Young Geometric Group Theory IV

Spa, Belgium

Sunday, January 11, 2015
–
Saturday, April 17, 2015

Contents

1 In memoriam Kamil Duszenko (1986–2014)

The *Young Geometric Group Theory* meeting, initiated by Piotr Przytycki, is an international yearly event in mathematics which aims to provide advanced training to young researchers in geometric group theory. Its main purpose is to introduce some of the most important contemporary research topics in all aspects of geometric group theory to an audience which mainly consists of young researchers, PhD students and post-docs.

This year's meeting is dedicated to the memory of **Kamil Duszenko**. A short evening session on Monday will provide the opportunity to learn more about his life and work.

Kamil studied at Wroclaw University, where he was working in Geometric Group Theory.

Gold medalist of the International Math Olympiad, he worked later in the main committee of the Polish National Olympiad, coming up with problems and writing up their solutions. In 2009 he received the first prize in the Jozef Marcinkiewicz Competition for the best student article in Poland.

He was one of the organisers of the first Young GGT Meeting in Bedlewo, responsible for the webpage, poster, and research statements brochure.

Having been diagnosed with acute lymphoblastic leukemia shortly after having filed his PhD, he left only a handful of articles. One of his results is that in any non-affine Coxeter group for each n there is an element that is not a product of less than n reflections. In his PhD he was studying the existence of hyperbolic quotients of non-affine Coxeter groups.

Kamil was very sociable, not missing an occasion to drop in for a seminar when he was visiting Warsaw and reporting on all the news from Wroclaw. Besides his mathematical activities, Kamil was also a hiker, a bridge player and a talented pianist: many of the partipants of the first YGGT meeting will remember his impressive playing of some pieces from the great classical repertoire resonating in the air around the Bedlewo castle.

Always ready to discuss passionately mathematics, his presence was inspiring and valuable to those who had the chance to meet him. Energetic, smiling, and perceptive, he will be greatly missed.

2 Time schedule

Sunday, 11th January 2015

17:00 – 19:00	Registration

Monday, 12th January 2015

09:00 – 09:50	**Danny Calegari — I**
10:00 – 10:50	**Bertrand Rémy — I**
10:50 – 11:30	*Coffee & tea*
11:30 – 12:20	**Denis Osin — I**
....	....
14:30 – 15:20	**Sara Maloni**
15:20 – 16:00	*Coffee & tea*
16:00 – 16:50	**Mark Hagen**
17:00 – 18:00	*Tutorials*
18:00 – 18:50	*Cocktails*
20:15 – 20:45	**Kamil's work**

Tuesday, 13th January 2015

09:00 – 09:50	**Danny Calegari — II**
10:00 – 10:50	**Ursula Hamenstädt — I**
10:50 – 11:30	*Coffee & tea*
11:30 – 12:20	**Denis Osin — II**
....	....
14:30 – 15:20	**Aditi Kar**
15:20 – 16:00	*Coffee & tea*
16:00 – 16:50	**Bertrand Rémy — II**
17:00 – 18:00	*Tutorials*
18:00 – 18:50	*Poster session*

Wednesday, 14th January 2015

09:00 – 09:50	**Ursula Hamenstädt — II**
10:00 – 10:50	**Alden Walker**
10:50 – 11:30	*Coffee & tea*
11:30 – 12:20	**Bertrand Rémy — III**
....	
14:00 – 17:00	*Excursion*
....	
17:00 – 18:00	*Coffee & tea*
18:00 – 18:50	**Jean Raimbault**

Thursday, 15th January 2015

09:00 – 09:50	**Danny Calegari — III**
10:00 – 10:50	**Ursula Hamenstädt — III**
10:50 – 11:30	*Coffee & tea*
11:30 – 12:20	**Denis Osin — III**
....	
14:30 – 15:20	**Petra Schwer**
15:20 – 16:00	*Coffee & tea*
16:00 – 16:50	**Bertrand Rémy — IV**
17:00 – 17:50	**Alexey Talambutsa**
18:00 – 18:50	*Tutorials*

Friday, 16th January 2015

09:00 – 09:50	**Danny Calegari — IV**
10:00 – 10:50	**Ursula Hamenstädt — IV**
10:50 – 11:30	*Coffee & tea*
11:30 – 12:20	**Denis Osin — IV**

3 Abstracts

Minicourse speakers

Danny Calegari
(U Chicago, USA)

Building surfaces

This minicourse will concentrate on combinatorial methods to build surfaces (and other things) out of pieces, with applications to subgroup construction, stable commutator length, and so on.

Ursula Hamenstädt
(University Bonn, Germany)

Hyperbolic $\mathrm{Out}(F_n)$*-graphs and their boundaries*

The Outer automorphism group $\mathrm{Out}(F_n)$ of a free group F_n with n generators acts on three different hyperbolic graphs. These are the free factor graph, the cyclic splitting graph and the free splitting graph.

We explain the structure of these graphs and discuss their Gromov boundaries. We also give some application towards an understanding of the geometry of $\mathrm{Out}(F_n)$.

Denis Osin
(Vanderbilt University, USA)

Acylindrically hyperbolic groups

I will survey recent advances in the study of groups acting acylindrically on hyperbolic spaces. A special emphasis will be made on the approach based on hyperbolically embedded subgroups. In particular, we will discuss the general version of group theoretic Dehn surgery and some of its applications. Most of the material will be based on the papers [1, 2, 3, 4, 5, 6, 7].

References

[1] F. Dahmani, V. Guirardel, D. Osin, Hyperbolically embedded subgroups and rotating families in groups acting on hyperbolic spaces, arXiv:1111.7048.

[2] M. Hull, Small cancellation in acylindrically hyperbolic groups, arXiv:1308.4345.

[3] M. Hull, D. Osin, Induced quasi-cocycles on groups with hyperbolically embedded subgroups, *Alg. & Geom. Topology* **13** (2013), no. 5, 2635-2665.

[4] A. Minasyan, D. Osin, Acylindrically hyperbolic groups acting on trees, arXiv:1310.6289.

[5] D. Osin, Acylindrically hyperbolic groups, arxiv:1304.1246; to appear in *Trans. Amer. Math. Soc.*

[6] D. Osin, Small cancellations over relatively hyperbolic groups and embedding theorems, *Annals of Math.* **172** (2010), 1-39.

[7] D. Osin, Peripheral fillings of relatively hyperbolic groups, *Invent. Math.* **167** (2007), no. 2, 295-326.

Bertrand Rémy
(École polytechnique, France)

Buildings and associated group actions

The lectures will be dealing with group actions on buildings (some cell complexes with nice symmetry properties and defined by means of Lie-theoretic data). The covered topics are organized as follows.

1. Definition of buildings
    - 1A. Coxeter groups and Coxeter complexes
    - 1B. Definition and first examples of buildings
    - 1C. Tits systems
2. The classical theories
    - 2A. Spherical buildings: Borel-Tits theory
    - 2B. Euclidean buildings: Bruhat-Tits theory
    - 2C. Relationship between the two theories
3. The exotic case
    - 3A. A nice metric property
    - 3B. Some interesting finitely generated groups
    - 3C. Some interesting profinite groups

References

[1] Peter Abramenko and Ken Brown *Buildings. Theory and Applications*, Graduate Texts in Mathematics **248**, Springer, 2008.

[2] Nicolas Bourbaki *Lie IV-VI*, Springer, 2007.

[3] Mark A. Ronan *Lectures on buildings (updated and revised)*, the University of Chicago Press, 2009.

Other speakers

Mark Hagen
(University of Michigan, USA)

Cubulating hyperbolic free-by-$\mathbb{Z}$ groups

Let F be a finitely generated free group and let $\Phi\colon F \to F$ be an automorphism. If $G = F \rtimes_\Phi \mathbb{Z}$ is word-hyperbolic, then G acts freely and cocompactly on a CAT(0) cube complex. I will explain some consequences of this result and give an outline of the proof. This talk is on joint work with Dani Wise.

Aditi Kar
(University of Southampton/ Oxford, UK)

Gradients in Group Theory

Rank and Deficiency gradients quantify the asymptotics of finite approximations of a group. These group invariants have surprising connections with many different areas of mathematics: 3-manifolds, L^2-Betti numbers, topological dynamics and profinite groups. I will give a survey of the current state of research in Gradients for groups and describe important open questions.

Sara Maloni
(Brown University, USA)

Polyhedra inscribed in quadrics, anti-de Sitter and half-pipe geometry

In this talk we will show that a planar graph is the 1-skeleton of a Euclidean polyhedron inscribed in a hyperboloid if and only if it is the 1-skeleton of a Euclidean polyhedron inscribed in a cylinder if and only if it is the 1-skeleton of a Euclidean polyhedron inscribed in a sphere and has a Hamiltonian cycle. This result follows from the characterisation of ideal polyhedra in anti-de Sitter and half-pipe space in terms of their dihedral angles. We also characterise those polyhedra in terms of the induced metric on their boundary.

(This is joint work with J. Danciger and J.-M. Schlenker.)

Jean Raimbault
(Université Paul Sabatier, Toulouse, France)

Hyperbolic manifolds of large volume

I will try to describe some results on the global geometry of some hyperbolic manifolds of large volume, and their application to the topology of such manifolds. (subject to changes later).

References

[1] *On the convergence of arithmetic orbifolds*, Jean Raimbault, arXiv preprint.

Petra Schwer
(KIT, Germany)

Why buildings are interesting

Buildings are simplicial complexes which generalize certain aspects of the geometry of finite projective planes, Riemannian symmetric spaces and trees. They were first introduced by Jaques Tits as combinatorial objects associated to exceptional groups of Lie type. Up to now buildings have been used in several fields of mathematics, such as reductive algebraic groups over local fields and their presentations, Kac–Moody groups and geometric group theory. They form prime classes of examples for CAT(0) and CAT(1) spaces.

In this talk I will introduce buildings and provide some examples of spherical and affine ones. Afterwards I will highlight two examples of my own research where buildings are used to study algebraic and geometric properties of groups.

Alexey Talambutsa
(Steklov Mathematical Institute of RAS, Moscow)

Relations between counting functions on free groups and free monoids

We find a complete set of linear relations between equivalence classes of counting functions on the free group F_n and the free monoid M_n, where two counting functions are considered equivalent if they differ by a bounded function. We use this to determine all linear relations between equivalence classes of counting quasimorphisms on free groups. We also construct an explicit basis for the vector space spanned by all equivalence classes of counting quasimorphisms on F_n. Moreover, we provide an algorithm of quadratic time complexity for checking if a given linear combination of counting functions on F_n is bounded.

(This is joint work with Tobias Hartnick.)

Alden Walker
(University of Chicago, USA)

Random groups contain surface subgroups

Gromov asked whether every one-ended hyperbolic group contains a subgroup isomorphic to the fundamental group of a closed surface. This question is open in general, although several classes of groups have been shown to contain surface subgroups. Perhaps the best-known example of this is [2]. I'll give some background on the question and also on the topic of random groups, and I'll sketch the proof that a random group contains many quasi-isometrically embedded surface subgroups.

References

[1] D. Calegari and A. Walker, *Random groups contain surface subgroups*, to appear in Jour Amer Math Soc.

[2] J. Kahn and V. Markovic, *Immersing almost geodesic surfaces in a closed hyperbolic three manifold*, Ann. Math. **175** (2012), no. 3, 1127–1190.

Poster session

Hyungryul Baik

Laminations on the circle and hyperbolic geometry

Benjamin Beeker (with Nir Lazarovich)

Resolutions of CAT(0) cube complexes

Federico Berlai

Kaplansky's stable finiteness conjecture

Henry Bradford

Expansion in groups

Jonas Deré

Which manifolds admit an expanding map?

Elisabeth Fink

Morse quasi-geodesics in torsion groups

Dawid Kielak

Nielsen realisation for right-angle Artin groups

Roman Kogan

Algorithms and software for higher dimensional Thompson's groups

John Lawson

Minimal mutation-infinitequivers from Coxeter simplices and elsewhere

Michal Marcinkowski

Gromov PSC conjecture and rationally inessential macroscopically large manifolds

Dionysios Syrigos

Irreducible laminations for IWIP automorphisms of free products and centralisers

Alex Taam

JSJ decompositions of Γ-limit groups

Research statements

Martina Aaltonen
(Univeristy of Helsinki, Finland)

Monodromy representations of completed coverings

Let $f\colon X \to Z$ be a mapping from a locally connected Hausdorff space onto a manifold, then f is a *completed covering*, if the collection of components of pre-images of open sets in Z form a basis of X, there are locally connected subsets $X' \subset X$ and $Z' \subset Z$ so that $f \restriction X'\colon X' \to Z'$ is a covering and if for every point z of Z and every open neighbourhood W of z there is selected a component V_W of $g^{-1}(W)$ in such a way that $V_{W_1} \subset V_{W_2}$ whenever $W_1 \subset W_2$, then $\cap_W V_W \neq \emptyset$.

Let $f\colon X \to Z$ be a completed covering between manifolds. Then a triple (Y,p,q) is *a monodromy representation* of f if Y is a locally connected Hausdorff space and the monodromy group G of f has an action on Y and a subgroup $H \subset G$ so that $Y/G \approx Z$, $Y/H \approx X$ and the associated orbit maps $p\colon Y \to X$ and $q\colon Y \to Z$ are completed coverings satisfying $q = p \circ f$. We call (Y,p,q) *locally compact* if Y is locally compact.

Let $f\colon X \to Z$ be a completed covering between manifolds. Then there exists completed coverings $p\colon Y \to X$ and $q\colon Y \to Z$ so that if f has a monodromy representation, then (the) monodromy representation of f is $(Y,p,q)_f$, see Fox [2]. If X and Z are compact manifolds, then $(Y,p,q)_f$ is a monodromy representation of f, see Berstein and Edmonds [1]. We show:

- The triple $(Y,p,q)_f$ is a monodromy representation of f if and only if q is a discrete map.
- The triple $(Y,p,q)_f$ is a locally compact monodromy representation of f if and only if q has locally finite multiplicity.

References

[1] I. Berstein and A. L. Edmonds. The degree and branch set of a branced covering. *Invent. Math.*, 45(3):213–220, 1978.

[2] R. Fox. Covering spaces with singularities A symposium in honor of S. Lefschetz., Princeton University Press, Princeton, N.J.: 243–257, 1957.

Carolyn Abbott
(University of Wisconsin - Madison, USA)

Short conjugators in higher rank lamplighter groups

I am a third year Ph.D. student working under Tullia Dymarz. I am currently working on bounding the length of short conjugators in higher rank lamplighter groups, using the geometric properties of their Cayley graphs.

A lamplighter group can be defined as a wreath product, $\Gamma_2(q) = \mathbb{Z}_q \wr \mathbb{Z}$, and its Cayley graph, called a Diestel-Leader graph, is the horocyclic product of two $(q+1)$-valent trees, T_1 and T_2; that is, $DL_2(q) = \{(x, y) | x \in T_1,\, y \in T_2,\, h(x) + h(y) = 0\} \subset T_1 \times T_2$, where h is a height function $h : T_i \to \mathbb{Z}$. Lamplighter groups have solvable conjugacy problem, and Sale gives a geometric method for finding a linear bound on the length of short conjugators in [1]. That is, given any two conjugate elements $u, v \in \Gamma_2(q)$, with $\|u\| + \|v\| = n$, one can find a conjugator whose length is bounded above by a linear function of n. His method relies on the geometry of the Diestel-Leader graph and the work of Stein and Taback, [2], who give a geometric method for bounding the lengths of elements in terms of the geometry of the Diestel-Leader graphs.

I am interested in extending Sale's methods to higher rank lamplighter groups, which can be defined as the semidirect product $\Gamma_d(q) = \mathbb{Z}_q[x, (l_1 + x)^{-1}, \ldots, (l_{d-1} + x)^{-1}] \rtimes_\phi \mathbb{Z}^n$. The l_i are elements of a commutative ring of order q, with pairwise differences $l_i - l_j$ invertible, and $(a_1, \ldots, a_d) \in \mathbb{Z}^n$ acts by multiplication by $x^{a_1}(l_1 + x)^{a_2} \ldots (l_{d-1} + x)^{a_d}$. The Cayley graph of $\Gamma_d(q)$ is a Diestel-Leader graph $DL_d(q)$, which is the horocyclic product of d $(q+1)$-valent trees. By generalizing Sale's method for the case $d = 2$, I hope to find a linear bound on the length of short conjugators in these higher lamplighter groups.

References

[1] Sale, Andrew. *The length of conjugators in solvable groups and lattices of semisimple Lie groups.* University of Oxford Ph.D. Thesis.

[2] M. Stein and J. Taback. *Metric properties of Diestel-Leader groups.* The Michigan Mathematical Journal 62 (2013), no. 2, 365–386.

Sylvain Arnt
(University of Neuchâtel, Switzerland)

Isometric affine action on Banach spaces

My research is about properties related to isometric affine actions of groups on some classes of Banach spaces, like Haagerup property or property PL^p. More precisely, I study stability of such properties by group constructions: semi-direct products, wreath products, amalgamated free products, etc. The characterization of the Haagerup property in terms of proper actions on spaces with measured walls (see [2, 3]) gives a geometric setting to consider this stability problems in the Hilbert case. I defined in [1] a generalization of the structure of space with measured walls, namely the structure of space with labelled partitions to study the case of isometric affine actions on Banach spaces. I obtained the following result :

Theorem 1. *A topological group acts properly by affine isometries on a Banach space if, and only if, it acts properly by automorphisms on a space with labelled partitions.*

The definition of spaces with labelled partitions was essentially based on the following result of G. Yu (see [5]): Let G be a finitely generated word-hyperbolic group, there exists an isometric affine and proper action of this group on an ℓ^p space i.e. G has property PL^p for some $p \geq 2$.

Thanks to Theorem 1, I was able to generalize a result of Cornulier, Stalder and Valette (see [4]) in the following way: the wreath product of a group having property PL^p by a Haagerup group has property PL^p.

References

[1] Arnt, S. (2013). Spaces with labelled partitions and isometric affine actions on Banach spaces. arXiv preprint arXiv:1401.0125.

[2] Chatterji, I., Druţu, C., Haglund, F. (2010). Kazhdan and Haagerup properties from the median viewpoint. Adv. Math., 225(2), 882-921.

[3] Cherix, P. A., Martin, F., Valette, A. (2004). Spaces with measured walls, the Haagerup property and property (T). Ergodic Theory Dynam. Systems, 24(06), 1895-1908.

[4] Cornulier, Y., Stalder, Y., Valette, A. (2012). Proper actions of wreath products and generalizations. Trans. Amer. Math. Soc., 364(6), 3159-3184.

[5] Yu, G. (2005). Hyperbolic groups admit proper affine isometric actions on l p-spaces. Geometric and Functional Analysis, 15(5), 1144-1151.

Hyungryul Baik
(University of Bonn, Germany)

Laminations on the Circle and Hyperbolic Geometry

My principal areas of interest are low-dimensional topology and geometric group theory. Recently I have focused on studying the theory of laminations on the circle which gives links among the theory of foliations in 3-manifolds and group actions on 1-manifolds.

A lamination on the circle is a set of pairs of points of the circle which can be obtained as the endpoints of a geodesic lamination of $\mathbb{H}^2$. Thurston in [1] showed that if an atoroidal 3-manifold M admits a taut foliation, then $\pi_1(M)$ acts faithfully on S^1 with a pair of transverse dense invariant laminations. Most 3-dimensional manifolds admit hyperbolic structures, and Agol's recent resolution of the Virtual Fibering conjecture [2] implies that every closed hyperbolic 3-manifold group has a tautly foliated finite-sheeted cover. Hence, group actions on the circle with invariant laminations arise naturally and frequently in the study of 3-manifolds.

My recent theorem proves that if a group acts on the circle with two transverse very-full invariant laminations, then it satisfies a version of Tits alternative and non-elementary one behaves similarly to the fundamental group of a hyperbolic 3-manifold which fibers over the circle. One can also study the case in which there is one extra very-full lamination. Another theorem of mine says that if a group acts on the circle with three transverse very-full invariant laminations, then the group is topologically conjugate to a Fuchsian group, and hence has infinitely many very-full invariant laminations. This gives a completely new characterization of Fuchsian groups in terms of their invariant laminations on the circle. All my results show that group actions on S^1 with very-full invariant laminations are closely related to hyperbolic geometry.

References

[1] William Thurston, *Three-manifolds, Foliations and Circles, I*, arXiv:math/9712268v1 (1997).

[2] Ian Agol, Daniel Groves, and Jason Manning, *The Virtual Haken conjecture*, arXiv:1204.2810 (2012).

Juliette Bavard
(Paris 6, France)

Big mapping class group

I'm interested in surface dynamics. More precisely, I study the mapping class group of the complement of a Cantor set in the plane, which arises naturally in this context.

To get informations on this group using geometric group theory, Danny Calegari defined a ray graph. This graph is an analog of the complex of curves for this surface of infinite type (the usual complex of curves of the plane minus a Cantor set has diameter 2). In [1], I showed that this ray graph has infinite diameter and is hyperbolic. I used the action of the mapping class group Γ of the complement of a Cantor set on this graph to find an explicit non trivial quasimorphism on Γ and to show that this group has infinite dimensional second bounded cohomology.

References

[1] Hyperbolicité du graphe des rayons et quasi-morphismes sur un gros groupe modulaire, arXiv:1409.6566.

Benjamin Beeker
(Technion, Israel)

Graph of groups and JSJ decompositions

The JSJ theory is a way to describe canonical splittings of finitely generated groups in graph of groups. I am studying two different kinds of JSJ decompositions.

To define what a JSJ decomposition is, we need the notion of universally elliptic subgroup. Given a group G and a decompositon Γ, a subgroup $H \subset G$ is *elliptic* in Γ if H is conjugated into a vertex group. Given a class of subgroups $\mathcal{A}$ of G, a subgroup $H \subset G$ is *universally elliptic* if for every decomposition of G as a graph of groups with edge groups in $\mathcal{A}$, the group H is elliptic. A decomposition is universally elliptic if every edge group is universally elliptic.

A decomposition Γ *dominates* another decomposition Γ' if every elliptic group of Γ is elliptic in Γ'. A decomposition is a JSJ decomposition if it is universally elliptic and it dominates every other universally elliptic decomposition.

The second kind of JSJ decomposition is the compatibility JSJ decomposition. Given a group G, a *G-tree* is a simplicial tree on which G acts cocompactly, without inversion. Given two G-trees $\mathcal{T}$ and $\mathcal{T}'$, we say that $\mathcal{T}$ *refines* $\mathcal{T}'$ if $\mathcal{T}'$ is obtained from $\mathcal{T}$ by collapsing some edge orbits. We say that $\mathcal{T}$ and $\mathcal{T}'$ are *compatible* if there existes a third G-tree which refines both $\mathcal{T}$ and $\mathcal{T}'$.

Given a class of subgroups $\mathcal{A}$ of G, a *compatibility JSJ tree* over $\mathcal{A}$ is a G-tree which is compatible with every G-tree with edge stabilizers in $\mathcal{A}$, and maxiaml for refinement under this assumption. This definition has been given by Guirardel and Levitt. They prove the existence of compatibility JSJ tree. Unlike usual JSJ decomposition, the compatibility JSJ tree is canonical and thus preserved by the automorphisms of the group.

In my thesis, I give a description of both those JSJ decompositions in a particular class of groups called $vGBS$ groups.

Federico Berlai
(University of Vienna, Austria)

Residual properties of discrete groups and Kaplansky's conjectures

I am a second-year PhD student at the University of Vienna, under the supervision of Professor Goulnara Arzhantseva. My research focuses on approximation of discrete groups, with emphasys on residual properties, and in particular on residually amenable groups.

In [1] I proved, among other things, that the class of residually amenable groups is closed under taking free products. In that preprint I also considered the proamenable topology of a residually amenable group. I proved that an HNN extension $A*_H = \langle A, t \mid tht^{-1} = h \quad \forall h \in H\rangle$ is residually amenable if and only if A is itself residually amenable and H is closed in the proamenable topology of A. A similar statement is true for amalgamated free products.

Another interest are Kaplansky's direct and stable finiteness conjectures. These conjectures are known to hold for sofic groups. I am planning to prove these conjectures for certain extensions of sofic groups, which are yet not known to be sofic.

My research is supervised by my advisor Goulnara Arzhantseva and supported by her ERC grant "ANALYTIC" no. 259527.

References

[1] F. Berlai, *Residual properties of free products*. Submitted for publication. ArXiv preprint: arXiv:1405.0244.

Matthias Blank
(University of Regensburg, Germany)

Relative Bounded Cohomology

I am currently working primarily with bounded cohomology, as well as uniformly finite homology and other coarse homology theories.

In order to construct *bounded cohomology*, instead of looking at general cochains as in regular cohomology of topological spaces, one only considers bounded cochains (with respect to the canonical ℓ^1-norm on the chain complex). This leads to a theory very different from ordinary cohomology, which is both enriched and complicated by the lack of accessible tools (like excision) for more general calculations.

In the study of bounded cohomology, ideas from geometric group theory are often central. Conversely, bounded cohomology can for instance detect whether a group is hyperbolic (or amenable) or not.

In order to circumvent problems of connectivity in several applications, we have introduced bounded cohomology for (pairs of) groupoids (in particular, for groups relative to a family of subgroups). In this setting, we have established a homological algebraic frame work to study resolutions that can calculate bounded cohomology. We apply this to prove a version of the relative mapping theorem.

For an introduction to *uniformly finite homology*, see my article with Francesca Diana. There, we show that the uniformly finite homology groups of amenable groups are infinite dimensional in many cases.

References

[1] M. Blank, *Relative Bounded Cohomology for Groupoids.* Ph.D. thesis in preparation (2014).

[2] M. Blank, F. Diana, *Uniformly finite homology of amenable groups*, Preprint arXiv. To appear in Geometric & Algebraic Topology.

[3] M. Gromov, *Volume and bounded Cohomology*, Publ. Math. IHES, 56 (1982).

[4] C. Löh, *Group Cohomology and Bounded Cohomology. An Introduction for Topologists*, Lecture Notes (2010). Available online via www.mathematik.uni-regensburg.de/loeh/teaching/topologie3_ws0910/prelim.pdf.

Henry Bradford
(University of Oxford, United Kingdom)

Diameter, Expansion and Random Walks in Linear Groups

I study spectral gap and related phenomena for families of finite groups. Let G be a finite group, $S \subseteq G$ a generating set. The *spectral gap* of the pair (G, S) is a measure of the *mixing time* of the simple random walk on (G, S): that is, if (G, S) has large spectral gap then only a small number of steps must be taken in such a walk before the associated probability distribution on G is close to uniform. Large spectral gap for (G, S) is strongly correlated with small *diameter*, that is the size of the smallest ball in the word metric induced on G by S, which is the whole of G.

A topic of specific interest in this field is the construction of *expanders*, which are sequences $(G_n, S_n)_n$ of pairs in which the spectral gaps are bounded away from zero. Expanders have found many applications in geometry; combinatorics and number theory [2], and the past decade has seen a revolution in constructions of expanders from linear groups, beginning with the work of Bourgain and Gamburd on $SL_2(p)$ ([1]).

As a particular application, if a finitely generated group Γ has many finite quotients with large spectral gap then there is hope of proving rapid escape of a random walk on Γ from a subset X by considering escape from the image of X in those quotients. This strategy has been applied by many authors, including Lubotzky and Meiri, who used it to study random walks in linear groups; mapping class groups of surfaces and automorphism groups of free groups (see [3] and references therein).

I research constructions of expanders; diameter bounds and escape of random walks in the setting of linear groups over non-archimedean fields.

References

[1] J. Bourgain, A. Gamburd. Uniform Expansion Bounds for Cayley Graphs of $SL_2(\mathbb{F}_p)$. Annals of Mathematics, 167 (2008), 625-642.

[2] A. Lubotzky. Expander Graphs in Pure and Applied Mathematics. arXiv:1105.2389

[3] A. Lubotzky, C. Meiri. Sieve Methods in Group Theory I: Powers in Linear Groups. arXiv:1107.3666

Sabine Braun
(Karlsruhe Institute of Technology, Germany)

Volume versus asymptotic invariants for large manifolds

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 [1]. While this problem remains open it is known that there is an upper bound for the ℓ^2-Betti numbers of such a manifold by the foliated integral simplicial volume [2].
In [3] 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. Combining the techniques presented there with methods 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 upper bound for the ℓ^2-Betti numbers of an aspherical manifold.
Furthermore I intend to axiomatize situations where techniques for bounding the simplicial volume can be transferred to similar estimates for the foliated integral volume. This could be helpful in showing bounds for the ℓ^2-Betti numbers by the volume entropy.

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Sam Brown
(University College London, UK)

Subgroups of fundamental groups of special cube complexes

Haglund and Wise's 2008 definition of a *special cube complex* [1] sparked a very fruitful few years in geometric group theory, the culmination of which was Agol's proof of the Virtual Haken Theorem [2]. I am interested in studying the techniques available for working with special cube complexes, in the hope that previously intractable problems in geometric group theory may be approachable in this setting.

One such problem concerns the interplay between algebraic and geometric properties of subgroups of hyperbolic groups. The *width* of a subgroup $H \subset G$ is the largest number n such that there exists a set of n distinct proper conjugates of H in G with infinite pairwise intersection. A subgroup $H \subset G$ is called *quasiconvex* if the corresponding subspace of the Cayley graph of G is a quasiconvex subspace (geodesics with endpoints in the subspace stay within a bounded distance of it). Gitik, Mitra, Rips and Sageev proved that quasiconvex subgroups of hyperbolic groups have finite width [3]. The converse is a long-standing open problem, credited in Bestvina's problem list [4] to Swarup. In the setting of special cube complexes, however, it seems that certain combinatorial techniques (in particular, Stallings' notion of *folding* [5]) provide a line of attack for the problem. This has been my main interest for the first half of my PhD.

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Michelle Bucher
(Geneva University, Switzerland)

Bounded cohomology, characteristic classes

My research interests concern the interactions between geometry and topology, typically for manifolds of nonpositive curvature. I am particularly interested in numerical invariants such as volumes, simplicial volumes, characteristic numbers and their relations, as for example given by Milnor-Wood inequalities.

For more information and references, please consult my webpage.

Caterina Campagnolo
(University of Geneva, Switzerland)

Bounded cohomology and surface bundles

I am a fourth 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. The question of boundedness for the remaining classes in degree $4k$ is open from degree 4 already.

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. One 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, $\Sigma_h \hookrightarrow E \to \Sigma_g$, using the information provided by the first Morita class to approach these questions.

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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Michael Cantrell
(University of Illinois, Chicago, USA)

Subadditive Ergodic Theorem for Nilpotent Groups

I am a Phd student working with Alex Furman. My research interests include: ergodic theory, group actions and geometric group theory, random walks, and symbolic dynamics over non-amenable groups.

Kingmann [1] generalized Birkhoff's ergodic theorem to subadditive cocycles over the integers. This generalization is powerful: for example, it allows for a simple proof of the law of large numbers for matrix multiplication [2], and is used in a variety of other contexts, for example sublinear tracking of geodesics [3, 4].

Percolation theory inspired a subadditive ergodic theorem for $\mathbb{Z}^d$ actions [5]. In the case of percolation, the subadditive ergodic theorem says that there is a single, deterministic asymptotic shape for almost every realization of the model. This result (which predates [5]) is fundamental to the theory. Moreover, percolation theory is an incredibly active field with applications from epidemiology and computer networks to materials science and petroleum engineering.

Neither the asymptotic shape theorem nor the subadditive ergodic theorem are known for more complicated groups. The aim of my thesis is to prove both in the case of nilpotent groups. My techniques differ from those in [5], and offer a new proof of the result therein.

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Pierre-Emmanuel Caprace
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Locally compact groups: structure, actions and geometry

Two fundamental theorems may be seen as foundational for the field which is nowadays called *geometric group theory*: namely Mostow (Strong) Rigidity and Gromov's Polynomial Growth. In both cases, the statement concerns a certain class of discrete groups, and a far-reaching property is established using geometric approaches. Moreover, in both cases, non-discrete Lie groups play a crucial role, although they do not appear explicitly in the statement. This happens to be often the case in geometric group theory: the isometry group of a proper metric space is naturally endowed with the structure of a locally compact group, which can be helpful in elucidating the set-up even though the latter is a priori only concerned with discrete groups. This is the main motivation underlying my current interest in the structure theory of locally compact groups. Concrete examples coming from explicit geometric objects are studied (CAT(0) spaces, Euclidean, hyperbolic or more exotic buildings, cube complexes) while a study of the general case is initiated, with a special emphasis on simple groups.

Matthew Cordes
(Brandeis University, USA)

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. I am currently investigating more properties of this boundary.

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 also investigating the connection between the Morse boundary and other boundaries defined for classes of spaces with some negative curvature (relatively hyperbolic groups, acylindrically hyperbolic groups, etc.).

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Sam Corson
(Vanderbilt University, USA)

Group Theory, Topology

I am currently interested in questions involving groups acting by measure preserving Boolean transformations on Lebesgue space. It is not clear whether every group of cardinality less than or equal to continuum acts faithfully on Lebesgue space in this way. Also, there are structural questions concerning the full group of measure preserving Boolean transformations. Every element is known to be a product of 8 or fewer involutions. It is not known whether 8 is the best possible bound. Also, there is no invariant known to classify all conjugacy classes ([F]).

Another research interest is the fundamental group of Peano continua. Such groups are known to be either finitely presented or of cardinality continuum ([P], [S]). A similar result (due to Greg Conner and myself) holds for the abelianization of the fundamental group, by similar techniques. I have developed applications of these techniques to understand further information about the fundamental groups of Peano continua.

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Benjamin Coté
(University of California, Santa Barbara, USA)

Artin groups arising from discrete complex reflection groups

One very surprising and beautiful connection between topology and algebra is Artin's braid group showing up as the fundamental group of the space of regular orbits of a hyperplane reflection arrangement [4]. Two papers in 1972 introduced Artin groups, which generalize this construction to finite real reflection arrangements (from spherical Coxeter Groups) [3], [2].

My advisor, Jon McCammond, along with a previous student Rob Sulway, recently used Garside structure theory to understand the Artin groups corresponding to Euclidean Coxeter groups [6].

As for complex reflection groups, the corresponding space have been shown to be $K(\pi, 1)$ [1].

The infinite discrete complex reflection groups acting on $\mathbb{C}^n$ are (mostly) classified [7]. Some progress has been made in understanding the fundamental groups of the corresponding spaces [5]. My research is focused on furthering this effort, specifically trying to understand the regular orbit space of discrete complex reflection arrangements where the linear part is primitive.

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Ellie Dannenberg
(University of Illinois at Chicago, USA)

Circle Packings on Projective Surfaces

My main research interests are in geometric topology. I am particularly interested in geometric structures on surfaces. In particular, I am interested in hyperbolic, complex, and complex projective structures.

In particular, I am currently studying complex projective surfaces which admit circle packings. A circle packing on a surface Σ is a collection of closed disks on Σ with disjoint interiors and triangular complementary regions. Then we can associate to such surfaces a graph τ on Σ which lifts to a triangulation of the universal cover, $\tilde{\Sigma}$. Kojima, Mizushima, and Tan have shown that C_τ maps properly to T_g in the case where τ has one vertex. I am interested in the case where τ has multiple vertices.

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Saikat Das
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Deformation Spaces of Trees

The complex of Deformation Spaces of Trees were proved to be contractible by V. Guirardel and G. Levitt in [1].

I have been trying to understand the deformation spaces of trees in order to get a better understanding of Out of a free product of groups. My immediate goal is to use the techniques of fold paths introduced by J. Stallings [2] and train track maps from $Out(F_n)$ introduced by M. Bestvina and M. Handel [3] in the set up of Deformation Spaces.

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Kajal Das
(Paris XI – Orsay)

I am Kajal Das, a second year PhD student in École Normale Supérieure de Lyon, France. My *directeur de thése* is Romain Tessera from Université Paris Sud 11. I primarily work on coarse geometry, measurable group theory and geometric group theory.

Last year I had been working on 'integrable measure equivalence', which is a variant of measure equivalence relation with an integrability condition on the co-cycles. This has been recently introduced by Bader-Furman-Sauer to prove some rigidity results for the lattices in $\mathrm{Isom}(H^n)$, $n \geq 3$, and for the co-compact lattices in $\mathrm{Isom}(H^2)$. I, with Romain Tessera, obtained an example a pair of groups which are quasi-isometric and measure equivalent but not integrable measure equivalent, which is a first example of this kind. Suppose Γ_g is the surface group of genus $g \geq 2$. The aforementioned examples are the canonical central extension of the surface group $\tilde{\Gamma_g}$ and the direct product $\Gamma_g \times \mathbb{Z}$. See [1].

This year I am working on some problems in coarse geometry and percolation theory.

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Jonas Deré
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Expanding maps on infra-nilmanifolds

Infra-nilmanifolds play an important role in dynamical systems, especially when studying expanding maps or Anosov diffeomorphisms. Because of the algebraic nature of these manifolds, questions about self-maps can be translated into questions about endomorphisms of their fundamental group. In this way, it was shown by M. Gromov in [3] that every expanding map on a closed manifold is topologically conjugate to an affine infra-nilendomorphism. Up till now it is unknown if a similar statement also holds for Anosov diffeomorphisms, although some partial results point in that direction, e.g. for infra-nilmanifolds and for codimension one Anosov diffeomorphisms.

These results motivate the study of infra-nilmanifolds admitting an Anosov diffeomorphism or an expanding map. In [2], we showed how these questions are related to the existence of certain automorphisms of nilpotent Lie algebras. As a consequence, the existence of an expanding map only depends on the commensurability class of the fundamental group of the manifold, answering a question stated in [1]. This result allows us to construct examples of nilmanifolds admitting an Anosov diffeomorphism but no expanding map.

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Thibaut Dumont
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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 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. This was asked and suggested by Monod in [3] in the form of the following problem.

Problem P. *Let $G = \mathbb{G}(F)$ be a simple group of F-rank $r > 0$ over a local field F. Quasify Klingler's cocycles in order to obtain new classes in degree $r+1$ for cohomology with polynomial growth degree $r-1$ (in suitable module).*

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Matthew Durham
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Teichmüller spaces and mapping class groups

Let S be a surface of finite type. My research centers on the interplay between negative and positive curvature characteristics of the coarse geometry of Teichmüller space, $\mathcal{T}(S)$, and the mapping class group, $\mathcal{MCG}(S)$. Much of my research to date is based on work of Masur-Minsky [MM99, MM00] on the curve complex and mapping class group and Rafi [Raf07] on the Teichmüller metric. Below, I will describe some of my thesis work and an application of it, as well as some work with Sam Taylor.

In [Dur13], I built a quasiisometry model for $\mathcal{T}(S)$ with the Teichmüller metric which is closely related to the Masur-Minsky marking complex [MM00]. In [Dur14], I use this space to study the asymptotic cones of $\mathcal{T}(S)$ with the Teichmüller metric, giving a new proof of the Brock-Farb geometric rank conjecture, a recent theorem of Eskin-Masur-Rafi [EMR13], which bounds the maximal dimension of quasiflats in $\mathcal{T}(S)$. Along the way, I showed that a thick-thin duality persists in the cones: depending on the basepoint sequence, either every point in an asymptotic cone of $\mathcal{T}(S)$ is a cut point or none is.

I am also interested in the subgroup structures of $\mathcal{MCG}(S)$. One particularly interesting family of subgroups are the *convex cocompact* subgroups, so-called because they act convex-cocompactly on $\mathcal{T}(S)$—equivalently, their orbits in $\mathcal{T}(S)$ are quasiconvex. In joint work with Sam Taylor [DT14], we gave the first characterization of convex cocompactness in terms of the intrinsic geometry of $\mathcal{MCG}(S)$. Our characterization is a strong notion of quasiconvexity, called *stability*. A stable subgroup is necessarily hyperbolic and stability guarantees that this hyperbolic behavior is preserved in its interaction with the ambient group. For instance, we recently proved that stable subgroups are precisely those subgroups which behave nicely with respect to Matt Cordes' Morse boundary [Cor14], a quasiisometry invariant which records quasigeodesics in the ambient group with certain hyperbolic-like properties.

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Ederson Ricardo Fruhling Dutra
(Kiel University, Germany)

Bridge number versus meridional rank

I have a masters degree on algebraic topology, precisely, I studied the braids groups on the sphere, where the existence of a cross section for the generalized Fadell-Neuwirth's fibration was discussed. The studies were conducted in the Federal University of Sao Carlos - Brazil.
My PhD research is based on the question whether or not the bridge number of a knot coincides with the meridional rank. The research makes use of geometric group theory's tools, precisely , the Bass-Serre theory and Folding of graphs of groups.

Eduard Einstein
(Cornell University, USA)

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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Michal Ferov
(University of Southampton, United Kingdom)

Separability properties of graph products of groups

For a group G one can define the *profinite topology* $\mathcal{PT}(G)$ on G as the topology with basis of open sets consisting of cosets of finite index subgroups of G. We say that group G is *residually finite* if and only if $\mathcal{PT}(G)$ is Hausdorff. If the conjugacy class $g^G = \{hgh^{-1} \mid h \in G\}$ is closed in $\mathcal{PT}(G)$ for every $g \in G$ we then say that G is *conjugacy separable* (CS), moreover if every subgroup of G open in $\mathcal{PT}(G)$ is CS as well we say that G is *hereditarily conjugacy separable* (HCS). The concept of profinite topology can be generalised to *pro-$\mathcal{C}$ topology* pro-$\mathcal{C}(G)$, where $\mathcal{C}$ is a class of finite groups satisfying some natural closure properties. The basis of open sets for pro-$\mathcal{C}(G)$ is then $\mathcal{B}_{\mathcal{C}}(G) = \{gN \mid g \in G$ and $N \trianglelefteq G$ such that $G/N \in \mathcal{C}\}$.

Let Γ be a simplicial graph, where $V\Gamma$ is the set of vertices of Γ and $E\Gamma$ is the set of edges, and let $\mathcal{G} = \{G_v \mid v \in V\Gamma\}$ be a family of groups. The graph product of $\mathcal{G}$ with respect to Γ is the group $\Gamma\mathcal{G}$ obtained from the free product $*_{v\in V\Gamma} G_v$ by adding relations

$$g_u g_v = g_v g_u \text{ for all } g_u \in G_u,\ g_v \in G_v \text{ such that } \{u, v\} \in E\Gamma.$$

Right angled Artin groups (RAAGs) and right angled Coxeter groups (RACGs) are special types of graph products.

In [1] I gave a proof that the class of $\mathcal{C}$-(H)CS is closed under taking arbitrary graph products whenever $\mathcal{C}$ is a extension closed variety of finite groups. In particular I showed that arbitrary (possibly infinitely generated) RACGs are HCS and 2-HCS, also that infinitely generated RAAGs are HCS and p-HCS for every prime number p.

Currently I am working on separability properties of groups of outer automorphisms of graph products, trying to establish necessary conditions on the graph Γ and the family of groups $\mathcal{G}$ so that the group Out$(\Gamma\mathcal{G})$ is residually finite.

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Elisabeth Fink
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Branch groups and Conjugacy Properties

Some of my past research focused on branch groups([1]). These are groups acting on infinite rooted trees. In particular, I investigated several problems in some classes of branch groups: growth of some branch groups, constructing non-trival words and lately conjugation properties, such as for example conjugacy growth of the Grigorchuk group.

Theorem 1. *Let $X = \{a, b, c, d\}$ be the standard generating set of the Grigorchuk group G. Then there exists an $n \in \mathbb{N}$, which is independent of g, such that every element $g \in G$ can written as*

$$g = \prod_{i=1}^{n} g_i^{-1} x_i g_i, \quad x_i \in X, g_i \in G.$$

This property has also been studied in other groups, for example under the name *reflection length* in Coxeter groups. It can immediately be seen to be independent of the chosen generating set. Another property of groups is the *conjugacy growth* of it. The *conjugacy growth function* counts the number of distinct conjugacy classes in a ball of radius n.

Theorem 2. *The conjugacy growth function $f(n)$ of the Grigorchuk group satisfies*

$$\frac{1}{n} e^{\sqrt{n}} \precsim f(n) \precsim \frac{1}{n} e^{n^{0.767}}.$$

I am currently intersted in quasi-isometry invariants of groups, but I have previously also studied the width of groups with respect to certain (infinite) subsets ([2], [3]).

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Giles Gardam
(University of Oxford, United Kingdom)

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
(University of Wrocław, Poland)

Boundary representations of hyperbolic 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 endow 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 their unitary equivalence classes are in one-to-one correspondence with rough similarity classes of metrics on G (two metrics d and d' are roughly similar if $|d - Ld'|$ is uniformly bounded for some $L > 0$).

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Alejandra Garrido
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Structure of branch and self-similar groups

I am a final year doctoral student, supervised by John S. Wilson. My research interests include structural results for branch and self-similar groups. These are classes of groups acting on infinite rooted trees, which provide examples of groups with exotic properties (finitely generated infinite torsion groups, groups of intermediate word growth, amenable but not elementary amenable groups, etc). One of the main examples is the Gupta–Sidki 3-group G which acts on the 3-regular rooted tree.

Theorem 1 ([1]). *All infinite finitely generated subgroups of G are abstractly commensurable to either G or $G \times G$. Moreover, G is LERF.*

To show that the commensurability classes of G and $G \times G$ are distinct, I studied with Wilson the finite index subgroups of branch groups ([2]). We developed a geometric realization of these subgroups as rigid stabilizers of orbits of the finite index subgroups. The results in [2] show that all branch actions of a branch group are "detected" by the subgroup structure. This has nice applications. For example, the following should be compared to a well-known fact about linear algebraic groups:

Theorem 2 ([3]). *Whether or not a branch group has the congruence subgroup property (every finite index subgroup contains a level stabilizer) is independent of the chosen branch action.*

I am interested in taking these structural ideas further, looking at locally compact envelopes of these groups, their commensurators, the structure of their invariant random subgroups, or applying them in other settings.

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Maxime Gheysens
(École polytechnique fédérale de Lausanne, Switzerland)

Structure of CAT(0) spaces and of their isometry groups

I am mostly interested in the geometry of CAT(0) spaces and in group actions on these spaces, especially rigidity of the latter. Several beautiful results are known to hold in the locally compact setting, for instance (see [1, 2, 3] for detailed statements):

1. equivariant splitting as a product of Euclidean spaces, symmetric spaces and spaces with totally disconnected isometry group;
2. characterization of symmetric spaces and buildings in that setting;
3. superrigidity of actions of irreducible uniform lattices in product of groups (this holds without local compactness);
4. characterization of amenable isometry groups of proper cocompact CAT(0) spaces.

However, very few results are known in the much wilder realm of non locally compact CAT(0) spaces. Most of my research focuses on understanding these more pathological spaces.

I have also a strong (and more recent) interest in the structure of totally disconnected locally compact groups and their locally normal subgroups (see [4]).

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Thibault Godin

Project MealyM

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 *automata-groups*) and their properties, especially since counter-examples to important group theoretical conjectures (Burnside, Milnor, Atiyah, Day or Gromov problems for instance) arose as automata groups.
As a PhD student, 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.
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 state-set, 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 the semi-group $\langle \rho_q, q \in Q\rangle_+$ with the composition of functions as semi-group operation. Moreover, if the production functions are permutations of the state-set – the automaton is said to be *invertible* – then one can consider the group generated $\langle \rho_q, q \in Q\rangle$.
On the other hand, one can ask what happens when the transition functions are permutations – the automaton is said to be *reversible*.
Indeed, any known examples of infinite Burnside or intermediate growth automata groups are non reversible, whereas automata generating free products are reversible.

It has been proven that a connected 3-state invertible-reversible Mealy automata cannot generate an infinite Burnside group [3],and, adding structure to the automata, that an invertible-reversible without bireversible connected component generates a torsion-free semi-group. The next step is now to weaken the structural hypotheses and to find free (semi-)groups of rank greater than 2, which would also gives us properties on the growth of the groups.

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Moritz Gruber
(Karlsruher Institut für Technologie, Germany)

Large Scale Geometry of Carnot Groups

My research is concerned with the large scale geometry of groups and other metric spaces. The filling invariants of Carnot groups are of special interest for me. These groups are nilpotent groups G which allow a grading of their Lie algebra $\mathfrak{g} = V_1 \oplus V_2 \oplus ... \oplus V_c$, where c denotes the nilpotency-class of G and $[V_1, V_i] = V_{i+1}$ with $V_m = 0$ for $m > c$. As a consequence these groups posses a family of self-similarities. With help of these self-similarities Young [1] computed the *higher filling functions* for the Heisenberg Groups H^{2n+1}. I used this result to examine the *higher divergence functions* [2], which, roughly speaking, measure the difficulty to fill an outside an r-ball lying k-cycle with an outside a ρr-ball, $0 < \rho \leq 1$, lying $(k+1)$-chain, and proved the following theorem:

Theorem 1. *Let H^{2n+1} be the Heisenberg Group of dimension $2n + 1$ and $k < n$.*
Then holds:

$$\mathrm{Div}_k(H^{2n+1}) \sim r^{k+1}$$

In the case $k = n$ we get

$$\mathrm{Div}_n(H^{2n+1}) \sim r^{n+2}$$

My current effort is to complete this theorem to the dimensions above the critical dimension and to get similar results for the quaternionic Heisenberg Groups.
Another subject of my research is the still unknown Dehn function of the octonionic Heisenberg Group.

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Dominik Gruber
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Graphical small cancellation groups

My research is focused on (infinitely presented) graphical small cancellation groups. Graphical small cancellation theory is a generalization of classical small cancellation theory due to Gromov that allows constructions of groups with prescribed embedded subgraphs in their Cayley graphs [1]. Groups with weakly embedded expander graphs are the only known groups that do not coarsely embed into Hilbert spaces and, therefore, are potential counterexamples to the Baum-Connes conjecture.

I am studying the combinatorial interpretation of graphical small cancellation theory: Given a labelled graph Γ with set of labels S, the *group defined by* Γ is given by the presentation $G(\Gamma) := \langle S \mid \text{words read on closed paths in } \Gamma\rangle$. A *piece* is a labelled path that occurs in two distinct places in Γ. The labelled graph Γ satisfies the *graphical* $C(n)$ *small cancellation condition* if no nontrivial closed path is the concatenation of fewer than n pieces.

In [2], I generalized fundamental properties of classical $C(6)$- and $C(7)$-groups to their graphical counterparts and showed that the graphical $C(7)$-condition can be used to construct lacunary hyperbolic groups with coarsely embedded infinite sequences of finite graphs. In joint work with A. Sisto [3], we showed that infinitely presented graphical $C(7)$-groups are acylindrically hyperbolic. We moreover constructed explicit small cancellation presentations that provide new examples of divergence functions of groups.

My research is supervised by my advisor Goulnara Arzhantseva and supported by her ERC grant "ANALYTIC" no. 259527.

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Thomas Haettel
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Geometry of homogeneous spaces, braid groups and coarse medians

I am interested in understanding the asymptotic geometry of homogeneous spaces, such as the space of maximal flats of a symmetric space of non-compact type or of a Euclidean building ([1],[2]).

I am also interested in CAT(0) spaces and groups. With Dawid Kielak and Petra Schwer, we have been studying simplical $K(\pi, 1)$'s for braid groups and other Artin groups of finite type, described by Tom Brady and Jon McCammond ([3],[4]). We have proved that some of them are CAT(0) ([5]).

More recently, I have been interested in the existence of Bowditch's coarse medians on various spaces and groups ([6],[7]).

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Tobias Hartnick
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Cohomological boundary rigidity

I am interested in locally compact groups - both discrete and non-discrete - acting on non-positively curved spaces. These include hyperbolic groups and various generalizations thereof, groups acting on CAT(0) cube complexes as well as semisimple algebraic groups over local fields and their discrete subgroups. Non-positive curvature allows one to attach a boundary action to these groups. Actually, there are many competing notions of boundary for non-positively curved groups, depending on whether you take a geometric, measure theoretic, analytic, combinatorial or representation theoretic point of view. These different boundary actions contain various types of large scale information about the group, but it is often hard to extract this information.

I am particularly interested in cohomological information that one can extract from these boundary actions. Given a measure space (X, μ) and a G-action on X we denote by $H^\bullet_{L^\infty}(G;X)$ the cohomology of the co-complex $(C^n, d^n : C^n \to C^{n+1})$, where $C^n := L^\infty(X^{n+1})^G$ and d denotes the usual homogeneous differential. By a theorem of Burger and Monod the cohomology $H^\bullet_{L^\infty}(G;X)$ coincides with the (continuous) bounded cohomology $H^\bullet_{cb}(G;\mathbb{R})$ of G with real coefficients, as long as X is amenable as a G-space. As most boundaries of groups of interest have this property, their cohomology $H^\bullet_{L^\infty}(G;X)$ is an invariant of the group G, and in particular independent of the concrete model of boundary. One may thus think of $H^\bullet_{cb}(G;\mathbb{R})$ as some kind of universal cohomological information of G-boundaries. One may then ask which type of information about $H^\bullet_{cb}(G;\mathbb{R})$ one can obtain from some specific boundary model. Also, one can try to relate $H^\bullet_{cb}(G;\mathbb{R})$ to other, more classical, invariants of G.

One question that I am particularly interested in is the following: What is the relation between $H^\bullet_{cb}(G;\mathbb{R})$ and the usual (continuous) group cohomology $H^\bullet_c(G;\mathbb{R})$ of G? If the natural comparison map is an isomorphism, then we can reconstruct all cohomological information about G from its boundary actions. We call this phenomenon *cohomological boundary rigidity* (CBR). CBR is known to fail for acylindrically hyperbolic groups and conjectured to hold for semisimple Lie groups. Little else is known.

Simon Heil
(Christian-Albrechts-University Kiel, Germany)

Groups acting on $\mathbb{R}$-tress and splittings of groups

I am mainly interested in Bass-Serre theory and splittings of groups over particular classes of subgroups, i.e. the JSJ-decomposition of a finitely generated group as constructed by E. Rips and Z. Sela in [1] or by P. Papasoglu and K. Fujiwara in [3].
I also study groups acting on real trees and Sela's limit groups and their use in the analysis of the structure of sets of solutions to system of equations in a free group [2].

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Joseph Helfer
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Combinatorial Group Theory Done Right

In this world of hyperbolic groups and quasi-isometries, is there any room left for the dinky combinatorial complexes and simple arguments about covering spaces of the days of yore?

Dani Wise says "yes", and I'm inclined to agree.

It is all too easy to do combinatorial group theory *wrong*. One can easily get lost in insane combinatorial schemes which obscure the true meaning of what you're doing and which no-one can understand.

What are examples of combinatorial group theory done right? Look at James Howie's tower method for studying one-relator groups! [1] It freed Magnus' proof of the Freiheitssatz from its chains of algebraic madness and gave us the tools to prove all sorts of results in a systematic way.

More recently, orderable groups have come on the scene as a new and powerful tool. Look at Mineyev's-Dicks' proof of the Strengthened Hanna Neumann Conjecture! [2] This perfidious lemma stumped experts for years but fell to the ground instantly once its orderable secrets were revealed.

Yes, the days of combinatorial group theory are anything but past. Indeed, this old mistress is as tantalizing as ever.

How does all this fit into my own research? Well I guess you'll just have to wait and see...

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Julia Heller
(KIT, Germany)

CAT(0) Groups and Spaces

My Master thesis shows that, if $f\colon S^n \to \Sigma$ is a homotopy equivalence, then the pulled-back tangent bundle $f^*(T\Sigma)$ of Σ is isomorphic to the tangent bundle TS^n of the sphere. The proof applies amongst others methods of both homotopy theory of fibrations and bundle theory.
In Münster, I attended the lecture courses "Spaces of nonpositive curvature" by Linus Kramer, "Geometric group theory" by Katrin Tent and "CAT(0) cube complexes" by Petra Schwer. In the seminar "Groups and nonpositive curvature", I gave a talk on *CAT(0) groups do not have a unique boundary*, which was based on [2]. The talk *Special Cube Complexes: Haglund-Wise Theory* I gave in the "Karlsruhe-Münster-Regensburg Research Seminar on Geometric Group Theory" was based on [3]. This seminar investigated a theorem of Agol on the virtual Haken conjecture, which is in [1].
Since October 2014, I am a PhD student under the supervision of Petra Schwer in Karlsruhe.

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Eric Henack
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Separablity properties of fundamental groups of graph of groups

A group is residually finite if for each non-identity element in the group, there is a normal subgroup of finite index not containing that element. A residually finite group is also called separable. Subgroup separability, conjugacy separability and subgroup conjugacy separability are also well-known separability properties. These properties were already established for different classes of groups. Some of these groups can be regarded as the fundamental group of a graph of groups. Hence it is a naturally arising question which conditions have to be satisfied for a graph of groups, s.t. the corresponding fundamental group has one or more of these mentioned separability properties. Our main tools for the approach will be Bass-Serre theory and special morphisms between graph of groups, since for any subgroup of the fundamental group of a graph of groups there exists a morphism between graph of groups representing this subgroup.

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Jesús Hernández Hernández
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Rigidity of the mapping class group and associated structures

I am on the second year of my PhD supervised by Dr. Hamish Short and Dr. Javier Aramayona at the Aix-Marseille Université. My research focuses on the rigidity phenomena of the mapping class group and combinatorial structures associated to compact surfaces.

The parallels between the behaviour of the mapping class group of a compact surface of negative Euler characteristic and that of arithmetic/algebraic groups and arithmetic lattices, have arised many analogies between properties of one and the other. In particular, the rigidity (and superrigidity) problem of the mapping class group is related to the rigidity result in semisimple Lie groups known as Mostow rigidty (Margullis superrigidity). I will be focusing on extending the rigidity results of several combinatorial structures, such as the Curve complex and the Hatcher-Thurston complex, into superrigidity results; this results will then be applied to the rigidity of the mapping class group, Teichmüller space and the Moduli space, among others.

Among the techniques used here, are those developed on the study of large-scale geometry and hyperbolic (and relatively hyperbolic) groups. The reason for this is the need of the study of different kinds of elements of the mapping class group and the study of the different properties needed in the homomorphisms between (a priori) different mapping class groups to achieve the rigidity.

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Nima Hoda
McGill University, Canada

Combinatorial Non-Positive Curvature and Groups

My research interests are focused on group theoretic properties of non-positively curved combinatorial complexes. This line of work traces its origins to Dehn's proof that the word problem is solvable for hyperbolic surfaces [1] and runs through metric and combinatorial generalizations of non-positive curvature, including CAT(0) spaces and small cancelation theory. Recent developments in this area include the introduction of systolic complexes by Januszkiewicz and Świątkowski [3] and independently by Haglund [2]. Graphs whose flag completions are systolic were studied earlier by Soltan and Chepoi [4].

Reduced disc diagrams of systolic complexes have properties related to those in small cancellation theory. Viewing their 2-cells as Euclidean equilateral triangles, they have no internal positive curvature and so must have a certain amount of positive curvature on their boundaries. Many of the properties of systolic complexes and groups that act on them stem from this fact [5].

In my work I study groups that act on combinatorial 2-complexes constructed from Euclidean triangles that satisfy a similar disc-diagrammatic non-positive curvature condition. Properties of such groups that I am interested in include torsion, orderability, automaticity and word-hyperbolicity.

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Camille Horbez

The horoboundary of outer space

Subgroups of automorphisms of free products and random walks on $\mathrm{Out}(F_N)$

My research focuses on the study of the group Out(F_N) of outer automorphisms of a finitely generated free group, and more generally of the group of outer automorphisms of a group that splits as a free product. My approach is geometric: I study actions of these groups on several spaces, such as outer space, or some hyperbolic complexes. These are analogues of the Teichmÿller space and the curve complex of a compact oriented surface S, used to study the mapping class group of S.

The main result of my thesis is a version of the Tits alternative for automorphism groups of free products (a group is said to satisfy the Tits alternative if each of its subgroups is either virtually solvable, or contains a non-abelian free subgroup). By a theorem of Grushko, every finitely generated group G splits as a free product of the form $G = G_1 * \cdots * G_k * F_N$, where each G_i is nontrivial, not isomorphic to $\mathbb{Z}$, and freely indecomposable. I proved that if both G_i and Out(G_i) satisfy the Tits alternative for all $i \in \{1, \ldots, k\}$, then so does Out(G). This gives in particular a new proof of the Tits alternative for Out(F_N), originally due to Bestvina, Feighn and Handel, and yields the Tits alternative for outer automorphism groups of right-angled Artin groups, or of toral relatively hyperbolic groups. The techniques I developed involve studying several Out(G)-spaces. I described a compactification of the relative outer space in terms of G-actions on trees, and also gave a description of the Gromov boundary of the relative cyclic splitting complex (which is hyperbolic). My techniques also lead to various alternatives for subgroups of Out(F_N) or Out(G). By investigating further the geometry of the associated complexes, I hope my techniques could provide other results about the structure of these subgroups.

I also have interests in random walks on Out(F_N). I have described two *boundaries* that give information about the asymptotic behaviour of the typical sample paths of the walk. I described the *horoboundary* of outer space with respect to the so-called Lipschitz metric (an analogue of Thurston's asymmetric metric on Teichmÿller spaces), as a quotient of Culler and Morgan's classical boundary of outer space. The horoboundary of a metric space, equipped with an action of a countable group G, is useful for understanding random walks on G: a theorem by Karlsson and Ledrappier states that almost every path of the walk is directed at infinity by some (random) horofunction. My description of the horoboundary of outer space enabled me to understand possible growth rates of conjugacy classes of F_N under random products of automorphisms. I established a version of Oseledets' theorem for random walks on $\mathrm{Out}(F_N)$, and gave a bound on the number of possible exponential growth rates. On the other hand, I described the *Poisson boundary* of $\mathrm{Out}(F_N)$: this is a measure space that encodes all information about the behaviour of sample paths of the walk at infinity. I proved that a typical sample path converges to a point in the Gromov boundary of the free factor complex, and established that the free factor complex, equipped with the hitting measure, is isomorphic to the Poisson boundary of $\mathrm{Out}(F_N)$.

Jingyin Huang
(New York University, USA)

Quasi-isometry rigidity of right-angled Artin group

My research is in the asymptotic geometry of $CAT(0)$ spaces and its application to quasi-isometry rigidity. It divides into two closed related parts:

(1) The structure of quasiflats of maximum rank in $CAT(0)$ spaces. Quasiflats or flats of maximum rank in $CAT(0)$ spaces of higher rank are analogues of geodesics or quasi-geodesics in Gromov hyperbolic spaces. They play an important role in understanding the large scale geometry of $CAT(0)$ spaces. I am interested the regularity of these quasiflats. For example, it is known that if X is a Euclidean building, then quasiflats of maximum rank are Hausdorff close to finite unions of Weyl cones ([KL97b, EF97, Wor06]). I have proved a cubical analogue of this fact, namely quasiflats of maximal rank in a $CAT(0)$ cube complex are Hausdorff close to finite unions of orthants, and I am currently working on more general $CAT(0)$ spaces.

(2) Quasi-isometry classification of right-angled Artin group (RAAG). The above quasiflats theorem implies that quasi-isometries between universal coverings of Salvetti complexes map top dimensional flats to top dimensional flats up to finite Hausdorff distance. Based on this, I can show that two RAAGs with finite outer automorphism group are quasi-isometric iff they are isomorphic. And I am currently looking at several cases where the outer automorphism group are allowed to be infinite.

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Michael Hull
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Acylindrical hyperbolicity

My research focuses on the class of *acylindrically hyperbolic groups*. Loosely speaking, these are groups admit a “weakly proper" action on a hyperbolic metric space [8]. Many interesting groups admit such actions: hyperbolic and relatively hyperbolic groups, mapping class groups, Out(F_n), CAT(0) groups which contain rank one isometries, and many others.

I am interested in how the existence of these actions influences the structure of the group. For example, these actions have been used to construct *quasimorphims* and *quasi-cocycles* on acylindrically hyperbolic groups, which have important applications to bounded cohomology and stable commutator length [1, 2, 4, 6].

Acylindricaly hyperbolicity also allows one to construct many normal subgroups and quotients through various forms of *small cancellation theory* [3, 5]. There are many applications of these constructions, including the existence of free normal subgroups [3], various exotic quotient groups [5], and dense permutation representations[7].

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David Hume
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Coarse geometry of Cayley graphs

Coarse embeddings of discrete metric spaces into Banach spaces have become an important topic in geometric group theory, combinatorics and K-theory, since any group admitting a coarse embedding into any uniformly convex Banach space satisfies the Novikov and coarse Baum-Connes conjectures. However, there are finitely generated groups which admit no such embedding into an ℓ^p space. In [Hum14] we prove that there are uncountably many coarse equivalence classes of such groups.

For more familiar classes of groups we prove some much stronger versions of coarse embeddability (cf. [Hum11, Hum12].

Mapping class groups quasi-isometrically embed into a finite product of simplicial trees, hence they have finite capacity dimension.

A relatively hyperbolic group G has finite capacity dimension if and only if its maximal peripheral subgroups do.

To prove these results we produce a classification of spaces which are quasi-isometric to tree-graded spaces, generalising Manning's bottleneck property for quasi-trees.

More recent work includes producing new examples of acylindrically hyperbolic groups coming from Kac-Moody groups, these have much more in common with the Cremona group than to other well-known examples [CaH14].

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Francesca Iezzi
(University of Warwick, UK)

Sphere complexes and related topics

Given a 3-manifold M_g which is the connected sum of g copies of $S^2 \times S^1$ the sphere graph of M_g, denoted by $\mathbb{S}(M_g)$, is the graph whose vertices are the homotopy classes of essential spheres in M_g, where two vertices are adjacent if the two corresponding spheres can be realised as disjoint spheres. The graph $\mathbb{S}(M_g)$ has been proven to be isomorphic to the free splitting graph of the free group F_g and is a very important tool for the study of the group $Out(F_g)$.

I am focusing in particular on two questions.

A first question concerns the relations between the sphere graph of the manifold M_g and the arc graph of any surface S whose fundamental group is the free group F_g. There is a natural map from the latter graph to the former one. In fact, the interval bundle on the surface S would be the handlebody V_g of genus g and the double of V_g is the manifold M_g. Therefore, given an arc a in S, the interval bundle over a is a disc in V_g, and its double is a sphere in the manifold M_g. It is known that this map is a quasi-isometrical embedding. Building on ideas of U. Hamenstadt and S. Hensel, I am trying to describe an explicit coarse projection from the sphere graph of M_g to the arc graph of S. This would have consequences concerning the relations between the mapping class group of S and the group $Out(F_g)$.

As a second project, given two maximal sphere systems embedded in the manifold M_g, I define a *standard position* for these two systems. This is an elaboration of Hatcher's normal form. Given two sphere systems in standard position I describe two ways of associating to them a dual square complex. The first method is constructive; the second method is more abstract, the square complex would be the Guirardel core of the product of two trees. I prove then that both methods produce the same square complex. This allows me to prove the existence, and in some sense uniqueness, of a standard form for two sphere systems.

Work is in progress and things are currently been written.

Kasia Jankiewicz
(McGill University, Montréal, Canada)

Cubes and Braids

I am a Phd student at McGill University working under the supervision of Piotr Przytycki and Dani Wise. My research interests are in geometric group theory, more specifically in CAT(0) cube complexes and groups acting on them nicely.

My master thesis ([1]) concerns small cancellation theory in its classical version, as well as its generalization, cubical small cancellation theory, introduced by Wise in [3]. The main result is a classification of minimal disc diagrams in the presentation complex of a cubical group presentation satisfying the C(9) cubical small cancellation condition. This generalizes a result of Wise for the C(12) condition that can be found in [3].

My PhD research project is to show that certain groups do not act nicely on a CAT(0) cube complex. A subgroup H of a group G is called a *codimension-1 subgroup* if H cuts G into several parts, i.e. the relative number of ends $e(G, H) > 1$. Sageev's construction ([2]) associates to a group G with a collection of codimension-1 subgroups a CAT(0) cube complex on which G acts non-trivially. This generalizes the famous Bass-Serre theory. I am interested in showing that some groups, e.g. braid groups on ≥ 4 strings or Artin groups of large type cannot be *cubulated*, i.e. do not admit proper and cocompact action by isometries on a CAT(0) cube complex. I would like to classify all codimension-1 subgroups of a group G and using this classification show that in some cases G does not have sufficiently many codimension-1 subgroups and hence cannot be cubulated.

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Paweł Karasek
(Institute of Mathematics of Polish Academy of Sciences, Poland)

Analytic number theory and additive combinatorics

I am a first year PhD student mostly interested in sieve theory, combinatorial and Fourier-analytic methods in number theory and theory of L-functions.

Vinogradov's theorem says that any sufficiently big odd number N can be represented as a sum of three primes. In my master thesis I calculated the asymptotic with respect to N of the number of solutions of the equation $c_1n_1 + ... + c_mn_m = N$ in $p_1, ..., p_m$ where $\Omega(n_i) = r_i$, $m > 2$ and $r_1, ..., r_m, c_1, ..., c_m$ are absolute constants (some technical assumptions should be made here, however I will skip this part for the sake of convenience). I used Hardy-Littlewood circle method combined with Vinogradov's method to achieve the analogous result for n_i primes and c_i varying from 1 to N^δ for some fixed $0 < \delta < 1$ (which is a novelty here) and then I used some combinatorial arguments to increase the number of prime divisors of n_i.

Currently my work is focused on the structure of the set $A + A + A$ where $A \in \{1, ..., N\}$; the case of A being sparse ($|A| < \epsilon N$, say) is not well understood yet. Hopefully these studies will lead to new variations of Vinogradov's theorem in some interesting sets (Chen primes are the good example) by using transference principle in the spirit of [1], [2].

I wish to get some knowledge about geometric group theory; I believe it is going to be an excellent inspiration during my combinatorial and graph-theoretic studies.

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Dawid Kielak
(RFW-Universität Bonn)

$\mathrm{Out}(F_n)$ **and** $\mathrm{Out}(\mathrm{RAAG})$

I am interested in the outer automorphism groups of free groups. In particular I would like to understand their linear representations and rigidity of homomorphisms between different groups in the family. I am also very much interested in property (T) and property FAb for this class of groups.

More recently I started thinking (together with Sebastian Hensel) about the Nielsen realisation theorem for $\mathrm{Out}(\mathrm{RAAG})$. Fascinating as it is in its own right, it is also an important tool that should allow a lot of techniques from $\mathrm{Out}(F_n)$ to be adapted to this more general collection of groups. We already have some preliminary results in this area.

Left-invariant orderings and fractions

Another area of my recent activity is the theory of left-invariant orderings, and associated problems in the structure of semigroups of groups. In particular I am interested in: determining the space of biorders of a free group; the existence of isolated points (in particular finitely generated orderings) in the space of left orders of surface groups; the question of whether $\mathrm{Out}(F_n)$ possesses a left-orderable torsion free subgroup of finite index (the same question for Mapping Class Groups is also interesting).

Steffen Kionke
(Heinrich-Heine Universität Düsseldorf, Germany)

Asymptotic properties of lattices in semisimple Lie groups

Let Γ be a lattice in a real semisimple Lie group G. My research is centered around the properties of subgroups of large index in Γ. In geometric terms, I am concerned with the structure of finite sheeted covers of the associated locally symmetric space X/Γ. Two aspects are particularly relevant, namely (a) the Betti numbers and (b) the properties of the group rings of the subgroups of large index.

(a) Let $(\Gamma_n)_n$ be a decreasing sequence of finite index normal subgroups in Γ with $\bigcap_n \Gamma_n = \{1\}$. What is the behaviour of the sequence of i-th Betti numbers $b_i(\Gamma_n, \mathbb{C})$ as n tends to infinity? Lackenby defined the *Betti number gradient* $\frac{b_i(\Gamma_n,\mathbb{C})}{[\Gamma:\Gamma_n]}$. It follows from the work of Lück that the Betti number gradient converges to the i-th L^2-Betti number $\beta_i^{(2)}(\Gamma)$ as n goes to infinity – even better, $\beta_i^{(2)}(\Gamma)$ can be computed easily using the symmetric space X. However, in many cases $\beta_i^{(2)}(\Gamma) = 0$ and still one expects the sequence Betti numbers to be unbounded. So, how fast can the Betti numbers grow? I am interested in lower bounds for the growth rate. For instance one can obtain such bounds if the tower of subgroups $(\Gamma_n)_n$ is constructed as a tower of congruence covers in a compact p-adic analytic group, see [1].

(b) The *Kaplansky Unit Conjecture* asks whether the units in the group ring $\mathbb{Z}[\Gamma]$ of a torsion-free group Γ are only the obvious units, i.e. of the form $\pm\gamma$ with $\gamma \in \Gamma$. It is known that every arithmetic lattice has a finite index subgroup satisfying the weaker *Zero divisor Conjecture*, but it is unknown if this remains true for the Unit Conjecture. In joint work with Jean Raimbault we show that this is true for lattices in the Lie groups $\mathrm{SO}(n,1)$, $\mathrm{SU}(n,1)$ and $\mathrm{Sp}(n,1)$. The result is based on the notion of diffuse group actions defined by Bowditch.

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Roman Kogan
(Texas A&M University, USA)

On the intersection of geometry and algebra

My research concerns objects on the interface of geometry and algebra.

My previous work in geometric group theory, join with F. Matucci and C. Bleak, involved the n-dimensional generalization of the Thompson group V introduced by Brin in [1]. Every element of V can be represented by a pair of labeled finite binary trees. I defined a canonical form of an element of nV as a pair of labeled finte binary trees with colored nodes, and wrote software ([2]) that computes it, visualizes the map for $n = 2$, and performs group operations. I am still interested in the conjugacy problem for nV.

The work and seminars of Rostislav Grigorchuk (resident in Texas A&M) have also influenced my interest in study of growth of groups, automata groups, and Grigorchuk groups in particular.

My current work is studying *amoebas* of polynomials ([3]) - images of varieties under $\log|\cdot|$ map. This area closely relates to tropical geometry, as tropical varieties can be seen as limits of amoebas in many cases. Remarkably, there is a connection between tropical geometry and group theory; for example, there is a family of groups for which existence of a finite presentation depends on whether a certain tropical variety contains a line (see [4]). A connection to automata groups was introduced by T. Kato in [5]. I am interested in studying such connections.

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Juhani Koivisto
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Large scale geometry and group rigidity

My research focuses on generalisations of Kazhdan's property (T) for groups, amenability on metric spaces, and their applications. In the case of Kazhdan's property (T) I have obtained a spectral condition for cohomological vanishing for uniformly bounded representations [1]. In the case of amenability on metric spaces I have obtained a Sobolev inequality characterisation for non-amenability, and more generally vanishing of fundamental class in controlled coarse homology, on metric measure spaces of bounded complexity [2]. In particular, I am interested in applying the latter to Gromov hyperbolic spaces.

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John Lawson
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Minimal mutation-infinite quivers

Cluster algebras were introduced in 2002 by Fomin and Zelevinsky [1]. Since then they have found relevance in many topics from the study of Coxeter groups to mathematical physics. These algebras are generated by variables found through a process of mutations on quivers — directed graphs with certain restirctions. These mutations are involutions which change the shape of the graph according to specific rules.

A quiver is mutation-finite if the number of quivers possibly attained from this initial quiver is finite, otherwise the quiver is mutation-infinite. It has been shown by Felikson, Shapiro and Tumarkin [2] that all mutation-finite quivers are constructed from a surface triangulation or are one of 11 known exceptional types.

A minimal mutation-infinite quiver is a mutation-infinite quiver such that all sub-quivers are mutation-finite. Following the work of Felikson, Shapiro and Tumarkin [2] classifying all mutation-finite quivers I have been working to classify all minimal mutation-infinite quivers. Hyperbolic Coxeter simplices give examples of minimal mutation-infinite quivers but are not the only such quivers. These quivers admit a number of moves through which they can be classified and I use these to give a small number of representatives which are either simplices or exceptional quivers.

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Nir Lazarovich
(Technion, Israel)

Regular CAT(0) Polygonal/Cubical Complexes

My main research interest is group actions on polygonal and cube complexes.

Given a natural number $k \geq 3$ and a finite graph L (respectively a finite flag simplicial complex L), it is natural to consider the CAT(0) (k, L)-complexes (resp. CAT(0) L-cube-complexes); these are polygonal complexes (resp. cube complexes) obtained by gluing regular k-gons (resp. cubes) such that at each vertex the link is isomorphic to L. The study of these complexes may provide various examples for geometric group actions which exhibit interesting algebraic and geometric properties.

A natural question arises: can one give a necessary and sufficient condition on the pair (k, L) (resp. on the complex L) such that there is a unique, up to isomorphism, CAT(0) (k, L)-complex (resp. L-cube-complex)? The few known examples of unique (k, L)-complexes have provided a fertile ground for many theorems.

Thus far, we were able to answer this question fully for the pair (k, L) when k is even and for cube complexes. The main result describes a simple combinatorial condition, called superstar-transitivity, on L for which there exists at most one (k, L)-complex (resp. L-cube-complex). This condition is also sufficient for uniqueness in pairs (k, L) where k is odd.

In light of these results, it is clear that complexes with superstar-transitive links play a special role in the world of polygonal/cube complexes. The aim of this research is to investigate the special properties of these complexes through the study of the general theory.

Adrien Le Boudec
(Orsay, France)

Large scale geometry of locally compact groups

Asymptotic cones. If G is a locally compact compactly generated group, the asymptotic cone of G associated to the scaling sequence (s_n) and the non-principal ultrafilter ω, is a metric space reflecting the geometric properties of G that are visible at scales (s_n). A group G is hyperbolic if and only if all its asymptotic cones are real trees. Olshanskii, Osin and Sapir initiated the study of finitely generated lacunary hyperbolic groups, i.e. finitely generated groups with one asymptotic cone a real tree, and proved that this class of groups is very large [4].

In [3], the class of locally compact lacunary hyperbolic groups is investigated. One of the results is that if a locally compact compactly generated group G admits one asymptotic cone that is a real tree and whose natural transitive isometric action fixes a unique boundary point, then G is actually a hyperbolic group. Combined with results of Drutu and Sapir about cut-points in asymptotic cones [1], this yields a characterization of connected Lie groups or linear algebraic groups over the p-adics having cut-points in one asymptotic cone.

Totally disconnected simple groups. My second main research interest concerns certain simple locally compact groups almost acting on trees. One example of such group is Neretin's group of homeomorphisms of the boundary of a regular tree that are piecewise tree automorphisms. I am interested in various properties of their large scale geometry, such as compact presentability [2], or their CAT(0) geometry.

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François Le Maître
(Université catholique de Louvain, Belgium)

Full groups in the measure preserving context

Full groups were introduced in Dye's visionary paper of 1959 as subgroups of $\mathrm{Aut}(X, \mu)$ stable under cutting and gluing their elements along a countable partition of the probability space (X, μ). However, the focus has since then been rather on full groups of equivalence relations induced by the measure preserving action of a countable group, which are Polish for the uniform topology. Indeed, Dye's reconstruction theorem ensures that these full groups, seen as abstract topological groups, completely determine the equivalence relation. Then, one can see in some cases how some invariants of the equivalence relation translate into topological invariants of the full group. In this context, I showed that the topological rank* of the full group of a probability measure preserving equivalence relation is equal to the integer part of its cost plus one [LM14a].

In a work in progress with Carderi, we unveil Polish full groups of a new kind, which arise as the full groups of orbit equivalence relations induced by probability measure preserving actions of locally compact second countable groups, and which still satisfy the reconstruction theorem. We study some of their topological properties such as amenability or topological rank.

I am also interested in the properties of Polish totally disconnected locally compact groups, when seen as closed subgroups of the group of permutations of the integers.

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*The topological rank of a topological group is the minimal number of elements needed to generate a dense full group.

Nils Leder
(WWU Muenster, Germany)

Group homology and homological stability

I am a last year master student at the WWU Muenster writing my master thesis under the supervision of Linus Kramer. In the following, I explain shortly the topic of my thesis.
Recall that group homology is a functor and hence, group homomorphisms induce homomorphisms in homology (see [1] for the definitions).
There is the natural question when those induced maps are isomorphisms. Moreover, we can consider series of groups $G_1 \underset{f_1}{\to} G_2 \underset{f_2}{\to} G_3 \underset{f_3}{\to} \dots$ and ask whether for a given $k \in \mathbb{N}$ there is a $n = n(k)$ such that the induced map $(f_i)_\star : H_k(G_i) \to H_k(G_{i+1})$ is an isomorphism for each $i \geq n$.
If such an n exists, we say that we have *homological stability* for the series of groups $(G_i, f_i)_{i\in\mathbb{N}}$.
My goal is to examine homological stability for series of spherical Coxeter groups (e.g. the symmetrical groups with the inclusions $S_n \hookrightarrow S_{n+1}$). Therefore, I apply spectral sequence arguments as provided by [2].

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Dooheon Lee
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The Canonical Visual Boundary of Rank 1 CAT(0) Groups

It is well known that if X, Y are δ-hyperbolic $CAT(0)$ spaces and $f : X \to Y$ is a quasi-isometry then f induces a homeomorphism $\partial f : \partial X \to \partial Y$ between geometric (or visual) boundaries. However, this does not hold for general $CAT(0)$ spaces. Croke and Kleiner found two quasi-isometric $CAT(0)$ spaces with non-homeomorphic visual boundaries [1].

One way to address this issue is to find some canonical geodesic rays $\subset \partial X$ of a given $CAT(0)$ space X. As an example, Charney and Sultan studied contracting boundaries $\partial_c X \subset \partial X$ of a $CAT(0)$ space X [2]. They showed that contracting boundaries with a suitable topology (instead of subspace topology of the visaul topology) is a quasi-isometry invariant.

However, the following question is still open:

Question 1. *Suppose G acts geometrically on $CAT(0)$ spaces X, Y and $f : X \to Y$ is a G-equivariant quasi-isometry. Assume there is $g \in G$, which is of rank 1. Then is $\partial_c f : \partial_c X \to \partial_c Y$ homeomorphism w.r.t. subspace topology?*

Also inspired by [2], we ask the following question:

Question 2. *Suppose G acts geometrically on $CAT(0)$ spaces X, Y and $f : X \to Y$ is a G-equivariant quasi-isometry. Assume there is a rank one element $g \in G$. Then, are there subsets $C_1 \subset \partial X$, $C_2 \subset \partial Y$ such that C_1 (resp. C_2) is a set of second Baire category in ∂X (resp. ∂Y) and some natural homeomorphism $\partial_* f : C_1 \to C_2$? (Here, we equip C_1, C_2 with subspace topology.)*

With the above assumption, it is not difficult to show that $\partial_c X$ is dense in ∂X but it is of first Baire category unless the spaces are Gromov-hyperbolic. We have some results for both questions but this project is in progress.

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Sang Rae Lee
(Texas A and M University, USA)

Cubical complexes

My research interests are in CAT(0) cubical complexes, Morse Theory and finiteness properties, Dehn functions and boundaries of groups.

Most of the spaces I deal with are CAT(0) cubical complexes. In case a complex is equipped with a Morse function, Bestvina-Brady Morse theory provides a nice tool to study level sets (or point pre-images). If a group acts on the level set geometrically. The topology and geometry of level sets translates into information of the group such as finiteness properties and Dehn functions.

I constructed a family of CAT(0) cubical complexes X_n on which Houghton's groups H_n acts, which fits into the above frame [1].

In the joint work with Noel Brady and Dan Guralnik I studied a family of 'Modified Right Angled Artin groups', which was to investigate the extent to which one can independently control topology and geometry of the level sets of a CAT(0) complex. We constructed examples of CAT(0) cubical complexes with simply connected level sets which have various Dehn functions (exponential or polynomial Dehn functions of prescribed degree ≥ 4) [2].

In the joint work with Yulan Qing, I have been studying the boundary of the complex X_n.

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Ana Claudia Lopes Onorio
(University of Southampton)

Let G be a discrete group and let F be a family of subgroups of G. There is a well-stabilished connection between Bredon cohomological dimension and the dimension of a classifying space for actions of G with stabilisers in F $\{$in the high-dimensional case$\}$. The Eilenberg-Ganea theorem corresponds to the case when F consists of just the trivial group. We propose to study the 1-dimensional case for all F, i.e., to look for an analogue of the Stallings-Swan theorem. If F consists solely of finite groups this result follows from work of Dunwoody, but beyond this nothing is known.

Rami Luisto
(University of Helsinki, Finland)

Geometry of QR-elliptic manifolds

The subjects of my current research involve the study of closed manifolds receiving a certain kind of mapping from the Euclidean space. Some of the questions originate from Gromov, who studied when a manifold is *elliptic*, i.e. when a Riemannian manifold N admits a Lipschitz mapping f $f : \mathbb{R}^n \to N$ with nonzero asymptotic degree. The two classes of mappings I mostly use are the non-injective generalizations of quasiconformal mappings called *quasiregular mappings* and their subclass of *Bounded Length Distortion (BLD) mappings*. Fundamental result in this area is the Varopoulos result, which states that the fundamental group of a quasiregularly elliptic manifold has polynomial growth, from which it follows by Gromov's theorem that such fundamental groups are virtually nilpotent. This enables the use of Pansu's theorems. This means that not only are the finitely generated fundamental groups of QR-elliptic manifolds coarsly quasi-isometric to the universal cover of the manifold in question, but their blow-down -limits are Carnot groups and equal the blow-down limit of the universal cover.

I am currently working on a paper with my advisor Pekka Pankka that uses these techniques to improve our knowledge the algebraic structure of a closed QR-elliptic manifold. We already have a preprint [1] that shows that in an extremal situation The fundamental group is virtually $\mathbb{Z}^n$ and all higher homotopy groups are trivial. The final identification of the group $\mathbb{Z}^n$ relies on Bass' formula on the growth rates of polynomialli growing finitely generated groups.

I have also taken part and partly organized in a study circle of geometric group theory in our university. Last year we studied Kleiner's proof of Gromov's theorem, and for this year we are planning, among other things, to study Carnot groups and the aforementioned Pansu's theorems.

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Michał Marcinkowski
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- **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 $||.||$). I am interested in the geometry of groups equipped with the biinvariant metric, especially in metric behavior of cyclic subgroups (i.e. distorsion).

- **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 admits PSC metric (as every 1-connected manifold) and macroscopic dimension of its universal cover is 0 (which is less then topological dimension). The Gromov conjecture has proven to be true for some classes of manifolds in a series of papers by A.Dranishnikov and D.Bolotov. Recently am interested in constructing manifolds with some properties (e.g. macroscopically large but small in other sense) and decide if they admit PSC metrics. Constructions I can offer involve right angled Coxeter groups.

Alexandre Martin
(Universität Wien, Austria)

Cocompact actions on non-positively curved polyhedral complexes

A central problem of geometric group theory which is at the heart of my research is the following:
Combination Problem. Given a group action on a simply-connected polyhedral complex, is it possible to deduce a property for the group – algebraic, geometric, analytic or algorithmic – out of the same property for the stabilisers of faces, provided one imposes conditions on the geometry of the complex and the way it is acted upon?
While such combination problems have been extensively studied in the context of groups acting on trees, the situation has remained mostly unaddressed in the case of non-proper actions on higher-dimensional complexes. I am currently interested in developing tools to tackle such combination problems, with a particular focus on the hyperbolicity of a group and the existence of a non-positively curved cubulation.
I have proven a combination theorem for hyperbolic groups generalising a theorem of Bestvina–Feighn for groups acting acylindrically and cocompactly on CAT(0) hyperbolic complexes of arbitrary dimension [1]. In a joint project with D. Osajda, we are currently generalising this to the case of groups acting on complexes endowed with a more combinatorial geometry, such as systolic and $C'(1/6)$-polygonal complexes.
In a joint work with M. Steenbock, we have proven the cubulability of groups obtained as classical $C'(1/6)$-small cancellation groups over a free product of finitely many cubulable groups [2]. We plan to use this to study the geometry of groups with surprising properties, such as large classes of (Rips–Segev) torsion-free hyperbolic groups without the unique product property.

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Henning Niesdroy
(University of Bielefeld, Germany)

Geometric reduction theory

In october 2012 I started my Ph.D. studies under supervision of Prof. Dr. Kai-Uwe Bux. Before I graduated, I was particularly interested in topology and group theory. In order to combine these two topics I joined the group of my supervisor to work in geometric group theory.

In the following, I give a short introduction of what my thesis is about:

Consider $\mathrm{SL}_n(\mathbb{R})$, the hyperbolic space $\mathbb{H}^n := \mathrm{SL}_n(\mathbb{R})/\mathrm{SO}_n(\mathbb{R})$ and the action of $\mathrm{SL}_n(\mathbb{Z})$ on $\mathbb{H}^n$. Reduction theory describes a fundamental domain $\mathrm{S}_n \subset \mathbb{H}^n$.

Generalizing reduction theory to s-arithmetic groups, Godement found an adelic formulation treating all places simultaneously. Let K be a global number field, $\mathcal{G}$ be a reductive group (think of SL_n), and let $\mathbb{A}$ be the ring of adeles of K. Then $\mathcal{G}(K)$ is discrete in $\mathcal{G}(\mathbb{A})$, and Godement finds a fundamental domain (coarsly) for the action of $\mathcal{G}(K)$ on $\mathcal{G}(\mathbb{A})$. Later, Behr and Harder transferred this to the case when K is not a global number field, but a function field.

In 2012 Bux-Köhl-Witzel gave a geometric reformulation of Behr-Harder. Now the natural question arises, whether this geometric reformulation can be transferred back to the case of a number field. My task is to actually do that.

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Tomasz Odrzygóźdź
(Institute of Mathematics of Polish Academy of Sciences, Poland)

Random groups and l^2-Betti numbers

I am a second year PhD student, mostly interested in geometric group theory and the theory of L^2-invariants in topology.

In my master thesis [1] I have introduced the square model for random groups: we quotient a free group on n generators by a random set of relations, each of which is a random reduced word of length four. My main result was that for densities $< \frac{1}{3}$ a random group with overwhelming probability does not have Property (T). In further research, with Piotr Przytycki, we generalized the „Isoperimetric Inequality" to some wide class of non-planar diagrams and, using it, defined a system of non-standard walls in the Cayley complex of a random group in the square model (similar idea of introducing non-standard walls was used for the Gromov model in [2]). Finally, using Sageev's construction, I proved that for densities $< \frac{3}{10}$ w.o.p. a random group in the square model acts properly on a CAT(0) cube complex.

L^2 homologies of a finite-dimensional, locally compact CW-complex are defined in the same way as simplicial homologies (with coefficients in $\mathbb{R}$) except that one uses as chains square-summable combinations of simplices instead of finite linear combinations. The i-th l^2-Betti number is then defined as the Murray-von Neumann dimension of the reduced i-th group of the l^2-homologies. The l^2-Betti numbers of finitely presented group are defined as the l^2-Betti numbers of the universal cover of its classifying space. The l^2-Betti numbers have many geometric interpretations, for example if $\beta_1^{(2)}(G) > 0$ for a group G then G is uniformly non-amenable. My goals are the following: find a connection between a space of l^2-homologies of a hyperbolic group G with the space of measures on the Gromov's boundary of G, find new estimations for l^2-Betti numbers of hyperbolic groups and calculate them for random groups.

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Damian Orlef
(University of Warsaw, Poland)

Properties of random groups in Gromov density model

My recent research has been mainly concerned with the study of random groups in Gromov density model. More precisely, I have been working on 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]).

In the near future I plan to work on determining the critical density for property (T) in the Gromov model.

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Andreas Ott
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Bounded cohomology via partial differential equations

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. As a remedy, extending Gromov's original definition, Burger and Monod introduced the continuous bounded cohomology $H^\bullet_{cb}(G;\mathbb{R})$ for any locally compact topological group G. It is defined as the continuous group cohomology $H^\bullet_c(G;\mathbb{R})$ but with the additional requirement that cochains on G be *bounded*; the resulting cohomology rings are then related by a natural comparison map

$$H^\bullet_{cb}(G;\mathbb{R}) \to H^\bullet_c(G;\mathbb{R}). \tag{1}$$

Over the last decade, continuous bounded cohomology of Lie groups has found applications to rigidity theory and higher Teichmüller theory. It is expected that the continuous bounded cohomology of Lie groups is much easier to compute than the bounded cohomology of discrete groups. In fact, Monod conjectured that, for any connected semisimple Lie group G with finite center, the map (1) is an isomorphism.

Presently, Monod's conjecture is basically known to be true in low degrees, but remains mysterious in higher degrees. The goal of this program is to unravel this mystery. For that purpose, I developed (jointly with T. Hartnick) new techniques that combine methods from group cohomology with methods from differential geometry and the theory of partial differential equations.

We made progress by proving surjectivity of the map (1) for all Hermitian Lie groups. Injectivity of (1) seems to be a much harder problem. In the simplest possible case of $G = SL_2(\mathbb{R})$, by finiteness of continuous cohomology, injectivity boils down to a vanishing theorem. Burger and Monod proved this in degree 3 (in which case there are no nonzero cocycles), while we were able to settle this in degree 4 (the first case where nonzero cocycles do exist). Our method uses PDEs and symmetry considerations in order to explicitly construct bounded primitives.

We are currently extending our method to higher degrees.

Cristina Pagliantini
(ETH Zürich, Switzerland)

Simplicial volume and bounded cohomology

I am interested in the estimation of *simplicial volume* of manifolds with non-empty boundary and its behaviour under topological operations [1]. Gromov introduced the simplicial volume in his pioneering work *Volume and bounded cohomology* [3], published in 1982. The simplicial volume is a homotopy invariant of compact manifolds defined via a natural ℓ^1-seminorm on real singular homology. More precisely, for an oriented manifold it is the ℓ^1-seminorm of the real fundamental class of the manifold itself.

As a powerful tool for computing the simplicial volume, Gromov himself introduced the theory of *bounded cohomology* [3]. Currently I am working on developing some aspects of the bounded cohomology of pairs of spaces and groups [2, 5]. Bounded cohomology constitutes a fascinating theory by itself since it allows to establish a link between geometry and group theory.

Furthermore I am analyzing the relation between simplicial volume and other topological invariants. For instance, Gromov conjectured that an aspherical oriented closed connected manifold with vanishing simplicial volume has zero Euler characteristic. Gromov himself suggested to use the *integral foliated simplicial volume* for which the corresponding statement is true. In [4] we proved that the simplicial volume and the integral foliated simplicial volume are equal for hyperbolic 3-manifolds. I am now approaching the case of hyperbolic manifolds of dimension bigger than 3.

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Maël Pavón
(ETH Zürich, Switzerland)

From Injective Hulls of Groups to CAT(0) Cube Complexes

I am at the beginning of my fourth year as a PhD student in Mathematics at ETH Zürich. My advisor is Prof. Urs Lang.

I am working primarily on injective metric spaces and metric injective hulls. A metric space Y is called *injective* if for any isometric embedding $i\colon A \to B$ of metric spaces and any 1-Lipschitz (i.e., distance-nonincreasing) map $f\colon A \to Y$, there exists a 1-Lipschitz extension $g\colon B \to Y$ of f, so that $g \circ i = f$. Examples of injective metric spaces include the real line $\mathbb{R}$, $l_\infty(I)$ for any index set I, and all complete metric trees. Isbell (cf. [1]) showed that every metric space X possesses an *injective hull* $(\mathrm{e}, \mathrm{E}(X))$; that is, $\mathrm{E}(X)$ is an injective metric space, $\mathrm{e}\colon X \to \mathrm{E}(X)$ is an isometric embedding, and every isometric embedding of X into some injective metric space factors through e.

For Γ a group with a finite generating system S, equipped with the word metric d_S induced by the alphabet $S \cup S^{-1}$, and letting $\Gamma_S := (\Gamma, d_S)$, it is shown in [2] that under some circumstances, $\mathrm{E}(\Gamma_S)$ has the structure of a polyhedral complex on which Γ acts properly by cellular isometries. If Γ_S is δ-hyperbolic, then $\mathrm{E}(\Gamma_S)$ is δ-hyperbolic, finite dimensional and the action of Γ is cocompact in addition.

I am studying criteria for the metric d_S which ensure that the injective hull $\mathrm{E}(\Gamma_S)$ has additional geometric properties. In some cases, $\mathrm{E}(\Gamma_S)$ can for example be endowed with the structure of a CAT(0) cube complex on which Γ is still acting geometrically, that is properly, and cocompactly in case Γ_S is δ-hyperbolic.

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Dominika Pawlik
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Combinatorial properties of boundaries of hyperbolic groups

The main area of my interest are Gromov boundaries of hyperbolic groups, their finite presentations and corresponding regularity properties. Recently, I have proved that every such boundary can be given (up to homeomoprhism) a "simplicial automatic" presentation as a *Markov compactum* as defined by Dranishnikov [3], i.e. as the inverse limit of a system of finite complexes in which every simplex can be assigned a finite type which determines the form of its pre-images. In addition, the dimension of these complexes can be bounded by $\dim \partial G$. In fact, the inverse limit of such system can be also equipped with a natural metric, quasi-conformally equivalent with the natural (i.e. Gromov visual) metric on the boundary.

It turns out that the methods used in proving these claims also allow to generalize (from the torsion-free case to all hyperbolic groups) the result of Coornaert and Papadopoulos [2] which provides a presentation of the boundary as a quotient of two infinite-word "regular" (in an appropriately adjusted sense) languages, which they call a *semi-Markovian space*.

This area is also connected with the (co)homological properties of the Gromov boundary. The Markov compactum presentation seems to allow an attempt to answer a question of Epstein [1], asking if there are algorithms computing the Čech cohomology groups of ∂G, or at least deciding if they coincide with those of a sphere. Also, Davis has asked [4] about the relation between the cohomological dimensions $\mathrm{cd}_{\mathbb{Q}}\, \partial G$ and $\mathrm{cd}_{\mathbb{Z}}\, \partial G$, while [3] provides certain tools for computing such dimensions for Markov compacta.

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Idan Perl
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Spaces of harmonic functions on groups

In 2007 Kleiner proved the following theorem: For any finitely generated group G of polynomial growth, the space of harmonic functions on G of some fixed polynomial growth is a finite dimensional vector space. Using this theorem Kleiner obtained a non-trivial finite dimensional representation of G, and discovered a new proof of Gromov's theorem: Any finitely generated group of polynomial growth has a finite index subgroup that is nilpotent (i.e. is virtually nilpotent). A natural question along these lines is whether the converse of Kleiner's theorem holds. That is: Let G be a finitely generated group, and let μ be a symmetric probability measure on G, with finite support that generates G. Let $HF_k = HF_k(G, \mu)$ denote the space of μ-harmonic functions on G whose growth is bounded by a degree k polynomial. Then the following are equivalent:

- G is virtually nilpotent.
- G has polynomial growth.
- $\dim HF_k(G, \mu) < \infty$ for all k.
- There exists $k \geq 1$ such that $\dim HF_k(G, \mu) < \infty$.

My research deals mainly with this question, and other questions that relate spaces of harmonic functions on groups with their algebraic and geometric properties.

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Hester Pieters
(University of Geneva)

Bounded cohomology and symmetric spaces

I am a fourth 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. 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 $\text{Isom}^+(\mathbb{H}^3)$ in degree 3 can be calculated using the complex of measurable maps on the boundary $\partial\mathbb{H}^3$ (see [1]). Generalizing his proof, I have shown that $H^*_c(\text{Isom}^+(\mathbb{H}^n);\mathbb{R}) = H^*_m(\partial\mathbb{H}^n;\mathbb{R})$ in all degrees and for real hyperbolic space $\mathbb{H}^n$ of any dimension. I am now trying to extend this result to other semisimple Lie groups. In the case of $\text{Isom}^+(\mathbb{H}^n)$ it implies in particular injectivity of the comparison map in degree 3.

I am also interested in using bounded cohomology techniques to study the connection between the topology and the geometry of manifolds. On Riemannian manifolds, typically of nonpositive curvature, invariants from topology such as for example characteristic numbers are often proportional to geometric invariants such as the volume. An example are the so called Milnor-Wood inequalities which relate the Euler class of flat bundles to the Euler characteristic of the base manifold. 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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Thibault Pillon
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Affine isometric actions of groups

I study affine isometric action of groups on Banach spaces. Such actions are fruitful in the study of groups. In particular, Kazhdan's property (T) and the Haagerup property can be expressed in term of properties of affine actions on Hilbert spaces. Together with B. Bekka and A. Valette in [BPV], we introduced and studied a notion of irreducbility for such actions. The approach leads to surprising connections with L^2-Betti numbers e.g.

Theorem 1. *Let Γ be a finitely generated non amenable ICC group. Then*

$$\beta^1_{(2)}(\Gamma = \sup\{t > 0 \mid \exists \textit{ an irreducible action of } \Gamma \textit{ with linear part } \lambda_t\}$$

where λ_t denotes the unitary represention induced on Γ by the unique $R(\Gamma)$-Hilbert module of von Neumann dimension t.

I'm also interesting in the study of compression exponents of groups, which tracks the best possible asymptotic behavior of orbits of affine actions. I'm trying to find optimal exponents for groups acting on L^p-spaces with $p > 2$. In particular, I produced explicit construction of proper actions of a free product of groups amalgamated over a finite subgroup.

A lot of properties and conjectures of groups have found geometrical analogues in the realm of large scale geometry. Together with P.-N. Jolissaint [JP], we showed that the so called BS-$\mathfrak{N}$ groups introduced by S. Gàl and T. Januszkiewicz [GJ] have non-equivariant compression exponent equal to 1 in most cases.

Finally, my scope of interests includes non linear geometry of Banach spaces, operator algebras, the structure of locally compact groups, and as a personal hobby combinatorial game theory.

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Doron Puder
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Words maps and spectra of cayley graphs

Let me briefly explain two of the questions I am currently interested in:

Measure-theoretic characterization of words:
Consider the measure induced on compact groups by words. Namely, fix some word $w \in F_k$, the free group on k generators $x_1, \ldots, x_k$. This word induces a measure on every compact group via the word map $w : G^k \to G$ (here G^k is the Cartesian product of G) and a push forward of the Haar measure on G^k.

It is an easy observation that any two words belonging to the same $Aut(F_k)$-orbit induce the same measure on every compact group. But does the converse hold? We have proved an important special case in [2] using the measure induced by words on Symmetric groups. We are currently trying to study the case of Unitary groups in the hope of extending the result.

Dominant irreducible representations in spectra of finite Cayley graphs:
Consider the spectrum of a given Cayley graph of a finite group G with generating set S, namely, the eigenvalues of its adjacency matrix A. The largest eigenvalue is $|S|$. The second largest determines the spectral gap of the graph and the extent to which it is a good expander.

The matrix A can be thought of as the image of $\sum_{s\in S} s$ under the regular representation. Because the regular representation is a sum (with multiplicities) of all irreducible ones, the spectrum of A is naturally decomposed to spectra of the different irreducible representations. For example, the trivial first eigenvalue always corresponds to the trivial representation. A natural question is which representation the second largest eigenvalue comes from.

Specifically, we consider the case of Symmetric groups. It was recently shown [1] that when S contains only transpositions, the standard representation is always dominant. We have some ideas of how to extend this result. In particular, we wish to understand if some meaningful statement holds for every S.

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Pierre Py
(IRMA, Université de Strasbourg & CNRS)

My present research lies at the intersection of complex differential geometry and group theory. I am interested in the study of fundamental groups of compact Kähler manifolds. This class of groups includes in particular (cocompact) lattices in the isometry group $\mathrm{PU}(n,1)$ of the complex hyperbolic space. Many questions which have been solved for lattices in other simple Lie groups are open for lattices in the group $\mathrm{PU}(n,1)$. For instance one can name the problem of arithmeticity, the problem of positivity of the virtual first Betti number, the largeness... Some of these questions can sometimes be addressed using a mixture of geometric group theory and complex geometry. Occasionally, I have also worked on questions related to the study of $\mathrm{CAT}(0)$ spaces and locally compact groups.

Nicolas Radu
(Université catholique de Louvain, Belgique)

Classification of strongly transitive compact spherical buildings and applications to the study of simple locally compact groups.

Jacques Tits conjectured in 1974 that the only finite spherical buildings of irreducible type and rank at least 2 which are strongly transitive are the buildings associated to an algebraic group over a finite field or to a twisted form of such a group [1]. This conjecture has been solved, and the purpose of my PhD project is to do the same work in the more general case of compact spherical buildings. We will therefore be interested in the conjecture stating that the only compact infinite spherical buildings of irreducible type and rank at least 2 which are strongly transitive are the buildings associated to an algebraic group over a local field. In my master's thesis under the supervision of Pierre-Emmanuel Caprace, we managed to reduce this conjecture to a purely topological one which is therefore more promising. Our strategy will now be to develop some tools that Burns and Spatzier introduced to find topological properties of compact spherical buildings [2]. We will not, however, only study building theory. We will also be interested in more classical mathematical objects to which buildings are directly related. Attention will in particular be given to making headway in the general study of simple locally compact groups which has recently been initiated [3]. The classification of strongly transitive compact spherical buildings which is the subject of this project would indeed help to find some natural hypotheses on such groups ensuring the existence of a cocompact spherical BN-pair.

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Ahmad Rafiqi
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Dilatation factors of pseudo-Anosov maps of hyperbolic surfaces

It is known from Thusrton's work that the dilatation of a pseudo-Anosov map of a hyperbolic surface is an algebraic integer bigger in absolute value than all its Galois conjugates, i.e. it is a *Perron* number. It is not hard to see that a dilatation is in fact *bi-Perron*, i.e. a Perron number λ with all Galois conjugates in the annulus $\{z \in \mathbb{C} : 1/\lambda \leq |z| \leq \lambda\}$.

We tried to address the converse of this. For a bi-Perron number, λ, given as the leading eigenvalue of a non-negative matrix, M, we give sufficient conditions on M to ensure that λ is the dilatation of a pseudo-Anosov map of a surface. When the sufficient condition is met, we give an explicit construction of the surface and the homeomorphism. Our construction was motivated by Thurston's construction using ω-limit sets of piecewise affine maps in the plane.

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Erik Rijcken
(Ghent University, Belgium)

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 $(\mathcal{T}, (U_v)_{v\in V(\mathcal{T})})$, where $\mathcal{T}$ is a rooted tree with root r, and U_v is a subgroup of $\mathrm{Aut}(B(r, \mathrm{d}(r, v)))$, i.e. a group of automorphisms of the subtree of $\mathcal{T}$ where we only go as far out from the root r as where v is located. We call the groups $(U_v)_v$ *root groups*. The axioms we then ask for are, for each $v \in V(\mathcal{T})$:

(LM1) U_v fixes v, and acts regularly on

$$\{w \in V(\mathcal{T}) \mid \mathrm{d}(v, r) = \mathrm{d}(w, r) \text{ and the path from } v \text{ to } w \text{ passes through } r\}\,;$$

(LM2) if $\mathrm{d}(v, r) = \mathrm{d}(w, r)$, then for any $g \in U_w$, we have $U_v^g = U_{v\cdot g}$;

(LM3) the action of U_v on $B(r, \mathrm{d}(r, v) - 1)$ is exactly the action of $U_{p(v)}$, with $p(v)$ the next vertex on the path from v to r.

Several properties that hold for Moufang sets are also valid for local Moufang sets, such as many identities involving μ-maps and Hua-maps. One can construct a local Moufang set with one root group and one particular element τ, and we can give a sufficient condition for it to become a local Moufang set, similar as in [2].

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Amin Saied
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The Cohomology of $Out(F_n)$ and related objects

Let $S_{g,n}$ denote the surface of genus g with n boundary components. The mapping class group of $S_{g,n}$ is defined to be the group of isotopy classes of orientation preserving homeomorphisms of $S_{g,n}$. It is a theorem of Dehn and Nielson that (for any $g \geq 1$) $Mod(S_{g,1}) \hookrightarrow Aut(F_{2g})$, and indeed, there is a well studied relationship between mapping class groups of surfaces and free group automorphisms. A particularly nice example of this connection is the Johnson homomorphism. Developed by Dennis Johnson in order to study the mapping class group, and indeed a particular subgroup of interest, the Torelli group, this has been extended to the Johnson homomorphism for $Aut(F_n)$, and is arguably more natural looked at in this light. Let $\mathcal{A}_n$ denote the (Andreadakis-)Johnson filtration (either for the $Mod(S_{g,1})$ or $Aut(F_n)$). The k-th Johnson homomorphism is an injective graded Lie algebra homomorphism

$$\tau_k : \mathrm{gr}^k(\mathcal{A}_n) \hookrightarrow \mathrm{Hom}_{\mathbb{Z}}(\mathrm{gr}^1(\mathcal{L}_n), \mathrm{gr}^{k+1}(\mathcal{L}_n))$$

where $\mathcal{L}_n$ denotes the lower central series for F_n (where $n = 2g$ if we are thinking of the mapping class group) [2, 3]. Morita constructed an obstruction to the surjectivity of these maps (except in the case $k = 1$ when τ_1 is an isomorphism), however, in general the cokernel is not well understood. By interpreting the target of the Johnson homomorphism as a space of trees, and by applying a remarkable theorem of Kontsevich, one is able to 'lift' these cokernel elements to (potential) cohomology classes of $Out(F_n)$, [1, 4]. At this time, the only known non-zero cohomology classes in $Out(F_n)$ arise from these so called Morita cycles. I am interested both in the Johnson cokernel, and finding cohomology classes for $Out(F_n)$ (and for $Aut(F_n)$) using these techniques. The main approach I am taking involves using hairy graph homology [1], an extension of the graph homology of Kontsevich [4], to probe both of these questions.

My advisor is Martin Kassabov.

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Andrew P. Sánchez
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Random groups and nilpotent groups

My research interests lie in geometric group theory, and in particular I have studied random groups and nilpotent groups.

I currently have two nearly-completed projects that were initiated this past summer that are both concerned with random groups. In the density model of random groups, a set R of relators is chosen (uniformly) randomly from freely reduced words of length ℓ in m generators, and we define the *density* $d = \lim_{\ell\to\infty} \frac{1}{\ell} \log_{2m-1} |R|$. The classic theorem in the density model of random groups is that for $d < 1/2$, random groups are (asymptotically almost surely) infinite hyperbolic, while for $d > 1/2$, random groups are (asymptotically almost surely) trivial [1]. In unpublished notes, Gady Kozma shows that there is a certain growth rate for $|R|$ at the threshold density $d = 1/2$ such that the resulting groups are still trivial. In my joint work with M. Duchin, K. Jankiewicz, S. Kilmer, S. Lelièvre, we have found that there is also a way to set $|R|$ to find infinite hyperbolic groups at the same density.

My other efforts have focused on random nilpotent groups (i.e., quotients of free nilpotent groups by randomly chosen relators). In ongoing work with M. Cordes, M. Duchin, Y. Duong, and M. Ho, we have established several results regarding the step and rank of random nilpotent groups. Additionally, we can lift some of our results to random groups in the density model, deriving information on their lower central series. For example, we observe that random groups are almost surely *perfect* at any positive density, and we find the threshold growth rate for $|R|$ for this fact to hold.

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Damian Sawicki
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From asymptotic dimension to coarse embeddability

I am a first-year Ph.D. student interested in metric aspects of discrete groups. My current research under the supervision of Dr Piotr Nowak concerns coarse embeddability and property A.

Recall that property A of Guoliang Yu implies coarse embeddability into Hilbert space and whether the converse holds (or when it does) has been an open problem inspiring researchers in the recent years. The first counterexamples due to Nowak were locally finite, later Arzhantseva, Guentner and Špakula found examples with bounded geometry. No counterexamples among groups had been known until the very recent work of Osajda [2].

The goal of my present research is to construct new examples of coarsely embeddable metric spaces without property A.

My previous work concerned different versions of asymptotic dimension. In [3], which is based on my B.Sc. thesis, I give a new proof of the fact that any metric space of asymptotic dimension n after some modification of the metric (to an equivalent one) has linearly controlled asymptotic dimension equal to n. My construction preserves a number of properties of the original metric (e.g. left-invariance), what – apart from formally strengthening previous results – leads to new observations.

In my M.Sc. work, I studied "wide equivariant covers" introduced in [1], which are a tool in the proofs of the Farrell–Jones and Borel conjectures. In particular, I showed that virtually cyclic groups are characterised by the existence of zero-dimensional coverings of this kind.

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Jeroen Schillewaert
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Projective Embeddings and Rigidity of Buildings

The main part of the proposal is on the geometries of the Freudenthal-Tits magic square (FTMS). Next to this investigation of Euclidean buildings is proposed, in particular rigidity questions. The latter also arise in the (FTMS), and they have spherical buildings at infinity. As such the two parts of the project are related.

The (FTMS) part of the proposal concerns (exceptional) algebraic groups and their associated geometries, one of our motives being to obtain a direct (geometric) construction of the 248-dimensional irreducible E8 module. The main goal of the proposal - for earlier and hence more modest versions of it I was recently awarded both an Oberwolfach Leibniz fellowship and a Marie Curie Fellowship - is to give a uniform axiomatic description of the embeddings in projective space of the varieties corresponding with the geometries of exceptional Lie type over arbitrary fields. This comprises a purely geometric characterization of F4,E6,E7 and E8 [SVM1, SVM2].

A Euclidean building has an associated building at infinity which is a spherical building. The easiest example would be the set of ends associated to a Bruhat-Tits tree, as described in Serre's book. One goal is to understand to what extent the building at infinity determines the building [SS]. Another goal is to learn more about the general class of CAT(0) spaces in the process, of which Euclidean buildings form an important class of examples as they have a lot of symmetry. More concretely, we want to obtain a Tits alternative for affine buildings.

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Peter Schlicht
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The cone of positive operators

In my PhD thesis (end of PhD in January 2014), I investigated the unitarisability of (representations of) discrete groups through the induced actions on the cone X of positive, invertible operators.

This space carries a nice metric d induced by the operator norm on the linear space of self-adjoint operators and the exponential map. Explicitely, the distance $d(x, \mathrm{id})$ of some $x \in X$ to the identity id is given by $\|\ln x\|$. The metric is transported to the whole of X by the isometries defined through $\varphi_a : \ x \mapsto axa^*$ for bounded invertible a. With the help of such isometries, one can also define geodesics for d between any two points in X: those are images of curves $t \mapsto x^t$ for $x \in X$ and $t \in [0, 1]$.

It turns out, that d is convex with respect to those geodesics and I could construct barycenters of finite sets with respect to this metric.

Given a linear representation of a group on a Hilbertspace, it is called unitarisable, if it is conjugate to a unitary representation. Groups, for which every uniformly bounded representation (i.e. the image of the representation inside the algebra of bounded operators is bounded) is unitarisable, are called unitarisable groups.

It is easy to see and classical, that amenable groups are unitarisable and it is an open question known as the Dixmier question, whether the converse also holds.

Now, unitarisability of a representation ρ corresponds to having a fixed point for the induced action on the space of positive invertible operators by isometries (g acts through $\varphi_{\rho(g)}$ in the notation from above).

Looking at the topology and geometry of this space, I could give a geometric proof for the existence of some universal constants for unitarisable groups, which were previously attained by Gilles Pisier using algebraic methods.

Now, I am interested in large scale properties of this metric space (like the boundary at infinity) and its dynamics under group actions.

Alessandro Sisto
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Acylindrically hyperbolic groups, random walks and bounded cohomology

The list of examples of acylindrically hyperbolic groups is extensive, as it includes non-elementary hyperbolic and relatively hyperbolic groups, Mapping Class Groups, $Out(F_n)$, many CAT(0) groups and small cancellation groups.

I am especially interested in random walks and bounded cohomology of acylindrically hyperbolic groups.

Random walks are models for "generic elements" of a given group. The most basic reason of interest is that it is very natural, when considering a family of objects, to ask questions of the kind "What does a generic object of this kind look like?".

Some things I am working on in this area include showing that random paths stay close to geodesics and studying subgroups generated by collections of random elements.

Bounded cohomology is a group invariant, or rather a family of group invariants, that has been proven useful to show "rigidity" results of various sorts. For example, in certain cases it can be used to show that there are severe restrictions on the kinds of homomorphisms that can exist between two groups, or that a certain group cannot act "interestingly" on spaces of a certain kind. Moreover, by a result of Ghys, the second bounded cohomology classifies, in a suitable sense, all actions by homeomorphism of a given group on the circle. It is also tightly connected to random walks.

The main goal of my research in this topic is to describe as fully as possible the bounded cohomology of acylindrically hyperbolic groups.

More specifically, I have been working on understanding their bounded cohomology using the so-called hyperbolically embedded subgroups.

Elefterios Soultanis
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Homotopies in Newtonian classes of maps

My research concentrates on Sobolev type maps between metric spaces, and can be split into two components: p-Poincaré spaces on the domain side, and locally convex (or more generally $K(\pi, 1)$-) target spaces. The domain side of my research is basically analysis on metric spaces; on the target, however, research questions include problems related to metric geometry and algebraic topology, as well as geometric group theory.

A specific question I am working on is finding a subclass of $K(\pi, 1)$ spaces for which p-quasihomotopy classes of maps in $N^{1,p}(X; Y)$ have good compactness properties (for compact X, Y), see [1]. The notion of p-quasihomotopy is in the spirit of [2], where the authors generalize on the work of R. M. Schoen and M. Gromov with applications to rigidity questions for discrete groups (see [3]).

A related question is when a map u in the Sobolev type space $N^{1,p}(X; Y)$ (called the Newtonian space) admits a lift $h \in N^{1,p}(X; \hat{Y})$, where $\hat{Y}$ is a given covering space of Y. I am currently working on a way of extending the classical answer for continuous maps to the Newton space setting, assuming some group theoretic properties from the fundamental group of the target space.

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Emily Stark
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Abstract commensurability and quasi-isometric classification

My research focuses on abstract commensurability and quasi-isometric equivalence for finitely generated groups. I am also interested in boundaries of groups, quasi-isometric rigidity, limit groups, and groups that act on CAT(0) cube complexes.

Two groups are said to be *abstractly commensurable* if they contain isomorphic subgroups of finite index. Finitely generated groups that are abstractly commensurable are quasi-isometric, though the converse is false in general. Two fundamental questions in geometric group theory are to characterize the abstract commensurability and quasi-isometry classes within a class of groups, and to understand for which classes of groups these classifications coincide.

In [2], we study the class of groups isomorphic to the fundamental group of two closed hyperbolic surfaces identified along an essential simple closed curve in each. We show that all groups in this class are quasi-isometric by constructing a bi-Lipschitz map between the universal covers of certain $K(G, 1)$ spaces equipped by a CAT(-1) metric. We prove there are infinitely many abstract commensurability classes of groups in this class; we characterize the abstract commensurability classes in terms of the ratio of the Euler characteristic of the surfaces and the topological type of the curves identified.

Together with Pallavi Dani and Anne Thomas, I am studying abstract commensurability for certain hyperbolic right-angled Coxeter groups, extending the work of Crisp and Paoluzzi in [1].

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Koen Struyve
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Euclidean buildings and groups

The central topic of my research are Euclidean buildings and related objects. As these buildings form an important class of CAT(0)-spaces, various questions concerning such spaces can be considered specifically for this subclass. One question I am particularly interested in is the existence of an infinite finitely generated torsion group acting properly discontinuously on a proper CAT(0)-space. One way to state this problem for arbitrary buildings (in a slightly more general way) is in the form of the following conjecture:

> If G is a finitely generated group acting on a building such that each element of G stabilizes a spherical residue, does the group as a whole stabilize some spherical residue?

Euclidean buildings and symmetric spaces often stand out among CAT(0)-spaces, which is made apparent by the existence of various common characterizations. A conjectural such characterization is known as 'rank rigidity'. One version of this conjecture is (see [2, Conj. 3.6.9]):

> Assume that G is an irreducible torsion-free CAT(0)-group such that every nontrivial element of G is contained in an abelian subgroup of rank at least 2. Then G is isomorphic to a lattice in the isometry group of symmetric spaces, Euclidean buildings, or their products.

I am interested in this problem in the context of piecewise Euclidean CAT(0)-complexes, as well as for systolic complexes, which are a combinatoric approximation to CAT(0)-spaces ([1]).

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Karol Strzałkowski
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Lipschitz simplicial volume

I am interested in the simplicial volume, which is a homotopy invariant of manifolds. 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. In spite of relatively easy definition, it is useful for proving e.g. degree theorems, it has also many connections with Riemannian geometry (see [1] for more details).

The above definition can be naturally generalised to the case of non-compact manifolds by considering ℓ^1 norm of the locally finite fundamental class. However, this generalised definition provides an invariant which is zero or infinite in most cases. One can therefore consider the Lipschitz simplicial volume $\|M\|_{Lip}$, i.e. the simplicial volume counted on locally finite chains with uniform Lipschitz constant.

I proved in [2] that in the case of complete, finite volume Riemannian manifolds with the sectional curvature bounded from above this volume has some crucial properties which hold for the classical simplicial volume in the compact case, but in general not in the non-compact case. Namely, we established 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 $\|\cdot\|_{Lip}$ is proportional to the Riemannian volume. To obtain this, I generalised the classical procedure of straightening simplices to the case of manifolds with an upper bound for the sectional curvature.

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Thierry Stulemeijer
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Computing abstract commensurators of profinite groups

In [1], the authors define the abstract commensurators of a profinite group as follow :

Definition 1. Let U be a profinite group. The **group of abstract commensurators** of U, denoted $\mathrm{Comm}(U)$, is defined as follows. Consider the set E of isomorphisms $\alpha : U_1 \to U_2$, where the U_i's are open compact subgroups of U and α is a topological isomorphism. Define an equivalence relation $\sim$ on E by $\alpha \sim \beta$ if and only if they coincide on some open subgroup of U. We set $\mathrm{Comm}(U) = E/\sim$.

In that same paper, the authors initiate the general study of abstract commensurators, and show its usefulness when it can be computed. A large class of examples have been computed in [2], a celebrated paper of Pink.

Theorem 1 (Corollary 0.3 in [2])**.** *Let G (resp. G') be an absolutely simple, simply connected alegebraic group over a local field k (resp. k'). Let U (resp. U') be an open compact subgroup of G (resp. G'). Then for any topological isomorphism $\alpha : U \to U'$, there exists a unique isomorphism of algebraic groups $G \to G'$ over a unique isomorphism of topological fields $k \to k'$ such that the induced morphism $G(k) \to G(k')$ extends α.*

But apart from these, very few abstract commensurators of other profinite groups have been computed. The goal of the research project is to give a building theoretic interpretation of Theorem 1, and hope to generalize the result to other families of groups.

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Krzysztof Święcicki
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Helly's theorem for systolic complexes

I am a second year PhD student at the Texas A&M University, interested in a geometric group theory. I recently passed my qualifying exams and I am about to start my research. I am mostly interested in questions related to coarse embeddings into the Hilbert space. I did my master degree at the University of Warsaw, where my advisor was Paweł Zawiślak. In my master thesis [2] I proved the analogue of Helly's theorem for systolic complexes.

Systolic complexes were introduced by Tadeusz Januszkiewicz and Jacek Świątkowski in [1]. They are connected, simply connected simplicial complexes satisfying some additional local combinatorial condition , which is a simplicial analogue of nonpositive curvature. Systolic complexes inherit lots of $CAT(0)$-like properties, however being systolic neither implies, nor is implied by nonpositive curvature of the complex equipped with the standard piecewise euclidean metric.

Recall classical Helly's theorem concerning convex subsets of Euclidean spaces. Suppose that $X_1, X_2, \ldots, X_n$ is a collection of convex subsets of $\mathbb{R}^d$ (where $n > d$) such that the intersection of every $d + 1$ of these sets in nonempty. Then the whole family has a nonempty intersection. There is a well known generalization of the classical Helly's theorem for $CAT(0)$ cube complexes, which inspired our study of the same phenomena for systolic complexes. Our main result is the following:

Let X be a systolic complex and let X_1, X_2, X_3, X_4 be its convex subcomplexes such that every three of them have a nontrivial intersection. Then there exists a simplex $\sigma \subseteq X$ such that $\sigma \cap X_i \neq \emptyset$ for $i = 1, 2, 3, 4$. Moreover, the dimension of σ is at most three.

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Dionysios Syrigos
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Outer Space for free products of Groups and Centraliser of an IWIP

The groups $Aut(F_n)$ and $Out(F_n)$, where F_n is the free group on n generators, are very important for Combinatorial and Geometric Group theory and they are well studied. In [1] Culler and Vogtmann constructed a contractible space, which is called 'Outer Space' or 'Culler-Vogtmann space', on which $Out(F_n)$ acts properly and as a result we can obtain a lot of interesting properties. Moreover, there are a lot of useful tools that are used to study CV_n and as a consequence $Out(F_n)$, like train track maps, laminations, currents and the Lipschitz metric.
A similar space can be constructed (see [4]) for a group G that can be written as a finite free product of groups, $G = G_1 * G_2 * ... * G_n * F_r$ which is contractible and we can obtain some results for the group $Out(G)$. Recently, some of the tools have generalised in the free product case, for example the train track maps and Lipschitz metric in [2]. Moreover, there are some more papers that indicate that other methods to study $Out(F_n)$ can be used for $Out(G)$, as well (see [5] or [6]).
My research focuses on understanding further similarities of these spaces. I am currently engaged in writing up my first results. More specifically, I have already generalised the construction of the stable lamination for an IWIP (irreducible automorphisms with irreducible powers) and a well known theorem (see [3]) that states that the centraliser of an IWIP in $Out(F_n)$ is virtually cyclic. The statement is slightly different in the free product case, because of the non-trivial kernel of the action of $Out(G)$ on the corresponding outer space.

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Nóra Gabriella Szőke
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Sofic groups

The idea of sofic groups (originally: initially subamenable groups) was introduced by Gromov ([3]) in 1999, as a common generalization of residually finite and amenable groups. These groups are of considerable interest because several important general conjectures of group theory were shown to be true for them. For example Gottschalk's surjunctivity conjecture for sofic groups was proved by Gromov in [3].

Possibly the biggest open question in the subject is whether all countable groups are sofic. So far we know that the class of sofic groups is closed under taking subgroups, direct products, inverse limits, direct limits, free products, extensions by amenable groups ([1]), and amalgamation over amenable subgroups ([2], [4]).

In my Master's thesis I clarified a proof of Elek and Szabó about the amalgamated products of sofic groups over amenable subgroups. The original proof in [2] contains an error and is incomplete.

It would be interesting to find some other constructions that the class of sofic groups is closed under. For example the following is an open question: Let G be a group, $N \triangleleft G$ a normal subgroup such that G/N is sofic and N is finite. Does it follow that G is sofic?

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Alexander Taam
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Research Statement

My current research is aimed at effectively finding decompositions and paramaterizations of groups that are discriminated by certain classes of groups. In particular, collaborating with A. Myasnikov and my advisor, O. Kharlampovich, I have formulated algorithms for finding JSJ-type decompositions, and presentations as iterated generalized doubles (as in [3]), for fully residually Γ groups, where Γ is a torsion-free hyperbolic group. I would like to extend these results to groups that are discriminated by RAAGs. The canonical presentations of fully residually Γ groups are found through the embeddings of such groups into the Γ-NTQ groups given in [4]. Recent progress in the theory of graph towers (a generalization of NTQ groups) by Kazachkov and Casals-Ruiz [2] gives some optimism that, formulated correctly, there are canonical decompositions which can be described effectively for groups descriminated by RAAGs. In some cases I have worked on measuring the computational complexity of certain algorithms related to equations over groups. I helped show that the problem of deciding if there is a solution to a quadratic equation over a torsion-free hyperbolic group is NP-complete [6]. I am also currently working on further methods for controlling depth functions of some residually finite groups, based on methods developed in [5] and [1].

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Subgroup Structure of Thompson's Group F

Thompson's group F was discovered in 1965 by Richard Thompson in connection with his work in logic. Although F and its generalizations have many interesting properties, subgroup structure of these groups is poorly understood. The solvable subgroups were classified completely by Collin Bleak in papers which came out of his 2005 thesis (see [1], [2], [3]). My current research is an exploration of a more general class of groups called the locally solvable subgroups. I have shown these groups are countable, there is a one-to-one correspondence between countably ordered sets and isomorphism classes of a nice family of locally solvable groups, and, as a result, there are uncountably many isomorphism classes of these groups.

As for other intriguing properties of F that have garnered interest in it: F is torsion-free but has no free subgroups of rank 2 or higher, it is lawless, it is finitely presented, it has a beautiful infinite presentation, it is the universal conjugacy idempodent, and it has close ties with associativity (see [4], [6], [7], [5]).

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Anne Thomas
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Lattices, Coxeter groups and buildings, and operator algebras

My research interests include:

1. Lattices in locally compact groups. An automorphism group of a locally finite polyhedral complex, such as a tree, product of trees or building, is naturally a locally compact group. This class of locally compact groups includes topological completions of Kac–Moody groups over finite fields. I study lattices in these locally compact groups, using techniques such as complexes of groups and finite group theory.

2. Coxeter groups and buildings. Coxeter groups are discrete groups generated by reflections, and are closely related to buildings. I study the large-scale geometry of Coxeter groups, and also use techniques of geometric group theory to investigate questions coming from algebraic combinatorics.

3. Operator algebras. Recently I have been collaborating with operator algebraists to construct and investigate new C^*-algebras associated to graphs of groups.

Scott Thomson
(University of Fribourg, Switzerland;
MPIM Bonn, Germany (from 1st Oct. 2014))

Arithmetic groups and hyperbolic manifolds

I am interested in arithmetic lattices acting on hyperbolic space. Arithmetic lattices are discrete subgroups of $\mathrm{Isom}(\mathbb{H}^n)$ obtained as groups of integral points in algebraic groups over number fields. It is well-known that these provide a source of examples of subgroups Γ of $\mathrm{Isom}(\mathbb{H}^n)$ acting with finite co-volume and hence leading to finite volume hyperbolic orbifolds and manifolds $\Gamma\backslash\mathbb{H}^n$. However as shown by M. Gromov and I. Piatetski-Shapiro (1986) these are not the only examples of finite-covolume discrete groups acting on hyperbolic space (i.e., there exist non-arithmetic lattices in $\mathrm{Isom}(\mathbb{H}^n)$). The Gromov–Piatetski-Shapiro examples were constructed by geometrically 'cutting and pasting' copies of arithmetically defined manifolds that had no common finite-index cover.

Hyperbolic manifolds may be studied more geometrically in terms of their *systole*. That is, the length of their shortest non-contractible curve may be related to other geometric invariants such as their volume, most famously by M. Gromov's 'systolic inequality'. More generally, for any dimension n it was shown that for any $\epsilon > 0$ there exists a closed hyperbolic n-manifold M with systole at most ϵ [1]. For a manifold M constructed as such an example, the volume $\mathrm{vol}(M)$ is bounded below by the quantity $1/\,\mathrm{systole}(M)^{n-2}$ and hence short systoles (in this construction) lead to large volumes.

If the systole in the above construction is short enough, then the manifolds so obtained are non-arithmetic and one has a new source of examples of non-arithmetic hyperbolic manifolds. I am interested in pursuing these examples further and investigating, for example, closed geodesic lengths of arithmetic versus non-arithmetic manifolds.

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Operad groups as a unified framework for Thompson-like groups

In [2] we propose to study a new class of groups, called operad groups, which contains a lot of Thompson-like groups studied in the literature before. Besides the classical Thompson groups F and V, it contains the higher dimensional Thompson groups nV and the braided version BV first defined by Brin, various groups of piecewise linear homeomorphisms of the unit interval studied by Stein and groups acting on ultrametric spaces via local similarities (Hughes). Roughly speaking, an operad group is the fundamental group of the category of operators naturally associated to an operad.

In [3] we show a homological result for operad groups implying that group homology with group ring or ℓ^2-coefficients vanishes in all degrees provided it vanishes in degree 0. As a corollary, we obtain first examples of groups of type F_∞ which are ℓ^2-invisible. This generalizes the results previously obtained with my PhD adviser in [1].

A famous problem in the study of Thompson-like groups is the question whether they are of type F_∞. In [4] we unify and extend results in this direction previously obtained for Thompson-like groups by various authors to the setting of operad groups.

In the near future, I intend to extend the theory of operad groups. Possible topics include dynamics at infinity, simplicity results and finite factor representations.

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Vera Tonić
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Relationship between asymptotic dimension of hyperbolic spaces and dimension of their boundary

I am interested in 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 ((Γ, d_{S_1}) and (Γ, d_{S_2}) being coarsely equivalent, for d_{S_1} and d_{S_2} corresponding word metrics, and S_1, S_2 finite generating sets of 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], Sergei Buyalo and Nina Lebedeva have proven the 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 currently examining the question: if X is a hyperbolic, geodesic space which is cobounded, but it is not proper and therefore ∂X need not be compact, is it still possible to achieve the same equality for X as above, and what additional properties might we have to ask of X in order to achieve this? This question is inspired by the possible validity of Buyalo and Lebedeva's formula for the curve complex.

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Dynamics of Free group automorphisms

The study of outer automorphism group of a free group F_N has greatly benefited from its analogy with the mapping class group of a surface. My first two projects deal with dynamics of fully irreducible outer automorphisms of F_N on the space of geodesic currents, which are analogous to pseudo-Anosov mapping classes in the surface case. In particular, I proved uniform north-south dynamics type results for fully irreducible outer automorphisms. See [1, 2] for details.

Currently, I am working on various questions related to curve complex analogs for the free group, including the Free Factor complex.

I also have an interest in dynamics on translation surfaces. Together with G. Work in [3], we explicitly compute the limiting gap distribution for saddle connections on the flat surface obtained by gluing the opposite sides of a regular octagon. Moreover, we show how to compute the gap distribution for an arbitrary Veech surface (X, ω) by parametrizing a Poincare section for the horocycle flow on the moduli space $SL(2, \mathbb{R})/SL(X, \omega)$.

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Matteo Vannacci
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Hereditarily just infinite groups that are not virtually pro-p

In my PhD I am studying a generalization of the family of groups introduced by Wilson in [3], that I will call *GW groups*. These groups are obtained as iterated wreath products of finite non-abelian simple groups. In [3] it is proven that GW groups are hereditarily just infinite profinite groups, they are not virtually pro-p and some of them are "large" in the sense that every finitely generated profinite group can be embedded in one of these groups. There are few properties of GW groups known: they are 2-generated and probabilistically 2-generated, but these results depend on the CFSG and do not give explicit generators. In [2] we study generation problems and we find explicitly few generators of GW groups with techniques independent from the CFSG. It turns out that GW groups are a really rich family with respect to the profinite lower rank and many behaviours are possible, this is investigated again in [2]. The final part of [2] is devoted to show that many GW groups do not have a finite profinite presentation. In this last year we moved our attention to to subgroup structure and subgroup properties in GW groups. In [1] we study a generalization of the "largeness" property of GW groups proving that GW groups are "universal" amongst finitely generated profinite groups with restricted composition factors. We studied also Hausdorff dimension in GW groups and proved that many GW groups have full Hausdorff dimension spectrum. The last achievement regarding GW groups had been the determination of the subgroup growth of these groups in a previously unkwown cases. In the last months I have been broadening my knowledge in general compact groups and locally compact totally disconnected groups, reading from textbooks and studying the topics from the Arbeitsgemeinschaft "Totally Disconnected Groups".

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Federico Vigolo
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Limit arguments in geometric group theory

In my research work I plan to investigate problems related to characterizations of large-scale properties via asymptotic cones (see [1] for a survey); rigidity properties obtained by studying boundaries at infinity (along the lines of Tukia's theorems [5] and Mostow Rigidity [4]); asymptotic properties of random walks on groups (e.g. probabilistic characterizations of algebraic properties or convergence to generic elements, see [2] and [3]). My research is funded by the EPSRC and the J.T.Hamilton scholarship of Balliol College, University of Oxford.

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Cora Welsch
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Coset posets of finitely generated groups and its connectivity properties (temporary)

I am just starting my PhD. At the moment I am working on an article called "Order complexes of coset posets of finite groups are not contractible" [1]. This article has connections to my master's thesis. My thesis' title is "Higher generation of groups by subgroups". In my master's thesis I was working with special simplicial complexes, namely a nerve of a covering of a group by cosets of a family of subgroups. It was invented by Abels and Holz in [2]. The connectivity of the nerve corresponds with the hight of the generation of the family of subgroups. I produced higher generating subgroups for Coxeter groups and their alternating subgroups. To find this subgroups I worked with nerves of finite groups and created highly connected nerves of direct products of cyclic groups.

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Phillip Wesolek
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The structure of non-discrete t.d.l.c. groups

My primary research interest is the application of descriptive set theory and geometric group theory to the study of non-discrete totally disconnected locally compact (t.d.l.c.) groups, typically when they are second countable (s.c.). Such groups arise throughout mathematics; they include the isometry groups of many metric spaces, e.g. locally finite trees, and p-adic Lie groups.

Results: In [2], I define the class of **elementary groups**, $\mathscr{E}$: the class $\mathscr{E}$ is the smallest class of t.d.l.c.s.c. groups such that $\mathscr{E}$ contains all discrete and profinite groups, is closed under group extensions, and is closed under countable directed unions of open subgroups. The class $\mathscr{E}$ is very robust; the host of permanence properties include closure under taking closed subgroups and forming Hausdorff quotients. In a t.d.l.c.s.c. group G, there is a unique maximal closed normal elementary subgroup the **elementary radical**, denoted $\mathrm{Rad}_{\mathscr{E}}(G)$. This radical leads to a surprising structure result.

Theorem 1 ([2]). *For G a compactly generated t.d.l.c.s.c. group, there is a finite series of closed characteristic subgroups $\{1\} = H_0 \leqslant H_1 \leqslant \cdots \leqslant H_n \leqslant G$ such that $G/H_n \in \mathscr{E}$ and for $0 \leqslant k \leqslant n-1$, $(H_{k+1}/H_k)/\mathrm{Rad}_{\mathscr{E}}(H_{k+1}/H_k)$ is a quasi-product with finitely many topologically characteristically simple non-elementary quasi-factors.*

Current projects: Every t.d.l.c.s.c. group is isomorphic to an element of $S(Sym(\mathbb{N}))$, the Chabauty space of $Sym(\mathbb{N})$; the set of these, $\mathrm{TDLC} \subseteq S(Sym(\mathbb{N}))$, is Borel. As the set of elementary amenable marked groups is non-Borel, [3], one asks: *Is $\mathscr{E} \subseteq \mathrm{TDLC}$ Borel?* The suspected negative answer is an essential step to a non-constructive approach to the following:

Question 1. *Is there a non-discrete compactly generated t.d.l.c. group that topologically simple and amenable? That is, do non-discrete Juschenko-Monod groups [1] exist?*

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Adam Wilks
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Systolic Groups and Various other Topics in Geometric Group Theory

I have just started a masters under the supervision of Piotr Przytycki. I am interested mostly with Systolic groups. Systolic complexes were introduced in [1] as means of finding examples of word hyperbolic groups. Systolic groups are groups that act proplerly and cocompactly on systolic complexes. It was shown in [2] that most triangle coxeter groups are systolic as well as the fact that the Coxeter group of type (2, 4, 4) is not systolic. In the paper it was posed whether the Coxeter groups of type (2, 4, 5) and (2, 5, 5) are systolic and this is a question I have been focusing on.

I am also interested in Cube complexes, a topic on which I attended a seminar run by Daniel Wise. Cube complexes exhibit a combinatorial condition that garuntees a CAT(0) structure and share some properties with systolic complexes. Another topic that I have been looking at is finding a way to produce acute triangulations for any polyhedra. There have already been some partial results, in particular in [3] it was shown how to give an acute triangulation of the 3-cube, the regular octahedron, and the regular tetrahedron.

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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 interested in which groups act freely or properly on CAT(0) cube complexes. Much of the work done in the past few years has focused on the (relatively) hyperbolic setting, culminating in a Agol's proof of Wise's conjecture [3], but there is much still to be understood outside of this setting. Specifically we can ask which groups can act freely or properly on finite dimensional CAT(0) cube complexes or are virtually special.

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Classification of non-exponential growing geometric outer automorphism

I am a PhD student under the direction of Professor Martin Lustig at University of Aix-Marseille with research interests in geometric group theory and dynamical system. The topics I'm interested in and have been studying about include Bass-Serre theory, Mapping Class Groups, Teichmueller Theory, topology and geometry of Culler Vogtmann Outer Space and dynamics of $Out(F_n)$ acting on outer space.

Currently my study concentrates on finding classification of geometric outer automorphisms, especially on finding an algorithm of determining non-exponential growing geometric automorphisms as well as constructing its surface model(s).

Denote F_n a finitely generated free group, $\hat{\phi} \in Out(F_n)$ is said to be geometric if its induced by a surface homeomorphism. In 1992, the work of Bestvina and Handel proved that an fully irreducible outer automorphism which preserves a non-trivial word up to a cyclic permutation is realized by a surface homeomorphism on a surface with connected boundary. And it's well known that a geometric automorphism has either linear or exponential growth. However there is still no complete classification of all geometric outer automorphisms.

My work is firstly determining the exact growth type of an outer automorphism of F_n by studying the relative train track representative from graph of group point of view. When $\hat{\phi}$ has non exponential growth, after passing $\hat{\phi}$ to a power, we shall either get a (efficient) Dehn twist automorphism on a graph of groups, from where we could further examine whether it comes from a surface model, or get verified that $\hat{\phi}$ has at least quadratic growth hence is non geometric.

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Arezoo Zohrabi
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Geometric Groups in Algebra

I am PhD student in Turin university under the supervision of Prof. Yu Chen. My mathematical interests are geometric groups theory and representation theory of groups. Currently my focus is on the linear algebraic groups, expecifically with congruence subgroups and representation of classical groups. During the master degree I worked on finite groups and the structure of NC-groups to find out all finite groups satisfying the condition

$$C_G(A) = N_G(A)$$

or

$$C_G(A) = A$$

for all abelian subgroups A of G.

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