# Abstracts
GSTGC 2010

Accessible to a 1st-year graduate student

Accessible to a 3rd or 4th year graduate student in geometry/topology not necessarily in this specific field

Accessible to a 3rd or 4th year graduate student in this specific field

Muhammad Adeel, University of Utah
**Graphs and free groups**
Sa 4:00-4:30, 1024 Dana Building

The free group derives its importance from the fact that every group is a quotient of some free group. The topological treatment of free groups not only results in a theory which has geometric contents but also in elegant proofs of many important theorems. In this talk, the theory of free groups will be explore via graphs and covering space theory. We will also look at the graph product of graph of groups which generalizes free products and HNN extensions.

Mio Alter, UT Austin +1/2
**Linear flows of line bundles over a Riemann surface as solutions to Lax pairs**
Su 11:20-11:50, 1046 Dana Building

Matrix polynomial functions $A$ and $B$ which satisfy $\frac{dA}{dt} = [A, B]$ are called a Lax pair. I will present a construction of Hitchin which gives a concrete way of interpreting linear flows on the space of line bundles over a Riemann surface as solutions to Lax pairs.

Carlos Barrera-Rodriguez, University of California Davis
**Heegaard what? A gentle introduction to Heegaard Splittings via Complexes of Curves**
Sa 11:20-11:50, 1028 Dana Building

In 1978 William J. Harvey introduced a simplicial structure on the collection of homotopy classes of essential simple closed curves on a surface $S$, commonly called the Curve Complex of $S$, to study the geometry of the action of the modular group of $S$ on the Teichmüller space of $S$. Later, in 1997, John Hempel discovered intrinsic relationship between Heegaard Splittings of 3-manifolds with splitting surface $S$ and the curve complex of $S$, work which inspired many topologists and geometers to study the topic more carefully. In this talk I will discuss the intrinsic relationship between curve and pants complexes and the geometry and topology of 3-dimensional manifolds. If time permits I will be discussing more specific and recent development in the area and my work on new curve complexes.

Anna Marie Bohmann, University of Chicago
**The $S^1$ equivariant generating hypothesis**
Su 12:00 - 12:30, 1040 Dana Building

The Freyd generating hypothesis is a long-standing conjecture in stable homotopy theory. An analogous conjecture can be formulated in any triangulated category with a set of compact generators. We formulate the appropriate conjecture in the equivariant stable homotopy category of a compact Lie group $G$. We then use work of Greenlees to show that this conjecture fails in the rational $S^1$ stable homotopy category. In fact, we find an explicit counterexample using familiar spaces.

KA CHOI, UC Berkeley +1/2
**Broken Lefschetz fibration and their examples**
Sa 4:00-4:30, 1046 Dana Building

Lefschetz fibration gives a topological way to understand symplectic 4-manifolds. It turns out every closed oriented 4-manifold admits a broken Lefschetz fibration which is a kind of generalization of Lefschetz fibration. We will look at some examples and see what people have done with it.

PRIYAVRAT DESHPANDE, University of Western Ontario
**Homotopy colimits**
Sa 11:20-11:50, 1040 Dana Building

Homotopy colimit is an important idea originating in homotopy theory that was developed by Quillen, Bousfield, Kan and others. It has not only reached remarkable extension and depth but it has also proved to be a versatile tool in a lot of other areas of mathematics. The aim of my talk is to motivate and explain the construction of homotopy colimits together with some applications. I will do it using examples and pictures, avoiding technical jargon from category theory.

SPENCER DOWDALL, University of Chicago +1/2
**Dilatations of pseudo-Anosovs in the point-pushing subgroup**
Su 11:20-11:50, 1024 Dana Building

Given a loop in the fundamental group $\pi_1(S, p)$ of a surface $S$, one may construct an element of the based mapping class group $\mathrm{Mod}(S, p)$ by pushing the basepoint $p$ around the loop. There is a nice geometric characterization, due to Kra, of when such a point-pushing mapping class is pseudo-Anosov. Every pseudo-Anosov mapping class has a unique number, called the dilatation, which can be thought of as its "stretching factor." We establish a lower bound on the dilatation of a point-pushing pseudo-Anosov in terms of the self-intersection number of the pushing curve. Our method uses properties of the Bass-Serre tree to estimate intersection numbers in hyperbolic space.

GEORGE DRAGOMIR, McMaster University
**Closed geodesics on compact developable orbifolds**
Su 12:00 - 12:30, 1046 Dana Building

The study of existence of closed geodesics is an old and beautiful topic in classical Riemannian geometry. The importance of closed geodesics comes not only from their applications to Riemannian geometry in the large, but also from their relationship to other branches of mathematics. One of the reasons for the interest in orbifolds is that they have similar geometric properties to manifolds. It is well known that any compact Riemannian manifold admits at least one nontrivial closed geodesic. However, the question of existence of closed geodesics of positive length on all compact Riemannian orbifolds is still not answered. In the classical case, the solution to this problem involves the study of the critical points of the energy function on some version of the space of closed curves. Guruprasad and Haefliger have adapted the same method to the orbifold setting and obtained the existence of closed geodesics for a large class of compact orbifolds, including all the non-developable ones. In this talk I will describe an approach fit for the developable case which not only gives us alternative elementary proofs for the known results but also further reduces the existence problem to a very particular type of developable orbifolds.

GUILLAUME DREYER, University of Southern California +1/2
**Hitchin representations and length functions**
Su 9:30-10:00, 1028 Dana Building

Let $S$ be a closed surface of negative Euler characteristic. We consider the space $\mathrm{Rep}_n(S)$ of homomorphisms from the fundamental group of $S$ to $SL_n(\mathbb{R})$, with $n > 2$. Hitchin gave a complete description of the connected components of the space $\mathrm{Rep}_n(S)$. A particularly interesting component is the one containing the Fuchsian representations, which is called the Hitchin component. Given a curve $c$ on $S$ and a representation $r$ in the Hitchin component of $\mathrm{Rep}_n(S)$, we can consider the eigenvalues of $r(c)$. We show how to extend these eigenvalue functions to length functions on the space of measured laminations on $S$, or more generally to the space of Hölder geodesic currents. This is based on Labourie's dynamical characterization of those representations which are in the Hitchin component.

TIMOTHY EMERICK, University of Virginia
**Hey dude, where's the bathroom?**
Su 9:30 - 10:00, 1024 Dana Building

Buildings are classically viewed as simplicial complexes which are built in terms of smaller complexes called apartments. However, the more modern approach to buildings is actually quite different; instead of viewing the building as a simplicial complex, you can view the building as a set in possession of a sort of floor plan (called a $W$-metric) which tells you how to "navigate" the building. This $W$-metric approach will be the subject of the talk. No prior exposure to buildings is assumed.

GREG FEIN, Rutgers Newark +1/2
$MCG$, **$\mathrm{Out}(F_n)$, and linear groups: These are a few of my favorite things**
Sa 10:40-11:10, 1024 Dana Building

You may have heard about these things (in particular the mapping class group of a surface and the outer automorphism group of a free group) that tons of geometric group theorists like to gab about. If, however, all you know about these wonderments are their names, then perhaps now is the time to learn a bit more and find out what all the fuss is about. I'll give a tour of some of the similarities and differences between the two groups, focusing in a bit on the classical classifications. We'll see how a lot about them can be explained via analogy with the (perhaps more familiar) linear groups and hyperbolic isometry groups. I promise there will be tons of examples to help us along the way.

MARTIN FRANKLAND, MIT +1/2
**Fibered category of Beck modules**
Su 10:10-10:40, 1040 Dana Building

Beck modules are a convenient notion of module over an object which recovers the usual notion in familiar settings (groups, commutative rings, Lie algebras…) and is well suited to provide coefficients for cohomology theories.

Instead of looking at modules over one object, what if we look at all modules over all objects, relating modules over different objects via pullbacks? This yields a category fibered over our original category. In this talk, I will present the construction in more detail and explain why I like to think of it as some kind of tangent bundle of the category.

WHITNEY GEORGE, University of Georgia
**Invariants of Legendrian knots using Chekanov's differential graded algebra**
Su 10:10-10:40, 1028 Dana Building

We define a Legendrian knot and its associated three classical invariants; the topological knot type, the rotation number, and the Thurston-Bennequin number. In the mid-90s, Eliashberg and Fraser proved that these three invariants classified the Legendrian unknot up to Legendrian isotopy. Later, Etnyre and Honda showed the classical invariants classified all torus knots and the figure eight knot. However, it was unclear if the knot $5_2$ could be classified by these three invariants. Chekanov developed a differential graded algebra, which is the focus of this talk; to show that knot $5_2$ cannot be classified by these invariants.

RICHARD GONZALES, University of Western Ontario
**Topology of group embeddings**
Sa 10:40-11:10, 1046 Dana Building

Let $G$ be a reductive group. A $G \times G$-variety $X$ is called an equivariant compactification of $G$ if X is normal, projective, and contains $G$ as an open and dense orbit. Regular compactifications and reductive embeddings are the main source of examples. My goal is to give an overview of the theory of group embeddings and their relations to GKM theory.

RYAN GRADY, University of Notre Dame +1/2
**Genera from deformation quantization**
Sa 1:20-1:50, 1040 Dana Building

I will recall the $\hat{A}$ and Witten genera of a manifold and give a few reasons why they are important (Atiyah-Singer Index Theorem, positive scalar/Ricci curvature, etc). I will then overview the work of Fedosov, Bressler, Nest, Tsygan, Felder, et al. on algebraic index theorems in deformation quantization. If time permits I would like to mention some recent work of Costello on the Witten genus.

KATE KEARNEY, Indiana University
**Knot genera**
Sa 10:40-11:10, 1028 Dana Building

The three genus, four genus, and concordance genus of knots are independent invariants that all give a measure of the types of surfaces bounded by the knot. We will define these and look at several examples to highlight the differences between these. We will discuss further notions of genus, including the stable four genus and stable concordance genus. This talk will assume a basic knowledge of knot theory, but will give all relevant definitions.

PAUL KINLAW, Dartmouth College
**Refocusing of null-geodesics in Lorentz manifolds**
Sa 1:20-1:50, 1046 Dana Building

Lorentz manifolds provide a purely mathematical model for spacetime which is used in the general theory of relativity. The null-geodesic curves represent light rays. We will start with an introduction to Lorentz metrics and a brief comparison with the more familiar Riemannian metrics. We will then cover several results on refocusing properties of null-geodesics in Lorentz manifolds, which are the subject of my thesis.

SANG RAE LEE, University of Oklahoma
**Geometry of Houghton's groups**
Su 10:10-10:40, 1024 Dana Building

Ken Brown showed that Houghton's group $H_n$ is of type $FP_{n-1}$ but not $FP_n$. To do this, he constructed contractible complexes on which $H_n$ acts. We show one can construct an $n$-dimensional CAT(0) cubical complex on which $H_n$ acts, although $H_n$ itself is not CAT(0) (because of its finiteness property). This new construction gives a simple proof for K. Brown's result. Moreover since these CAT(0) complexes for $H_n$ enjoy interesting geometric properties, it is worth investigating their geometry, e.g. their boundaries.

John Lind, University of Chicago
**2-vector bundles**
Sa 4:00-4:30, 1040 Dana Building

A vector bundle is a collection of vector space parametrized by a base space $B$. A 2-vector space is a collection of module category over the category of vector spaces parametrized by $B$. A 2-vector bundle of rank 1 is essentially a ($S^1$-)gerbe, in the sense of geometry. These are inherently 2-categorical objects. I will discuss their $K$-theory and connection to stable homotopy theory.

Yevgeniy Liokumovich, University of Toronto
**Homotopy of closed curves on a 2-disc**
Su 10:10-10:40, 1046 Dana Building

Frankel and Katz in 1993 answered negatively a question of Gromov: if we consider the set of Riemannian 2-discs of uniformly bounded diameter, is it possible to place a uniform bound on how much a closed curve needs to stretch when it is homotoped from the boundary to a point? I will include a quick overview of their construction and discuss how the situation changes when we also bound volume or curvature.

Yi Liu, UC Berkeley
**Knot groups onto hyperbolic knot groups**
Su 12:00-12:30, 1024 Dana Building

In the 1970s, John Simon asked whether a knot group maps onto at most finitely many knot groups. This is affirmatively answered if the target knots are restricted to be hyperbolic. This is a joint work with Ian Agol.

Joel Louwsma, California Institute of Technology
**Immersed surfaces in the modular orbifold**
Sa 11:20-11:50, 1024 Dana Building

A hyperbolic conjugacy class in the modular group $PSL(2,\mathbb{Z})$ corresponds to a closed geodesic in the modular orbifold. Some of these geodesics virtually bound immersed surfaces, and some do not; the distinction is related to the polyhedral structure in the unit ball of the stable commutator length norm. We prove the following stability theorem: for every hyperbolic element of the modular group, the product of this element with a sufficiently large power of a parabolic element is represented by a geodesic that virtually bounds an immersed surface. This is joint work with Danny Calegari.

Dustin Mulcahey, CUNY Graduate Center
**Towards an unstable change of rings**
Sa 10:40-11:10, 1040 Dana Building

In this talk, I will explore one direction of finding an unstable variant of the Morava change of rings isomorphism. After some background, I will begin by considering the general problem of finding sufficient conditions for a change of Ext between two comonads. I will then specialize to the case of the categories of unstable BP comodules and unstable $K(n)$ comodules.

Joao Miguel Nogueira, UT Austin
**Incompressible surfaces in handlebodies and boundary reducible 3-manifolds**
Su 11:20-11:50, 1028 Dana Building

In this talk we prove that for every compact surface with boundary, orientable or not, there is an incompressible embedding of the surface into the genus two handlebody. In the orientable case the embedding can be either separating or non-separating. We also consider the case in which the genus two handlebody is replaced by an orientable 3-manifold with a compressible boundary component of genus greater than or equal to two.

JULIEN ROGER, University of Southern California
**The quantum Teichmüller Space and invariants of surface diffeomorphisms**
Sa 1:20-1:50, 1028 Dana Building

The quantum Teichmüller space is a deformation of the algebra of rational functions on the classical Teichmüller space of a surface with punctures. I will describe its construction and then explain how to build quantum invariants of surface diffeomorphisms from its representation theory.

DAVID ROSE, Duke University
**Categorification and knot homology**
Su 11:20-11:50, 1040 Dana Building

Categorification can be viewed as the process of lifting scalar and polynomial invariants to homology theories having those invariants as (graded) Euler characteristics. In this (expository) talk, we will discuss categorification in general and as manifested in Khovanov homology and other knot homology theories. Examples will be given showing how the categorified invariants are stronger and often more useful than the original invariants.

MATTHEW SAMUEL, Rutgers New Brunswick
**Combinatorics of Grassmannians**
Su 9:30-10:00, 1040 Dana Building

We present various combinatorial results by others and of our own describing aspects of Grassmannians of Lie types A, B, C, and D. We describe CW structures whose cells are indexed by various kinds of box diagrams and discuss notions of "positivity" of multiplicative structure constants in ordinary cohomology, equivariant cohomology, and algebraic K-theory. We will also discuss various methods for computing these structure constants in a positive, combinatorial fashion.

GREG SCHNEIDER, SUNY Buffalo
**Box-dot diagrams for "regular" rational tangles**
Sa 4:00-4:30, 1028 Dana Building

We introduce a new presentation for rational tangles which illustrates a geometric connection to the number theory of positive regular continued fractions. This presentation also admits a suitable extension to the contact setting, allowing us to define a natural Legendrian embedding of a particular class of rational tangles into the standard contact Euclidean 3-space. We will briefly discuss how these box-dot diagrams, along with an associated construction, can be used to determine when the Legendrian flyping operation yields tangles which are not Legendrian isotopic, further refining an earlier result of Traynor.

JONAH SINICK, University of Illinois at Urbana-Champaign
**Real places and surface bundles**
Su 12:00 - 12:30, 1028 Dana Building

A finite volume hyperbolic 3-manifold has an associated finite extension of the rational numbers called its *trace field*. In a 2006 paper, Danny Calegari proved that the trace field associated to a hyperbolic surface bundle with fiber the once punctured torus has no real places. We present some new findings concerning hyperbolic surface bundles with fibers other than the once punctured torus, complementing Calegari's result.

CHUNYI SUN, Yale University
**Non-bounded generation of word-hyperbolic groups**
Sa 1:20-1:50, 1024 Dana Building

A finitely generated group $\Gamma$ is boundedly generated if there is a finite ordered set $S = \{g_1, g_2, \ldots, g_k\}$ such that every element $g$ in $\Gamma$ can be written as a product of powers of elements in $S$, i.e. $g = g_1^{n_1} \cdot g_2^{n_2} \cdot \cdots \cdot g_k^{n_k}$ . For example, for $n \geq 3$, $\mathrm{SL}(n, \mathbb{Z})$ is boundedly generated by elementary matrices but $\mathrm{SL}(2, \mathbb{Z})$ is not bounded generated by any finite set $S$. I would like to show that non-elementary word-hyperbolic groups are not boundedly generated with two different arguments. One uses known answers of Burnside problem of word-hyperbolic groups, and the other generates a contradiction with the exponential growth of word-hyperbolic groups.

GUN SUNYEEKHAN, University of Notre Dame
**Converse of Lefschetz fixed point theorem**
Sa 11:20-11:50, 1046 Dana Building

The famous Lefschetz fixed point theorem states that if a smooth self map $f$ of a compact smooth manifold $M$ is homotopic to a fixed point free map, then the Lefschetz number $L(f) = 0$. In general, the converse does not hold.

I will show that the fixed points of $f$ determine an element in a framed bordism group of a twisted free loop space of $M$. Then I will show that if $\dim(M) > 2$ such an element vanishes if and only if $f$ is homotopic to a fixed point free map.

ENXIN WU, University of Western Ontario
**An introduction to diffeological spaces**
Su 9:30-10:00, 1046 Dana Building

Manifolds are very nice objects in modern mathematics. However, the category of manifolds is not that pleasant. Many generalizations of manifolds were proposed in the 1980's. Diffeological spaces are one of them, which were first defined by J. Souriau in 1980, and later systematically developed by P. Iglesias-Zemmour, J. Baez, A. Hoffnung and others. In this talk, some known results on the basic properties of diffeological spaces and some of their differential, geometric and topological aspects will be described. Some new results on the general topological aspects and categorical aspects will be presented at the end.