.

Olga Turanova *Discrete Approximations to partial differential equations*

There is a wide class of discrete approximations for nonlinear PDEs that converge to the actual solution of the equation, but for which the rate of convergence remains unknown. In this talk, I will motivate why we want to study these rates of convergence and discuss some classes of equations for which a rate has been obtained.

Sara Jensen *On the Character Degree Simplicial Complex of a Finite Solvable Group*

In this talk, we introduce the character degree simplicial complex of a finite group G. We will discuss the history and development of this simplicial complex, and we will focus on results pertaining to the structure of the homology groups of this simplicial complex. Familiarity with basic algebraic topology would be helpful, but knowledge of the results of character theory should not be necessary.

Sara Lapan *Complex dynamics: Existence of Attracting Domains*

One of the guiding questions behind the study of local (discrete) holomorphic dynamics is: given a germ f of a holomorphic self-map of C^m that fixes a point (say the origin), can it be written in a simpler form? If so, then the dynamical behavior of the map can be more easily understood. In this talk, we will focus on the case when the linear term in the power series expansion for f near the origin is the identity so that f is of the form: $f(z) = z + P_k(z)+$(higher order terms), where P_k is a homogeneous polynomial of degree k that is not identically zero. We want to know how points near the origin behave upon iteration of the map f and when there is a domain attracted to the origin under iteration. In dimension 1, the Leau-Fatou Flower Theorem tells us, among other things, of the existence of such domains. In this talk, we will discuss this theorem as well as similar results in higher dimensions, including work that I have done in this area.

Sonja Mapes *Poset resolutions and rigid monomial ideals*

Finite atomic lattices, which arise as the lcm-lattice of a monomial ideal, play an important role in studying free resolutions of monomial ideals. In this talk I will discuss this relationship as well as give a brief description of Clark's poset resolution construction. This construction can be seen as a more combinatorial analog to cellular resolutions. Using the poset resolution construction we can construct the minimal free resolution of a certain class of rigid monomial ideals and we hope to extend our result to all rigid monomial ideals. This talk will not assume any previous knowledge about free resolutions or monomial ideals.

Tullia Dymarz *Quasi-isometries vs. Bilipschitz equivalence*

Geometric group theorists treat finitely generated groups as metric spaces via the word metric. This word metric depends on a generating set so to deal with this limitation we introduce two notions of equivalence: quasi-isometry and

bilipschitz equivalence. In this talk we show that while for many groups these notions are equivalent for some groups they are not.

Zhilan Feng *Mathematical modeling of infectious diseases*

Mathematical modeling of infectious diseases has affected vaccination policy throughout the developed world and, via the WHO, elsewhere. Policy goals vary with disease and setting, but preventing outbreaks is common. This is attained by exceeding the population immunity threshold. While immunity seems to be at or above the threshold for many vaccine-preventable diseases in the US, policymakers are concerned about heterogeneity due to personal-belief exemptions to vaccination. We use an epidemiological model with preferential mixing to evaluate the impact of such heterogeneity on our efforts to prevent disease outbreaks. A more generalized mixing that incorporates both spatial and age heterogeneities will also be discussed.