Young Geometric Group Theory V

Karlsruhe, Germany

Monday, the 15th of February, 2016
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Friday, the 19th of February, 2016

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1 Minicourse speakers

Martin Bridson
(University of Oxford, UK)

Profinite recognition of groups, Grothendieck Pairs, and low-dimensional orbifolds

I shall begin by discussing the history of the following general problem: to what extent is a residually-finite group determined by its set of finite quotients (equivalently, its profinite completion)? A precise instance of this question was posed by Grothendieck in 1970: he asked if there could exist pairs of finitely presented, residually finite groups $H < G$ such that the inclusion map induces an isomorphism of profinite completions but H is not isomorphic to G.

Ideas developed in connection with non-positive curvature have led to significant progress on such questions in recent years, and I shall explain several aspects of this work. I shall explain the construction that allowed Fritz Grunewald and I to answer Grothendieck's question, and an elaboration that solves the infinite genus problem: there exist infinite families of finitely presented subgroups of $\mathrm{SL}(n, \mathbb{Z})$ all of which have the same finite quotients.

Fundamental groups of orbifolds of dimension at most 3 enjoy a greater degree of profinite rigidity than arbitrary groups. I shall present positive and negative results in this context. In particular I shall explain how Reid, Wilton and I proved that the fundamental groups of punctured torus bundles can be distinguished from each other and from other 3-manifold groups by means of their profinite completions.

If time allows, I shall explain why there is no algorithm that can determine which finitely presented groups have non-trivial finite quotients.

Alessandra Iozzi
(ETH Zürich, Switzerland)

Irreducible lattices in CAT(0) groups and bounded cohomology

Bounded cohomology is by now one of the “classical” tools to approach rigidity questions. Without getting involved into technicalities, we will illustrate for example how it can be used to show that the behaviour of "large" discrete groups $G < \mathrm{Aut}(T) \times \mathrm{Aut}(T')$ acting cofinitely by automorphisms on a product of trees $T \times T'$ is very different from the one of their cousins acting on the product of hyperbolic planes. We will construct concrete examples of such groups $G < \mathrm{Aut}(T) \times \mathrm{Aut}(T')$ and illustrate some of their stunning properties. We will moreover show how the median class of an action on a tree, an easily and concretely defined bounded cohomology class, can be used to construct quasimorphisms of the group and identify properties of the given action. We will then move to the median class of a group acting on a CAT(0) cube complex and propose some new open problems.

Lee Mosher
(Rutgers University, USA)

Relative train track theory and applications

Relative train track theory is a powerful tool for proving theorems about $\mathrm{Out}(F_n)$. We will develop the elements of this theory and its connections to geometric invariants of $\mathrm{Out}(F_n)$, motivating the theory as we go along with some very basic applications, and leading up to new applications (joint work with Handel) regarding the second bounded cohomology of subgroups of $\mathrm{Out}(F_n)$.

Karen Vogtmann
(Warwick University, UK)

Spaces of graphs and automorphisms of free groups

Automorphism groups of free groups bear similarities to both lattices in Lie groups and to surface mapping class groups. In this minicourse we will explore the cohomology of these groups using tools from topology and a little representation theory. No prior familiarity with the subject will be assumed.

2 Other speakers

Khalid Bou-Rabee
(The City College of New York, USA)

The topology of local commensurability graphs

Let G be a group and p a prime number. The *p-local commensurability graph* of G has all finite-index subgroups of G as vertices, and edges are drawn between A and B if $[A : A \cap B][B : A \cap B]$ is a power of p. In this talk, I will talk on recent work that draws group-theoretic properties from the diameters of components of these graphs. The *connected diameter* of a graph is the supremum over all graph diameters of every component of the graph. Every p-local commensurability graph of any nilpotent group has connected diameter equal to one, and the reverse implication is true. In contrast, every nonabelian free group has connected diameter equal to infinity for all of their p-local commensurability graphs. Moreover, solvable groups, in a sense, fill in the space between free groups and nilpotent groups. This talk covers joint work with Daniel Studenmund and Chen Shi.

Spencer Dowdall
(Vanderbilt University, USA)

The geometry of hyperbolic extensions of free groups

W. Thurston's celebrated hyperbolization theorem shows that a fibered 3–manifold admits a hyperbolic structure if and only if it is the mapping torus of a pseudo-Anosov homeomorphism. From an algebraic perspective, this gave the first examples of hyperbolic extensions of surface groups and pointed towards a more general theory of hyperbolic group extensions. Indeed, with the introduction of convex cocompact subgroups of mapping class groups, such a theory is is now well-established for surface group extensions.

In this talk, I will discuss joint work with Sam Taylor that develops a general theory for hyperbolic extensions of free groups: Each subgroup Γ of $\mathrm{Out}(F_n)$ naturally gives rise to a free group extension $1 \to F_n \to E_\Gamma \to \Gamma \to 1$, and it turns out that the hyperbolicity of E_Γ is closely linked to the action of Γ on what we term the "co-surface graph". After introducing this graph, I will explain why E_Γ is hyperbolic whenever Γ quasi-isometrically embeds into the co-surface graph and give conditions characterizing the hyperbolic extensions that arise in this way.

References

[1] Spencer Dowdall and Samuel J. Taylor, *Hyperbolic extensions of free groups*, Preprint arXiv:1496.2567.

[2] Spencer Dowdall and Samuel J. Taylor, *The co-surface graph and the geometry of hyperbolic free group extensions*, Forthcoming.

Camille Horbez
(Université Paris Sud, France)

Growth under random products of automorphisms

I will present various results describing the typical growth of either a curve on a hyperbolic surface under random products of mapping classes of the surface, or of a conjugacy class in a free group under random products of automorphisms.

Michael Hull
(University of Illinois at Chicago, USA)

Highly transitive groups

A group action on a set Ω is called k-transitive if for any two ordered k-tuples of distinct elements of Ω, some group element takes the first k-tuple to the second. The study of k-transitive actions of finite groups has a long history and is now well-understood using the classification of finite simple groups. However, much less is known in the case of infinite groups. We will show that many infinite groups G which arise in various algebraic and geometric contexts satisfy the following dichotomy: either G admits no faithful 2-transitive actions, or G is *highly transitive*, that is G admits a faithful action that is k-transitive for all k. In addition, we prove that being highly transitive has strong algebraic consequenses for a group. In particular, a highly transitive group G either contains a normal subgroup isomorphic to the infinite alternating group or G is mixed identity free.

References

[1] M. Hull, D. Osin, *Transitivity degrees of countable groups and acylindrical hyperbolicity*, arXiv:1501.04182, to appear in Israel J. Math.

Kathryn Mann
(University of California Berkeley, USA)

Large scale geometry of homeomorphism groups

Standard techniques of geometric group theory apply to finitely (or compactly) generated groups. But not all interesting groups are compactly generated or locally compact! In this talk, I'll introduce a framework for studying the large-scale geometry of such "large" groups. The group of homeomorphisms of a manifold provides a particularly interesting example: here the large scale geometry appears to reflect the topology of the manifold, and also to provide some new insight into questions on dynamics of group actions. This work is joint with C. Rosendal.

Chen Meiri
(Technion Haifa, Izrael)

Maximal subgroups of $\mathrm{SL}(n, \mathbb{Z})$

More than three decades ago Margulis and Soifer proved the existence of maximal subgroups of infinite index in $\Gamma := \mathrm{SL}(n; \mathbb{Z})$, answering a question of Platonov. Since then, it is expected that there should be examples of various different natures. However, as the proof is non-constructive and relies on the axiom of choice, it is highly non-trivial to put the hand on specific properties of the resulting groups. In this talk we will show that indeed, maximal subgroups $\Delta \leq \Gamma$ of different nature do exist. Our main focus is not on the structure of the abstract group Δ but on the associated permutation representation $\Gamma \curvearrowright \Gamma/\Delta$ and on the action of Δ on the associated projective space $\mathbb{P} = \mathbb{P}^{n-1}(\mathbb{R})$. This is joint work with Tsachik Gelander.

Doron Puder
(Institute for Advanced Study, Princeton, USA)

Word measures on groups

We study measures induced by free words on finite and compact groups. For example, if w is a word in $F_2 = \langle x, y \rangle$ and G is finite/compact, sample at random two elements from G, g for x and h for y, and evaluate $w(g, h)$. The measure of this random element is called the w-measure on G.

I will explain some of the motivation for the study of word measures, both from the free group side and from the finite/compact groups side. I will also describe a recent work, with Michael Magee, where we study word measures on Unitary groups and find new interesting connections between random matrix theory on the one hand and the theory of commutator length in free groups and maps from surfaces to graphs on the other.

Nicholas Touikan
(Stevens Institute of Technology, United States)

Makanin-Razborov diagrams for relatively hyperbolic groups (Joint with Inna Bumagin)

Let Γ be a relatively hyperbolic group and G an arbitrary finitely generated group. In this talk I will present my joint work with Inna Bumagin on the construction of a Makanin-Razborov diagram, an algebraic object that encodes $\mathrm{Hom}(G, \Gamma)$. Our work treats the parabolic subgroups as "black boxes". This is a significant departure from previous results of Daniel Groves and Emina Alibegovic where the parabolic subgroups are free abelian, and therefore have specific algebraic and geometric properties.

I will focus on our principal innovation, a method to construct meaningful asymptotic cones from homomorphisms to relatively hyperbolic groups. This presentation should be accessible to anyone familiar with δ-hyperbolic geometry.

Ric Wade
(University of British Columbia, Canada)

Subspace arrangements and BNS invariants

There is a natural chain complex associated to a pair $(V, \mathcal{V})$ consisting of a vector space V and a set of subspaces $\mathcal{V}$. We can look at its homology $H_*(V, \mathcal{V})$. The BNS invariant of a group G determines a set of subspaces $\mathcal{V}_G$ in the vector space $V = \mathrm{Hom}(G, \mathbb{R})$ of homomorphisms from G to $\mathbb{R}$. The associated homology $H_*(V, \mathcal{V}_G)$ is (yet) another invariant of G. We will look at some examples involving right-angled Artin groups and their automorphisms. This is joint work with Matthew Day (University of Arkansas).

References

[1] Matthew B. Day and Richard D. Wade. Subspace arrangements, BNS invariants, and pure symmetric outer automorphisms of right-angled Artin groups. *ArXiv preprint 1508.00622*

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3 Poster session

Carolyn Abbott

Not all finitely generated groups have universal acylindrical actions

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Giles Gardam

The word problem and one-relator groups

Łukasz Garncarek

Boundary representations of hyperbolic groups

Thibault Godain

Reversible Mealy automata and the Burnside problem

Sahana Hassan Balasubramanya

Acylindrical group actions on quasi-trees

Mikhail Hlushchanka

Exponential growth of some iterated monodromy groups

HyoWon Park

On a class of right-angled Artin groups

Bram Petri

Combinatorics, Probability and Surfaces

Tomasz Prytuła

Classifying spaces for families for systystolic and small cancellation groups

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Yuri Santos Rego

Solvable S-Arithmetic Groups and their Finiteness Length

Damian Sawicki

Warped cones and coarse embeddings

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4 Research statements

Martina Aaltonen
(University of Helsinki, Finland)

Branched covers

I am a third year PhD student at the University of Helsinki. My adviser is Pekka Pankka from Univeristy of Jyväskylä. I work with branched covers between manifolds.

A map $f\colon M \to N$ between n-manifolds is called a branched cover, if it is a (continuous), open and discrete map; f maps open sets to open sets and $f^{-1}\{y\} \subset N$ is a discrete set for every $y \in N$. The map f is called proper if the pre-image $f^{-1}F$ of every compact subset $F \subset N$ is compact. The branch set $B_f \subset M$ of f is the set of points in M for which f fails to be a local homeomorphism.

By Väisälä [2] and Church and Hemmigsen [1] we know that the covering dimension of B_f and fB_f is less or equal to $n-2$ for a branched cover $f\colon M \to N$ between manifolds. However, the properties of the branch set B_f and fB_f are not well understood. In particular, there is no general lower bound for the dimension of B_f and fB_f. In [1] we introduce with Pankka a condition for proper branched covers between manifolds under which fB_f has local dimension $n-2$ and prove the following:

Let $f\colon M \to N$ be a proper branched cover between manifolds so that the local multiplicity of f is less or equal to three at every point in M. Then either f is a covering map or the dimension of fB_f is $n-2$.

References

[1] Church-Hemmingsen, Church, Philip T. and Hemmingsen, Erik, Light open maps on n-manifolds, Duke Math. J

[2] Väisälä, J., Discrete open mappings on manifolds, Ann. Acad. Sci. Fenn. Ser. A I, **392** (1966), no. 10.

[3] Aaltonen, Martina and Pankka, Pekka, Abelian points of branched covers, ArXiv e-prints 2015

Carolyn R. Abbott
(University of Wisconsin-Madison, USA)

Generating sets for acylindrically hyperbolic groups

I am a fourth year Ph.D. student working under Tullia Dymarz. I am interested in acylindrically hyperbolic groups, in particular their generalized loxodromic elements and their (infinite) generating sets.

In a group action on a hyperbolic space, an element is loxodromic if it acts as translation along a quasi-axis. An acylindrically hyperbolic group may have multiple acylindrical actions on different hyperbolic spaces, and the loxodromic elements for each action need not coincide. An element that is loxodromic for some acylindrical action is called generalized loxodromic. If every generalized loxodromic element of a group is loxodromic for a particular acylindrical action on a hyperbolic space, then that action is called universal. However, I showed that it is not the case that every acylindrically hyperbolic group has a universal action; Dunwoody's example of an inaccessible group does not have such an action. [1] I am currently working on building hyperbolic spaces on which certain acylindrically hyperbolic groups have universal actions.

Additionally, given an acylindrically hyperbolic group, some (infinite) generating sets will result in hyperbolic Cayley graphs on which the group acts acylindrically. I am interested in the relationships between such generating sets. For example, how does a generating set that corresponds to a universal action relate to other generating sets?

References

[1] Abbott, Carolyn. "Not all acylindrically hyperbolic groups have a universal acylindrical action," arXiv:1505.02990.

Byunghee An
(Institute for Basic Science, Center for Geometry and Physics, Republic of Korea)

Braid groups and related topics

I have studied in braids and related topics, such as, homological representations [1] and automorphism groups for braid groups on surfaces [3], the conjugacy problem on the classical braid group [2], and braid groups on CW complexes [1], which is a generalization of braid groups on graphs.

I am also interested in the following subjects: CAT(0)-ness of the classical braid group, relationship between right-angled Artin groups and braid groups on various topological spaces, and so on.

References

[1] Byunghee An, *Automorphisms of braid groups on orientable surfaces*, submitted to J. Knot Theory Ramifications, 2014.

[2] Byunghee An, Ki Hyoung Ko, *A family of pseudo-Anosov braids with large conjugacy invariant sets*, J. Knot Theory Ramifications 22 (2013), no. 6.

[3] Byunghee An, Ki Hyoung Ko, *A family of representations of braid groups on surfaces*, Pacific J. Math. 247 (2010), no. 2, 257–282.

[4] Byunghee An, Hyowon Park, *On the structure of braid groups on complexes*, submitted to J. Topology, 2015.

Assaf Bar-Natan
(McGill University, Canada)

Systems of Closed Curves Intersecting at Most Once

Consider a system Γ_g of closed simple curves on M_g, the genus g surface without boundary, which are pairwise non-homotopic, and are pairwise disjoint. It is a classical result of M. Juvan et al [1] that

$$|\Gamma_g| \leq max\{1, 3(g-1)\}$$

In the theory of mapping class groups, pairwise non-homotopic simple closed curves arise as a natural construction in trying to characterize the actions of such groups on M_g. With this motivation, I am interested in finding the maximal size of a system of pairwise non-homotopic closed curves on M_g.

A construction by J. Malestein et. al [2] gives a quadratic lower bound on the $max\{|\Gamma_g|\}$ by constructing a family of g^2 such curves on M_{2g-1}. In the same paper they also show that $max\{|\Gamma_g|\} \leq (g-1)(2^{2g}-1)$, leaving a large gap between the upper and lower bounds. The upper bound was improved to a cubic one by P. Przytycki in [3], showing that

$$max\{|\Gamma_g|\} \leq g(4(2g-2)(2g-1)+1)+2g-1$$

I am interested in either showing that the cubic upper bound is sharp, or in improving it to get a quadratic upper bound on $max\{|\Gamma_g|\}$.

References

[1] M. Juvan, A Malnič, and B. Mohar; Systems of Curves on Surfaces, Journal of Combinatorial Theory, Series B 68, 7-22 (1996) Article No. 0053.

[2] Justin Malestein, Igor Rivin, and Louis Theran, Topological Designs, arXiv 1008.3710v5, Jan. 2013.

[3] P. Przytycki, Arcs Intersecting at Most Once, GAFA 25, pp 658-670, 2015.

Benjamin Barrett
(University of Cambridge, United Kingdom)

Boundaries of hyperbolic groups

I am interested in the computability of topological properties of Gromov boundaries of hyperbolic groups. The topology of the boundary ∂G of such a group G determines many algebraic properties of the group. For example, ∂G is disconnected if and only if G acts non-trivially on a simplicial tree with directed edges with finite edge stabilisers [1]. If ∂G is connected, ∂G has a local cut point if and only if G admits such an action with virtually cyclic edge stabilisers [2].

Work of Bestvina and Mess [1] gives a condition on the Cayley graph of G that is shown to be equivalent to ∂G being connected; this condition is shown to be computable in [4]. I aim to apply similar techniques to other topological questions.

References

[1] Stallings, J. R., On torsion-free groups with infinitely many ends. Ann. Math., vol. 88 (1968), 312–334

[2] Bowditch, B. H., Cut points and canonical splittings of hyperbolic groups. Acta Math., vol. 180 (1998), 145–186

[3] Bestvina, M. and Mess, G., The boundary of negatively curved groups. J. Am. Math. Soc., vol. 4 (1991), 469–481

[4] Dahmani, F. and Groves, D., Detecting free splittings in relatively hyperbolic groups. Trans. Amer. Math. Soc., vol. 369 (2008), 6303–6318

Benjamin Beeker
(HUJI, Israel)

JSJ decompositions and CAT(0) cube complexes

I am interested in JSJ theory. I have been studying different JSJ decompositions of Generalized Baumslag-Solitar groups. I described some of there properties and gave some criterion for their constructibility and unconstructibility ([1], [2]).

I am also interested in CAT(0) cube complexes (CCC) and extending properties already known for trees. With Nir Lazarovich, we describe a construction of resolution of actions on CCC [3] that extend the one of Dunwoody for actions on trees [6], and gave some topological applications. We describe an analog in higher dimension of Stallings folds [4], and use them to give some characterizations of quasiconvex subgroups of hyperbolic groups acting properly and cocompactly on CCC.

We also have been studying boundaries of hyperbolic groups acting on CCC, giving sufficient conditions for them to have a $\mathbb{S}^2$ as a boundary [5].

References

[1] **B Beeker**, *Abelian JSJ decomposition of graphs of free abelian groups*, J. Group Theory. 17 (2014) 337–359

[2] **B Beeker**, *Compatibility JSJ decomposition of graphs of free abelian groups*, Internat. J. Algebra Comput. 23 (2013) 1837–1880

[3] **B Beeker**, **N Lazarovich**, *Resolutions of CAT(0) cube complexes and accessibility properties*, to appear in Algebr. Geom. Topol.

[4] **B Beeker**, **N Lazarovich**, *Stallings folds forCAT(0) cube complexes and undistorted subgroups*, Work in progress.

[5] **B Beeker**, **N Lazarovich**, *Sphere boundaries of hyperbolic groups*, Work in progress.

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Edgar A. Bering IV
(University of Illinois at Chicago, U. S. A.)

Dynamics and Right-Angled Artin subgroups of $Out(F_n)$

There are two known approaches to proving that, after passing to powers, a colletion of pseudo-Anosov or Dehn-twist mapping classes generate a Right-Angled Artin subgroup of the mapping class group. The first approach, via coarse geometry, due to Clay, Leininger, and Mangahas [CLM12], has been generalized to give an analogous result for the outer automorphism group of a free group by Taylor, but only for certain families of outer automorphisms [Tay15]. Koberda gives a proof that uses an analysis of the action of the mapping class group on the space of projective measured laminations [Kob12]. My aim is to carry out a similar proof for outer automorphisms acting on the Culler-Morgan boundary of Outer Space or other analog of projective measured laminations. Work in progress suggests this approach will apply to a larger class of outer automorphisms than Taylor's proof, but may not be strong enough to show that the resulting subgroup is quasi-isometrically embedded.

References

[CLM12] Matt T. Clay, Christopher J. Leininger, and Johanna Mangahas, *The geometry of right-angled Artin subgroups of mapping class groups*, Groups Geom. Dyn. **6** (2012), no. 2, 249–278.

[Kob12] Thomas Koberda, *Right-angled Artin groups and a generalized isomorphism problem for finitely generated subgroups of mapping class groups*, Geom. Funct. Anal. **22** (2012), no. 6, 1541–1590.

[Tay15] Samuel J. Taylor, *Right-angled Artin groups and* $\mathrm{Out}(\mathbb{F}_n)$ *I. Quasi-isometric embeddings*, Groups Geom. Dyn. **9** (2015), no. 1, 275–316.

Jonas Beyrer
(UZH, Zürich, Switzerland)

Möbius geometry on the boundary of non-positively curved spaces in particular higher rank symmetric spaces

I am a PhD student at the university of Zürich under the supervision of Prof. V. Schroeder, starting my second year. I am interested in Möbius structures on the boundaries of non-positively curved spaces and their connection to isometries in the inside. For rank one symmetric spaces all Möbius maps can be extended to isometries in the inside, going back to M. Bourdon, see [1]. I am trying to generalize this result to higher rank symmetric spaces. Instead of the ideal boundary, I use the Fürstenberg boundary to minimize the impact of flats. Using a similar construction as M. Bourdon uses for rank one spaces one gets a "generalized" cross ratio on the Fürstenberg boundary. At the moment I am trying to prove that Möbius maps with respect to this cross ratio can be extend to isometries in the inside.

References

[1] M. Bourdon. Sur le birapport au bord des cat(-1) espaces. *Inst. Hautes Etudes Sci. Publ. Math. No. 83*, pages 95 - 104, 1996.

Michael Brandenbursky
(Ben-Gurion University, Israel)

Quasi-morphisms in geometry and topology

One of the mainstream and modern tools in the study of algebraic structure of non-Abelian groups are quasi-morphisms. A *quasi-morphism* on a group H is a function $\varphi\colon H \to R$ which satisfies the homomorphism equation up to a bounded error: there exists $C > 0$ such that $|\varphi(hh') - \varphi(h) - \varphi(h')| \leq C$ for all $h, h' \in H$.

Study of quasi-morphisms is a hot topic since they are used in many fields of mathematics. For instance, they are related to bounded cohomology (due to Gromov), stable commutator length (due to Bavard, Calegari), metrics on diffeomorphism groups (due to Eliashberg, Gambaudo, myself and others), displacement of sets in symplectic topology (due to Entov, Polterovich and others), dynamics (due to Ghys, Polterovich and others), knot theory (due to Malyutin), orderability (due to Eliashberg, Polterovich, Ben-Simon, Hartnick and others) study of braid and mapping class groups (due to Bestvina, Fujiwara, Gambaudo, Ghys and others) and of concordance group of knots (due to Cochran, Harvey, Kędra and myself). In addition, they detect undistorted elements, which relate them to the celebrated Zimmer conjecture.

Some of the basic questions are: Which invariants of knots define quasi-morphisms on surface braid groups? How are they related to the notion of orderability? What is the relation between quasi-morphisms and the celebrated L^p-metrics on groups of volume-preserving diffeomorphisms of smooth manifolds? Is the group of volume-preserving diffeomorphisms of the three-sphere bounded with respect to any bi-invariant metric? Which non-Abelian groups admit quasi-isometric embeddings into the group of Hamiltonian diffeomorphisms of a symplectic manifold equipped with the autonomous metric?

References

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[2] Brandenbursky M., Kędra J.: *On the autonomous metric on the group of area-preserving diffeomorphisms of the 2-disc*, Algebraic & Geometric Topology, **13** (2013), 795–816.

Sabine Braun
(Karlsruhe Institute of Technology, Germany)

ℓ^2-Betti numbers and simplicial volume

The goal I try to accomplish in my PhD thesis is to establish an upper bound for the ℓ^2-Betti numbers of an aspherical manifold in terms of its Riemannian volume.
Gromov raised the question whether there is a universal bound for the ℓ^2-Betti numbers of an aspherical manifold by its simplicial volume [2]. While this problem remains open, it is known that the corresponding statement is true if you use the *foliated integral simplicial volume* [1].
In [2] my PhD adviser showed an analogue of Gromov's main inequality for the foliated integral volume instead of the simplicial volume, leading to an upper bound of ℓ^2-Betti numbers of an aspherical manifold by its volume under a lower Ricci curvature bound. The proof involves techniques motivated by Gaboriau's theory of ℓ^2-Betti numbers of equivalence relations [3]. Combining these methods with nerve techniques developed by Guth in [4] is expected to provide the key to obtain a curvature-free upper bound of the foliated integral simplicial volume. This should yield the desired estimate for the ℓ^2-Betti numbers.
Furthermore, a similar approach might lead to a curvature-free version of Gromov's main inequality, bounding the simplicial volume of a Riemannian manifold by its volume.

References

[1] D. Gaboriau, *Invariants ℓ^2 de relations d'equivalence et de groupes*, Publ. Math. Inst. Hautes Études Sci. 95 (2002), 93-150.

[2] M. Gromov, *Metric structures for Riemannian and non-Riemannian spaces*, Reprint of the 2001 English edition, Modern Birkhäuser Classics, Birkhäuser Boston, Inc., Boston, MA, 2007. Based on the 1981 French original.

[3] L. Guth, *Volumes of balls in large Riemannian manifolds*, Ann. of Math. (2) 173 (2011), no.1, 51-76.

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[5] M. Schmidt, *L^2-Betti numbers of $\mathcal{R}$-spaces and the Integral Foliated Simplicial Volume*, Universität Münster, 2005. doctoral thesis.

Sam Brown
(University College London, UK)

Non-positive and negative curvature for cube complexes

Haglund and Wise's 2008 definition of a *special cube complex* [4, 5] sparked a very fruitful few years in geometric group theory, the culmination of which was Agol's proof of the Virtual Haken Theorem [1]. Special cube complexes are a particularly nice example of *non-positively curved* cube complexes, which can be defined either using a local thinness condition (called the CAT(0) condition) on triangles, or using a purely combinatorial condition on the cube complex [2]. For the first part of my PhD, my research focussed on understanding subgroups of special cube complexes; in particular, the interplay between their algebraic and geometric properties.

Often, when studying special cube complexes, one insists that the fundamental group G of the cube complex is δ-hyperbolic. This gives a natural geometric action of G on a CAT(0) space; however, as a hyperbolic group, G may also act on a CAT(-1) space, and it is an open question whether all hyperbolic groups possess such an action. I have investigated this in the case of hyperbolic *limit groups*, using their hierarchical structure, and shown that they are indeed CAT(-1). Moreover, the question of whether all hyperbolic groups are CAT(-1) can be reduced (via the JSJ decomposition) to those hyperbolic groups without a free or cyclic splitting [3]. I am now looking again at cube complexes to see whether similar techniques might be applied.

References

[1] I. Agol. The virtual Haken conjecture. *Doc. Math.*, 18:1045–1087, 2013.

[2] M. R. Bridson and A. Haefliger. *Metric spaces of non-positive curvature*. Springer-Verlag, Berlin, 1999.

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Counting and distribution

If G is a group acting on a set X, $\mathcal{O}$ is an orbit of that action encoding interesting information, and (Y_T) is a sequence of "growing" subsets of X, then what can be said of $\#\{\mathcal{O} \cap Y_T\}$ as $T \to \infty$? To give some flavor to this question, here are some situations I am/have been interested in.

Apollonian circle packings – Take four mutually tangent circles in the plane. In each curvilinear triangular interstice, pack a new circle, tangent to each edge. Repeat this process indefinitely and you obtain an Apollonian circle packing. One can track the generation of new circles by associating to each a simple numerical invariant, its curvature. The study of patterns in the arising arithmetic sequence of curvatures has been a hot topic in the past few years. The challenge is that the symmetry group underlying the packing generation is a "thin" subgroup of $\mathrm{SO}_{\mathbb{R}}(3,1)$, i.e. it has infinite covolume in $\mathbb{H}^3$.

Double cosets of cofinite Fuchsian groups – By the Bruhat decomposition, any element in $\mathrm{PSL}(2,\mathbb{R})$ may be written uniquely as the product $\left[\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right] = \left[\begin{smallmatrix} 1 & a/c \\ & 1 \end{smallmatrix}\right] \left[\begin{smallmatrix} & -1/c \\ c & \end{smallmatrix}\right] \left[\begin{smallmatrix} 1 & d/c \\ & 1 \end{smallmatrix}\right]$. Similarly, for a lattice $\Gamma < \mathrm{PSL}(2,\mathbb{R})$ with a cusp (say, at ∞, and associated stabilizer subgroup Γ_∞), one can order the elements of the double cosets $\Gamma_\infty \backslash \Gamma / \Gamma_\infty$ according to matrix entries such that they are uniformly distributed [1]. Some fundamental sums in the theory of automorphic forms are indexed by such double cosets.

Tracking the winding of closed geodesics on a cusped hyperbolic surface S – There is an analogue of the rotation number for closed regular curves in $\mathbb{C}^\times$ that applies to closed geodesics on S. This invariant can be realized by a quasimorphism $\phi : \pi_1(S) \to \mathbb{Z}$. There is no algorithm to compute the rotation of a given closed geodesic, but one can understand the distribution of rotation numbers $\phi(\gamma)$ with respect to arc length $\ell(\gamma)$ as an application of Selberg's trace formula.

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Caterina Campagnolo
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Bounded cohomology and surface bundles

I am a fifth year PhD student, working under the supervision of Michelle Bucher.

The main topic of my thesis is the study of surface bundles via their characteristic classes, as defined by Morita (see [2]). A result of Gromov implies that these classes are bounded in degree $2(2k+1)$, or in other words, that they can be represented by cocycles which are uniformly bounded.

One advantage of the theory of bounded cohomology, initiated by Gromov in the beginning of the 80's [1], is that good bounds for norms of cohomology classes naturally give rise to Milnor-Wood inequalities. An aspect of my work is thus to try to compute the norms of the characteristic classes of surface bundles, with as aim to produce new inequalities between classical invariants of surface bundles, such as the signature, the Euler characteristic or the simplicial volume of the total space of the bundle. The simplicial volume on homology classes is the dual object to the norm of cohomology classes; hence one can use it to obtain values of cohomology norms, or vice versa. Nevertheless exact computations of it are still rare.

I am focussing on surface bundles over surfaces, $\Sigma_h \hookrightarrow E \to \Sigma_g$. One open question in this domain is whether the total space of such a bundle can support a hyperbolic structure. Inequalities involving the simplicial volume could help find the answer.

An important object in my research is the mapping class group of surfaces. In fact, characteristic classes of surface bundles are, in the universal case, cohomology classes of the mapping class group. Thus I have an interest in any geometric or group theoretical information on this group.

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Sven Caspart
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Translation manifolds

A finite translation surface is a compact Riemannian surface, i. e. a surface with a complex structure, together with a holomorphic 1-form. The singularities of the finite translation surface are the points where the 1-form vanishes. The justification of the name comes from the fact that in all non-singular points the holomorphic 1-form induces locally a chart (by integrating over paths) and the changes of coordinates of these charts are translations. Put in another way and slightly more general, a translation surface is a 2-dimensional manifold whose changes of coordinates are translations. From this point of view, a finite translation surfaces is a translation surface with additional restrictions on its metric completion (being a closed manifold) and the singularities (only finitely many).

Because finite translation surfaces can be described by Riemannian surfaces and holomorphic 1-forms, we can take advantage of the moduli and Teichmüller space of compact Riemannian surfaces to get a moduli and Teichmüller space for translation surfaces, respectively. In particular we have a metric on those spaces and also an affine structure and a measure on (subsets of) them.

There is a natural action of $\mathrm{GL}_2(\mathbb{R})$ on a translation surface. Pictorial this action corresponds to the transformation of the surfaces when drawn in $\mathbb{R}^2$. Of particular interest is the action of $\left(\begin{smallmatrix} e^t & 0 \\ 0 & e^{-t} \end{smallmatrix}\right)$ which corresponds to the geodesic flow in the moduli and Teichmüller space. During my thesis I studied the dynamics of this flow on the moduli space of translation surfaces.

In my PhD thesis I want to leave the 2-dimensional case and generalise the concept of translation surface to higher dimensions. The broadest definition (2-dimensional manifold with a particular atlas) can easily be generalised. However, the concept of a finite translation surface cannot, because the notion of a complex structure is not known for odd (real) dimensions. Another problem are the singularities. In two dimensions a singularity is a point, whereas in higher dimension it can be a point, a line, a surface or a mixture of it.

Corina Ciobotaru
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New unitary representations for groups acting on d–regular trees

The theory of unitary representations of locally compact groups is very well understood only for some very particular examples of groups: for $SL(2, \mathbb{R})$ and for $G < Aut(T_d)$ a closed subgroup that acts 2–transitively on the boundary ∂T_d of the d–regular tree T_d. When the closed subgroup $G < Aut(T_d)$ is not boundary 2–transitive, very little is know about its set of irreducible unitary representations. In this context, I am interested to construct a particular irreducible unitary representation of such a group $G < Aut(T_d)$. The existence of this representation is a consequence of [1, Thms. 1.1 and 3.11] and known properties of Gelfand pairs and Hecke algebras. This representation is a non-trivial irreducible unitary representation of G whose space of K–invariant vectors is of dimension at least 2 - here we denote by K the stabilizer in G of a vertex of the d–regular tree. The strategy would be to generalize the the construction given in [2].

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Antoine Clais
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Quasi-conformal properties of boundaries of hyperbolic spaces

My main interests of research are the quasi-conformal structure on boundaries of hyperbolic spaces, in particular buildings. The motivation for this is that the quasi-conformal structure of the boundary led to several results of rigidity since G.D. Mostow.

In this context the Loewner property and, its weaker version, the *combinatorial Loewner property* (CLP) are effective tools as they have been used on boundaries of Fuchsian buildings and Coxeter groups (see [1] and [2]).

Recently, I investigated the quasi-conformal structure on boundaries of right-angled hyperbolic buildings thanks to combinatorial tools (see [3]). In particular, I found examples of buildings of dimension 3 and 4 whose boundaries satisfy the CLP. Now I try to improve my understanding of the boundaries of hyperbolic buildings and of the combinatorial analysis in the aim of exhibiting new examples of hyperbolic buildings that are *quasi-isometrically rigid*.

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Matthew Cordes
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Morse Boundaries

While the ideal boundary of a hyperbolic space is invariant under quasi-isometry, Croke and Kleiner showed this is not the case for the ideal boundary of CAT(0) spaces. However, if one restricts attention to rays with hyperbolic-like behavior, so called “Morse” rays, then one can define a boundary on any proper geodesic space. (A geodesic γ is M-*Morse* if for any constants $K \geq 1$, $L \geq 0$, there is a constant $M = M(K, L)$, such that for every (K, L)-quasi-geodesic σ with endpoints on γ, we have $\sigma \subset N_M(\gamma)$.) I proved that this boundary is a quasi-isometry invariant and has nice visibility property. In the case of a CAT(0) space, the Morse boundary coincides with the the "contracting boundary" of R. Charney and H. Sultan [1] and coincides with the ideal boundary on delta hyperbolic spaces.

I am currently investigating the the connection between the Morse boundary and and other boundaries defined for classes of spaces with some negative curvature (relatively hyperbolic groups, acylindrically hyperbolic groups, etc.). I am especially interested in understanding the what the Morse boundary can us about “nice" subgroups of these groups.

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Study of manifolds via symmetries

The study of effective smooth torus actions on compact smooth Riemannian manifolds has been successfully used to obtain classification results for manifolds with positive or non-negative curvature and large isotropy groups (see for example [1]). Further work was done in [2], where the authors showed that several basic results of smooth torus actions on compact simply connected manifolds, and of isometric torus actions on simply connected Riemannian manifolds with positively or non-negative curvature hold under weaker conditions that do not involve the existence of a group action. Many of this results hold because the decomposition of the manifold by the orbits yield a singular Riemannian Foliation.

In [4], Oh show that a compact simply connected 5-manifold M, that admits and effective action of a torus T^3 is diffeomorphic to connected sums of $\mathbb{S}^5$ and finitely many copies of the two $\mathbb{S}^3$-bundles over $\mathbb{S}^2$. Following the work done in [3] the following question arrises:

Try to classify compact simply connected 5-manifolds with a Singular Riemannian Foliation by three-dimensional tori.

In this context I am interested in extending general results from smooth torus actions in the more general setting of singular Riemannian foliations, particularly in low dimensions.

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Rémi Coulon
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Geometry of torsion groups

The free Burnside group of rank r and exponent n denoted by $\mathbf{B}_r(n)$ is the quotient of the free group $\mathbf{F}_r$ by the (normal) subgroup generated by the n-th power of every element. Since the work of Adian, Novikov, Ol'shanskiĭ, and others it is known that $\mathbf{B}_r(n)$ is infinite as soon as $r \geq 2$ and n is sufficiently large. Despite all the progresses, Burnside groups are still mysterious. For instance their outer automorphism groups have been hardly studied. The projection $\mathbf{F}_r \twoheadrightarrow \mathbf{B}_r(n)$ induces a canonical map $\mathrm{Out}(\mathbf{F}_r) \to \mathrm{Out}(\mathbf{B}_r(n))$. We used this map to embed free groups in $\mathrm{Out}(\mathbf{B}_r(n))$ and therefore provide numerous examples of outer automorphisms of $\mathbf{B}_r(n)$ [1]. An important question is to understand which information can be carried through the map $\mathrm{Out}(\mathbf{F}_r) \to \mathrm{Out}(\mathbf{B}_r(n))$. Our first step in this direction was to determine which automorphisms of $\mathbf{F}_r$ have infinite order as elements of $\mathrm{Out}(\mathbf{B}_r(n))$. To that end we used the theory of train track representatives. It also led to an unexpected characterization of the growth of automorphisms of $\mathbf{F}_r$.

Theorem (Coulon-Hilion)**.** [2] *Let $r \geq 2$. Let Φ be an outer automorphism of $\mathbf{F}_r$. Φ is exponentially growing if and only if there are integers κ, n_0 such that for all odd integers $n \geq n_0$, Φ induces an outer automorphism of infinite order of $\mathbf{B}_r(\kappa n)$.*

One reason that makes these groups difficult to study is that we do not know a metric space on which it acts "nicely". In a joint work with V. Guirardel, we have made a step forward to overcome this difficulty. We are able to produce an infinite torsion group acting properly on a CAT(0) cube complex, (however the torsion is not bounded).

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Robert Crowell
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I am a first year master‘s student at the University of Bonn. I spent one year at the KIT studying mathematics before that, where I focused on Topology, Geometry and Group Theory. These lectures sparked my interest in those areas. Currently at Bonn I am taking more advanced courses in these fields that will take me to the research frontier.

One of the challenging but very appealing features of modern mathematics is the interplay of methods from different fields that previously seemed unrelated. Naturally, my research interests are still vague, but the interplay of group theory, topology and methods from dynamics is a fascinating area (e.g. group actions and ergodic theory), bringing together measure-theoretic and analytic tools with algebraic and topological methods to study geometric and algebraic structures.

I hope this conference will give me a glimpse at some ongoing research and guide me in deciding on master‘s thesis topic.

Jonas Deré
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Expanding maps on infra-nilmanifolds and generalizations

In [2], M. Gromov completed the proof that every manifold admitting an expanding map is, up to finite cover, homeomorphic to a nilmanifold. These manifolds are constructed as the quotient space $\Gamma\backslash N$ with Γ a uniform lattice of a 1-connected nilpotent Lie group N. Since then it was an open question to give an algebraic characterization of which nilmanifolds admit an expanding map.

In my research, see [1], I showed that the existence of an expanding map on a nilmanifold depends only on the covering Lie group. More precisely, a nilmanifold $\Gamma\backslash N$ admits an expanding map if and only if the Lie algebra corresponding to N has a positive grading. One of the applications is the construction of a nilmanifold admitting an Anosov diffeomorphism but no expanding map, which is the first example of this type.

It is an interesting problem to generalize these results to the class of polycyclic groups, where expanding maps can be generalized to the notion of dis-cohopfian groups. Recall that a group G is called dis-cohopfian if it has an injective group morphism $\varphi : G \to G$ such that

$$\bigcap_{n\in\mathbb{N}} \varphi^n(G) = \{e\}\,.$$

For example, it is unknown whether this property is invariant under taking finite index subgroups for polycyclic groups.

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Cocycle growth of the Steinberg representation

Let F be a finite extension of $\mathbb{Q}_p$. The Steinberg representation $\mathbf{St}$ of a simple F-algebraic group G of rank r, or rather the group of its F-points, is a pre-unitary irreducible representation. In fact [1], it is the only non-trivial admissible irreducible representation of G with non-trivial cohomology, more precisely,

$$\mathrm{H}^n(G, \mathbf{St}) = \begin{cases} \mathbb{C} & \text{if} \quad n = r, \\ 0 & \text{else}. \end{cases}$$

In [2], Klingler built natural cocycles for the non-trival class in degree r for arbitrary rank by mean of the Bruhat-Tits building X of G using retractions onto appartements and the alternating volume form of the latter. We believe the norm of this cocycle to grow as a *polynomial* of degree r.

The same author built in [3] an explicit isomorphism between $\mathbf{St}$ and the space of ℓ^2 harmonic functions on the chambers of X via a transformation of Poisson type. Using this I was able to compute an explicit sublinear upper bound in the case where X is a $(q+1)$-regular tree. In rank 2, this leads to study the geometry of $\tilde{A}_2$-buildings, where many difficult questions exist. For example, what does the convex hull C of three points look like? Can the orbit of a chamber under the action of the stabiliser of C be precisely described? I have obtained partial results to the first question in my PhD dissertation.

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Eduard (Teddy) Einstein
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Group properties that are recursive modulo word problem

Given $\mathcal{P}$, a property of groups, it is natural to ask whether there is an algorithm to determine whether or not a finite group presentation gives rise to a group satisfying $\mathcal{P}$. If such an algorithm exists, we say that the property $\mathcal{P}$ is recursive. Adyan and Rabin showed that many properties of groups, particularly triviality, are not recursively recognizable by an algorithm [1, 2, 5].

Their theorem, however, does not apply when we restrict our attention to classes of groups which have uniformly solvable word problem. We say that a property of groups is recursive modulo word problem if $\mathcal{P}$ can be recursively recognized by an algorithm among any class of groups with uniformly solvable word problem. Among recent results, Groves, Manning and Wilton showed that finite presentations which present the fundamental group of a closed geometric 3-manifold are recursively recognizable [4]. On the other hand, Bridson and Wilton showed that there is no algorithm to distinguish whether the fundamental group of a compact square complex (which has solvable word problem) has a non-trivial finite quotient [3]. Hence, deciding whether a group has trivial profinite completion is not recursive modulo word problem. I am interested in using geometric techniques to determine whether other group properties, particularly those satisfied by hyperbolic groups, are recursive modulo word problem.

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Viveka Erlandsson
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Curves on Hyperbolic Surfaces

My research interests are in hyperbolic geometry. During my PhD I was studied hyperbolic 4-manifolds, and recently I have become more interested in hyperbolic surfaces. Although I am still pursuing both these lines of research I will here concentrate on the latter.

In a joint project with Juan Souto (see [2]) we investigate the asymptotic growth of the number of multicurves with k self intersections as their length grow. More precisely, if γ_0 is a multicurve (possibly non-simple) on a hyperbolic surface Σ and $\mathcal{S}_{\gamma_0} = \mathrm{Map}(\Sigma) \cdot \gamma_0$ its mapping class orbit, we are interested in the number of curves of type γ_0 with length bounded by L and we study the limit

$$\lim_{L\to\infty} \frac{|\{\gamma \in \mathcal{S}_{\gamma_0} | \ell_\Sigma \leq L\}|}{L^{6g-6+2r}}.$$

In the case when γ_0 is simple the existence of this limit is due to Mirzakhani. We build on her result to show, among other things, that the limit exists for a general γ_0 in the case when Σ is homeomorphic to a once punctured torus.

Moreover, together with Federica Fanoni, we study the *multicurve graphs* of hyperbolic surfaces. These graphs can be seen as interpolating between the curve graph and the pants graph of the surface. We have been studying simplicial embeddings of these graphs and shown (under the right hypothesis) that such embeddings must be induced by embeddings of the underlying surfaces (see [1] for definitions and details). We are currently investigating some geometric properties of these graphs.

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Federica Fanoni
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(Hyperbolic) surfaces: curves and parameter spaces

In my research I focus on surfaces, often endowed with a hyperbolic structures, and their parameter spaces. In particular, I am interested in problems in three main topics: geometric properties of hyperbolic surfaces, systems of curves with some constraint and complexes associated to a surface. Here are some examples of questions I am interested in:

- For closed surfaces, there are constructions of hyperbolic surfaces with systoles (shortest closed geodesics) of length at least $4/3 \log g$ and the best known upper bound is of order $2 \log g$. Which is the right bound? Together with Hugo Parlier, we obtained in [1] bounds on lengths and number of systoles.
- What is the bound to the size of sets of curves pairwise intersecting at most some fixed number of times? What if we ask that they fill (cut the surface into disks or once-punctured disks)? An answer to the second question can be found in [2].
- Hyperbolic surfaces with a filling set of systoles form a subset of Teichmüller space, called Thurston set. What can we say about it?
- The multicurve graphs are graphs associated to a surface and interpolating between two known complexes, the curve complex and the pants graph. Which properties do they have? In [3], Viveka Erlandsson and I studied embeddings between these graphs.

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Carsten Feldkamp
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Magnus property for some special groups

I am a first year PhD student working under the supervision of Oleg Bogopolski and Benjamin Klopsch. The area I am mostly interested in is geometric group theory.

A group G possesses the *Magnus property* if for any two elements u, v of G with the same normal closures the element u is conjugated to v or v^{-1}. By $\pi_1(S_g^+)$ (resp. by $\pi_1(S_g^-)$) we denote the fundamental group of a closed orientable (resp. nonorientable) surface of genus $g \geqslant 1$. In [1] Oleg Bogopolski and Konstantin Sviridov proved as a corollary of their main theorem that every surface group $\pi_1(S_g^-)$ with $g \geqslant 4$ possesses the Magnus property. Leaving out the more or less trivial cases $\pi_1(S_1^-) = \langle\, x \,|\, x^2 \,\rangle$ and $\pi_1(S_2^-) = \langle\, x, y \,|\, x^2y^2 \,\rangle$, the question whether $\pi_1(S_3^-)$ possesses the Magnus property or not remained open. In my master's thesis [2] I proved, amongst others, the Magnus property of the remaining group $\pi_1(S_3^-)$ using the presentation $\pi_1(S_3^-) = \langle\, x, y, z \,|\, x^2y^2z^2 \,\rangle$. Note that the surface groups $\pi_1(S_g^+)$ and $\pi_1(S_g^-)$ are limit groups except of the cases: $\pi_1(S_g^-)$, $g = 1, 2, 3$.

In my PhD thesis I want to study Magnus theorems for abstract and profinite groups.

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Elia Fioravanti
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Actions on higher-rank symmetric spaces

I am first-year PhD student under the supervision of Cornelia Drutu.
As an undergraduate, I observed that the Teichmüller space of a hyperbolic surface S can be embedded in the space of efficient fundamental cycles of S (the terminology is that of [1]) and that this map exhibits an interesting boundary behaviour ([2]).
I am currently investigating the geometry of actions of linear groups on higher-rank symmetric spaces, especially those of infinite-covolume discrete groups of isometries, along the lines of the papers [3], [4] and [5].

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Dominik Francoeur
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Groups acting on rooted trees

Groups acting on rooted trees are a source of many interesting examples in group theory, such as infinite finitely generated groups, groups of intermediate growth or amenable but not elementary amenable groups.

I am currently interested in a family of self-similar branch groups first introduced by Šunić in [1] as close generalizations of the first Grigorchuk group. The torsion groups in this family are spinal groups and therefore have intermediate growth following a result of Bartholdi and Šunić ([2]), but the question of the growth of the non-torsion groups is still unresolved. I am also working on establishing which of these groups contain maximal subgroups of infinite index.

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Meridional rank vs bridge number

For any knot K we have the inequality $w(K) \leq b(K)$, where $b(K)$ denotes the bridge number of K and $w(K)$ denotes the minimal number of conjugates of the meridian needed to generate the knot group $\pi_1(S^3 - K)$. In [K] S. Cappell and J. Shaneson, as well as K. Murasugi, have asked if the equality $w(K) = b(K)$ holds for any knot K in S^3. This in known to be true for some family of knots due to work of various authors, see [1], [2], [4]. In our research we intend to make progress on this question by finding new classes of knots where the equality persists.

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Algorithms for the word problem in one-relator groups

The word problem of a group is to decide, given a word in a fixed generating set, whether or not it represents the trivial element. It is a classical result of Magnus [1] that one-relator groups have solvable word problem. Magnus' algorithm is however very slow, with time complexity not bounded by any finite tower of exponentials [2]). It has been conjectured by Myasnikov that one-relator groups have word problem solvable in polynomial time, perhaps even quadratic time [3]. The Dehn function of a group is a measure of the complexity of its word problem, and can be thought of as the time complexity of a naïve non-deterministic algorithm to solve the word problem. In fact, the word problem of a group is in NP if only if the group embeds in a group of polynomial Dehn function [4].

The Baumslag group $G = \langle\, a, b \,|\, a^{a^b} = a^2 \,\rangle$ has Dehn function $\mathrm{tower}_2(\log n)$, a tower of exponentials of growing length, which is conjectured to be the worst case among one-relator groups. In spite of its pathological Dehn function, this group has recently been shown to have word problem solvable in polynomial time [2]. The algorithm uses 'power circuits', a form of integer compression. I am working to use similar ideas from computer science along with standard geometric group theory techniques to solve the word problem in other one-relator groups in polynomial time.

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Łukasz Garncarek
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Geometric group theory and representations of groups

My scientific interests revolve around geometric group theory and representation theory of groups. In my PhD thesis [1] I investigate the *boundary representations* of hyperbolic groups. Let G be a hyperbolic group endowed with a hyperbolic invariant metric d, quasi-isometric to the word metric. This allows to equip the boundary of G with a *visual metric*, and the resulting Hausdorff measure μ, called the Patterson-Sullivan measure. In this way we obtain an action of G on a measure space $(\partial G, \mu)$, which preserves the class of μ, and can be promoted to a unitary representation on $L^2(\partial G, \mu)$. I proved that all these representations are irreducible, and classified them up to unitary equivalence.

Earlier, I investigated representations of some diffeomorphism groups [2], and Thompson's groups [3]. During this project I made a little excursion into harmonic analysis on Lie groups [4]. Among my other interests, there is also property RD—a certain estimate on the operator norm of convolution operators on a group [5].

Recently, I was interested in von Neumann algebras related to Hecke algebras of Coxeter groups [6].

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Ilya Gekhtman
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Teichmuller Dynamics, Patterson-Sullivan theory, and Random Walks on Groups with Hyperbolic Properties

I am interested in geometric group theory and dynamical systems. I completed my Ph.D under Prof. Alex Eskin at the University of Chicago. My thesis was on the dynamics of convex cocompact subgroups of mapping class groups. For a convex cocompact subgroup $G < Mod(S)$ of a mapping class group I constructed an analogue of the Patterson-Sullivan measure on the boundary PMF of Teichmueller space, and used this to constrct the measure of maximal entropy on a suitable infinite cover of moduli space. I showed that this measure is mixing, and used it to compute precise multiplicative asymptotics for orbit growth of G in the TeichmÃijller metric. As a step, I showed that the logarithms of the dilatations of pseudo-Anosov elements of any nonelementary subgroup of the mapping class group generates a dense subgroup of $\mathbb{R}$. The associated paper [1] is under review in Geometry and Topology. In other work, [2] I proved that the action of the mapping class group on PMF has stable type III_λ for some $\lambda > 0$. In recent work I also prove the same for geometrically finite subgroups of isometries of $CAT(-1)$ spaces. This is a key step in proving certain pontwise ergodic theorems for these spaces, following the work of Bowen and Nevo. In ongoing work joint with Samuel Taylor and Giulio Tiozzo, we show that for any nonelementary action of a hyperbolic group on a Gromov hyperbolic space, typical (with respect to the Patterson-Sullivan measure) word geodesics sublinearly track space geodesics and the proportion of elements in a ball of radius R in the word metric that act loxodromically goes to 1 as R grows. I am also working on a project (with Leonid Potyagailo and Wenyuan Yang) that relates the Martin and Floyd boundaries of relatively hyperbolic groups.

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Thibault Godin
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Mealy Machines: Decision Problems and Random Generation

My research lies between *(geometrical-)group theory* and *automata theory*. *Mealy machines* – a special type of automaton, can be seen as (semi-)groups of automorphisms acting on the k-ary rooted tree (see [2, 4]). It is interesting to look at these groups (so-called *automaton groups*) and their properties, especially since counter-examples to important group theoretical conjectures arose as automaton groups.
I am part of the project MealyM, which has two main axes. First, respond to theoretical (semi-)group problems using computer science techniques, along with classical geometrical group techniques [1], and secondly to use Mealy machines to generate random (semi-)groups, either finite or infinite.
A Mealy automaton is a letter-to-letter deterministic transducer, given by $\mathcal{A} = (Q, \Sigma, \{\delta_i : Q \to Q\}_{i\in\Sigma}, \{\rho_q : \Sigma \to \Sigma\}_{q\in Q})$ where Q is the stateset, Σ is the alphabet, δ_i is the transition function associated to the letter i and ρ_q the production function associated to the state q. If the automaton reads a letter i in state q then it goes to state $\delta_i(q)$ and produces the letter $\rho_q(i)$. The semi-group generated by $\mathcal{A}$ is $\langle \rho_q, q \in Q\rangle_+$. Moreover, if the production functions are permutations of the stateset – the automaton is said to be *invertible* – then one can consider the group generated $\langle \rho_q, q \in Q\rangle$.
One can ask what happens when adding structure, requiring that the transition functions are permutations of the alphabet – the automaton is said to be *reversible*, or that output letters induce permutations of the stateset – coreversible automaton.

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Moritz Gruber
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Large Scale Geometry of Carnot Groups

My research is concerned with the large scale geometry of lie groups and other metric spaces. Filling invariants of *Carnot groups* are of special interest for me. These groups are nilpotent lie groups G which allow a grading of their lie algebra $\mathfrak{g} = V_1 \oplus V_2 \oplus \cdots \oplus V_c$, where c denotes the nilpotency-class of G and $[V_1, V_i] = V_{i+1}$ with $V_m = 0$ for $m > c$. For example, every 2-step nilpotent lie group is a Carnot group.
The filling invariants I'm most interested in, are the *filling functions* and the *higher divergence functions*. The former measure, roughly speaking, how difficult it is to fill a k-cycle with a $(k+1)$-chain, while the latter do the same with the additional condition for the cycle and the chain to avoid an r-ball around a basepoint, where r is proportional to the k^{th}-root of the volume of the cycle. This two quantities are invariant under quasi-isometries and hence, by the lemma of Švarc-Milnor, make sense for combinatorial groups.

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Thomas Haettel
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Artin groups, lattices and nonpositive curvature

R. Charney asks wether all Artin groups may be CAT(0). With D. Kielak and P. Schwer ([1]), we proved that the n-strand braid group is CAT(0) for $n \leq 6$, using the construction of T. Brady and J. McCammond ([2, 3]). It involves the geometry of spherical buildings and the lattice of noncrossing partitions.

Right-angled Artin groups are well-known to act geometrically on a CAT(0) cube complex, the Salvetti complex. But for more general Artin groups, knowing which ones act nicely on CAT(0) cube complex is an open question. In a recent work, I study which Artin groups act geometrically on a CAT(0) cube complex. But even for the 4-strand braid group, it is still unknown if it has the Haagerup property, or even if it acts properly on a CAT(0) cube complex.

B. Bowditch proposed a generalization of nonpositive curvature, by defining coarse median spaces and groups ([4, 5]). For instance, hyperbolic groups, cubical groups and mapping class groups are coarse median. Answering a question of B. Bowditch, I proved that higher rank lattices are not coarse median ([6]). As a corollary, we get that higher rank symmetric spaces or Euclidean buildings are not quasi-isometric to CAT(0) cube complexes.

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Sahana Hassan Balasubramanya
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Acylindrical group actions on quasi-trees

A group G is called *acylindrically hyperbolic* if it admits a non-elementary acylindrical action on a hyperbolic space. This class is broad enough to include many examples of interest, e.g., non-elementary hyperbolic and relatively hyperbolic groups, $Out(F_n)$, etc. The main goal of my research was to answer the following: *Which groups admit non-elementary cobounded acylindrical actions on quasi-trees?*(By a quasi-tree I mean a connected graph quasi-isometric to a tree, which form a subclass of hyperbolic spaces)

My motivation comes from the following easy observation. If instead of cobounded acylindrical actions we consider cobounded proper (i.e., geometric) ones, there is a crucial difference between the groups acting on hyperbolic spaces and quasi-trees. Indeed a group G acts geometrically on a hyperbolic space if and only if G is a hyperbolic group. On the other hand, Stallings theorem on groups with infinitely many ends implies that groups admitting geometric actions on quasi-trees are exactly virtually free groups. Thus one could expect that the answer to the above would produce a proper subclass of the class of all acylindrically hyperbolic groups, which generalizes virtually free groups in the same sense as acylindrically hyperbolic groups generalize hyperbolic groups. My main result (stated below), in joint work with my advisor, Denis Osin, shows that this does not happen.

Theorem: *Every acylindrically hyperbolic group admits a non-elementary cobounded acylindrical action on a quasi-tree.*

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Tobias Hartnick
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Bounded cohomology of Lie groups and their discrete subgroups

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The bounded cohomology ring $H_b^\bullet(\Gamma;\mathbb{R})$ of a group Γ is a very powerful invariant, but unfortunately very hard to compute. In fact, there is not a single group for which it is known except for those cases where it is known to be 0. If Γ is a lattice in a Lie group G, then $H_b^\bullet(\Gamma;\mathbb{R})$ is related to the continuous bounded cohomology $H_{cb}^\bullet(G;V)$ of the ambient group G with respect to various coefficents modules V. So, as a first step towards understanding the bounded cohomology of lattices, one can try to understand as much as possible about the continuous bounded cohomology of Lie groups.

There has been a lot of progress concerning continuous bounded cohomology of Lie groups over the last decade, but sadly we still do not even know $H_{cb}^5(\mathrm{SL}_2(\mathbb{R});\mathbb{R})$. There is a complete conjectural picture though, which predicts the structure of the ring $H_{cb}^\bullet(G;\mathbb{R})$ for any Lie group G. The key open problem is to prove that for simple Lie groups G, the comparison map $H_{cb}^\bullet(G;\mathbb{R}) \to H_c^\bullet(G;\mathbb{R})$ into the continuous cohomology is an isomorphism. With various co-authors I work on different aspects of this conjecture. While there is good progress towards surjectivity of the comparison map, we understand still very little concerning injectivity.

Since the best understood case so far is that of $\mathrm{SL}_2(\mathbb{R})$ (where the conjectured isomorphism is proved in degrees ≤ 4) one would like to apply these results to the study of lattices in $\mathrm{SL}_2(\mathbb{R})$ and in particular to free groups. Recent work of Lewis Bowen gives some evidence that a certain part of the bounded cohomology of free groups in even degrees ≥ 4 might vanish. Bowen's argument uses L^2-Betti numbers and Benjamini-Schramm convergence. It has long been conjectured that L^2-Betti numbers are related to bounded cohomology, but the precise nature of the relation remains unclear. So far, the behaviour of bounded cohomology under Benjamini-Schramm limits has not been investigated, and I would be very interested in any results in this direction.

Simon Heil
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Systems of equations in hyperbolic groups and formal solutions

Solutions to systems of equations in particular groups have been widely studied in the past decades. Makanin constructed an algorithm to solve a system of equations in free groups and Razborov gave a complete description of the solution set of such a system. This algorithm played a crucial role in the celebrated proof of the Tarski conjectures which was done independently by Sela [2] and Kharlampovich/Miasnikov [1]. While Kharlampovich/Miasnikov used their own version of Makanin's algorithm, Sela used a more geometrical approach which both result in a finite tree, known as the Makanin-Razborov diagram, which describes in some sense all homomorphisms from a finitely generated group G into a free group.
Limit groups (also known as fully residually free groups) also play an important rule in Sela's proof. Sela not only proofed the Tarski conjectures for free groups, but also settled the question of the elementary equivalence for torsion-free hyperbolic groups, i.e. the question which groups have the same first-order theory as a given torsion-free hyperbolic group [3].
On the one hand I am trying to prove separability properties for limit groups, using properties of the MR diagram. On the other hand I am interested in the question if one can remove the torsion-freeness assumptions in Sela's proofs and still get a valid result. For example in the construction of the MR diagram over a hyperbolic group and in the proof of the existence of so-called formal solutions one has to address a lot of additional issues when dealing with torsion.

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Julia Heller
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Noncrossing Partitions, Buildings and the Braid Group

I am a second year PhD student under the supervision of Petra Schwer. In my PhD project, I want to find out whether the braid groups B_n are CAT(0) groups for all n. This is a conjecture stated by Brady and McCammond [2] and verified for $n \leq 6$ [2],[3].

A group is a CAT(0) group if it acts nicely on a CAT(0) space. In the case of the braid group, one considers the action on the Brady complex [1], which is an Eilenberg-MacLane space. To find out whether this single-vertex complex is locally CAT(0), one examines the equivalent question whether the link complex Δ is CAT(1). There exists a nice combinatorial description of Δ, since it is the order complex of the noncrossing partition lattice. The fact that Δ can be viewed as a subcomplex of a spherical building enabels us to use the well known building language to better understand Δ. As a byproduct of the investigation of the complex Δ, we also get information about the noncrossing partition lattice, that is interesting from the combinatorial point of view.

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Separability properties of groups

There are several different separability properties for groups. For example the residually finiteness, the locally extendable residually finiteness (also known as subgroup separability) and the conjugacy separability. Any of these properties can be "translated" into the "language" of the profinite topology of the corresponding group. As well as the relatively new subgroup conjugacy separability property: A group G is called subgroup conjugacy separable (SCS), if for any two finitely generated non-conjugated subgroups $U_1, U_2 \leq G$, there exists a homomorphism φ from G to a finite group E such that $\varphi(U_1)$ and $\varphi(U_2)$ are not conjugate in E. Although all of these separability properties belong to my field of interest, I am investigating at the moment several groups whether they are SCS or not. For example groups which can be regarded as fundamental groups of several graph of groups. Some techniques which are usable for establishing the SCS-property for groups can be looked-up in the papers below, where it is proven that fundamental groups of closed compact surfaces are SCS [1] as well as all virtually free groups [2][3].

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Sebastian Hensel
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Low-dimensional Topology and Mapping Class Groups

My research interest lies in the intersection of low-dimensional topology and geometric group theory. Broadly speaking, I am interested in everything that involves a mapping class group somewhere – be it of a surface, a handlebody, a doubled handlebody or something else entirely.

Recently, I have been particularly interested in the geometry of curve graphs and their analogs (arc, sphere and disk graphs). With Piotr Przytycki and Richard Webb [4] I found a new and short proof of hyperbolicity of curve and arc graphs with small uniform constants. In joint work with Piotr Przytycki and Damian Osajda [3] I developed a version of dismantlability for arc, sphere and disk graphs, which has various impliciations. As an example, it implies Nielsen realisation type results in all these settings with a unified proof, and can be used to show that very natural candidates are in fact classifying spaces for proper actions for mapping class groups.

Currently, I am also investigating Nielsen realisation for outer automorphism groups of RAAGs in joint work with Dawid Kielak [2, 3].

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Nicolaus Heuer
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Quasihomomorphisms

I am a first year Ph.D. student working under Martin Bridson. I am currently working on quasihomomorphisms (QHM) with noncommutative target for which [1] is the main reference. A quasihomomorphism is a map between groups $f : G \to H$ s.t. the defect

$$D(f) = \{f(h)^{-1}f(g)-1f(gh); g, h \in G\}$$

is finite. Trivial QHM are bounded maps and homomorphisms. QHM are very rigid. For example, QHM to torsion free hyperbolic groups are either trivial or map to a cyclic subgroup ([1]). I characterised QHM to symmetric spaces of rank 1. In this case, QHM either act as homomorphisms restricted to a totally geodesic submanifold, are bounded, restrict to a geodesic or map to a parabolic subgroup. I have also characterised QHM with various preimages, s.t. abelian and free groups. I want to generalise these results to higher rank symmetric spaces and linear groups.
Let Δ be the group generated by $D(f)$. There is a connection with QHM and finite maps of automorphisms of Δ. When f acts via conjugation on Δ it gives rise to a finite map $G \to Aut(\Delta)$ that induces a homomorphism $G \to Out(\Delta)$. In some cases, e.g. when Δ has no center, the converse holds. I want to investigate this relation.

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Christoph Hilmes
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CAT(0) spaces

I attend the lecture course "Geometric group theory" by Linus Kramer in Münster. I am interested in the intersection of group theory with algebraic topology.
Also I attend the lecture course "CAT(0) cube complexes" by Olga Varghese. We study the geometry of CAT(0) spaces and group actions on these spaces.

Mikhail Hlushchanka
(Jacobs University Bremen, Germany)

Iterated Monodromy Groups in Holomorphic Dynamics

The aim of my PhD project is to study the connection between dynamical systems, geometry, and algebra in terms of an algebraic object called the *iterated monodromy group* (IMG). This is a self-similar group $\mathrm{IMG}(f)$ associated to every branched covering $f : \mathcal{M} \to \mathcal{M}$ of a topological space $\mathcal{M}$ (in particularly to every postcritically finite rational map on $\widehat{\mathbb{C}}$), introduced by Nekrashevych. IMG encodes in a computationally efficient way combinatorial information about the map f and its dynamics [Nek05].

It was observed that even very simple maps generate groups with complicated structure and exotic properties which are hard to find among groups defined by more "classical" methods. For instance, $\mathrm{IMG}(z^2 + i)$ is a group of intermediate growth [BP06] and $\mathrm{IMG}(z^2 - 1)$ is an amenable group of exponential growth [GrZ02, BarV05]. Unfortunately, we still face a lack of general theory which would unify and explain these nice examples.

Recently, we managed to provide examples of two families of rational maps whose IMGs have exponential growth. The Julia sets of these rational maps are given either by the whole Riemann sphere or a Sierpiński carpet. The latter imply that the obtained examples are beyond the available methods of construction from [Nek05]. Remarkably, the proofs use the "geometry" of the tilings which are associated to the maps, obtained in [BM].

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Camille Horbez
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Geometry of Out(F_N), automorphisms of free products, random walks on mapping class groups and Out(F_N)

My research concentrates on the group Out(F_N) of outer automorphisms of a finitely generated free group, studied in analogy to mapping class groups, via its action on various topological spaces such as Culler–Vogtmann's outer space, or hyperbolic analogues of the curve complex. A *leitmotiv* in my research consists in investigating the geometry *at infinity* of these various spaces, with a view towards understanding algebraic properties of Out(F_N).

In my thesis, I established a version of the Tits alternative for the automorphism group of a free product, providing in particular a new proof of the Tits alternative for Out(F_N) (originally due to Bestvina–Feighn–Handel): every subgroup of Out(F_N) either contains a nonabelian free subgroup, or is virtually solvable. The techniques I used involve arguments coming from the theory of random walks on groups. One of my current goals is to develop these techniques to get more precise classification results for subgroups of the automorphism group of a free product of countable groups.

I am also interested in random walks – or more general ergodic processes – on mapping class groups and Out(F_N), especially through the question of understanding the typical growth of curves on a surface under random products of mapping classes, or of conjugacy classes of a free group under random products of automorphisms.

Jingyin Huang
(McGill University, Canada)

Geometry and rigidity of right-angled Artin groups

My research is motivated by the following 2 questions. (1) Given two RAAGs G_1 and G_2, when are they quasi-isometric? (2) Let G be a RAAG and let H be any group quasi-isometric to H, is H commensurable to G?

For question (1), it turns out that if both G_1 and G_2 have finite outer automorphism group, then they are quasi-isometric if and only if they are isomorphic [Hua14]. For question (2), currently I can show that if G belongs to a certain class of 2-dimensional RAAGs, then H is quasi-isometric to G if and only if H is commensurable to G. The proof of such results is closely related to following topics.

(1) Quasi-isometry invariants for CAT(0) spaces. If the underlying space is Gromov-hyperbolic, then its boundary is a natural quasi-isometry invariants. In general it is not true for non-hyperbolic spaces. Here we turn to the of quasiflats of maximum rank in CAT(0) spaces, and study their regularity. This provides us a quasi-isometry invariant which is robust enough in the case of RAAGs.

(2) Structure of right-angled building. The right-angled building associated with a RAAG G turns out to be an important link between the asymptotic geometry of G and the combinatorial structure of G.

(3) Rigidity of lattice. The examples provided in [BM00, Wis96] about lattices in product of trees are one of the obstructions for question (2). And I am interested in whether such phenomenon has its analogue in more general RAAGs.

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Bryan Jacobson
(Vanderbilt University, USA)

Equations in acylindrically hyperbolic groups

I am a third year PhD student working under Denis Osin. My research is focused on problems related to equations in acylindrically hyperbolic groups.

A group G is called acylindrically hyperbolic if it admits an acylindrical action on a hyperbolic space S such that the limit set of G on the Gromov boundary ∂S contains more than two points. (See [1] for equivalent definitions.) In acylindrically hyperbolic groups, we have several features at our disposal (e.g. properties of loxodromic elements, particular collections of hyperbolically embedded subgroups, etc.) that can help us to use our knowledge about particular solutions to an equation to obtain information about either the coefficients of the equation or other solutions.

A subset S of a group G is called algebraic if it is closed under the Zariski topology on G (or verbal topology as in [2]); that is, S is algebraic if and only if it can be written as a finite union of solution sets to systems of (single-variable) equations in G. Basic examples of algebraic subsets include finite subsets and centralizers of subsets. Recently, I was able to show that given an acylindrically hyperbolic group G, a non-elementary subgroup H of G is algebraic if and only if it is a virtual centralizer of some finite subgroup of G.

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Kasia Jankiewicz
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Cubulating Artin groups

I work in geometric group theory. My research interests include CAT(0) cube complexes, Artin and Coxeter groups and random groups.

A group is cocompactly cubulated if it acts properly and cocompactly by combinatorial automorphisms on a CAT(0) cube complex. Given a graph Γ with vertex set S and with each edge (s,t) labelled by an integer $m_{st} = m_{ts} \geq 2$, the Artin group $A(\Gamma)$ is given by the presentation $\{S \mid \underbrace{sts\ldots}_{m_{st}} = \underbrace{tst\ldots}_{m_{ts}}\}$. The Artin group $A(\Gamma)$ is 2-dimensional if the Davis complex of the Coxeter group defined by Γ is 2-dimensional.

In joint work with Piotr Przytycki and Jingyin Huang, we give a characterization of cocompactly cubulated 2-dimensional Artin groups, in terms of their defining graphs. More precisely, we prove that for a 2-dimensional Artin group $A(\Gamma)$ the following conditions are equivalent:

- $A(\Gamma)$ is cocompactly cubulated,
- $A(\Gamma)$ has a finite index subgroup that is cocompactly cubulated,
- each connected component of Γ is either
  - a vertex, or an edge, or else
  - all its leaves are labelled by even numbers, and all the other edges are labeled by 2.

The question of which Artin groups act properly but not necesserily cocompactly on a CAT(0) cube complex remains open. In further work, I would like to answer this question.

Arpan Kabiraj
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Curves in hyperbolic surface and the Goldman Lie algebra

Given two oriented closed curves x and y in an oriented surface F, the Goldman bracket [3] between x and y is the signed sum of the free homotopy classes of the loop products of x and y at each intersection point. It becomes a well defined Lie bracket on the free vector space generated by the free homotopy classes of oriented closed curves on F, when extended linearly. This Lie algebra is known as the Goldman Lie algebra.

In my dissertation, I have proved the following result, conjectured by Chas and Sullivan.

Theorem[1] *The center of the Goldman Lie algebra of any closed orientable surface F is one dimensional and is generated by the class of the trivial loop. If F is an orientable surface of finite type with boundary then the center of the Goldman Lie algebra is generated by the set of all free homotopy classes of oriented closed curves which are either homotopic to a point or homotopic to a boundary component or a puncture.*

A pair of free homotopy classes of closed curves in an hyperbolic surface F are said to be length equivalent if for any hyperbolic structure on F, the length of the geodesic representative of one class is equal to the length of the geodesic representative of the other class.

In [2], I have constructed infinitely many pairs of length equivalent curves in an orientable hyperbolic surface. My construction shows that given a self intersecting geodesic α on F and any self-intersection point P of α we can obtain an infinite sequence of such pairs. I have also related these examples with the terms of Goldman bracket.

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Holger Kammeyer
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ℓ^2-invariants of spaces and groups

It has proven to be a successful idea to lift classical topological invariants of a compact space (Betti numbers, Reidemeister torsion) to refined invariants on the universal covering (ℓ^2-Betti numbers, ℓ^2-torsion). Unless the fundamental group is finite this requires dealing with noncompact spaces and functional analytic tools (group von Neumann algebras) are required to handle them. I am particularly interested in the case of locally symmetric spaces where the invariants depend on the group only and reveal interesting information about lattices in semisimple Lie groups [1]. Another question of interest asks whether ℓ^2-invariants can be recovered asymptotically from their classical counterparts. For ℓ^2-Betti numbers this question has a long history and a variety of approximation results are known by now. The approximation theory of ℓ^2-torsion is way more mysterious and intriguing. It has consequences for torsion growth in homology which are also of number theoretic interest, particularly so in the case of arithmetic groups. I have started to investigate approximation questions for Novikov–Shubin numbers which capture the difference of reduced and unreduced ℓ^2-cohomology and can also be seen as a generalization of the growth rate of groups [2].

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Dawid Kielak
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Nielsen realisation problems and group algebras

I am very much interested in the Nielsen Realisation problem: given a group G and a finite subgroup $H \leqslant \mathrm{Out}(G)$, can we find a metric $K(G,1)$ on which H acts in a way realising the embedding $H \leqslant \mathrm{Out}(G)$? The answer is known to be positive for many groups, including surface groups, as well as finitely generated free and free-abelian groups. Together with Sebastian Hensel we are trying to answer this question for right-angled Artin groups (RAAGs) (building on [2]) and for limit groups (using some of the ideas of [3]).

I am also interested in various questions related to the structure of group algebras. Together with Stefan Witzel we are trying to establish whether any two elements of the group algebra of Thompson's group F over the field of two elements admit a left common multiple. This is known to hold for amenable groups, and so a negative answer would prove non-amenability of F.

Together with Florian Funke we are trying to extend a result of McMullen [5] to the setting of free-by-cyclic groups; we would like to show that for such groups the Alexander norm provides a lower bound for the Thurston norm (defined in this generality by Friedl and Lück in [1]). Our approach revolves around studying determinants for matrices over group algebras.

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Steffen Kionke
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Zeta functions of representations of profinite groups

Consider a compact p-adic Lie group G, for example, the special linear group $G = \mathrm{SL}_n(\mathbb{Z}_p)$ over the p-adic integers $\mathbb{Z}_p$. In general such a group has infinitely many distinct continuous irreducible representations over $\mathbb{C}$ and it is a difficult problem to understand these representations. For instance: How many irreducible representations of dimension d does G admit?

Let $r_d(G)$ denote the number of d-dimensional irreducible representations of G. In the field of *representation growth* one tries to understand the asymptotic behaviour of the numbers $r_d(G)$ as d tends to infinity by considering the Dirichlet generating series of these numbers – the so-called representation zeta function. For the group $G = \mathrm{SL}_3(\mathbb{Z}_p)$ this was extensively studied by Avni, Klopsch, Onn and Voll in [1]. However, already for $G = \mathrm{SL}_4(\mathbb{Z}_p)$ the problem appears to be out of reach.

In a joint research project with Benjamin Klopsch we approach the problem from a different perspective by associating a zeta function to every (possibly infinite dimensional) admissible representation of G. The zeta function encodes the irreducible constituents and their multiplicities. We study the behaviour of these zeta functions under different algebraic operations such as induction, restriction and tensor products. This generalizes the above problem and can be understood as counting some (instead of all) representations (see [2]).

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Svenja Knopf
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Beyond Relative Hyperbolicity: Acylindrical Group Actions and the Farrell-Jones Conjecture

I am a 4th year PhD student utilizing geometric group theory to contribute to the long list of groups the Farrell-Jones Conjecture [3] is known for.

Bartels and Lück have shown that the K- and L-theoretic Farrell-Jones Conjecture (FJC) holds for hyperbolic and CAT(0)-groups [1] and lately Bartels [2] showed that the conjecture also holds for (strong) relatively hyperbolic groups if FJC is already known for the peripheral subgroups.

A group is said to act *acylindrically* on a metric graph if there is a k such that the stabiliser of any geodesic segment of length k is finite. The notion of a group acting acylindrically on a fine hyperbolic graph is a generalization of relative hyperbolicity. It is my goal to adapt the methods of [2] to prove that FJC holds for a group acting acylindrically and cocompactly on a fine hyperbolic graph provided that FJC is already known for all vertex groups. This begs the question how to construct such groups. While it is easy to form an amalgamated free product that acts acylindrically on its Bass-Serre tree, the following two questions seem to be open:

Question: When is the amalgamated free product of two (relatively) hyperbolic groups NOT again relatively hyperbolic?

Question: Is there a finitely generated group that is not (known to be) relatively hyperbolic, but acts (minimally, cocompactly and) acylindrically on a (fine) hyperbolic graph?

I would be very interested in discussing any of these questions.

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Roman Kogan
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Measures associated with actions of finite automata and their Schreier graphs

My research is currently focused on Mealy automata and their Schreier grpahs. There are two projects I am working on:

1. Given a transitive action of a Mealy machine A on the standard binary tree, one can, for a Mealy machine B consider the distribution of (directed graph) distances by which the vertices of the tree on a given level are moved by B in the cycle generated by the action of A. This, in some cases, gives rise to a shift-invariant measure (suggested by Y. Vorobets) with interesting properties.

   The long-term goal is to use these properties to show linearity of the Schreier graph of the Aleshin automaton (shown to be quadratic by Pak and Malyshev in [1]).

2. Given a Markov measure, what is its pushforward by the action of a Mealy machine? What are the generalizations? (The question was answered for Bernoulli measures by Kravchenko in [2])

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Juhani Koivisto
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Analysis on metric spaces with applications to GGT

Sobolev inequalities and amenability We have established a connection between the vanishing of uniformly finite homology by J. Block and S. Weinberger, amenability, and $(1, 1)$-Sobolev inequalities for a large class of metric measure spaces; and more generally controlled coarse homology by P. W. Nowak and J. Špakula, and weighted $(1, 1)$-Sobolev inequalities [3]. In particular, we have proved that the fundamental class vanishes in the controlled coarse homology if the Gromov boundary is connected and uncountable [4]. This has applications for both geometric amenability of LCCG groups, and analysis on metric spaces. To name one, we have obtained a solution for the asymptotic Dirichlet problem replacing an earlier $(1, 1)$-Sobolev inequality assumption [1] by the above boundary condition .

Kazhdan property (T) and rigidity of groups Our results so far include developing L^p-cohomology over reflexive Banach spaces generalising the L^2-cohomology over Hilbert spaces by W. Ballman and J. Świątkowski. As an application, we have obtained a spectral condition for uniformly bounded representations on Hilbert spaces [2]. A spectral condition for isometric representations on reflexive Banach spaces is part of ongoing work.

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Jan-Bernhard Kordaß
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Moduli spaces of Riemannian Metrics with Curvature Bounds

It is a well-known fact that the space of riemannian metrics over a smooth manifold is a cone, whereas it is a relatively new result that if one restricts to metrics of a certain curvature behaviour (e.g. positive scalar curvature), the topological structure can be very difficult (e.g. in [BER14] the non-triviality of certain higher homotopy groups is shown). The quotients of these spaces of metrics under the action of the diffeomorphism group are referred to as moduli spaces. For my recently started Ph.D., I am considering moduli spaces with lower curvature bounds of various kind. In particular, I am interested in the topic's connection to index theory in the case of positive scalar curvature, as indicated by the results of Kreck and Stolz [KS93], and to the existence of non-diffeomorphic souls on open manifolds in the case of non-negative sectional curvature (cf. [KPT05]).

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Yannick M. Krifka
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Volume Rigidity

I am just about to finish my master's degree at the university of Heidelberg under the supervision of Prof. Wienhard. After that I am going to start my PhD position at the ETH Zurich with Prof. Iozzi as my advisor.

My master's thesis works out the details of [1]. The main result of [1] is the so called *volume rigidity theorem*, which can be regarded as a generalization of Mostow's rigidity theorem for finite volume hyperbolic manifolds of dimension at least three. To every lattice embedding $i\colon \Gamma \hookrightarrow \mathrm{Isom}^+(\mathbb{H}^n)$ and any representation $\rho\colon \Gamma \to \mathrm{Isom}^+(\mathbb{H}^n)$ ($n \geq 3$) we associate a real number $\mathrm{Vol}(\rho)$, the so called volume of ρ. The definition of $\mathrm{Vol}(\cdot)$ is by means of bounded cohomology and is reminiscent of the Toledo invariant of surface group representations [2]. Now the volume rigidity theorem asserts, that

$$|\mathrm{Vol}(\rho)| \leq |\mathrm{Vol}(i)| = \mathrm{Vol}(M),$$

where $M = i(\Gamma)\backslash\mathbb{H}^n$. Moreover equality holds, if and only if there is an isometry conjugating i and ρ.

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Ronja Kuhne
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Computational complexity of the homeomorphism problem restricted to Seifert fibered spaces

Due to Perelman's recent proof of Thurston's geometrization conjecture the homeomorphism problem for three-dimensional manifolds (that is deciding whether two compact three-manifolds are homeomorphic) is known to be decidable. However, the exact computational complexity of the homeomorphism problem is still open.

As a first-year PhD student under the supervision of Saul Schleimer and Brian Bowditch I plan to study the computational complexity of the homeomorphism problem when restricted to the class of Seifert fibered spaces. These three-dimensional manifolds, which can be thought of as a kind of bundle over two-dimensional orbifolds with fiber the circle, have been analysed both from the topological and geometric point of view (see for example Scott's article [1]). I aim to use the existing recognition algorithms for small Seifert fibered spaces presented by Rubinstein (cf. [2]) and Li (cf. [3]) to prove that the Seifert fibered space recognition problem lies in the complexity class NP, which consists of all decision problems whose *true*-instances can be verified in polynomial time by a non-deterministic Turing machine.

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Nir Lazarovich
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From trees to CAT(0) cube complexes

CAT(0) cube complexes can be seen as higher dimensional generalizations of trees, and, as such, exhibit much of the structure found in trees. In view of this analogy, my research focuses, among other things, on finding higher dimensional analogues of tools which were introduced in the study of trees, and applying them to CAT(0) cube complexes and the groups which act on them.

- Uniquely determined regular CAT(0) complexes, i.e complexes which are uniquely determined by the condition of having the same link at each vertex, and their automorphism groups (See [2, 3]).
- Dunwoody resolutions for CAT(0) cube complexes, finding bounds for the number of tracks in higher dimensional patterns and their applications to geometric group theory and low dimensional topology. (Joint with B. Beeker [1])
- Stallings foldings for CAT(0) cube complexes and their application to quasiconvex subgroups in cubulated hyperbolic groups. (Work in progress with B. Beeker)
- Detecting hyperbolic groups with $\mathbb{S}^2$ boundaries. (Work in progress with B. Beeker)

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Nils Leder
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Homological stability

I have started my PhD studies this year (advisor: Prof. Linus Kramer).
In my Master thesis, I considered homological stability for spherical Coxeter groups. Using stability results for symmetric groups (viewn as the Coxeter groups of type A_n) by Moritz Kerz [2], I was able to prove the following result about homological stability for Coxeter groups of diagram C_n and D_n:

Let $n \in \mathbb{N}, n \geq 2$ and W_{n+1}, W_n be Coxeter groups of diagram C_{n+1} resp. C_n or of diagram D_{n+1} resp. D_n. Then, for $n > 2k + 1$ we have

$$H_k(W_{n+1}, W_n) = 0 \ .$$

The main tool in the proof is the *stability pair spectral sequence* developed by Jan Essert in [1]. This is a spectral sequence which converges to 0 and involves the relative homology groups $H_k(W_{n+1}, W_n)$ on the first page.
I am still working on the question whether the homological stability for the symmetric groups can also be deduced from the associated stability pair spectral sequence (and induction).
Moreover, I am interested in bounded cohomology and especially in its connection to quasi-morphisms as studied in [3]

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Eon-Kyung Lee
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Braid groups and right-angled Artin groups

The braid group B_n is an infinite group which is interpreted geometrically with n strands and has the natural epimorphism to the n symmetric group. Braid groups are connected to knot theory, since any knot may be represented as the closure of a certain braid. These groups are also related to mapping class groups, since the braid group B_n is isomorphic to the mapping class group of a punctured disk with n punctures. I have studied braid groups with major interest in the structural properties of conjugacy classes.

As a natural generalization of braid groups Artin groups arose. These groups span a wide range of groups and have strong connection with geometry. I am interested in Artin groups, especially in constructing Garside structures on them.

Right-angled Artin groups (RAAGs) are those Artin groups. These groups are defined by means of graphs. They have attracted much interest in geometric group theory due to their actions on CAT(0) cube complexes. It is known that any RAAG embeds in a RAAG of a tree, which implies that any RAAG embeds in a braid group. I am interested in RAAGs, especially embeddibility between them.

Sang-Jin Lee
(Konkuk University, Korea)

Braid groups, Artin groups and Garside groups

I have studied the conjugacy problem in the Garside groups. Garside group is a lattice-theoretic generalization of finite type Artin groups. I am interested in general Garside groups, but also concerned with algebraic and geometric properties of particular Garside groups such as the Artin groups of finite type and the braid groups associated to the complex reflection groups.

Recently, Eon-Kyung Lee and I investigated the discreteness of the translation numbers in Garside groups, showing that, in terms of the properties of translation numbers, Garside groups are as good as word hyperbolic group. We also studied some related topics in the braid groups and the Artin groups.

I am also interested in the geometric group theoretic approaches to the braid groups and the Artin groups of finite type.

Arielle Leitner
(Technion, Israel Institute of Technology, Israel)

Limits Under Conjugacy of the Diagonal Cartan Subgroup in $SL(n, \mathbb{R})$, and Generalized Cusps on Convex Projective Manifolds

A geometric transition is a continuous path of geometries which abruptly changes type in the limit. The most intuitive example is from spherical to Euclidean geometry: imagine blowing up a sphere so that eventually it becomes so large, it looks like a plane [2].

I study limits of conjugacies of the diagonal Cartan subgroup in $SL(n, \mathbb{R})$. In $SL(3, \mathbb{R})$, there are 5 limit groups up to conjugacy [4, 5], determined by degenerate triangles. For $n \leq 5$, there are finitely many limit groups in $SL(n, \mathbb{R})$ up to conjugacy, but for $n > 6$, there is a continuum of non-conjugate limits of the Cartan subgroup [7].

When is it possible to deform a convex projective structure on a manifold and get new convex projective structures? The ends of the manifold must have the structure of generalized cusps [3]. I have classified generalized cusps on convex projective manifolds in dimension 3 [6]. I am working with Ballas and Cooper on dimension n [1].

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Ivan Levcovitz
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Divergence in Groups

My research interests lie in geometric group theory, low-dimensional topology and hyperbolic geometric. More specifically, I am interested in questions relating to quasi-isometry invariants of groups, quasi-isometric classification/rigidity, CAT(0) geometry, relatively hyperbolic groups and Coxeter groups.

Divergence in groups has particularly drawn my attention. Roughly speaking, divergence is a measure of how quickly geodesics stray apart from one another in a metric space. The Cayley graph of a group is often the metric space considered. It is easy to see that for Euclidean spaces, divergence is always linear. On the other hand, in hyperbolic space, it is also not hard to show divergence is exponential. There exist interesting examples in other groups of divergence functions whose growth lies between linear and exponential. I am curious which functions can arise as divergence functions of groups and in which settings. I am also interested in the relationship between divergence and other geometric properties such as thickness and being CAT(0).

Lately, I have been working with Coxeter Groups. These groups have a rich combinatorial and geometric structures, yet they are complex enough to provide interesting examples in geometric group theory.

Gabriele Link
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Ergodic geometry of discrete groups

I am interested in discrete groups acting on CAT(0)-spaces such as symmetric spaces of the non-compact type, geometric rank one manifolds, products of rank one Hadamard spaces and CAT(0)-cube complexes. I am in particular interested in the structure of the limit sets of such groups and in ergodic properties of the geodesic flow (or Weyl chamber flow) of the associated quotient space. A recent result in this direction is the following generalization of Hopf-Tsuji-Sullivan dichotomy first stated in the context of Fuchsian groups and later for quotients of CAT(-1)-spaces by T. Roblin ([2]).

Theorem [L., Picaud][1] Let M be a manifold of non-positive curvature with a rank one periodic geodesic. Then the geodesic flow is either completely dissipative and non-ergodic or completely conservative and ergodic (with respect to an appropriate, possibly infinite measure on the unit tangent bundle of M).

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Ana Claudia Lopes Onorio
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Bredon cohomological dimension 1

The Bredon cohomological and geometric dimensions of a group G, respectively denoted by $cd_{\mathcal{F}}G$ and $gd_{\mathcal{F}}G$, is a generalising construction of the classical cohomological and geometric dimensions which considers a family $\mathcal{F}$ of subgroups of G and the action of G on a contractible G-CW-complex with stabilisers in $\mathcal{F}$.

An analogue for the Eilenberg-Ganea theorem proved by Lück [1]

$$gd_{\mathcal{F}}G \leq max\left\{3, cd_{\mathcal{F}}G\right\},$$

shows that there exists a contractible G-CW-complex of minimum dimension $gd_{\mathcal{F}}G$ such that the action of G has stabilisers in $\mathcal{F}$ and, for each $H \in \mathcal{F}$, the H fixed point set is contractible.

Stallings [2] and Swan [3] proved that, if $cd(G) = 1$, then G acts freely on a tree i.e. $gdG = 1$. A natural question to ask is: if $cd_{\mathcal{F}}G = 1$, is $gd_{\mathcal{F}}G = 1$, given any family $\mathcal{F}$ of subgroups of G? A result by Dunwoody [4] gives a positive answer for the family of finite subgroups of G. Recently, Diegrijse [5] proved that, for the family $\mathcal{F}$ of virtually cyclic subgroups of G, the result also applies. The aim of my research is to investigate what happens if the family considered is the virtually $\mathbb{Z}^n$ subgroups of G, for $n \leq 2$.

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Marissa Loving
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Two-generator subgroups of pure surface braid groups

I am a third year graduate student working with Chris Leininger. My current research is focused on pure surface braid groups and is closely related to a paper published by Leininger and Margalit in which they proved that any two elements of the pure braid group either commute or generate a free group [1]. My goal is to answer a question posed to the authors of [1] by Tom Church, namely, does this result hold for two elements in any pure surface braid group.

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Michał Marcinkowski
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Biinvariant word length, and positive scalar curvature and macroscopic dimension

- **Biinvariant word length**. Let G be a group generated by a symmetric set S and let $\overline{S}$ be the minimal conjugacy invariant set containing S. The biinvariant word metric, denoted $||.||$, is the word metric defined with respect to the (in most cases infinite) set $\overline{S}$. It may be dramatically different from the standard word metric (e.g. $SL_n(\mathbf{Z})$ is bounded in $||.||$ if $n > 2$). I am interested in the geometry of groups equipped with the biinvariant metric, especially in metric behavior of cyclic subgroups.

- **Positive scalar curvature and macroscopic dimension.** Macroscopic dimension (defined by Gromov) of a metric space is one of those where bounded spaces have dimension 0. Let M be a closed smooth manifold which admits a Riemannian metric of positive scalar curvature (briefly PSC). In a search of topological obstruction to PSC, Gromov conjectured that the universal cover of M has deficiency of macroscopic dimension. Such manifolds are called macroscopically small. For example S^n, $n > 1$, admits a PSC metric (as every 1-connected manifold) and macroscopic dimension of its universal cover is 0 (which is less then the topological dimension). Recently am interested in constructing manifolds with 'exotic' properties (e.g. macroscopically large but small in other sense) and PSC metrics. Constructions involves right angled Coxeter groups.

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Alex Margolis
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Asymptotic Topology and Splittings of Groups

A seminal result of John Stallings says that a finitely generated group splits as an amalgamated free product or HNN extension over a finite subgroup if and only if its Cayley graph is coarsely separated by a point [1]. In particular, this shows that splittings over finite groups are preserved under quasi-isometry.

In [2], Papasoglu shows that a finitely presented one ended group that is not virtually a surface group splits over a 2-ended subgroup if and only if the Cayley graph is coarsely separated by a line.

It is easy to see that when a group splits over a subgroup, the subgroup coarsely separates the Cayley graph of the group. Although the converse is not true in general, I am investigating special cases when the converse holds. If the ambient group satisfies some coarse topological assumptions, then the converse is shown to hold for certain classes of subgroups. It follows that certain group splittings are invariant under quasi-isometry. I am also looking for interesting counter examples showing when the converse does not hold.

The JSJ theory of groups says that there exist graph of groups decompositions of finitely presented groups which encode all splittings over a certain class of subgroups. This was originally shown by Rips and Sela in [3], but has since been extended by others. I am interested in when JSJ decompositions are invariant under quasi-isometry. This is known for JSJ decompositions over 2-ended groups [2], and I would like to extend this to JSJ decompositions over larger classes of edge groups.

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Suraj Krishna Meda Satish
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Hyperbolic Groups and Cubical Groups

I am a first-year PhD student at Orsay. My advisors are Frédéric Haglund and Thomas Delzant.

My thesis will entail the study of the relationship between hyperbolic groups and cubical groups, especially in either of the following directions:

1. If a hyperbolic group is not virtually free, does it contain a non-virtually free cubical group, such as a surface group?
2. If a hyperbolic group is locally indicable, is it cubical (a group is locally indicable if every finitely generated subgroup surjects onto $\mathbb{Z}$)?

A very special case of the second question has been treated recently by Hagen and Wise [1], in an article on which I worked for my master's thesis. To show that a group is cubical, Hagen and Wise find many quasi-convex subgroups which separate the ambient group "at infinity". The study of these questions in individual cases will already be non-trivial: for example, when the hyperbolic group is the fundamental group of a nonpositively curved 2-complex.

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Mehrzad Monzavi
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Surface Subgroups for Compact Manifolds of Negative Curvature

My principal areas of interest are geometric group theory and low-dimensional topology. Recently I have focused on proving the existence of surface subgroups in compact manifolds of negative curvature.

It has been conjectured by M. Gromov that every one-ended hyperbolic group contains a surface subgroup i.e. subgroups which are isomorphic to the fundamental group of a closed surface.

J. Kahn and V. Markovic in [1] proved that every closed hyperbolic 3-manifold contains a quasifuchsian surface subgroup.

In other words, every cocompact lattice in $SO(3,1)$ contains infinitely many surface subgroups.

U. Hamenstädt in [2] showed that a closed rank-one locally symmetric spaces which is different from a hyperbolic manifold of even dimension contain surface subgroups. However, U. Hamenstädt has informed me that her theorem holds true for even dimensional hyperbolic manifolds

In view of the conjecture of Gromov, it seems desirable to generalize these results to compact manifolds of pinched negative curvature. More specificly, it would be valuable to have a precise bound on the pinching constant.

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Víctor M. G. Moreno
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Classifying spaces for larger families of subgroups

Let G be a group. A collection $\mathfrak{F}$ of subgroups of G is a family if it is closed under conjugation and taking subgroups. A G-CW-complex X is said to be a classifying space $E_{\mathfrak{F}}G$ for the family $\mathfrak{F}$ if for each subgroup $H \leq G$ $X^H \simeq \{*\}$ if $H \in \mathfrak{F}$, and $X^H = \emptyset$ otherwise. The spaces $\underline{E}G = E_{\mathfrak{F}}G$ (known as *universal space for proper actions*) for $\mathfrak{F} = \mathfrak{F}in$ the family of finite subgroups and $\underline{\underline{E}}G = E_{\mathfrak{F}}G$ for $\mathfrak{F} = \mathcal{V}cyc$ the family of virtually cyclic subgroups have been widely studied for their appearance as the geometric objects in the Baum-Connes and Farrell-Jones conjectures respectively. For a first introduction into the subject see, for example, the survey [1].

In [2], Lück and Weiermann develop a methodology to construct models for $E_{\mathfrak{G}}G$ from known classifying spaces for a family $\mathfrak{F} \subseteq \mathfrak{G}$ for G and some key subgroups lying on $\mathfrak{G} \setminus \mathfrak{F}$.

Based on this methodology, I am building classifying spaces for families larger than $\mathfrak{F} = \mathcal{V}cyc$ of discrete groups of a certain kind and studying the Bredon–cohomological dimensions of such groups.

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Sam Nariman
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Braid groups and discrete diffeomorphisms of the punctured disk

My primary interests is to understand the cohomology of diffeomorphism groups as discrete groups. I proved homology of surface diffeomorphisms as discrete groups are stable with respect to genus [1].

Recently I got interested in realization problem of the mapping class groups by diffeomorphism groups. Morita proved that for large enough g the mapping class group of a surface of genus g, denoted by $\mathrm{Mod}(\Sigma_g)$, cannot be realized as a subgroup of the surface diffeomorphism group $\mathrm{Diff}(\Sigma_g)$, by showing that $H^6(\mathrm{Mod}(\Sigma_g);\mathbb{Q})$ is not a summand of $H^6(\mathrm{Diff}(\Sigma_g);\mathbb{Q})$. Surprisingly, the situation is different for the braid groups. While there is no section from braid groups to diffeomorphism groups of punctured disks, as N. Salter and B. Tshishiku recently showed, I proved [2] that the homology groups of the braid group are summands of the homology groups of the discrete diffeomorphisms of a disk with punctures. Using factorization homology, I also showed that there is no homological obstruction to realize surface braid groups by diffeomorphism groups of the punctured surface. Moreover I proved that discrete diffeomorphism groups of punctured disks exhibit homological stability and their stable homology is the same as the homology of a certain double loop space. As an application of this method, I proved there is no homological obstruction to lifting the “standard" embedding of Br_{2g+2} into $\mathrm{Mod}_{g,2}$ to a group homomorphism between diffeomorphism groups.

These phenomena of having no homological obstruction while there is no lifting of the mapping class groups interest me.

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Thomas Ng
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Groups with Rational Growth

An automatic structure equips a group with computational machines called finite state automata that accept a language of normal forms of words in a fixed generating set. This notion was introduced by Thurston as a class of groups with particularly tractable solutions to classical decision problems about groups [3], who also proved that having an automatic structure is invariant under change of generating set.

The finiteness of the automata induces a finite recurrence relation on the growth function of the group, $S(n)$. This is equivalent to the statement that the power series with k^{th} coefficient $S(k)$ is a rational function. Groups with this property are said to have *rational growth*. The class of groups of rational growth however extends beyond automatic groups to certain Baumslag-Solitar groups [1], the Heisenberg group [2], and higher Heisenberg groups [4]. Remarkably, Stoll shows that for higher Heisenberg groups rationality of the growth series is not preserved under change of generating set.

I am interested in exploring what other types of groups have rational growth and what other types of groups if any that exhibit both rational and transcendental growth series. Furthermore, it is known that mapping class groups of surfaces are automatic [5], while $Out(F_n)$ despite sharing many similar properties fails to be automatic for $n \geq 3$. I would like to better understand $Out(F_n)$ in order to verify whether it has rational growth.

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Jordan Nikkel
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Subgroups and Geometric Structure of the Thompson Groups

In 1965, Richard Thompson defined three groups F, T, and V. The smallest group F was first defined to be the set of piece-wise linear homeomorphisms of $[0, 1]$ to itself with breakpoints dyadic rationals and integer powers of 2 as slopes on the pieces. T is an extension of F that consists of similar homeomorphisms of $S^1 = [0, 1]/\sim$ with $0 \sim 1$ [1]. These groups also have natural definitions in terms of actions on pairs of full binary trees. Much work has been done recently in studying the structure of these groups and their subgroups. For example, the notion of a 2-dimensional core, akin to Stalling's core for free groups, has been introduced in [3] to help determine if a subgroup of F is in fact all of F. Vaughan Jones also showed that all unoriented links are encoded in a natural way in F, and then he defined a subgroup $\vec{F}$ that encodes all oriented links [4].

I am trying to generalize some recent results from F to T. Specifically, when Jones defined $\vec{F}$, he defined $\vec{T}$ in a similar manner; Mark Sapir and Gili Golan then showed in [2] that $\vec{F} \cong F_3$, which is defined similarly to $F = F_2$ using 3-adic intervals and powers of three for the slopes on these intervals. As a result, Jones asked whether $\vec{T} \cong T_3$. Another result which may be generalized to T comes from the definition of quasi-finite index in [3]: a subgroup H of a group G is said to be of quasi-finite index if there are finitely many subgroups of G containing H. There it is proven that the stabilizer subgroups in F of finitely many points are of quasi-finite index, and hence the same question can be asked of these subgroups in T.

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Damian Orlef
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Properties of random groups in Gromov density model

My recent research is mainly concerned with the study of random groups in Gromov density model. I am working on the problem of computing the critical density for property (T) - either by expanding the Żuk's theorem or justifying its optimality.

In the meantime I also consider the problem of determining if the Unique Product Property holds for random groups. In the process so far I proved that random groups are not left-orderable (see [1]).

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Andreas Ott
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Bounded group cohomology

Gromov's bounded cohomology of discrete groups has proved to be a fruitful concept in geometry, topology and group theory. However, it is notoriously difficult to compute and not much is known in higher degree. My research is about finding new techniques for explicit constructions of cocycles and primitives in order to make bounded group cohomology more accessible to computations.

Using methods from partial differential equations, harmonic analysis, representation theory and homological algebra I investigate vanishing theorems for the continuous bounded cohomology of Lie groups in higher degree. In joint work with T. Hartnick I recently proved that the continuous bounded cohomology of $\mathrm{SL}_2(\mathbb{R})$ with real coefficients vanishes in degree four. In fact, these methods should give a hint on how to approach the more difficult task of computing the bounded cohomology of discrete groups, like for example the bounded cohomology of the free group $\mathbb{F}_2$ in degree four, which is not known.

On the other hand, given a concrete class in bounded cohomology it is usually of great interest to compute its Gromov norm, since this norm carries geometric information, like for example the simplicial volume in the case of the volume class. I study concrete expressions for cocycles in terms of polylogarithms as discovered by Goncharov in order to compute these Gromov norms for the bounded cohomology of SL_n.

HyoWon Park
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Graph braid groups and related groups

My research interest lies on Geometric Group Theory and Topology. During the years as a Ph.D. candidate, I focused on graph braid groups, homology groups of graph braid groups, presentations of graph braid groups and condition of graph whose braid groups are right-angled Artin groups in [2, 4]. After I received the Ph.D degree, my research interest extended to cube complexes and related topics. For example, right-angled Artin groups and their automorphism groups, cube complex on which (classical) braid groups act.

My main questions are as follows: 1. When is a graph braid group a right-angled Artin group?; 2. Are the braid groups on finite simplicial complexes, that are embedded into a surface, CAT(0)?; 3. Quasi-isometric(or commensurable) classification of right-angled Artin group.

I research progress for the above questions: Remaining unknown cases of the first question are braid index 2 or 3, other cases were proved in [2, 3]. For the second question, we studied braid groups on simplicial complexes in [1]. We can construct a finite cube complex, which is not CAT(0) but for braid index 2, we try to modify the complex to CAT(0) cube complex. For the third question I am working on the class of right-angled Artin groups whose defining graphs are thin-chordal.

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Aitor Perez
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Groups of intermediate growth

I recently started my PhD under the supervision of Tatiana Smirnova-Nagnibeda in the University of Geneva. In my master thesis, I studied Grigorchuk's group and, in particular, the proof of its intermediate growth ([1] and [2]).

I am now focusing on other examples of similar groups, such as the Grigorchuk-Erschler group, which, together with Grigorchuk's group, is a particular case of the family defined in [3], or the iterated monodromy group $IMG(z^2+i)$ ([4]).

I am also interested in other families of branch groups acting on wider trees, as for instance the one introduced by Sunic in [5], which contains Grigorchuk's group, the Grigorchuk-Erschler group and the Gupta-Fabrykowski group, among other interesting examples, Grigorchuk's extension of his original family to the p-ary tree T_p or the Gupta-Sidki groups ([6]).

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Christopher Perez
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Marked groups and limit groups

A *marked group* is a pair (G, S) consisting of a group G and an ordered generating set $S = (s_1, \ldots, s_n)$. Two marked groups (G, S) and (G', S') with $S' = (s'_1, \ldots, s'_n)$ are isomorphic as marked groups if and only if the bijection $s_i \mapsto s'_i$ induces an isomorphism of groups $G \to G'$. Let $\mathcal{G}_n$ be the set of marked groups which are marked with n elements, up to isomorphism of marked groups. By convention, an S-word in (G, S) is identified with an S'-word in (G', S') via the bijection $s_i \mapsto s'_i$. With this convention we may identify labels in the respective Cayley graphs (G, S) and (G', S') and define a metric on $\mathcal{G}_n$ such that any two groups are at a distance at most e^{-2R+1} if their Cayley graphs have the same labeled balls of radius R centered at the identity. A marked group in $\mathcal{G}_n$ is a *limit group* if it is a limit of marked free groups in this topology. There are in fact several equivalent characterizations of limit groups, in particular a finitely generated group G is fully residually free if and only if it has the same universal theory as a free group if and only if some marking of G is a limit of marked free groups [1].

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Benjamin Peters
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Hurwitz spaces of translation surfaces

I am interested in translation surfaces, especially in translation coverings of tori. The space of translation coverings with prescribed covering data, e. g. degree, ramification points and translation structure on the covered surface, is called *Hurwitz space of translation surfaces*. A fruitful example with many interesting properties was found by my advisor Frank Herrlich and by Gabriela Schmithüsen [1].

Translation surfaces and their orbit closures are closely related. I am currently trying to understand the $\mathrm{SL}_2(\mathbb{R})$ orbit closures of translation surfaces in a special Hurwitz space of translation surfaces of genus 3. Due to work from Eskin, Mirzakhani and Mohammai [3] it is known that they are affine invariant submanifolds. I am trying to compute their possible dimensions and classify them, which is already achieved for genus 2 by McMullen [4] and only partially for genus 3 with methods from Wright [2].

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Bram Petri
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Combinatorics, probability and low dimensional manifolds

I am interested in combinatorial and random constructions related to low dimensional manifolds. Examples of these are random hyperbolic surfaces and 3-manifolds, curve graphs, flip graphs and pants graphs.

Questions and topics I enjoy thinking about are:

- What is the geometry of a 'typical' (hyperbolic) 2- or 3-manifold?
- Surfaces with extremal properties (eg. maximal systole)
- The geometry and topology of curve, flip and pants graphs

Concretely, I have worked on short curves on random surfaces [Pet13], [Pet14] the genus of curve, flip and pants graphs together with my doctoral advisor Hugo Parlier [PP14] and surfaces without short curves together with Alex Walker [PW15].

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Hester Pieters
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Bounded cohomology and symmetric spaces

I am a final year PhD student working under the supervision of Michelle Bucher and I am interested in bounded cohomology. More specifically, one of the things I study is the natural comparison map $H^*_{cb}(G;\mathbb{R}) \to H^*_c(G;\mathbb{R})$ between continuous bounded cohomology and continuous cohomology. In general this map is neither injective nor surjective. It is conjectured to be an isomorphism for semisimple Lie groups, but so far this has only been established in a few cases. For the group of isometries of 3-dimensional real hyperbolic space, injectivity of this comparison map in degree 3 follows from a result of Bloch which says that the continuous cohomology of $\mathrm{Isom}^+(\mathbb{H}^3)$ can be realized on the boundary $\partial\mathbb{H}^3$ [1]. Generalizing his proof, I have shown that $H^*_c(\mathrm{Isom}^+(\mathbb{H}^n);\mathbb{R}) = H^*(C^*(\partial\mathbb{H}^n;\mathbb{R})^{\mathrm{Isom}^+(\mathbb{H}^n)},\delta)$ for real hyperbolic space $\mathbb{H}^n$ of any dimension [2]. This implies in particular injectivity of the comparison map in degree 3 for $\mathrm{Isom}^+(\mathbb{H}^n)$.

I am also interested in using bounded cohomology techniques to study the connection between the topology and the geometry of manifolds. Let M be a manifold and let $\beta \in H^q(M;\mathbb{R})$ be a cohomology class. The Gromov norm $\|\beta\|_\infty$ is by definition the infimum of the sup-norms of all cocycles representing β:

$$\|\beta\|_\infty = \inf\{\|b\|_\infty \mid [b] = \beta\} \in \mathbb{R}_{\geq 0} \cup \{+\infty\}$$

The value of this norm is only known for a few cohomology classes. I would like to determine its value for certain cohomology classes of Hermitian symmetric spaces, especially in top dimension. This could lead to new Milnor-Wood type inequalities and computations of the simplicial volume.

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Tomasz Prytuła
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Classifying spaces for families for non-positively curved groups

Let G be a discrete group and $\mathcal{F}$ be a family of subgroups of G. A G–CW-complex X is a *model for the classifying space* $E_{\mathcal{F}}G$ if for every subgroup $F \leqslant G$ the fixed point set X^F is contractible if $F \in \mathcal{F}$ and empty otherwise.

Given G and $\mathcal{F}$, the question is whether there exists a finite dimensional model for $E_{\mathcal{F}}G$, and if so, what is the smallest possible dimension of such a model?

I try to answer this question for certain classes of non-positively curved groups: the *systolic* groups of Januszkiewicz and Świątkowski [1] and the graphical small cancellation groups. The families I consider are those of all finite subgroups, all virtually cyclic subgroups and all virtually abelian subgroups, denoted by $\mathcal{FIN}$, $\mathcal{VCY}$ and $\mathcal{VAB}$ respectively.

Following the approach of W. Lück [2], together with D. Osajda we construct models for the classifying space $E_{\mathcal{VCY}}G$ for systolic groups, with the dimension bounded from above by the dimension of the systolic complex on which G acts. Currently we are working on constructing low-dimensional models for $E_{\mathcal{FIN}}G$ and $E_{\mathcal{VCY}}G$ for groups acting properly on $C(6)$ graphical small cancellation complexes.

We expect that our approach can be used to construct finite dimensional models for $E_{\mathcal{VAB}}G$ for systolic and small cancellation groups.

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Word Measures on Groups

Word measures on a compact group G are defined as follows. Let w belong to the free group F_r on r generators $x_1, \ldots, x_r$. The w-measure on G is defined by substituting x_i, for every $1 \leq i \leq r$, with an independent, Haar-distributed random element of G and evaluating the product defined by w to obtain a random element of G.

The motivation for the study of word measures on groups lies both in the free groups side and in the compact groups side. In the free groups side, the study is motivated by questions about measure-theoretic separability of $\mathrm{Aut}\,(F_r)$-orbits, the dynamics of $\mathrm{Aut}\,(F_r)$, profinite topology in F_r and more. Moreover, this line of research has led to unexpected results of independent interest, such as new criteria for primitivity of words, or new insights and results in the theory of commutator length of words.

From the compact groups side, there are also a few different sources of motivation. The main goal, in my view, lies in questions about random walks with random generators. For example, let $\mathrm{Cay}\,(G, \{g, h\})$ be a Cayley graph of a finite group G with respect to two independent uniformly random generators. The walks of length N from the identity are encoded by not-necessarily-reduced words on two letters and of length N:

$$\left(g + h + g^{-1} + h^{-1}\right)^N = \sum_w w\,(g, h)\,.$$

Thus, the analysis of spectral gap in this Cayley graph is closely related to questions about word measures on G.

So far, we have studied word measures on the Symmetric groups [1] and on Unitary groups [2]. Both involved some very beautiful mathematics and led to some very nice results and consequences. There are still many interesting directions and open problems to explore.

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Dehn functions for mapping tori of right angled Artin groups

The Dehn function of a group G measures the worst case number of relator applications needed to verify that a trivial word of length n is trivial. More geometrically, the Dehn function measures the worst-case area of loops in the Cayley 2-complex of G, as a function of perimeter.

Given a simplicial graph $\Gamma = (V, E)$, define the right angled Artin group:

$$A_\Gamma := \langle\, V \mid [v, w] = 1 \text{ if } (v, w) \in E \,\rangle.$$

RAAGs interpolate between two extremes: free groups, coming from edgeless graphs, and free-abelian groups, coming from complete graphs.

Groups of the form $G \rtimes_\phi \mathbb{Z}$ are called *algebraic mapping tori*. The groups $F_k \rtimes_\phi \mathbb{Z}$ have Dehn functions that are linear or quadratic, and these are classified by whether or not ϕ is atoroidal [2]. The groups $\mathbb{Z}^n \rtimes_\phi \mathbb{Z}$ have Dehn functions that are exponential or polynomial, and the Dehn function is determined by the growth of the automorphism ϕ. [3, 1]

I am interested in what can be said about the Dehn function of $G \rtimes_\phi \mathbb{Z}$ when G is a RAAG. Can it be anything other than polynomial or exponential? Can the Dehn functions be classified by properties of ϕ? In joint work with Tim Riley, we have worked out a classification for the Dehn functions of mapping tori for the bases $F_2 \times \mathbb{Z}$ and $\mathbb{Z}^n * \mathbb{Z}$. We are currently considering these questions for 2-dimensionsional irreducible RAAG bases. These RAAGs come from the connected, triangle-free graphs, the most basic example of which are the complete bipartite graphs. They have relatively few automorphisms, which gives us hope that a classification may be possible.

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CAT(0) Cube Complex and Out(F_n)

My current research projects center around Out(F_n) and CAT(0) cube complexes. Specifically, I am in the process of understanding the connection between Guirardel core and the geometry of Out(F_n). A G-tree is a tree with an isometric action of G. Given two G-trees T, T', Guirardel constructed a core $C(T \times T')$ that is a finite CAT(0) cube complex which captures both splittings of G. The growth of the core is studied by Bestvina, Behrstock and Clay. I am interested in using their construction of the core and connect the geometric properties of the core with the group-theoretic properties of G. Specifically, I aim to understand the diameter of the core, the boundaries in the quotient, and the singularities, among other things. More generally, the core gives a new way to study pairs of points in spaces that can be characterized by actions on trees. Free splitting complex is another example of such spaces. In this direction my goal is to understand the core along the folding path as constructed by Mosher and Handel in their proof of the hyperbolicity. I will benefit greatly from talking and working with Vogtmann, Mosher and Wade, among others.

My other projects includes boundary of CAT(0) cube complexes and CAT(0) groups. A group is CAT(0) if it acts geometrically on a CAT(0) space. The question that motivated my Ph.D study: do CAT(0) groups have unique boundaries? Croke and Kleiner answered the question negatively for right-angled Artin groups. My thesis using their result and construction and answered the question negatively for the group of right-angled Coxeter groups. The more subtle, more difficult question is to understand whether the counterexample I constructed is a pair of boundaries that are homeomorphic as spaces at all, leaving out the group structure. I would like to find collaborators in the program that may be interested in this project. Tool that may be helpful may come from mapping the visual boundary with other boundaries that capture different aspects of CAT(0) cube complexes such as contracting boundary introduced by Charney, the simplicial boundary by Hagen and the Roller boundary.

Nicolas Radu
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Uniform lattices in $\tilde{A}_2$-buildings

An $\tilde{A}_2$-building is a simply connected simplicial complex Δ of dimension 2 such that, for each vertex v of Δ, the simplicial sphere of radius 1 around v is isomorphic to the incidence graph of a projective plane.

One natural question is: does there exist an $\tilde{A}_2$-building Δ which is locally non-Desarguesian (i.e. there is a vertex v of Δ for which the projective plane associated to v is non-Desarguesian) and admitting a uniform lattice $\Gamma \leq \mathrm{Aut}(\Delta)$ (i.e. a discrete group Γ acting cocompactly on Δ)?

A way to construct such a building would be to use the work of Cartwright-Mantero-Steger-Zappa [1]. In this article, the following definition is given.

Definition: Let P and L be the set of points and lines respectively in a projective plane Π. A bijection $\lambda : P \to L$ is called a *point-line correspondence*. A set $\mathcal{T}$ of triples (x, y, z), where $x, y, z \in P$, is called a *triangle presentation* over P compatible with λ if

1. given $x, y \in P$, if y and $\lambda(x)$ are incident then there exists a unique $z \in P$ such that $(x, y, z) \in \mathcal{T}$; otherwise there is no such $z \in P$;
2. $(x, y, z) \in \mathcal{T}$ implies that $(y, z, x) \in \mathcal{T}$.

Given Π, λ and $\mathcal{T}$ as above, the authors can construct an $\tilde{A}_2$-building Δ which is locally isomorphic to Π and a group Γ acting simply transitively on the set of vertices of Δ. In order to answer *yes* to the above question, one could therefore take a non-Desarguesian projective plane (e.g. the Hughes plane of order 9) and try to find λ and $\mathcal{T}$ satisfying the above conditions.

I am currently trying to do so, with the help of a computer. I also explore other ways to construct such an $\tilde{A}_2$-building and consider the possibility that the answer to the question is *no*.

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Anja Randecker
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Wild singularities of translation surfaces

For me, a *finite translation surface* $(X, \mathcal{A})$ is a connected surface X with a translation atlas $\mathcal{A}$ so that the metric completion $\overline{X}$ with respect to the translation metric is a compact surface and $\overline{X} \setminus X$ is discrete. My research is on the generalization by dropping the two conditions on the metric completion. We call these objects *(general) translation surfaces*.

The most visual way to define a finite translation surface is by considering finitely many polygons in the plane so that the edges come in pairs that have the same direction and length. When identifying the edges in these pairs and excluding the vertices we obtain a finite translation surface.

The elements of $\overline{X} \setminus X$ are called *singularities* and in the construction in the last paragraph they are exactly the former vertices of the polygons. For finite translation surfaces, the singularities are cone points with cone angle $2\pi k$ for some $k \geq 2$, hence called *cone angle singularities*. For a general translation surface, the singularities can be more complicated. For instance, there exist singularities which are infinite angle analogs of cone points. These are called *infinite angle singularities*.

In [2], Chamanara describes a first example of a translation surface which has a singularity that is neither a cone angle nor an infinite angle singularity. Singularities of this type are called *wild*.

Examples of wild translation surfaces have been studied in the last ten years but the systematic study of wild singularities started quite recently with the work of Bowman and Valdez [1] and was carried on in my PhD thesis [3].

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Colin Reid
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Totally disconnected locally compact groups

My main research area is totally disconnected locally compact (t.d.l.c.) groups. T.d.l.c. groups arise naturally as automorphism groups of discrete geometric structures such as graphs and buildings, as well as non-Archimedean analogues of Lie groups; from a group-theoretic perspective, the characteristic feature of t.d.l.c. groups is that they have a distinguished commensurability class of subgroups, namely the compact (profinite) open subgroups. The collection of compact open subgroups itself carries a natural metric, and the special properties of the points of minimal displacement with respect to this metric (known as tidy subgroups) give considerable insight into the dynamics of automorphisms of t.d.l.c. groups (see [1]). Recently I have worked with Phillip Wesolek on the normal subgroup structure of locally compact groups ([6]), and with Pierre-Emmanuel Caprace and George Willis on compactly generated simple groups, using structures arising from subgroups with open normalizer ([4]). I am also interested in the role played by contraction groups, which behave quite differently in the t.d.l.c. case to how they behave in connected groups ([2, 3, 5]).

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Generalizing Moufang sets to a local setting

In [1], De Medts and Segev describe Moufang sets as an equivalent way of looking at abstract rank one groups, and hence as a tool to study rank one groups over fields. My research is aimed at generalizing the concept of Moufang sets such that the new type of structure includes rank one groups over local rings, such as $\mathsf{PSL}_2(R)$ with R a local ring.

The concept I propose to introduce is a so-called *local Moufang set*. This is a structure $((X,\sim),(U_x)_{x\in X})$, where $(X,\sim)$ is a set with equivalence relation, and U_x is a subgroup of $Aut(X)$ preserving $\sim$. We call the groups U_x *root groups*. For each $x\in X$, we denote $U_{\overline{x}}$ for the induced action of U_x on $X/\sim$. The axioms we then ask for are:

(LM1) If $x\sim y$ for $x,y\in X$, then $U_{\overline{x}}=U_{\overline{y}}$.
(LM2) For $x\in X$, U_x fixes x and acts sharply transitively on $X\setminus\overline{x}$.
(LM2') For $\overline{x}\in X/\sim$, $U_{\overline{x}}$ fixes $\overline{x}$ and acts sharply transitively on $X/\sim\setminus\{\overline{x}\}$.
(LM3) For $x\in X$ and $g\in G$, we have $U_x^g=U_{xg}$.

One of the immediate consequences is that $(X/\sim,(U_{\overline{x}}))$ is a Moufang set. Many of the basic theory of Moufang sets can be extended to local Moufang sets: one can construct local Moufang sets with one root group and one special involution, the Hua subgroup is the two-point stabilizer of two generic points, there is a Bruhat-like decomposition... Recently, I found a set of conditions that are necessary and sufficient for a local Moufang set to be $\mathsf{SL}_2(R)$, for some local ring R, generalizing Theorem 6.1 from [2].

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Automorphism Groups of Polygonal Complexes

The main objects in my research are polygonal complexes and their automorphism groups. A polygonal complex X is a two dimensional cell complex which consists of regular polygons glued together by isometries along their edges. I am mainly focused on polygonal complexes which are simply connected, nonpositively curved and have strong symmetry properties. A classification of the trivalent case was given by Swiatkowski [Sw].

One can equip the automorphism group Aut(X) of X with a topology by using the pointwise stabilizers of finite subcomplexes as neighbourhood basis of the identity. This way these automorphism groups provide a big class of non classical examples for totally disconnected locally compact groups. I am interested in a very geometric way of looking at these groups [Ba] following the structure theory initiated by Willis in 1994 [Wi].

Many other questions regarding the automorphism groups of polygonal complexes were collected by Farb, Hruska and Thomas [FHT]. One of the problems I am concerned with is finding conditions so that Aut(X) is linear.

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Torsion and Randomness in the Mapping Class Group

My current research interests focus primarily upon the mapping class group of a surface, $Mod(S_g)$. This is a well studied example in geometric group theory, containing a rich geometric and algebraic structure as well as many applications. In [1] it was shown that the mapping class group is always generated by 6 elements of finite order. This suggests that studying the finite subgroups of the mapping class group may produce new insight into its structure. I have been investigating the existence of finite subgroups of $Mod(S_g)$ which are *finitely maximal* (i.e. finite subgroups which are not contained in any other finite subgroup). I have found, given any prime $p \geq 7$, for sufficiently high genus, $Mod(S_g)$ always contains a conjugacy class of finitely maximal subgroup of order p. I am currently exploring the asymptotic growth of the number of such subgroups as genus increases. In addition to providing insight into the mapping class group itself, finite subgroups of the $Mod(S_g)$ assist in studying the moduli space, $\mathcal{M}_g$, of the surface. For example, finitely maximal subgroups of the mapping class group create a stratification of the branch locus of $\mathcal{M}_g$ (see [2] for details).

I am also interested in the application of probability to various aspects of geometric group theory that have emerged over the past several years. Most remarkably, these random methods have produced not only important information about "generic" objects, but often yield results which appear, at first, to have nothing to do with probability. I am particularly curious about exploring Dunfield and Thurston's model for random 3-manifolds utilizing random walks in the mapping class group [3].

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Finiteness Length of some S-arithmetic Groups

I recently started my PhD in Bielefeld under supervision of Prof. Dr. Kai-Uwe Bux. We investigate the finiteness lenght of S-arithmetic groups and aim to establish it in new cases.

Recall that a (discrete) group Γ is of Type F_n when it admits a classifying space with finite n-skeleton. The finiteness length is the greatest $\phi(\Gamma) = n \in \mathbb{N} \cup \{\infty\}$ for which Γ is of type F_n. Now take a linear algebraic group $\mathcal{G}$ defined over a global field $\mathbb{K}$ and a finite set S of places over $\mathbb{K}$ containing all the archimedean ones, and let Γ be an S-arithmetic subgroup of $\mathcal{G}(\mathbb{K})$. For the sake of exposition, think of $\mathcal{G}$ as a subgroup of some SL_m defined by polynomials (e.g. SL_m itself, GL_{m-1}, unitriangular matrices, etc.). Denoting by $\mathcal{O}_S$ the ring of S-integers of $\mathbb{K}$, such a group Γ is of the form $\Gamma = \mathcal{G}(\mathcal{O}_S) \leq \mathrm{SL}_m(\mathbb{K})$.

We are currently working on the case where $\mathbb{K}$ is an algebraic number field. In this setting, a Hasse Principle deduced by A. Tiemeyer [3] allows one to deal with one non-archimedean valuation at a time, that is, the case where Γ is just a p-arithmetic group. Now suppose $\mathcal{G}$ is $\mathbb{K}$-split solvable, i.e. a semi-direct product $\mathcal{G}(\mathbb{K}) = \mathcal{T} \ltimes \mathcal{U}$ where $\mathcal{T}$ is a $\mathbb{K}$-split torus and $\mathcal{U}$ is unipotent. Here there is a conjectural characterization due to H. Abels and S. Holz [2] for the finiteness length of Γ relating it to a family of subgroups of $\mathcal{U}(\mathbb{K})$ which are in some sense contracting with respect to the p-adic norm and the action of $\mathcal{T}$. Such subgroups were already succesfully used by Abels in [1] via his main results there and works of A. Borel, J. Tits and M. Kneser to establish conditions for F_2 for arbitrary S-arithmetic groups.

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Damian Sawicki
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Warped cones, profinite completions, coarse amenability and embeddability

I study large-scale properties of warped cones, like Yu's property A (coarse amenability) and coarse embeddability into Banach spaces (primarily into the Hilbert space).

The warped cone construction [2] is the following – we start with a compact metric space Y with an action of a finitely generated group Γ. We embed Y in the sphere in some Banach space E in a bi-Lipschitz way and consider the infinite cone over Y. The warped metric is the largest metric d_Γ such that $d_\Gamma(x, x') \leq d_E(x, x')$ and $d(x, sx) \leq 1$, where s belongs to a finite set of generators S of Γ. The obtained metric space does not depend on E and S (up to bi-Lipschitz equivalence).

I constructed [5] warped cones without property A yet coarsely embeddable into the Hilbert space (it used to be an open question whether the two are equivalent), using examples of box spaces with the same properties and a refinement of the notion of profinite completion.

With my PhD advisor, Piotr Nowak, we showed [1] that if the Γ-action on Y has a spectral gap in $L_p(Y, m; E)$ for some p and a finite invariant measure m, then the obtained warped cone does not embed coarsely into E. These are the only examples of spaces non-embeddable into a large class of Banach spaces other than Lafforgue's strong expanders.

Before, during my Bachelor and Master studies, I considered different versions of asymptotic dimension [3, 4].

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Growth of subgroups of relatively hyperbolic groups

Let G be a finitely generated group with generating set X. Let H be a, not necessary finitely generated, subgroup of G.
I am interested in the exponential growth rate $lim_{n\to\infty} \sqrt[n]{g_H(n)}$, where $g_H(n)$ denotes the number of Elements of H which lie in the ball of radius n with respect to the wordmetric d_X.

It is well known, that this limit exists for $H = G$, but in general this limit does not have to exist, even if we assume H to be cyclic, see [1]. In my master thesis, I showed that the exponential growth rate of any subgroup of a finitely generated hyperbolic group exists.

Currently I am working on the case, where G is a finitely presented group, which is hyperbolic relative to a finite collection of subgroups with polynomial growth. This class especially includes Sela's Limit groups.

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ℓ^2-invariants and quasi-isometry

I study ℓ^2-Betti numbers and Novikov-Shubin invariants of finitely generated discrete and compact generated locally compact groups. Novikov-Shubin invariants measure the difference between the reduced and the unreduced p-th ℓ^2-homology. They agree if and only if the p-th Novikov-Shubin invariant is equal ∞^+.
In my PhD thesis I try to investigate if the vanishing of the p-th ℓ^2-Betti number of a compact generated locally compact group G is a quasi-isometry-invariant of G. Another goal is the quasi-isometry of Novikov-Shubin invariants of locally compact groups. In [1] my PhD advisor showed that for finitely generated *amenable* groups the claim is true. It is also known, that the property, to have the k-th Novikov-Shubin Invariant equal ∞^+, is a quasi-isometry invariant.

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Combinatorics of Coxeter groups and complexes and applications of buildings

CAT(0) spaces and groups acting on them play a prominent role among the many objects studied in geometric group theory. Buildings, although of algebraic origin, form a main class of examples of CAT(0) spaces. Most of my research is centered around the geometry of buildings and their applications. More recently I started working on systolic complexes, combinatorics of Coxeter groups and combinatorial methods in representation theory [2].

Together with Anne Thomas and Elisabeth Milićević [1] we study non-emptiness and dimensions of affine Deligne Lusztig varieties, short ADLVs, using combinatorial and geometric methods in Coxeter complexes. As an application of our results on ADLVs we were able to obtain new exact calculations of reflection length of elements in affine Weyl groups. This extends works of McCammond and Petersen [4]. We expect other applications of the folding techniques developed in this project and are trying to extend them to right-angled Coxeter complexes.

I am also interested in the following question: Can one characterize non-convex CAT(κ) sub-complexes of CAT(κ) complexes? This question is motivated by the fact that the CAT(0) property of braid groups can be studied via curvature of certain sub-complexes of type A spherical buildings. See for example my joint paper with Dawid Kielak and Thomas Haettel [3]. In the meantime Haettel showed that braid groups are not cubical.

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Universal groups for right-angled buildings

The central focus of my research is the study of totally disconnected locally compact (t.d.l.c.) groups, particularly groups constructed as subgroups of the automorphism group of locally finite graphs.

In particular, I am interested in the universal groups defined by Burger and Mozes [1], which are closed subgroups of the automorphism group of regular trees and whose local actions are prescribed by a finite permutation group. These groups are examples of (topologically) simple compactly generated t.d.l.c. groups.

In my research I generalized the notion of universal groups to the setting of right-angled buildings (which has regular trees as a subclass). The local action of a universal group on a semi-regular right-angled building is prescribed by a set of finite transitive permutation groups (one for each generator of the respective Coxeter group). Universal groups for locally finite semi-regular right-angled buildings also form a class of t.d.l.c. compactly generated groups and we have shown that they are abstractly simple.

Further steps in my research will be trying to relate the group-theoretical properties of the finite groups that prescribe the local action to the topological properties of the universal group. This is in the spirit of what has been done for trees, for example by Burger and Mozes [1] who consider the case where the local action is 2-transitive, and by Caprace and De Medts [2] who assume the local action to be primitive.

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Dehn functions of subgroups of right-angled Artin groups

The question of what is a possible range for the Dehn functions (a.k.a. isoperimetric profile) for certain classes of groups is a natural and interesting one. Due to works of many authors starting with Gromov, we know a lot about the isoperimetric profile for the class of all finitely presented groups (see the survey and references in [1]). Much less is known for many natural subclasses, for example for subgroups of right-angled Artin groups. The so-called Bestvina–Brady kernels give examples of subgroups in right-angled Artin groups with Dehn functions polynomial of order n^k, where $k = 1, 2, 3$ or 4. In [3] Bridson gave an example of a subgroup in a right-angled Artin group with the exponentially growing Dehn function.

In the recent project with Noel Brady [2], we constructed a series of subgroups of certain right-angled Artin groups such that their Dehn functions are polynomials of arbitrary degree. They are built in several stages. First we produce certain free-by-cyclic groups for which the conjugating automorphism is growing polynomially with a prescribed degree d. Then we form their doubles (in the sense of Bieri) and prove that their Dehn functions grow polynomially with degree $d + 2$. To establish (virtual) embeddings of the latter groups to right-angled Artin groups, we build special (in the sense of Haglund and Wise [4]) covers for the presentation 2–complexes of these groups.

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Davide Spriano
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Acylindrical hyperbolicity

I am a master student and am interested in acylindrical hyperbolicity and related notions.

Over the past few years many people have tried to understand which classes of groups share some of the interesting properties of hyperbolic groups. In order to address this question, many such classes of group were identified, for instance groups which act weakly properly discontinuously in the sense of Bestvina and Fujiwara on hyperbolic spaces, or groups with a proper infinite hyperbolically embedded subgroup.

It turned out that many of those notions are equivalent to acylindrical hyperbolicity, as shown by Osin in [1]. In particular, one could ask which is the relationship between having a hyperbolically embedded subgroup and relative hyperbolicity. These notions turn out to be equivalent under some mild hypothesis, which are automatically satisfied for finitely generated groups. Subsequently, one could try to generalize this notion to a family of subgroups or to a metric space. In the latter case, we obtain what is called a tree-graded space.

Thus, acylindrically hyperbolicity leads to a surprisingly large set of interesting spaces and notions which are strictly related to it, see also [2].

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Karol Strzałkowski
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Lipschitz simplicial volume

Simplicial volume is a homotopy invariant of manifolds useful for proving e.g. degree theorems, it has also many connections with Riemannian geometry (see [1] for more details). Given closed n-dimensional manifold M its simplicial volume M is defined as

$$\|M\| = inf\{|c_1| \,:\, c \in C_n(M, \mathbb{R}) \text{ represents the fundamental class}\},$$

where $|\cdot|_1$ denotes the ℓ^1 norm in $C_n(M, \mathbb{R})$ with respect to the basis consisting of singular simplices.

This definition can be generalised for non-compact manifolds by taking ℓ^1 norm of locally finite fundamental class. However, many properties of the simplicial volume do not hold any more in the non-compact case. It is therefore reasonable to take a metric into account and compute ℓ^1 norm of Lipschitz fundamental class instead.

I am interested in generalising properties of classical simplicial volume to the non-compact, Lipschitz case. I proved in [2] that for complete, finite volume Riemannian manifolds with the sectional curvature bounded from above Lipschitz simplicial volume satisfies the product inequality which bounds $\|M \times N\|_{Lip}$ in terms of $\|M\|_{Lip}$ and $\|N\|_{Lip}$ and the Proportionality Principle, which states that for manifolds with isometric universal covers $\|M\|_{Lip}$ is proportional to the Riemannian volume. Both properties hold for classical simplicial volume, but not in the non-compact case without Lipschitz restriction on chains. There are still many properties known for simplicial volume but not generalised yet to the non-compact, Lipschitz case, such as behaviour with respect to connected sums and dependence on the fundamental group.

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Daniel Studenmund
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Abstract commensurators of solvable groups

My research primarily addresses questions arising at the intersection of geometric group theory and the study of discrete subgroups of Lie groups. One of my interests is computing *abstract commensurators* of finitely generated groups. The abstract commensurator $\mathrm{Comm}(\Gamma)$ of a group Γ is the group of all equivalence classes of isomorphisms between finite index subgroups of Γ, where two isomorphisms are equivalent if they agree on some finite index subgroup of Γ. For example, $\mathrm{Comm}(\mathbb{Z}) \cong \mathbb{Q}^*$. The abstract commensurator of Γ is a natural generalization of $\mathrm{Aut}(\Gamma)$ and thus is an object of fundamental interest in the study of infinite groups.

A celebrated result of Margulis [Mar91] is that an irreducible lattice Γ in a semisimple Lie group G is *arithmetic* if and only if the map $\Gamma \to \mathrm{Comm}(\Gamma)$ induced by conjugation has infinite index image. Roughly speaking, the abstract commensurator of an arithmetic lattice $\Gamma = G(\mathbb{Z})$ in a centerless semisimple Lie group $G \neq \mathrm{PSL}_2(\mathbb{R})$ is virtually isomorphic to $G(\mathbb{Q})$. In this sense, abstract commensurators of lattices in semisimple Lie groups are well-understood.

My thesis describes abstract commensurators of all lattices in solvable Lie groups. For such a lattice Γ, there is an algebraic group A so that $\mathrm{Comm}(\Gamma) \cong A(\mathbb{Q})$. I am interested in extending this result to other lattices and other solvable groups. For example, the abstract commensurator of the lamplighter group contains every finite group as a subgroup. What can be said about abstract commensurators of other solvable S-arithmetic groups over fields of positive characteristic?

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Thierry Stulemeijer
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Convergence of algebraic groups

The motivation for this project is to build new examples of **interesting topologically simple** groups (more specifically, totally disconnected, locally compact, compactly generated, topologically simple groups).

A few months ago, Pierre-Emmanuel Caprace and Nicolas Radu had a nice idea that might generate new examples. This works as follow. Consider $\{K_n \mid \mathbb{Q}_p \leq K_n,\ \dim_{\mathbb{Q}_p}(K_n) = n$ and $\mathcal{O}_{K_n}/\mathfrak{m}_{K_n} \simeq \mathbb{F}_p\}$. As is well known, $SL_2(K_n)$ acts on a $(p+1)$-regular tree, and the kernel of the action is the center Z_n of $SL_2(K_n)$, so that $SL_2(K_n)/Z_n \leq \mathrm{Aut}(T_{p+1})$.

When we let n vary, we obtain a collection of closed subgroups of $\mathrm{Aut}(T_{p+1})$. Now, we can endow the space of closed subgroups of $\mathrm{Aut}(T_{p+1})$ with the Chabauty topology. This space is compact, so that one immediately wonder what the accumulations points might look like. A first result is that the accumulation points are in fact the kind of groups we would like to constructs.

Proposition 1 (P.-E. Caprace and N. Radu, unpublished)**.** *The accumulation points of $\{SL_2(K_n)/Z_n\}$, taken in the Chabauty space of $\mathrm{Aut}(T_{p+1})$, are interesting topologically simple groups.*

But unfortunately, this observation does not give rise to new groups, due to the following surprising result.

Proposition 2 (N. Radu, unpublished)**.** *$(SL_2(K_n)/Z_n)_{n\in\mathbb{N}}$ converges in the Chabauty space of $\mathrm{Aut}(T_{p+1})$, and the limit is $SL_2(\mathbb{F}_p(\!(T)\!))/Z$.*

Note that in fact, there is nothing special about $\mathbb{Q}_p$ here, and one may instead start the discussion with any extension K of $\mathbb{Q}_p$.

Now, there are two obvious questions one might ask. What happens for other groups of rational rank 1 ? And what does the situation become in higher rank ? We try to answer those two questions.

Nóra Gabriella Szőke
(EPFL, Switzerland)

Topological full groups of minimal Cantor group actions

Let G be a group acting by homeomorphisms on a compact space Σ. The *topological full group* of this action is defined to be the group of piecewise G homeomorphisms on Σ. The action is called *minimal* if Σ has no proper G-invariant closed subset.

This construction yields interesting groups in the case when Σ is a Cantor space. For any minimal action of $\mathbf{Z}$, Matui proved that the commutator subgroup of the topological full group is simple, and in many cases it is also a finitely generated (infinite) group ([4], [1]). It was recently proved by Juschenko and Monod that the topological full group of any minimal Cantor $\mathbf{Z}$-action is amenable ([3]). Combining this with the previous results gives us the first examples of finitely generated infinite simple amenable groups.

Grigorchuk and Medynets asked if this theorem holds for other amenable groups as well. Elek and Monod found a counterexample, they proved that it fails already for $G \cong \mathbf{Z}^2$ ([2]). They were able to construct a minimal Cantor $\mathbf{Z}^2$-action for which the topological full group contains a non-abelian free group.

As we can see from the counterexample, there are many amenable groups for which the topological full group is not always amenable. It remains an open problem to determine those groups G for which the topological full group of any minimal Cantor G-action is amenable.

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Sam Tertooy
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Reidemeister classes

The definition of a conjugacy class in a group can be extended using automorphisms to create twisted conjugacy classes. Let G be a group and $\phi \in \text{Aut}(G)$. We define an equivalence relation $\sim$ on G by

$$g \sim g' \iff \exists h \in G : g = hg'\phi(h)^{-1}.$$

The equivalence classes are called twisted conjugacy classes or Reidemeister classes. The Reidemeister number $R(\phi)$ is defined as the number of ϕ-twisted conjugacy classes. In particular, $R(\text{Id})$ is just the number of conjugacy classes of G [1]. This theory is connected with Nielsen fixed point theory: if $f : X \to X$ induces $f_\#$ on $\pi_1(X)$, then the Nielsen number $N(f)$, which is a homotopy invariant lower bound on the number of fixed points of f, is always bounded above by the Reidemeister number $R(f) = R(f_\#)$, and determining the finiteness of $R(f_\#)$ is generally easier than computing $N(f)$. It was shown that for selfmaps f of a nilmanifold, either $N(f) = 0$ and $R(f) = \infty$, or $N(f) = R(f)$ [2].

I am interested in whether or not almost-crystallographic groups admit a finite Reidemeister number $R(\phi)$ for some automorphism ϕ. Groups that do not admit a finite Reidemeister number are said to have the R_∞ property. In [3] and [4], it was determined which almost-crystallographic groups of dimension two and three respectively have the R_∞ property.

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Vera Tonić
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Asymptotic dimension of hyperbolic spaces and dimension of their boundary

My research interest is asymptotic dimension theory, which is a large scale analog of covering dimension in coarse geometry. Asymptotic dimension was introduced by Mikhail Gromov, and can be defined as follows: for a metric space X and $n \in \mathbb{N}_{\geq 0}$, we say that $\operatorname{asdim} X \leq n$ if every uniformly bounded cover $\mathcal{U}$ of X can be coarsened to a uniformly bounded cover $\mathcal{V}$ of X with multiplicity of $\mathcal{V} \leq n+1$.

Since asdim is preserved by coarse equivalence between metric spaces, for any finitely generated group Γ its $\operatorname{asdim} \Gamma$ is invariant of the choice of a generating set for Γ.

Asymptotic dimension is useful in investigating discrete groups, and my particular interest is in formulas connecting asdim of a group with the covering dimension $\dim$ of its boundary at infinity. For example, in [1], S. Buyalo and N. Lebedeva have proven Gromov conjecture that the asymptotic dimension of every hyperbolic group Γ equals the covering dimension of its Gromov boundary plus 1, that is, $\operatorname{asdim} \Gamma = \dim \partial\Gamma + 1$. In fact, they have proven this equality for a wider class of spaces X than hyperbolic groups, namely for spaces which are hyperbolic, geodesic, proper and cobounded.

I am interested in the situation in which a space X is hyperbolic and geodesic, but it is not proper, which means that ∂X need not be compact, and whether it is possible to achieve the same inequality for X as above, and what additional properties might we have to ask of X in order to achieve this.

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Caglar Uyanik
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Dynamics of free group automorphisms and subgroup structure of $Out(F_N)$

I am a PhD student working with Ilya Kapovich and Chris Leininger. My research so far focused on dynamics of the action of $Out(F_N)$ on the space of geodesic currents on F_N, where a geodesic current is a measure theoretic generalization of a conjugacy class of an element in the free group. I showed that natural analogs of pseudo-Anosov mapping classes in the $Out(F_N)$ setting, called fully irreducible and hyperbolic, act on the space of projectivized geodesic currents with generalized uniform North-South dynamics, [2, 3, 4]. Currently, I am involved in a project where we are considering several generalizations of the geodesic currents space *relative* to a free factor system. We aim to prove North-South dynamics type statements to derive certain conclusions about the subgroup structure of $Out(F_N)$. In addition to above, I have also done some work on dynamics on translation surfaces [5], symbolic dynamics [1], and involved in a project related to automorphisms of right-angled Artin groups. Recently, I have also started thinking about convex cocompactness in $Mod(S)$ and $Out(F_N)$.

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Federico Vigolo
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Expanders and action on measure spaces

The *Cheeger constant* of a finite graph G is defined as the smallest ratio $|\partial W|/|W|$ where W varies among the subset of vertices $W \subset V(G)$ with $|W| \leq |V(G)|/2$ and ∂W is the set of edges linking W with its complement $V(G) \smallsetminus W$. A sequence of larger and larger finite graphs G_n is a *family of expanders* if they all have uniformly bounded degrees and their Cheeger constants are bounded away from zero.

Expander graphs have a huge number of applications, both in pure and applied mathematics. But it is generally rather difficult to explicitly construct such families. See [1] and [2] for a survey on the subject.

In my research I have been working on a geometrical way of defining families of expanders by approximating measurable actions on measure spaces. Such an approach seems to be particularly interesting when applied to actions on probability spaces that also carry a metric, such as compact Riemannian manifolds. This construction can be used to prove results relating to Lubotzky-like problems and warped cones (see [3] for the definition).

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Stefan-Christoph Virchow
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Applications of Character Theory and Character Estimates

I am a second year PhD student at the University of Rostock under the supervision of Professor Jan-Christoph Schlage-Puchta. My research focuses on applications of character theory and character estimates to problems on the symmetric group. More precisely, I showed the following:

Firstly, I gave a new proof of Dixon's conjecture: The probability that a pair of random permutations generates either A_n or S_n is $1 - 1/n + \mathcal{O}(n^{-\frac{3}{2}+\epsilon})$. My proof is based on character theory and does not need the classification of the finite simple groups.

Secondly, I considered the orbits of the following group action:

$$\begin{aligned}\big(\mathrm{Aut}(F_k) \times \ \mathrm{Aut}(G)\big) \times \mathrm{Epi}(F_k \twoheadrightarrow G) &\to \mathrm{Epi}(F_k \twoheadrightarrow G)\\ \big((\tau,\sigma),\phi\big) &\mapsto \sigma \circ \phi \circ \tau^{-1}.\end{aligned}$$

These orbits are called *systems of transitivity* or short T_k*-systems*. I proved that the number of T_2-systems of A_n is at least

$$\frac{1}{8n\sqrt{3}} \exp\left(\frac{2\pi}{\sqrt{6}} n^{1/2}\right)(1 + o(1)).$$

Applying this result, I obtained a lower bound for the number of connected components of the product replacement graph $\Gamma_2(A_n)$.

Finally, denote by $r_q(\tau) := \#\{\sigma \in S_n : \ \sigma^q = \tau\}$ the root number function and let χ be an irreducible character of S_n. I studied the asymptotic behavior of the multiplicities $m_\chi^q := \langle r_q, \chi\rangle$ of the root number functions and found an asymptotic formula for m_χ^q as q tends to ∞.

Katie Vokes
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Large scale geometry of curve complexes

Given a surface S, we can consider the set of all essential, non-peripheral simple closed curves on S up to isotopy. There are a number of simplicial complexes associated to a surface where each vertex is some subset of this set of curves. For example, the *curve complex* $\mathcal{C}(S)$ has one vertex for each isotopy class of curves, with $k+1$ vertices spanning a k-simplex if some representative curves from their respective isotopy classes are pairwise disjoint. The curve complex and related complexes have been much studied over the past few decades, in part because the mapping class group $\mathrm{Mod}(S)$ (the group of isotopy classes of homeomorphisms from S to itself) acts naturally on $\mathcal{C}(S)$. In fact, the mapping class group is quasi-isometric to another complex, the *marking graph* $\mathcal{M}(S)$ of S, where markings are certain collections of curves which cut the surface S into disks and peripheral annuli.

The curve complex of any surface is a Gromov hyperbolic space, as was first proved by Masur and Minsky [2]. Any hyperbolic space satisfies the *coarse median* property defined by Bowditch [1]. In this case, the median of three points is a centre of a geodesic triangle with those three points as vertices, which is well-defined up to bounded distance. Bowditch also shows that the mapping class group (or equivalently the marking graph) has a coarse median structure, where the median is the centroid constructed by Behrstock and Minsky. A current aim of my project is to show that other curve complexes such as the separating curve complex also have this property. This is the subcomplex of $\mathcal{C}(S)$ spanned by separating curves and is not quasi-isometrically embedded in $\mathcal{C}(S)$.

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Phillip Wesolek
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Large scale topological structure of locally compact groups

My primary research interest is the application of descriptive set theory and geometric group theory to the study of locally compact groups. I am particularly interested in the interaction between local structure and large scale geometric structure in locally compact groups. Indeed, the presence of both local and large scale structure has surprising consequences.

If $L < K$ are closed normal subgroups of a locally compact group G and there is no closed normal subgroup of G strictly between L and K, then K/L is a **chief factor** of G.

Theorem 1 (Reid, Wesolek [1])**.** *If G is a compactly generated locally compact group, then G admits a finite series of closed normal subgroups $\{1\} = G_0 \leq G_1 \cdots \leq G_n = G$ so that each factor G_i/G_{i-1} is either compact, discrete, or a chief factor.*

Current project: An interesting large scale property which is sensitive to the presence of local structure is amenability. Indeed, amenability is *not* a quasi-isometry invariant for compactly generated locally compact groups in general; the groups must also be unimodular.

For discrete groups, i.e. in the absence of local structure, there are many exotic examples of amenable groups; e.g. Grigorchuk's celebrated groups of intermediate growth. Surprisingly, it is unknown if there exists exotic locally compact amenable groups with non-trivial local structure.

Let $\mathcal{AE}$ be the smallest class of locally compact groups that contains all compact groups, discrete amenable groups, and locally compact abelian groups and that is closed under taking group extensions, closed subgroups, Hausdorff quotients, and directed unions of open subgroups.

Question 1. *(Non-discrete Day question) Is every amenable locally compact group an element of $\mathcal{AE}$?*

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Adam Wilks
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Systolic Groups

I am interested mostly with Systolic groups. Systolic complexes were introduced in [1] as means of finding examples of word hyperbolic groups. A systolic complex is a simply connected simplicial complex with a restriction on the size of cycles without diagonals. 2-dimensional systolic complexes are CAT(0). Systolic groups are groups that act proplerly and cocompactly on systolic complexes.

It was shown in [2] that most triangle coxeter groups are systolic and that the triangle coxeter group of type (2, 4, 4) is not systolic. In the paper it was posed whether the triangle Coxeter groups of type (2, 4, 5) and (2, 5, 5) are systolic. I am trying to show that neither of theses groups are systolic. To do so I am looking at how these groups act on some systolic complex X. Using the systolic fixed point theorem, it is seen that finite subgroups fix certain cliques of X and this fact is used as a handle to show that these actions cannot possibly be cocompact.

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Esmee te Winkel
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Sticky laminations of the circle

I am interested in laminations of the circle, or equivalently, geodesic laminations of hyperbolic surfaces. At the moment I am studying the structure of sticky laminations. One goal is to fully understand a theorem of Calegari, which states that whenever the fundamental group of a closed irreducible 3-manifold admits an action on the circle with a sticky lamination, then the manifold is Haken [1].

We say two pairs of points in the circle are linked if the points of the first pair are contained in two different components of the complement in S^1 of the second pair [2]. A lamination of the circle is a closed subset in the space of unordered pairs of distinct points in S^1, with the property that no two elements of the lamination are linked. Considering the circle as the ideal boundary of the hyperbolic plane, a lamination corresponds to a closed set of disjoint geodesics in the hyperbolic plane, called a geodesic lamination. Usually, we consider a lamination Λ together with a group Γ of homeomorphisms that preserve the lamination.

Calegari proves that the sticky laminations (Λ, Γ) are classified up to isomorphism by the partitions of a positive number into distinct positive integers ≥ 2. Even more, the group Γ of homeomorphisms that preserve the lamination is isomorphic to the fundamental group of a graph of groups. This is an important result to gain insight in the structure of sticky laminations.

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Daniel J. Woodhouse
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CAT(0) Cube Complexes

Following the research program of Dani Wise (see [1] [2]), I am interesting in which groups act on CAT(0) cube complexes. Much of the recent progress made has been made in understanding the (relatively) hyperbolic setting, most notably with Agol's proof of Wise's conjecture [3], but outside of this setting there is still much work to be done.

A group is *tubular* if it splits as a graph of groups with vertex groups isomorphic to $\mathbb{Z}^2$ and edge groups isomorphic to $\mathbb{Z}$. Wise provided a criterion which determines if a tubular group acts freely on a CAT(0) cube complex [4]. The criterion is constructive in the sense that it gives immersed walls that are then dualized via Sageev's construction to obtain a CAT(0) cube complex. In [5] I provide a further criterion for finite dimensionality of the cubulation. There are many interesting applications of this criterion, including to separability of the associated codimension-1 subgroups, and to their quasi-embeddability.

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Research Statement

Below is a list of some of my current research projects:

- *Compactification of strata*: My advisor John Smillie developed a way to compactify the stratum similar to the Borel-Serre compactification of Outer space. We are currently working on understanding the properties of this compactification. For example, we described the strata of meromorphic differentials that contain differentials with zero residue at all the cone points, and built affine manifold models of this compactification in a few small strata. An application of this compactification is that it gives an alternative description of some phenomena in horocycle orbit closures obtained by "pushing" a $GL(2,\mathbb{R})$-orbit closure found by Smillie, Weiss, Clavier and others.

- *Constructing pseudo-Anosov maps*: This is a joint project with Harry Baik and Ahmad Rafiqi. We build examples of pseudo-Anosov maps on finite surfaces that approximate affine maps on infinite translation surfaces by interpreting the latter as end-periodic maps [F].

- *Generalizing McMullen's theorem to Outer space*: This is a joint project with Farbod Shokrieh. Koberda [K] proposed a conjecture that generalizes a theorem by McMullen, that given any $\phi \in Out(F_n)$ irreducible with irreducible powers, let $\lambda(\phi)$ be its expansion factor, $\rho(\phi)$ be the spectral radius of the induced map ϕ_* on the abelianization of F_n, then, either there is a finite lift $\tilde{\phi}$ such that $\rho(\tilde{\phi}) = \lambda(\tilde{\phi})$, or $\lambda(\tilde{\phi}) - \rho(\tilde{\phi})$ is bounded away from 0 for any finite lift $\tilde{\phi}$. We conjectured that the second case happens when there is "local obstacle", i.e. when the expanding lamination of ϕ can not be oriented at a vertex.

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Alexander Zakharov
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Intersecting subgroups in groups acting on trees

The question of bounding the rank of the intersection of subgroups in terms of their ranks in a given group dates back to 1950s when Hanna Neumann proved that for finitely generated subgroups of a free group $\overline{r}(H \cap K) \leqslant 2\,\overline{r}(H)\overline{r}(K)$, where $\overline{r}(H) = max\,(r(H) - 1, 0)$, and $r(H)$ is the rank of H. Hanna Neumann also conjectured that in fact $\overline{r}(H \cap K) \leqslant \overline{r}(H)\overline{r}(K)$, and this long-standing conjecture was finally proved in 2011 independently by Joel Friedman and Igor Mineyev. Sergei Ivanov and Warren Dicks ([1]) proved estimates of this type for subgroups of free products of groups.

During my PhD (my advisor was Anton Klyachko) I generalized these results to larger classes of groups acting on trees ([2], [3]). The main result of [3] is the following theorem.

Theorem. *Let G be a group acting on a oriented tree T with finite quotient and finite edge stabilizers, and suppose H and K are finitely generated subgroups of G which act freely on T (and thus are free). Then $\overline{r}(H \cap K) \leqslant 6m\,\overline{r}(H)\overline{r}(K)$, where m is the maximum of the orders of the edge stabilizers.*

This theorem applies to free products with finite amalgamated subgroup, to HNN-extensions with finite associated subgroups, as well as to virtually free groups.

Currently we are working together with Sergei Ivanov on some further generalizations of these results. I have also started working on the asymptotic cones of right-angled Artin groups with Ilya Kazachkov and Montserrat Casals-Ruiz.

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