## ABSTRACTS

## Ian Agol:

Title: On a virtually gutless conjecture of Thurston

## Mladen Bestvina:

Title: The cohomological dimension of Torelli groups
Abstract: We prove that the cohomological dimension of the Torelli group in genus $g>1$ is $3 g-5$. This answers a question of Geoff Mess, who proved the lower bound and also settled the case $g=2$. The technique involves decomposing Teichmuller space according to minimal length cycles representing a fixed homology class and studying the action of the Torelli group on the associated cell complex. This is joint work with Kai-Uwe Bux and Dan Margalit.

## Jeff Brock

Title: Splittings, models, and bounds in hyperbolic geometry
Abstract: Though the geometrization conjecture raises the possibility of extracting geometric information from a purely topological description of a 3 -manifold, it does not directly provide it. Following the classification of infinite volume, tame hyperbolic 3-manifolds, we will describe a program to begin with the simple combinatorial data of a certain type of Heegaard splitting of a hyperbolic 3-manifold and extract geometric estimates with constants depending only on the genus of the splitting. This is joint work with Yair Minsky, Hossein Namazi, and Juan Souto.

## Dick Canary

Title: Introductory Bumponomics: Untouchable points in boundaries of deformation spaces of hyperbolic 3-manifolds

Abstract: In this talk, we study the space $A H(M)$ of all (marked) hyperbolic 3-manifolds homotopy equivalent to a fixed compact 3 -manifold $M$ (with boundary.) The topology of the interior of $A H(M)$ is quite simple and has been well-understood since the 1970's. However, in the last decade it has become clear that the global topology of $A H(M)$ is quite complicated. We will survey the history and discuss recent joint work with Brock, Bromberg and Minsky, which shows, in many cases, that the topology is well-behaved at "most" points in the boundary of $A H(M)$.

## Daryl Cooper

Title: Topology and real projective geometry.
Abstract: We will discuss some aspects of real projective geometry from the viewpoint of low dimensional topology.

## Yasha Eliashberg

Title: Quasimorphisms and the quantum product in contact homology

## Benson Farb

Title: Analogies and contrasts between Riemann's moduli space and locally symmetric spaces
Abstract: It is a classical theme to compare and contrast the moduli space of genus g Riemann surfaces with locally symmetric orbifolds. In this talk I will explain how this analogy works and why it is useful (and, I think, interesting.) I will also present some recent conjectures about these moduli spaces which arise from this way of thinking.

Michael Freedman (To be confirmed)
Title: Three-manifold positivity
NOTE: This lecture will be transmitted electronically, subject to technical feasibility.

## Etienne Ghys

Title: Osculating curves

## Bill Goldman

Title: Complete affine 3-manifolds and hyperbolic surfaces
Abstract: When can a group G act on Euclidean 3-space with quotient a 3-manifold? When G acts isometrically, it is a finite extension of a free abelian group, and the various actions are easily classified. However when the action of $G$ is only assumed to be affine, the classification is still open. The most interesting cases were discovered by Margulis in the early 1980's and occur when the quotient is noncompact and $G$ is a nonabelian free group. In this case $G$ acts by Lorentz isometries of Minkowski $(2+1)$-space and the clasification closely relates to hyperbolic structures on noncompact surfaces. This talk will survey the geometry and deformation theory of these surprising geometric structures, and how they fit in the broader context of conformally flat Lorentzian 3-manifolds.

## Ko Honda

Title: Reeb vector fields and open book decompositions
Abstract: According to a theorem of Giroux (and building on the work of Thurston-Winkelnkemper), there is a 1-1 correspondence between isotopy classes of contact structures and equivalence classes of open book decompositions. We give partial results towards calculating the contact homology of a contact structure $(M, \xi)$ (in dimension 3 ) which is supported by an open book with pseudo-Anosov monodromy. This is joint work with Vincent Colin.

## John Hubbard

Title: Semi-groups of Thurston mappings in Teichmuller space and their limit sets.
Abstract: Let $f: S^{2} \rightarrow S^{2}$ be a post-critically finite branched mapping, with post-critical set $P_{f}$. There is then a Thurston mapping $\sigma_{f}: T_{P_{f}} \rightarrow T_{P_{f}}$. Denote by $\pi: T_{P_{f}} \rightarrow M_{P_{f}}$ the projection to moduli space. There never is a map $\phi: M_{P_{f}} \rightarrow M_{P_{f}}$ such that $\pi \circ \sigma_{f}=\phi \circ \pi$, but Nekrashevych and Bartholdi showed in 3 cases that there is a map $g: M_{P_{f}} \rightarrow M_{P_{f}}$ in the other direction, i.e., such that $g \circ \pi \circ \sigma_{f}=\pi$.

Sarah Koch's recent thesis (May 2007) shows that such a backwards map $g$ exists in much greater generality, in particular, it exists for all bicritical topological polynomials, and in many other cases as well. In these cases $g$ is an endomorphism of $\mathbf{P}^{n}$, leading to a satisfactory understanding of the dynamics of these endomorphisms.

Moreover, there are many $f$ 's which share the same $g$, which only depends on the combinatorics of how $f$ acts on the post-critical set. The corresponding maps $\sigma_{f}$ generate a semi-group of mappings in Teichmuller space, which have a limit set that can be understood. This leads to a whole new understanding of how maps $\sigma_{f}$ operate. It also leads to a new understanding of Thurston obstructions.

In my talk, I will describe the developments above, and illustrate on the computer just what the semigroup really is.

## Marc Lackenby

Title: The crossing number of composite knots
Abstract: It is a longstanding conjecture in knot theory that crossing number is additive under connected sum. In other words, does $c(K \# L)=c(K)+c(L)$, where $K \# L$ is the connected sum of two knots K and L , and $c()$ denotes the crossing number of a knot? In my talk, I will outline a proof that $c(K \# L)$ lies somewhere between $(c(K)+c(L)) / 281$ and $c(K)+c(L)$.

## John Milnor

Title: Wild and tame dynamics on the projective plane
Abstract: The dynamics of a rational map of the real or complex projective plane can be relatively wild, for example with intermingled attracting basins. It can also be relatively tame, for example with attracting invariant circles in the real case, or with attracting Herman rings in the complex case. This talk, based on work with Araceli Bonifant, will discuss such examples.

## Yair Minsky

Title: Coarse geometry of the mapping class group

## Maryam Mirzakhani

Title: Ergodic properties of the space of measured laminations

## John Morgan

Title: The Poincaré Conjecture and Thurston's Geometrization Conjecture
Abstract: An overview of Perelman's arguments proving these two conjectures using Ricci flow with surgery. The talk will present a description of the basic results of Ricci flow and of the topological and geometric nature of the surgeries needed to create a Ricci flow with surgery defined for all time. Then an introduction will be given to the collapsing space methods needed to finish the argument.

## Robert Myerhoff

Title: The hyperbolic 3-manifold of minimum volume
Abstract: In the late 1970's Bill Thurston proved that the set of volumes of hyperbolic 3-manifolds is well-ordered. In particular, there is a minimum volume in the set. In joint work with Dave Gabai and Peter Milley, we prove that the Weeks manifold (obtained by (5,1), (5,2) Dehn filling on the Whitehead Link) is the unique hyperbolic 3 -manifold of minimum volume. A sketch of the proof of this result will be given.

## Oded Schramm

Title: Conformally invariant scaling limits of discrete random systems
Abstract: Many random two-dimensional systems appear to exhibit conformal invariance in large scales. Until recently, there was no proof or explanation for this apparent conformal invariance (except in the case of Brownian motion). I will describe these random systems, explain some of the recent insights, and show how conformal invariance is instrumental in the understanding of these systems.

## Richard Schwartz

Title: Outer billiards, unbounded orbits, and the modular group
Abstract: Outer billiards is a simple dynamical system defined relative to a planar convex shape. B.H. Neumann introduced this system in the 1950s, and J. Moser popularized it in the 1970s as a toy model for celestial mechanics. All along, one of the central questions has been: Does there exist a shape for which the corresponding outer billiards system has an unbounded orbit? In this talk, I will explain my recent solution to this problem in which I show that outer billiards has an unbounded orbit when defined relative to the Penrose kite, the convex tile that arises in the well-known Penrose tiling. I will also discuss work-in-progress, in which I show that actually outer billiards has unbounded orbits when defined relative to almost every kite. Along the way, I will explain a connection between outer billiards on kites and the modular group. I will demonstrate all the ideas in the talk using Billiard King, a graphical user interface I built for the purpose of studying this problem.

## Daniel Sleator-Robert Tarjan

## Title: Our work with Bill on lengths of graph transformations

Abstract: In this talk we'll present some of our joint work with Bill Thurston. Although the problems presented here emerged from the field of computer science, it turned out that Bill's unique way of thinking led to beautiful solutions.

Binary search trees are an important class of data structures for representing a list of items. In attempting to devise efficient binary search tree algorithms - or prove lower bounds on such algorithms it's useful to understand the underlying combinatorial structure of the space of $n$-node binary search trees. By applying techniques from hyperbolic geometry, we give a tight lower bound of $2 n-6$ on the "rotation distance" between pairs of binary trees. We'll summarize this beautiful proof.

In a separate (but related) problem we consider derivations in a transformational system such as a graph grammar. We develop an efficient encoding scheme for such derivations. This encoding scheme has a number of diverse applications. It can be used in efficient enumeration of combinatorial objects or for compact representation of program and data structure transformations. It can also be used to derive lower bounds on lengths of derivations. We show, for example, that $\Omega(n \log n)$ "diagonal flips" are required in the worst case to transform one $n$-vertex numbered triangulated planar graph into some other one.

## Dennis Sullivan

## Title: Nonlinear Homology

Abstract: Solutions of geometric PDEs like J holomorphic curves in a symplectic deformation class of manifolds or minimum energy connections on a deformation class of riemannian four manifold often yield systems of nonlinear manifolds. These are often individually non compact but their frontiers are described by topologically defined operations on other members of the system. There is usually an action filtration so the frontier pieces have strictly smaller action. This picture admits an algebraic description in terms of a triangular system of algebraic equations to be solved in a chain complex modeling the spaces of maps , connections, etc where the PDE imposes a constraint. There is also a system of equations describing how the moduli spaces taken together which solve the first system of equations vary as the PDE is perturbed. These two systems of algebraic equations define the cycles and homologies of "Nonlinear Homology."

The underlying algebraic intuition comes from interpreting nonlinear cycles as dga maps and nonlinear homologies as homotopies of dga maps. (dga means differential graded algebra)This intuition derives in turn from the analogy between dga homotopy categories and the homotopy category of topological spaces in algebraic topology. New invariants of the geometric structures underlying the PDEs can then be derived by tracing back through the analogies various invariants from algebraic topology beyond linear homology like hopf invariants and massey products.

## Dylan Thurston

## Title: Combinatorial link Floer homology via grid diagrams

Abstract: We give a combinatorial definition of Heegard-Floer homology. In particular, this yields a very simple algorithm for computing the knot genus. Our method is based on grid diagrams. By restricting the moves on grid diagrams, we get a representation for transverse or Legendrian knots; using this, we also distinguish several new examples of knots which are not transversally simple.

## Karen Vogtmann

Title: Actions of the group of outer automorphisms of a free group
Abstract: What kind of space can have an interesting action by the group $\operatorname{Out}\left(F_{n}\right)$ ? Thurston's analysis of the mapping class group of a surface via its action on Teichmuller space motivated the definition of one such space, now known as Outer space. Outer space shares several useful properties with Teichmuller space, but also differs in important ways, so that in order to prove the analogs of Thurston's theorems one must also consider actions on other spaces. There is an added benefit that these other spaces often have additional uses. In this talk I will describe several spaces on which $\operatorname{Out}\left(F_{n}\right)$ acts and some relations between them; I will also show that there are strong restrictions on the type of space on which $O u t\left(F_{n}\right)$ can act non- trivially.

