GSCAGT 2019 Title and Abstract List

Talks marked with a dagger (†) indicate expository talks

Thin position of 4-manifolds

Roman Aranda Cuevas, University of Iowa

In 2012, D. Gay and R. Kirby proved that M can be decomposed as the union of three 4-dimensional 1-handlebodies with pairwise intersection 3-dimensional handlebodies and triple intersection closed orientable surface of genus g. Such decomposition is called a trisection of M. One can think of trisections as the 4-dimensional analogue of Heegaard splittings of M with the "trisection surface" being the triple intersection of the 4-dimensional 1-handlebodies.
In 1994, M. Scharlemann and A. Thompson introduced a complexity for handle decompositions of 3-manifolds called the width. In the last decade, taking a minimal width decomposition of a 3-manifold has been a useful technique. As an example, M. Scharlemann and J. Schultens used this to show that the connected sum of n knots in S^3 has tunnel number at least n. In this talk, we use the ideas of trisections of 4-manifolds to define the width of a Kirby diagram and introduce the notion of thin position of a compact smooth 4-manifold with connected boundary.

Classifying 2-stratifolds with finite fundamental group

John Bergschneider, Florida State University

2-Stratifolds are surfaces everywhere except along a finite collection of simple closed curves where n-sheets meet. In contrast to surfaces, there is no general classification of 2-stratifolds. But the finite fundamental group of these spaces are known to be the finite Fuchsian groups. We explore a solution on how to classify 2-stratifolds where 3-sheets meet.

Graph products as hierarchically hyperbolic groups

Daniel Berlyne, The Graduate Center, CUNY

Two of the best understood ways of combining groups are free products and direct products. Graph products provide a way of interpolating between these two extremes, by taking a collection of groups (indexed by the vertices of a graph) and combining them by taking their free product and then imposing commutation relations between pairs of groups that are joined by an edge in the graph. For example, right-angled Artin groups are graph products where all the vertex groups are copies of $\mathbb{Z}$.
We show that graph products are hierarchically hyperbolic relative to their vertex groups, giving the first non-trivial set of concrete examples of relatively hierarchically hyperbolic groups. This is joint work with Jacob Russell.

Enumeration of real curves on surfaces

Xujia Chen, Stony Brook University

How many complex degree d rational curves pass through $3d-1$ general points in $\mathbb{CP}^2$? This classical question, which in general can be asked for any complex surface, was answered by Kontsevich's recursion, proved by Ruan-Tian in the early 90s by pulling back a cobordism from a simple oriented manifold to the oriented moduli space of these curves. In the early 2000s, Welschinger defined signed invariant counts of real rational curves on real surfaces (complex surfaces with a conjugation). Solomon's recursions, announced in 2007, determine these counts completely for many surfaces. I will describe a topological perspective on pulling back cobordism relations by maps between not (necessarily) manifolds and its application which finally established Solomon's recursion in 2018.

The Hilbert series and invariants of circle representations

Emily Cowie, University of Oklahoma

The Hilbert series derived from a finite dimensional representation of the complex circle $\mathbb{C}^{\times}$ is computed to identify the weight vectors with Gorenstein and non-Gorenstein invariant algebras. In this talk, I will present an explicit formula for the Hilbert series in terms of partial Schur polynomials, as well as the first few coefficients in the series.

On macroscopic dimension of non-spin 4-manifolds (joint with A. Dranishnikov)

Michelle Daher, University of Florida

Gromov introduced the concept of macroscopic dimension to describe some large scale phenomenon of the universal covering of manifolds with positive scalar curvature. He discovered some large scale dimensional deficiencies of the universal covering of such manifolds which he formulated as follows:
Gromov's conjecture: The macroscopic dimension of the universal covering $\widetilde{M}$ of a closed n-manifold M with psc satisfies the inequality $\dim_{mc}\widetilde{M} \leq n-2$ for a metric on $\widetilde{M}$ lifted from M. This can be done in 2 steps. First step is to show that $\dim_{mc}\widetilde{M} \leq n-1$ and the next step is to show that $\dim_{mc}\widetilde{M} \leq n-2$.
Gromov asked the following question: Is it true that for any manifold M^n, $\dim_{mc}\widetilde{M} \leq n-1$ implies $\dim_{mc}\widetilde{M} \leq n-2$? In this talk I show that the answer to the above question is yes for 4-manifolds with non-spin universal cover and residually finite fundamental group.

Hausdorff dimension of limit sets of Anosov subgroups

Subhadip Dey, University of California, Davis

As an application of the Patterson-Sullivan theory, introduced by Patterson to study Fuchsian groups and then further developed by Sullivan to study Kleinian groups, one can relate the critical exponent (which measures the growth rate of an orbit) of a discrete subgroup Γ of the isometry group of n-dimensional hyperbolic space $\mathbb{H}^n$ with the Hausdorff dimension of its limit set Λ in the visual boundary of $\mathbb{H}^n$. For example, if Γ is convex-cocompact (or more generally, geometrically finite), then, by a result of Sullivan, the critical exponent of Γ equals with the Hausdorff dimension of Λ. *Anosov subgroups*, introduced by Labourie and further developed by Guichard-Wienhard and Kapovich-Leeb-Porti, generalize the notion of convex-cocompact subgroups in higher rank. We show that the Hausdorff dimension of the "flag limit set" of an Anosov subgroup Γ of G (a semisimple Lie group) in the associated flag manifolds G/P (quotient by a parabolic subgroup P) can be realized as a *certain* critical exponent of Γ. This is a joint work with Misha Kapovich.

Khovanskii bases

Daniel Ehrmann, University of Pittsburgh

Khovanskii bases were originally developed by Dr. Kaveh and Dr. Manon, and are a far generalization of Grobner bases for an arbitrary algebra A. In this talk I will be reviewing Grobner bases and SAGBI bases, and showing how we can use Khovanskii bases to apply Grobner theory in an algebra A, with a generalized version of the Buchburger criterion and Buchburger algorithm as well as other tools that are needed.

Mahler measure and Lehmers question (†)

Lydia Eldredge, Florida State University

This talk will be a short survey of the Mahler measure and Lehmer's question. The Mahler measure of a monic polynomial in $\mathbb{Z}[x]$ is the product of $\max\{1, |r|\}$ for all roots r of the polynomial. In a sense, this measures how far a polynomial is from being cyclotomic. Kronecker's theorem implies that the Mahler measure of an irreducible polynomial is 1 only when the polynomial equals x or is cyclotomic. Lehmer asked if the measure of non-cyclotomic polynomials is bounded away from 1. This talk presents progress on this question and provides a discussion of some related problems.

Stars at infinity in Teichmüller space

Nathan Fisher, Tufts University

In 2005, Anders Karlsson introduced stars at infinity, a construction that provides added structure to any compactification of a metric space. The stars in the boundary, defined using just the metric itself, are powerful enough to give new proofs to well-known results across geometry and dynamical systems. During the talk, I will define stars, motivate their importance, and state a new result on stars in the Thurston boundary of Teichmüller space. This is joint work with Moon Duchin.

Comparing the number of D_4 and S_4 extensions of global fields

---

Daniel Keliher, Tufts University

Ordered by height, 100% of degree n polynomials have Galois group S_n over $\mathbb{Q}$. When ordered by their discriminant, about 83% of quartic extensions of $\mathbb{Q}$ have associated Galois group S_4, while only 17% have Galois group D_4. We study this disparity over a general number field K by studying the ratio between the number of D_4 and S_4 quartic extensions of K. When K is quadratic, we show that this ratio can be biased arbitrarily close to 100% of quartic extensions being D_4. Further, we show that in some sense, a bias towards more D_4 quartic extensions is typical of quadratic number fields, significantly contrasting with the case over $\mathbb{Q}$. Time permitting, we will discuss a function field analogue of these results wherein we seek to give conditions on curves $\mathcal{C}/\mathbb{F}_q$ which admit more D_4 quartic covers than S_4. This is joint work with Matthew Friedrichsen.

Positive curvature and fundamental group

Elahe Khalili Samani, Syracuse University

A 1960s question of Chern asks if every abelian subgroup of the fundamental group of a Riemannian manifold with positive sectional curvature is cyclic. While this is not true in general, there are some positive results in this direction in the presence of symmetry. I will discuss some new structural results along these lines that will be part of my Ph.D. thesis. Please note: While the problem is motivated by Riemannian geometry, the proof involves mostly topological and algebraic techniques. The only background required for the talk is elementary group theory and some algebraic topology (fundamental group, cohomology).

Similarity classes of certain Hermitian lattices

Freda Li, Wesleyan University

A quadratic form over $\mathbb{Q}$ is a homogeneous polynomial of degree 2 in n variables over $\mathbb{Q}$. If we consider a quadratic form over $\mathbb{Z}$, we get an integral quadratic form and an associated object called a quadratic lattice. One of the main questions in the study of quadratic lattices is the question of classification. Chan and Marino showed that for $n \geq 2$, there are finitely many similarity classes of positive definite strictly n regular quadratic lattices in $n+4$ variables.
Hermitian lattices are closely related objects to quadratic lattices. Many results for quadratic lattices have Hermitian analogues. In this talk I will introduce Hermitian lattices and consider the analogous result to Chan and Marino's.

Palindromic, polynomially-growing free-by-cyclic groups are CAT(0)

Rylee Lyman, Tufts University

Corresponding to each automorphism of a free group, there is a cyclic semi-direct extension of the free group. Gersten in 1994 gave an example of such a free-by-cyclic group which is a "poison subgroup" for non-positive curvatureany group containing it cannot act geometrically on a CAT(0) space. His argument is both beautiful and geometric. Gerstens proof provides context for our result; we show that in contrast with the general case, virtually all free-by-cyclic groups associated to polynomially-growing palindromic automorphisms do admit a geometric action on a CAT(0) space.

Enriching Bézout's Theorem

Stephen McKean, Georgia Institute of Technology

Bézouts Theorem is a classical result from enumerative geometry that counts the number of intersections of projective planar curves over an algebraically closed field. Using a few tools from A^1-homotopy theory, we enrich Bézouts Theorem for perfect fields. Over non-algebraically closed fields, this enrichment imposes a relation on the tangent directions of the curves at their intersection points.

Hyperbolic knots and hidden symmetries

Priyadip Mondal, University of Pittsburgh

The isometries of nontrivial finite covers of a hyperbolic knot which are not lifts of isometries of the knot are called the hidden symmetries of that knot. The inspiration behind understanding hidden symmetries of hyperbolic knots come from the following question of Neumann and Reid:
Do we see hidden symmetries in any hyperbolic knot apart from the figure eight and the two dodecahedral knots? In the talk, I will consider the hyperbolic knots obtained from Dehn surgeries on unknot of two component hyperbolic links. I will explain how existence of hidden symmetries in infinitely many of such knots for a fixed hyperbolic link is related to the number fields and varieties associated with the hyperbolic link. The talk is on joint work with Eric Chesebro and Jason DeBlois.

Bounded generation of SL_2 over rings of S-integers with infinitely many units

---

Aleksander Morgan, University of Virginia

Let $\mathcal{O}$ be a localization of the ring integers in a number field k. We prove that if the group of units $\mathcal{O}^\times$ is infinite then every matrix in $\Gamma = \mathrm{SL}_2(\mathcal{O})$ is a product of at most 9 elementary matrices. This completes a long line of research in this direction. As a consequence, we obtain that Γ is boundedly generated as an abstract group.

Perspectives on the mirror symmetry group

Evangelos Nastas, Florida Atlantic University

This talk will provide a delineation of how to form the maximum possible system of linearly independent trivial vector fields of an odd dimensional sphere of arbitrary dimension via utilizing the mirror symmetry group.

Hochschild cohomology of twisted tensor product algebras (and brackets for certain quantum complete intersections)

Pablo Ocal, Texas A&M University

Given two algebras, it is well known how to compute their Hochschild cohomology. We will discuss how we can use this information to compute the Hochschild cohomology of their twisted tensor product, where the twisting is only assumed to respect the grading of the algebras. We will see how this new computations are useful to obtain the Gerstenhaber bracket of some quantum complete intersections.

On regular h-local rings

Akeel Nasir Omairi, Florida Atlantic University

A ring R is said to have the UDI property if, for any R-module that decomposes into a finite direct sum of indecomposable ideals, this decomposition is unique apart from the order and isomorphism class of the indecomposable ideals. Goeters and Olberding introduced this concept for Noetherian integral domains in a 2001 paper and noted that the UDI property implies that the domain is h-local. In considering the UDI property for arbitrary commutative (Noetherian) rings, we are led to consider the h-local property for commutative rings in general: We say that the ring R is regular h-local if each regular element is contained in only finitely many maximal ideals, and each regular prime ideal is contained in a unique maximal ideal. We explore the connection of regular h-local with regular divisorial; most results rely on the additional assumption that the ring be a Marot ring. Interesting examples can be constructed using idealization.

Normal subgroups in the Cremona group (†)

Adriano Pacifico, University of Toronto

The group of birational transformations of $\mathbb{CP}^2$, called the Cremona group, is an infinite group containing algebraic groups of arbitrarily high dimension. The question of whether this group is simple dates as far back as 1894, but was more recently asked by Dolgachev and Manin in the sixties and by Mumford in the seventies. In 2010, Cantat and Lamy showed the Cremona group is not simple by exhibiting many normal subgroups using techniques from hyperbolic geometry, geometric group theory and algebraic geometry. In this talk, I will discuss some of the ideas that go into the proof of this result.

Splittings of groups and actions on trees (†)

Christopher Perez, University of Illinois at Chicago

Infinite groups can be studied by looking at how they split, i.e. how they can be expressed as amalgamated free products and HNN extensions, and more generally as graphs of groups. Splittings arise in a very geometric way when considering fundamental groups of spaces, and they can be found by studying how groups act on trees. In this talk we will give an overview of Bass-Serre theory and briefly discuss some applications in group theory, geometry and topology, and logic.

Actions of solvable Baumslag-Solitar groups on hyperbolic metric spaces

---

Alexander Rasmussen, Yale University

In geometric group theory, we try to understand groups via their actions on various metric spaces. A particularly fruitful class of actions to study is the actions on *Gromov hyperbolic spaces*, spaces whose geometries generalize that of the classical hyperbolic spaces. In this talk I will discuss the actions of *solvable Baumslag-Solitar groups* on Gromov hyperbolic spaces. The Baumslag-Solitar groups are a classically-studied family of groups that all have simple presentations. We classify completely the cobounded actions of solvable Baumslag-Solitar groups on Gromov hyperbolic spaces, up to a natural equivalence relation. A solvable Baumslag-Solitar group has finitely many such equivalence classes of actions, and they all come from actions on the hyperbolic plane, or on certain Bass-Serre trees. This is joint work with Carolyn Abbott.

The Weyl algebra $A_1(k)$ and the genesis of quantum mechanics (†)

Ann Rogers, DePaul University

The creation of quantum mechanical theory in the early 20th century was arguably the most significant, unsettling, and profound landmark in the history of theoretical physics. Unlike Newtonian mechanics or Einstein's theory of relativity, the mathematical formalism of quantum mechanics was not birthed of a single person's insight, but arose from three distinct approaches: Heisenberg-Born-Jordan's matrix mechanics, Dirac's quantum algebra, and Schrödinger's wave mechanics. Amazingly, all three interpretations independently relied upon the properties of one of the most versatile and distinguished examples of a noncommutative ring, which subsequently became known to algebraists as the first Weyl algebra $A_1(k)$. In particular, we show how regarding $A_1(k)$ variably as a ring of differential operators, as a subalgebra of a matrix algebra, and as a quotient of a free algebra respectively correspond to each of the formalisms developed by Schrödinger, Heisenberg, and Dirac.

π_1-injectivity in Euclidean Artin groups

Gordon Rojas Kirby, University of California, Santa Barbara

The word problem for Artin groups is still unknown. In this talk I will define a new polyhedral cell complex used to study Euclidean Artin groups, as well as convex subcomplexes. In this setting, the word problem is equivalent to showing that the kernel of the map on fundamental groups of subcomplexes induced by inclusion eventually stabilizes. This allows us to attack the word problem with direct techniques from geometric group and combinatorics.

From hierarchical to relative hyperbolicity

Jacob Russell, The Graduate Center, CUNY

The success of Gromovs coarsely hyperbolic spaces has inspired a multitude of generalizations. We compare the first of these generalizations, relatively hyperbolic spaces, with the more recently introduced hierarchically hyperbolic spaces. We show that relative hyperbolicity can be detected by examining simple combinatorial data associated to a hierarchically hyperbolic space. As an application, we prove the separating curve graph of a closed surface is relatively hyperbolic and recover a theorem of Brock and Maseur on the relative hyperbolicity of the Weil-Peterson metric on Teichmüller space.

Area and limited length spectrum data

Noelle Sawyer, Wesleyan University

The marked length spectrum of a metric on a compact Riemannian manifold records the length of the shortest closed curve in each free homotopy class. Let S be a surface. It is known that an inequality between the marked length spectra of two metrics on S implies a corresponding inequality between the areas with respect to the metrics. Using some dynamical tools, I will show that the same conclusion holds if the inequality only holds on particular subsets of free homotopy classes.

Statistics of square-tiled surfaces: symmetry, saddle connections and short loops

---

Sunrose Shrestha, Tufts University

Square-tiled surfaces are a class of translation surfaces that are of particular interest in geometry and dynamics because, as covers of the square torus, they share some of its simplicity and structure. In this talk, we will look at counting problems that result from focusing on properties of the square torus one by one. We will consider the implications between these properties and their frequency in each stratum of translation surfaces.
This is joint work with Jane Wang (MIT).

Zeta functions of nilpotent groups and algebraic groups

Fikreab Solomon, The Graduate Center, CUNY

The study of subgroup growth zeta functions is a relatively young research area. In my thesis, I consider nilpotent groups and I attempt to generalize the notion of the cotype zeta function of an integer lattice to finitely generated nilpotent groups. The Dirichlet coefficients of the zeta functions are expressed in terms of Hall-Littlewood polynomials. The zeta functions help in determining the distribution of subgroups of finite index and provide more refined invariants in the analytic number theory of nilpotent groups. A similar attempt on algebraic groups and connections with Cohen-Lenstra heuristics will also be discussed.

Invariants of 2-knots (†)

Shruthi Sridhar, Princeton University

Invariants for knots have been studied for over a century, yet identifying invariants for 2-knots (embeddings of S^2 into S^4) is a harder problem. In this talk I'll give a brief introduction to 2-knot theory, their invariants, and discuss results about an analogue of finite type invariants for ribbon 2-knots as described by Habiro and others.

A new construction of pseudo-Anosov homeomorphisms

Yvon Verberne, University of Toronto

Thurston obtained the first construction of pseudo-Anosov homeomorphisms by showing the product of two parabolic elements is pseudo-Anosov. A related construction by Penner involved constructing whole semi-groups of pseudo-Anosov maps by taking appropriate compositions of Dehn twists along certain families of curves. In this talk, I will present a new construction of pseudo-Anosov homeomorphisms on n-times punctured spheres.

Hybrid subgroups of complex hyperbolic isometries

Joseph Wells, Arizona State University

In the 1980's, Gromov and Piatetski-Shapiro introduced a technique called "hybridization" which allowed them to produce non-arithmetic hyperbolic lattices from two non-commensurable arithmetic lattices. It has been asked whether an analogous hybridization technique exists for complex hyperbolic lattices, because certain geometric obstructions make it unclear how to adapt this technique. In this talk I'll present a candidate construction and some recent progress with hybrids in $\mathrm{SU}(2,1)$. Some of this is joint work with Julien Paupert.

Branching rules for splint root systems

Yao-Rui Yeo, University of Pennsylvania

Branching rules in group representation theory are the mathematical counterpart of the phenomenon of "broken symmetry" in physics. For example, Gelfand-Tsetlin patterns yields a very transparent algorithm to describe the spectrum of the restriction of an irreducible representation of the "big" group $G(n)$, which is either the unitary group or the orthogonal group, to the "small" group $G(n1)$. Given a splint root system, one can try to understand its branching rule. In this talk we discuss methods to understand such branching rules, and give precise formulas for specific cases, including the restriction functor from the exceptional Lie algebra $\mathfrak{g}_2$ to $\mathfrak{sl}_3$.