BRIN MATHEMATICS RESEARCH CENTER

Workshop: Low-Dimensional Topology & Homeomorphism Groups

SEPTEMBER 6 - 10, 2022

Speakers

Oliver Edtmair, UC Berkeley
Benson Farb, University of Chicago
David Gabai, Princeton University
Sherry Gong, Texas A&M University
Michael Hutchings, UC Berkeley
Umberto Hryniewicz, RWTH Aachen University
Seraphina Lee, University of Chicago
Eduard Looijenga, Tsinghua University
Nicki Magill, Cornell University
Cheuk Yu Mak, University of Edinburgh
Vlad Markovic, University of Oxford
Marco Mazzucchelli, ENS Lyon
Dusa McDuff, Columbia University
Maggie Miller, Stanford University
Anubhav Mukherjee, MSRI
Rohil Prasad, Princeton University
Nick Salter, University of Notre Dame
Sobhan Seyfaddini, Sorbonne Université
Hongbin Sun, Rutgers University
Bena Tshishiku, Brown University
Luya Wang, UC Berkeley
Tadayuki Watanabe, Kyoto University
Amie Wilkinson, University of Chicago

Organizers

Lei Chen, University of Maryland
Dan Cristofaro-Gardiner, University of Maryland
Boyu Zhang, University of Maryland

About the Workshop

This is a workshop about low-dimensional topology and homeomorphism groups. Recently there has been a huge amount of exciting progress in these areas. A main goal of this workshop is to bring together researchers who do not routinely interact with each other, with the hope that conversations between these groups could be fruitful.

BRINMRC.UMD.EDU

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College Park, MD 20742

DEPARTMENT OF MATHEMATICS

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Workshop Overview

This is a workshop about low-dimensional topology and homeomorphism groups. Recently there has been a huge amount of exciting progress in these areas. A main goal of this workshop is to bring together researchers who do not routinely interact with each other, with the hope that conversations between these groups could be fruitful.

Organizing committee

Lei Chen, University of Maryland

Dan Cristofaro-Gardiner, University of Maryland

Boyu Zhang, University of Maryland

Schedule at a Glance

	Tuesday	Wednesday	Thursday	Friday	Saturday
8:00					
	Breakfast	Breakfast	Breakfast	Breakfast	
9:00	Sherry Gong	Oliver Edtmair	Tadayuki Watanabe	Hongbin Sun	Michael Hutchings
10:00	Maggie Miller	Benson Farb	Sobhan Seyfaddini	Marco Mazzucchelli	Cheuk Yu Mak
11:00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
	Anubhav Mukherjee	Eduard Looijenga	Bena Tshishiku	Seraphina Lee	Umberto Hryniewicz
12:00				Margaret Doucette	
	Lunch	Lunch	Lunch (on your own)	Lunch	
13:00					
14:00	David Gabai	Nick Salter	Rohil Prasad	Dusa McDuff	
15:00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
	Luya Wang	Vlad Markovic	Amie Wilkinson	Nicki Magill	
16:00					

All talks will be held in the Brin Mathematics Research Center, located on the fourth floor of the CSIC Building.

* Vlad Markovic talk will be in the Math Colloquium room, Kirwan 3206.

Workshop Schedule

Tuesday, September 6, 2022

8:30 - 8:55 Breakfast

8:55 - 9:00 Doron Levy (University of Maryland/Director, Brin MRC)
Opening

9:00 - 9:45 Sherry Gong (Texas A&M University)
An A-infinity category from instantons

10:00 - 10:45 Maggie Miller (Stanford University)
Obstructing equivalence even with an extra dimension of freedom

10:45 - 11:15 Coffee Break

11:15 - 12:00 Anubhav Mukherjee (MSRI / Princeton University)
Exotically embedded submanifolds in 4-manifolds and stabilizations

12:00 - 2:00 Lunch

2:00 - 2:45 David Gabai (Princeton University)
Knotted 3-balls in S^4 and knotted 3-spheres in $S^1 \times S^3$

2:45 - 3:15 Coffee Break

3:15 - 4:00 Luya Wang (UC Berkeley)
Fixed point-free pseudo-Anosovs and the cinquefoil

Wednesday, September 7, 2022

8:30 - 9:00 Breakfast

9:00 - 9:45 Oliver Edtmair (UC Berkeley)
Disk-like surfaces of section and symplectic embeddings

10:00 - 10:45 Benson Farb (University of Chicago)
Mapping class groups of K3 surfaces from a Thurstonian viewpoint, I

10:45 - 11:15 Coffee Break

11:15 - 12:00 Eduard Looijenga (University of Chicago)
Mapping class groups of K3 surfaces from a Thurstonian viewpoint II

12:00 - 2:00 Lunch

2:00 - 2:45 Nick Salter (University of Notre Dame)
What do we know about the topology of strata?

2:45 - 3:15 Coffee Break

3:15 - 4:15 Vlad Markovic (University of Oxford)
Unramified correspondance and virtual homology of mapping class groups

Thursday, September 8, 2022

8:30 - 9:00 Breakfast

9:00 - 9:45 Tadayuki Watanabe (Kyoto University)
Theta-graph and diffeomorphisms of some 4-manifolds

10:00 - 10:45 Sobhan Seyfaddini (CNRS & Sorbonne Université)
On the algebraic structure of groups of area-preserving homeomorphisms

10:45 - 11:15 Coffee Break

11:15 - 12:00 Bena Tshishiku (Brown University)
Nielsen realization for 3-manifolds

12:00 - 2:00 Lunch (on your own)

2:00 - 2:45 Rohil Prasad (Princeton University)
Generic equidistribution of periodic orbits for area-preserving surface diffeomorphisms

2:45 - 3:15 Coffee Break

3:15 - 4:00 Amie Wilkinson (University of Chicago)
Asymmetrical diffeomorphisms

Friday, September 9, 2022

8:30 - 9:00 Breakfast

9:00 - 9:45 Hongbin Sun (Rutgers University at New Brunswick)
All 3-manifold groups are Grothendieck rigid

10:00 - 10:45 Marco Mazzucchelli (École normale supérieure de Lyon)
Existence of global surfaces of section for 3-dimensional Reeb flows

10:45 - 11:15 Coffee Break

11:15 - 11:45 Seraphina Lee (University of Chicago)
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12:15 - 2:00 Lunch

2:00 - 2:45 Dusa McDuff (Columbia University)
Infinite Staircases in Hirzebruch surfaces

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3:15 - 4:00 Nicki Magill (Cornell University)
Infinite Staircases in Symplectic Embeddings

Saturday, September 10, 2022

9:00 - 9:45 Michael Hutchings (UC Berkeley)
Quantitative closing lemmas for contact three-manifolds

10:00 - 10:45 Cheuk Yu Mak (University of Edinburgh)
Lagrangian link quasimorphisms and the non-simplicity of Hameomorphism group of sphere

11:15 - 12:00 Umberto Hryniewicz (RWTH Aachen University)
Existence of global surfaces of section, and applications

12:00 - 12:05 Workshop Closing

Abstracts of talks

An A-infinity category from instantons

Sherry Gong

Texas A&M University

Tuesday, September 6, 2022 @ 9:00 AM

Given n points on a disk, we will describe how to build an A-infinity category based on the instanton Floer complex of links, and explain why it is finitely generated. This is based on work in progress with Ko Honda.

Obstructing equivalence even with an extra dimension of freedom

Maggie Miller

Stanford University

Tuesday, September 6, 2022 @ 10:00 AM

In 1982, Livingston asked whether two boundary-parallel surfaces in the 4-ball with the same boundary and that are homeomorphic as surfaces must be isotopic rel. boundary. We recently constructed such a pair of surfaces that are not related by any diffeomorphism of the 4-ball; I'll talk about this construction (which is joint with K. Hayden, S. Kim, JH. Park, and I. Sundberg) and related work in 5D (with M. Hughes and S. Kim).

Exotically embedded submanifolds in 4-manifolds and stabilizations

Anubhav Mukherjee

MSRI / Princeton University

Tuesday, September 6, 2022 @ 11:15 AM

An important principle in 4-dimesional topology, as discovered by Wall in the 1960s, states that all exotic phenomena are eliminated by sufficiently many stabilizations (i.e., taking connected sum with $S^2 \times S^2$'s). Since then, it has been a fundamental problem to search for exotic phenomena that survives one stabilization. In this talk, we will establish the first pair of orientable exotic surfaces (in a puctured K3) which are not smoothly isotopic even after one stabilization. A key ingredient in our argument is a vanishing theorem for the family Bauer-Furuta invariant, proved using equivariant stable homotopy theory. This theorem applies to a large family of spin 4-manifolds and has some interesting applications in Smale's conjecture (about exotic diffeomorphisms on S^4). In particular, it implies that the S^1-equivariant or non-equivariant family Bauer-Furuta invariant do not detect an exotic diffeomorphism on S^4 and it suggests that the Pin(2)-symmetry could be a game changer. This is a joint work with Jianfeng Lin. Also if time permits I will discuss exotically embedded 3-manifolds in 4-manifolds which is an upcoming work joint with Nobuo Iida, Hokuto Konno and Masaki Taniguchi.

Knotted 3-balls in S^4 and knotted 3-spheres in $S^1 \times S^3$

David Gabai

Princeton University

Tuesday, September 6, 2022 @ 2:00 PM

We demonstrate codimension-1 knotting in S^4 and $S^1 \times S^3$. That is, there are 3-balls with boundary the standard 2-sphere in the 4-sphere which are not isotopic rel boundary to the standard 3-ball and there are non separating 3-spheres in $S^1 \times S^3$ not isotopic to the standard 3-sphere. The latter induces diffeomorphisms of $S^1 \times S^3$ that are homotopic to but not isotopic to the id. (Joint work with Ryan Budney)

Fixed point-free pseudo-Anosovs and the cinquefoil

Luya Wang

UC Berkeley

Tuesday, September 6, 2022 @ 3:15 PM

I will discuss joint work with Braeden Reinoso and Ethan Farber on showing that the pseudo-Anosov representative of any genus-two, hyperbolic, fibered knot in the 3-sphere with nonzero fractional Dehn twist coefficient has an interior fixed point. Combined with work of Baldwin-Hu-Sivek where they use the number of fixed points of appropriate area-preserving diffeomorphism to constrain ranks of Floer homology, this shows that knot Floer homology detects the cinquefoil T(2,5). In particular, T(2,5) is the only genus-two L-space knot. I will discuss some tools from train tracks and train track maps, and outline the main ideas of our proof.

Disk-like surfaces of section and symplectic embeddings

Oliver Edtmair

UC Berkeley

Wednesday, September 7, 2022 @ 9:00 AM

Symplectic embedding problems, i.e. the question whether one symplectic manifold embeds into another, are of central importance in symplectic geometry. Such problems are intimately related to Hamiltonian dynamics and this relationship has been used to construct a plethora of obstructions to symplectic embeddings. Going in the opposite direction, I will discuss how disk-like global surfaces of section, a concept from dynamics, can be used to construct symplectic embeddings. This yields partial progress towards Viterbo's conjecture on symplectic capacities of convex domains: The cylindrical embedding capacity agrees with the first ECH capacity on convex domains.

Mapping class groups of K3 surfaces from a Thurstonian viewpoint, I

Benson Farb

University of Chicago

Wednesday, September 7, 2022 @ 10:00 AM

In many ways the state of our understanding of homeomorphisms of 4-manifolds in 2022 is essentially that of our understanding of homeomorphisms of 2-manifolds in 1973, before Thurston changed everything. In this talk I will report on some first steps in a project (joint with Eduard Looijenga) whose ultimate goal is to change this. I will focus on the case of K3 surfaces.

Mapping class groups of K3 surfaces from a Thurstonian viewpoint II

Eduard Looijenga

University of Chicago

Wednesday, September 7, 2022 @ 11:15 AM

Among the most basic mapping classes of K3 manifolds of infinite order are those that act unipotently on the homology. Such mapping classes can be represented by diffeomorphisms that preserve a fibration of the K3 manifold into genus one surfaces with 24 "fishtails" as singular fibers. Even the simplest cases turn out to be remarkably rich in their geometry. We describe some of these cases and indicate how this fits in the Thurstonian approach that was outlined in part I (joint with Benson Farb).

What do we know about the topology of strata?

Nick Salter

University of Notre Dame

Wednesday, September 7, 2022 @ 2:00 PM

A translation surface is a polygon in the complex plane whose edges are identified by Euclidean translations. This naive-seeming construction leads to incredibly deep mathematics, both by way of dynamics ($SL_2(\mathbb{R})$ acts on translation surfaces via its action on the plane) and algebraic geometry (a translation surface is equivalent to a Riemann surface equipped with a holomorphic 1-form). Translation surfaces have moduli spaces called *strata*. The global topology of strata is at present quite mysterious, but there are indications that this could be a very rich story potentially of interest not only to topologists, but geometric group theorists, dynamicists, and algebraic geometers as well. I will discuss what we do and don't know about the topology of strata.

Unramified correspondance and virtual homology of mapping class groups

Vlad Markovic

University of Oxford

Wednesday, September 7, 2022 @ 3:15 PM

I shall discuss my recent work showing that the Bogomolov-Tschinkel universality conjecture holds if and only if the mapping class groups of a punctured surface is large (which is essentially the negation of the Ivanov conjecture about the mapping class groups). I will also discuss my recent work with O. Tosic regarding the closely related Putman-Wieland conjecture.

Theta-graph and diffeomorphisms of some 4-manifolds

Tadayuki Watanabe

Kyoto University

Thursday, September 8, 2022 @ 9:00 AM

We construct many mutually non-isotopic diffeomorphisms of some non simply-connected 4-manifolds such as $M \times S^1$ or $M \times I$ for some spherical 3-manifolds M by surgery along theta-graphs. Moreover, these diffeomorphisms are pseudo-isotopic to the identity. In the proof of the non-triviality of the diffeomorphisms, we utilize a twisted analogue of Kontsevich's characteristic class for smooth bundles, which is obtained by extending a higher dimensional analogue of Marché–Lescop's "equivariant triple intersection" in configuration spaces of 3-manifolds to allow local coefficient systems of $\mathbb{C}\pi$-modules. The results presented in this talk include joint works with Boris Botvinnik and with Yuji Ohta.

On the algebraic structure of groups of area-preserving homeomorphisms

Sobhan Seyfaddini

CNRS & Sorbonne Université

Thursday, September 8, 2022 @ 10:00 AM

In an influential article from the 1970s, Albert Fathi, having proven that the group of compactly supported volume-preserving homeomorphisms of the n-ball is simple for $n \geq 3$,asked if the same statement holds in dimension 2. In a joint work with Cristofaro-Gardiner and Humilière, we proved that the group of compactly supported area-preserving homeomorphisms of the 2-disc is not simple. This answers Fathi's question and settles what is known as "the simplicity conjecture" in the affirmative.

In fact, Fathi posed a more general question about all compact surfaces: is the group of "Hamiltonian homeomorphisms" (which I will define) simple? In my talk, I will review recent joint work with Cristofaro-Gardiner, Humilière, Mak and Smith answering this more general question of Fathi. The talk will be for the most part elementary and will only briefly touch on Floer homology which is a crucial ingredient of the solution.

Nielsen realization for 3-manifolds

Bena Tshishiku

Brown University

Thursday, September 8, 2022 @ 11:15 AM

Given a manifold M, the Nielsen realization problem asks when a finite subgroup of the mapping class group Mod(M) lifts to Diff(M) under the natural projection Diff(M) $\to$ Mod(M). In this talk we consider the Nielsen realization problem for 3-manifolds and give a solution for subgroups of Mod(M) generated by sphere twists. This is joint work with Lei Chen.

Generic equidistribution of periodic orbits for area-preserving surface diffeomorphisms

Rohil Prasad

Princeton University

Thursday, September 8, 2022 @ 2:00 PM

In this talk, I will explain why a generic area-preserving diffeomorphism of a closed, oriented surface has an equidistributed sequence of periodic orbits. The proof relies on various properties of spectral invariants from Periodic Floer Homology.

Asymmetrical diffeomorphisms

Amie Wilkinson

University of Chicago

Thursday, September 8, 2022 @ 3:15 PM

All 3-manifold groups are Grothendieck rigid

Hongbin Sun

Rutgers University at New Brunswick

Friday, September 9, 2022 @ 9:00 AM

A finitely generated residually finite group G is said to be Grothendieck rigid if for any finitely generated proper subgroup $H < G$, the inclusion induced homomorphism $\hat{H} \to \hat{G}$ on their profinite completions is not an isomorphism. There do exist finitely presented groups that are not Grothendieck rigid. We will prove that, if we restrict to the family of finitely generated 3-manifold groups, then all these groups are Grothendieck rigid. The proof relies on a precise description on non-separable subgroups of 3-manifold groups.

Existence of global surfaces of section for 3-dimensional Reeb flows

Marco Mazzucchelli

École normale supérieure de Lyon

Friday, September 9, 2022 @ 10:00 AM

A global surface of section for a nowhere vanishing vector field on a closed 3-manifold is a compact surface whose interior is transverse to the vector field, and whose boundary components are closed orbits of the vector field.

In this talk, based on joint work with Gonzalo Contreras, I will focus on the class of Reeb vector fields of closed contact 3-manifolds. I will outline a proof of the existence of global surfaces of section for those Reeb vector fields satisfying the C^∞ generic Kupka-Smale condition: non-degeneracy of the closed orbits, and transversality of the stable and unstable manifolds of the hyperbolic closed orbits.

The class of 3-dimensional Reeb vector fields comprises the geodesic vector fields of closed Riemannian surfaces. As an application of the existence of global surfaces of section, I will provide a new characterization of Anosov Reeb vector fields of closed contact 3-manifolds, which implies the validity of the C^2 structural stability conjecture for Riemannian geodesic flows of closed surfaces.

Mapping class groups of del Pezzo surfaces

Seraphina Lee

University of Chicago

Friday, September 9, 2022 @ 11:15 AM

In this talk, we examine subgroups (for example, finite ones) of the mapping class groups $\pi_0(\mathrm{Homeo}^+(M^4))$ of del Pezzo surfaces M^4. We present some examples of realizations of these subgroups by diffeomorphisms and the structures that these diffeomorphisms preserve on the manifold M^4.

Smooth Models for Certain Fibered Partially Hyperbolic Systems

Margaret Doucette

University of Chicago

Friday, September 9, 2022 @ 11:45 AM

We prove that under restrictions on the fiber, any fibered partially hyperbolic system over a nilmanifold is leaf conjugate to a smooth model that is isometric on the fibers and descends to a hyperbolic nilmanifold automorphism on the base.

Infinite Staircases in Hirzebruch surfaces

Dusa McDuff

Columbia University

Friday, September 9, 2022 @ 2:00 PM

The ellipsoidal capacity function $c_X(z)$ of a symplectic four manifold X measures how much the form on X must be dilated in order for it to admit an embedded ellipsoid of eccentricity z. In most cases there are just finitely many obstructions to such an embedding besides the volume. If there are infinitely many obstructions, X is said to have a staircase.This talk will give an almost complete description of these staircases when X is a Hirzebruch surface H_b formed by blowing up the projective plane with weight b. There is an interweaving, recursively defined, family of obstructions that show there is an open dense set of shape parameters b that are blocked, i.e. have no staircase, and an uncountable number of other values of b that do admit staircases. Moreover, there are interesting symmetries that act on the set of staircases. This is joint work with Nicki Magill and Morgan Weiler.

Infinite Staircases in Symplectic Embeddings

Nicki Magill

Cornell University

Friday, September 9, 2022 @ 3:15 PM

The four dimensional ellipsoid embedding function of a symplectic manifold M measures when a symplectic ellipsoid embeds into M. It generalizes symplectic ball packing numbers. In 2012, McDuff and Schlenk computed this function for a ball. The function has a delicate structure known as an infinite staircase, which implies an intricate interplay between flexibility and rigidity in the embeddings. An infinite staircase consists of infinitely many non smooth points accumulating at some finite value. Since then, it's been determined not all symplectic manifolds have infinite staircases. Based on work with McDuff and Weiler, we will discuss the classification of which Hirzebruch surfaces have infinite staircases. This talk will focus on the construction of particular symplectic embeddings via almost toric fibrations and how the structure of these embeddings is in correspondence with certain homology classes in blow ups of the complex projective plane.

Quantitative closing lemmas for contact three-manifolds

Michael Hutchings

UC Berkeley

Saturday, September 10, 2022 @ 9:00 AM

A contact form on a closed three-manifold has an associated Reeb vector field, and there is much interest in studying periodic orbits of this vector field (called "Reeb orbits" for short). Irie proved a closing lemma asserting that given a "positive" deformation of a contact form supported in an open set, Reeb orbits intersecting the open set must appear within arbitrarily short time. "Quantitative" closing lemmas refine this statement to give upper bounds on the time needed to find an orbit with a given upper bound on the period. We prove general quantitative closing lemmas for contact three-manifolds, in terms of "spectral gaps" in new "spectral invariants" defined in terms of holomorphic curves with point constraints. In some examples, such as irrational ellipsoids, these quantitative closing lemmas are sharp.

Lagrangian link quasimorphisms and the non-simplicity of Hameomorphism group of sphere

Cheuk Yu Mak

University of Edinburgh

Saturday, September 10, 2022 @ 10:00 AM

In this talk, we will explain the construction of a sequence of homogeneous quasi-morphisms of the area preserving homeomorphism group of the sphere using Lagrangian Floer theory for links. This sequence of quasi-morphisms has asymptotically vanishing defect, so it is asymptotically a homomorphism. We will then explain how studying the subleading asymptotic of these quasimorphisms enable us to show that the Hameomorphism group is not the smallest normal subgroup of the area preserving homeomorphism group. This is a joint work with Daniel Cristofaro-Gardiner, Vincent Humilière, Sobhan Seyfaddini and Ivan Smith.

Existence of global surfaces of section, and applications

Umberto Hryniewicz

RWTH Aachen University

Saturday, September 10, 2022 @ 11:15 AM

One might ask if global surfaces of section (GSS) for Reeb flows in dimension 3 are abundant in two different senses. One might ask if GSS are abundant for a given Reeb flow, or if Reeb flows carrying some GSS are abundant in the set of all Reeb flows. In this talk, answers to these two questions in specific contexts will be presented. First, I would like to discuss a result, obtained in collaboration with Anna Florio, stating that there are explicit sets of Reeb flows on which are right-handed in the sense of Ghys; in particular, for such a flow all finite (non-empty) collections of periodic orbits span a GSS. Then, I would like to discuss genericity results, obtained in collaboration with Colin, Dehornoy and Rechtman, for Reeb flows carrying a GSS; as a particular case of such results, we prove that a C^∞-generic Reeb flow on a closed 3-manifold carries a GSS. As an application, we show that a C^∞-generic Reeb flow on closed 3-manifolds has positive topological entropy.

The Brin Mathematics Research Center

The Brin Mathematics Research Center is a research center that sponsors activity in all areas of pure and applied mathematics and statistics. The Brin MRC was funded in 2022 through a generous gift from the Brin Family. The Brin MRC is part of the Department of Mathematics at the University of Maryland, College Park.

Activities sponsored by the Brin MRC include long programs, conferences and workshops, special lecture series, and summer schools. The Brin MRC provides ample opportunities for short-term and long-term visitors that are interested in interacting with the faculty at the University of Maryland and in experiencing the metropolitan Washington DC area.

The mission of the Brin MRC is to promote excellence in mathematical sciences. The Brin MRC is home to educational and research activities in all areas of mathematics. The Brin MRC provides opportunities to the global mathematical community to interact with researchers at the University of Maryland. The center allows the University of Maryland to expand and showcase its mathematics and statistics research excellence nationally and internationally.

List of Participants

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Luya Wang, UC Berkeley
Margaret Doucette, University of Chicago
Zihao Liu, Rice University
Weiyan Lin, CUNY-Grad Center
Brayan Ferreira, IMPA - Instituto de Matemática Pura e Aplicada
Anastasiia Sharipova, Pennsylvania State University
Julian Chaidez, Princeton University/Institute for Advanced Study
Bill Goldman, University of Maryland
Lei Chen, University of Maryland
Dan Cristofaro-Gardinar, University of Maryland
Boyu Zhang, University of Maryland
Xinle Dai, Harvard University