GEOMETRIC GROUP THEORY

Będlewo, 18–24 April 2004

Organizers:

Werner Ballmann, Mladen Bestvina, Brian Bowditch, Tadeusz Januszkiewicz, Pierre Pansu, Zlil Sela, Jacek Świątkowski

with assistance from:

Jan Dymara, Tomasz Elsner, Światosław R. Gal, Damian Osajda

with financial support from:

Instytut Matematyczny Uniwersytetu Wrocławskiego
Rektor Uniwersytetu Wrocławskiego
Centrum Banacha Polskiej Akademii Nauk
Komitet Matematyki Polskiej Akademii Nauk

Goulnara Arjantseva

Uniform non-amenability and Kazhdan's constants

For any finitely generated group G an invariant $F\ddot{o}lG \geq 0$ is introduced which measures the "amount of non-amenability" of G. We study the basic properties of this invariant, the class of uniformly non-amenable groups (where $F\ddot{o}lG > 0$), the class of weakly amenable groups (with $F\ddot{o}lG = 0$). We exhibit a family of non-amenable groups (in particular including all non-solvable Baumslag-Solitar groups) which are not uniformly non-amenable. We derive a relation between our uniform Fölner constant and the uniform Kazhdan constant with respect to the left regular representation of G.

This is a joint work with J Burillo, M Lustig, L Reeves, H Short, E. Ventura.

Gregory Bell

A Hurewicz-type theorem for asymptotic dimension and applications to geometric group theory

The asymptotic dimension (asdim) of a metric space was defined by Gromov in his study of asymptotic invariants of infinite groups. It is the large-scale analog of Lebesgue covering dimension and can be defined as the minimal multiplicity of a cover of a metric space by uniformly bounded sets with a prescribed (large) Lebesgue number. Asymptotic dimension of finitely groups (in the word metric) became interesting following a theorem of Yu which states that the Novikov higher signature conjecture for Γ is true provided Γ has finite asymptotic dimension. This meant that a lot of work was done in showing finiteness of asdim, without concern for exact formulas and sharp upper bounds.

An important result of classical dimension theory is the Hurewicz theorem on mappings which lower dimension. This gives the following product-type estimate: Let X and Y be compact metric spaces and f a continuous function. Then $\dim X \leq \dim Y + \max\{\dim f^{-1}(y)\}$ In this paper, we translate the classical theorem of Hurewicz to an asymptotic formulation. In particular we prove the following theorem: Let $f : X \to Y$ be a Lipschitz map of the geodesic metric space X to the metric space Y. Suppose that for every $R > 0$, $asdim f^{-1}(B_R(y)) \leq n$ uniformly in Y. Then, $asdimX \leq asdimY + n$.

Our main application of this theorem is to the case where the metric space in question is a finitely generated group with the word metric. This allows us to give tight upper bound estimates for the asymptotic dimension of fundamental groups of complexes of groups, free products, and HNN extensions. We also prove a useful extension theorem for groups which we apply to polycyclic and nilpotent groups. In particular we show that the asdim of such a group does not exceed its Hirsch length.

This is joint work in progress with A. Dranishnikov.

Oleg Bogopolski

Mean Dehn functions of groups

The complexity of the word problem for group presentations can be measured with the help of Dehn functions. S.M. Gersten proved that this problem is decidable for a presentation of G iff the corresponding Dehn function is recursive. It is known that for hyperbolic groups this function is linear, for automatic groups it is at most quadratic, for f.g. nilpotent groups of degree d it is polynomial of degree at most $d + 1$. There are f.g. one-relator groups with exponential or even superexponential Dehn functions.

However, the Dehn functions have the following defect: for some groups they growth too quickly because of some specific words, whose portion is small. Therefore it seems reasonable to investigate the mean Dehn functions of groups, which reflect the complexity of the word problem in average.

According to M. Gromov, the mean Dehn function of a finite presentation $P = \langle X \,|\, R\rangle$ is the function $g : \mathbb{N} \to \mathbb{R}$ such that $g(n)$ is equal to the sum of areas of all reduced words of length at most n in the free group $F(X)$ which are equal to 1 in the group $G(P)$, divided by the number of these words. The following two theorems were proved by O. Bogopolski and E. Ventura in a joint paper (in progress).

Theorem 1. The mean Dehn function $g(n)$ of any f.g. abelian group G is dominated by the function $Cn(\log n)^2$, where C is a constant depending on the presentation of G.

Theorem 2. The mean Dehn function $g(n)$ of any f.g. nilpotent group G of degree 2 is dominated by the function $Cn^{9/4}(\log n)^{3/2}$, where C is a constant depending on the presentation of G.

These theorems were proved with the help of a Kolmogorov's lemma. In my talk I will give an observation of known results on Dehn functions, a sketch of the proofs of the above theorems, and I will settle some conjectures on the mean Dehn functions.

Martin R. Bridson

Profinite completions and representations of groups

In 1970 Alexander Grothendieck posed the following question: Let G_1 and G_2 be finitely presented, residually finite groups, and let $u : G_1 \to G_2$ be a homomorphism that induces an isomorphism of profinite completions (equivalently, for every commutative ring A, the restriction functor u^* is an equivalence between the category of finitely presented A modules with a G_2 action and those with a G_1 action); does it follow that u itself is an isomorphism?

In 2003 Fritz Grunewald and I showed that the answer to this question is "no". We also settled a second question of Grothendieck by exhibiting finitely presented, residually finite groups G that have infinite index in their Tannaka duality groups $\mathrm{cl_A(G)}$ for every commutative ring $A \neq 0$.

In this talk I'll explain the origins of Grothendieck's questions and outline our resolution of them.

Inna Bumagin

Automorphisms and splittings of limit groups

We consider the relationship between the automorphisms and splittings in two different aspects. First, we show that every automorphism of a limit group preserves a JSJ decomposition of the group (this part is an adoptation of joint work with D.Wise). The other aspect is a generalization of a theorem proved by Paulin for hyperbolic groups: we show that if G is a rigid vertex group in the JSJ decomposition of a limit group, then G has a finite outer automorphism group relative to the edge subgroups. It was proved by O.Kharlampovich and A.Myasnikov that a JSJ decomposition of a limit group can be constructed effectively. Combined together, all these results lead to a solution to the isomorphism problem for finitely generated fully residually free, or limit groups. This is joint work with O.Kharlampovich and A.Myasnikov.

Kai-Uwe Bux

Growth in Iterated Monodromy Groups

(Joint work with Rodrigo Perez)

Iterated Monodromy Groups stem from complex dynamics. They are groups of automorphisms of infinite regular rooted trees and are similar to Grigorchuk's group. Let T be the infinite binary rooted tree, in which every non-root vertex has precisely three neighbors: its parent, its left child, and its right child. The automorphism group W of T admits a wreath product decomposition

$$W = W \wr \mathbf{Z}_2 = (W \times W) \rtimes \mathbf{Z}_2$$

where $\mathbf{Z}_2$ is generated by the "swap" automorphism σ that interchanges the left and right subtree. This decomposition can be used to describe automorphism by equations or systems of equations. E.g., the equation

$$\xi = (\xi, 1)\sigma$$

has a unique solution: The σ on to the right tells us that ξ swaps the children of the root. With this knowledge, we can see how

$$\xi = (\xi, 1)\sigma$$

acts on the grandchildren of the root. Iterating the procedure specifies the automorphism ξ.

I will discuss the intermediate growth of the following three groups:

a) Grigorchuk's group $G = \langle \sigma, \alpha, \beta, \gamma \rangle$ where:

$$\alpha = (\beta, \sigma)$$
$$\beta = (\gamma, \sigma)$$
$$\gamma = (\alpha, 1)$$

b) The group $H = \langle \sigma, \alpha, \beta \rangle$ where:

$$\alpha = (\beta, \sigma)$$
$$\beta = (\alpha, 1)$$

c) The group $I = \langle \sigma, \alpha, \beta \rangle$ where:

$$\alpha = (\beta, \sigma)$$
$$\beta = (1, \alpha)$$

This group is the iterated monodromy group for $z^2 + i$. Intermediate growth of this group has been claimed by V. Nekrashevych.

I will present a more or less unified approach to the intermediate growth for all these groups: each group is just a little more involved than the previous one and requires a little refinement in the argument.

John Crisp

Automorphisms and abstract commensurators of 2-dimensional Artin groups

Let Δ denote a graph with no loops or double edges and edges labelled by integers ¿1. The Artin group $G(\Delta)$ is defined by a presentation with generators the set $V(\Delta)$ of vertices of Δ and relations $sts... = tst...$ involving words of length m_e whenever $e = \{s, t\}$ is an edge of Δ with label m_e. Each Artin group is associated to a Coxeter group $W(\Delta)$ obtained by adding the relations $s^2 = 1$ for each generator s. The best-known example of an Artin group is the braid group B_n on n strings (associated to the symmetric group S_n).

It is know since (Dyer-Grossman, 1981) that the automorphism group of B_n is a semi-direct product of the inner automorphism group with the involution induced by reversal of orientation in the complex plane. However there seem to be few results in the literature concerning automorphism groups of Artin groups more generally. The automorphism groups of dihedral type Artin groups have been computed (Gilbert, Howie, Metaftsis and Raptis, 2000), and a generating set is known for the right-angled Artin groups, where all labels are 2 (Servatius, 1989; Lawrence, 1995). These latter include the free groups for which of course there is an extensive literature.

In this talk we consider a class of two dimensional Artin groups which we denote CLTTF, defined by the following conditions: (C) Δ is a connected graph with at least 3 vertices; (Large Type) all edge labels are ¿2; and (Triangle Free) Δ contains no circuit of length 3. We give a description of the automorphism group of a CLTTF Artin group as an extension of a finite group (containing, for example, automorphisms induce by automorphisms of the defining graph Δ) by the group generated by inner automorphisms and certain Dehn twist automorphisms about separating edges and vertices of Δ. In particular, when Δ has no separating edges or vertices then we have $Aut(G(\Delta)) = Inn(G(\Delta)) \rtimes (C2 \times Aut(\Delta))$.

The main technical steps involved in obtaining the above results adapt naturally to the study of abstract commensurators. We find therefore (with a little more work) that if the defining graph Δ of a CLTTF Artin group (i) has no separating edge or vertices, and (ii) satisfies a further "vertex rigidity" condition, then the abstract commensurator group of $G(\Delta)$ is equal to the automorphism group just described.

Francois Dahmani

Accidental parabolics in relatively hyperbolic groups

By the construction of relative analogues of Rips and Sela's canonical representatives, we prove a finiteness theorem on the set of images of a finitely presented group in a relatively hyperbolic group. The case of the morphisms of a surface group in a group of geometrically finite 3-manifold is a theorem of Thurston.

Thomas Delzant

Fundamental groups of Kahler manifolds

(Joint work with Misha Gromov)

We study fundamental groups of Kahler manifolds via their cuts (relative ends). If a Kahler manifold admits an holomorphic map to a Riemann surface of positive genus, then its fundamental group G admits a cut, i.e a subgroup H s.t the pair (G, H) is not connected at infinity. We study the converse problem and give some examples.

Martin J. Dunwoody

Groups acting on R-trees

Let G be the group with presentation

$$G = \langle a, b, c, d, z | abcd = dcba, a^{-1}za = z^2, b^{-1}zb = z^2, c^{-1}zc = z^2, d^{-1}zd = z^2 \rangle.$$

Let N be the normal closure of z in G. So G is the splitting extension of N by H, the subgroup generated by $\{a, b, c, d\}$ which is an orientable surface group of genus 2.

Consider a tessellation of the hyperbolic plane by octagons. Let Γ be the graph determining this tessellation. Thus Γ is an 8-regular plane graph, whose dual graph Γ' is also 8-regular. There is an action of H on the hyperbolic plane by isometries which induces an action on Γ in which there is one orbit of vertices and 4 orbits of edges. Diametrically opposite edges of an octagonal face lie in the same edge orbit. Let A be one of the faces of Γ. Orient the edges of A as shown in Fig 1.

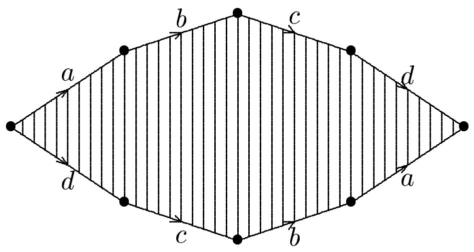

Fig 1

Extend this orientation to an orientation $\mathcal{O}$ of $E\Gamma$ in such a way that the orientation is preserved under the action of H. Define $\phi : V\Gamma \to \mathbf{Z}$ in the following way. For the left hand vertex of A put $\phi(v) = 0$. For any other vertex u, choose an oriented edge path $e_1, e_2, \ldots, e_n$ from v to u. let $\phi(u) = \epsilon_1 + \epsilon_2 + \ldots \epsilon_n$ where $\epsilon_i = 1$ if e_i is in $\mathcal{O}$ and $\epsilon_i = -1$ if $\bar{e}_i$ is in $\mathcal{O}$. The fact that ϕ is well defined follows from the fact that it is the unique function such that $\phi(v) = 0$ and such that $\delta\phi(e) = 1$ for each edge in $\mathcal{O}$.

Consider a vertex $u \in V\Gamma$. We can extend ϕ linearly to $E\Gamma$ and then to the hyperbolic plane, and we regard ϕ as defining a height function. The contours in A will be as in Fig 1(b) and in the neighbourhood of a vertex as in Fig 2. Note that at each vertex there is a "monkey saddle". If we start at the centre of A there is a path (proceeding upwards) to the boundary of the hyperbolic plane intersecting only translates of edge a and another path intersecting only translates of edge b. The value of ϕ on either of these paths is monotone decreasing. Similarly there is a path proceeding downwards which only intersects translates of edge c (or of d) and on these paths also ϕ is monotone decreasing.

It can be shown that the structure of N is determined by the geography of the hyperbolic plane with the above height function. In fact N has a generating set $\{z_v | v \in V\Gamma\}$. For each oriented edge e with $\iota e = p$ and $\tau e = q$ we have the relation $z_p^2 = z_q$. It is a consequence of these relations that $z_u = z_v$ if and only if we have both $\phi(z_u) = \phi(z_v)$ and also there is a path from u to v in Γ for which the height of the intermediate vertices of the path is never less than $\phi(z_u)$. However there are vertices u, v with $\phi(z_u) = \phi(z_v)$ for which there is no such path. For example in Fig 2 v and w have the same height, which is one more than that of the centre vertex, but there is no path from u to v which does not drop in height by at least one.

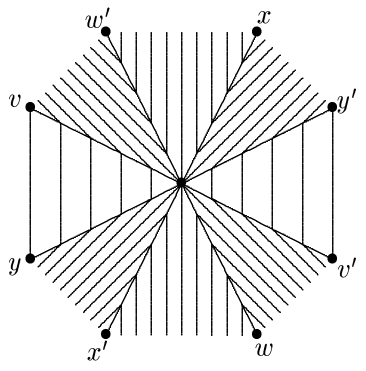

Fig 2

In fact N is a tree product of groups which is not small as it contains non-cyclic free subgroups.

The group G has incompatible splittings over small subgroups - specifically soluble Baumslag-Solitar groups. But it it is does not have a small normal subgroup whose quotient is a surface group. This suggests that the theory of JSJ-decompositions of finitely presented groups over slender groups does not extend easily to decompositions over small subgroups.

Another interesting property of G is that it is non-Hopf. Thus there is a homomorphism $\nu : G \to G$ in which $\nu(a) = a, \nu(b) = b, \nu(c) = c, \nu(d) = d, \nu(z) = z^2$. This homomorphism is surjetive, but not injective, since for example $z_v \neq z_w$ but $\nu(z_v) = \nu(w)$.

Also G admits actions on $\mathbf{R}$-trees in which point stabilizers are locally cyclic and arc stabilizers are cyclic. This action is not stable. If we take a sequence of arcs, totally ordered by inclusion, whose intersection is a point, then they will have cyclic stabilizers and their union is locally cyclic but not cyclic.

The action corresponds to a foliation of the hyperbolic plane for which the restriction of the height function ϕ to each leaf is unbounded and monotone.

For any finitely presented group G acting on an $\mathbf{R}$-tree T with cyclic arc stabilizers there is a decomposition of G as the fundamental group of a graph of groups in which edge groups are cyclic and each vertex group either fixes a point of T or acts by isometries on $\mathbf{R}$ or is the fundamental group of a complex of groups in which the underlying complex is a 2-orbifold and edge groups are cyclic. The example described above is such a vertex group.

Reference

M.J.Dunwoody. *A tessellation and a group acting on trees.*

http://www.maths.soton.ac.uk/pure/preprints.phtml.

Jan Dymara

Weighted cohomology of Coxeter groups

The L^2-Betti numbers of a building of type (W, S) and thickness q can be expressed using a smaller cochain complex, the weighted cochain complex of W. This complex makes sense for any real $q > 0$. The Hecke algebra with parameter q associated to the Coxeter group is then used to measure the dimensions of L^2-cohomology groups. We calculate these dimensions under the assumption that q or q^{-1} is in the region of convergence of the growth series of W.

This is a joint work with M.Davis, T.Januszkiewicz and B.Okun.

Murray Elder

Geodesic languages for the lamplighter group

In this talk I will show that the full language of geodesic in the lamplighter group with the standard wreath product generating set is context-free and not counter, and that this presetnation has no regular language of geodesics.

Mark Feighn

Counting maps from a surface to a graph (with Mladen Bestvina)

Fix a non-abelian free group F. Let G_g be the fundamental group of an orientable surface of genus g and let the element b_g of G_g represent the boundary. For an element x_g in F there is a natural equivalence relation on homomorphisms from G_g to F taking b_g to x_g.

We show that there are x_g such that the number of equivalence classes consisting of injective maps goes to infinity with g. This answers a question of Zlil Sela. We will touch on the relation with his work on the Tarski problem.

An eprint is available at: http://www.andromeda.rutgers.edu/ feighn/research.html

Koji Fujiwara

Fixed point set of a parabolic isometry of a CAT(0) space

This is a joint work with Nagano and Shioya. Let X be a proper CAT(0) space such that the space of direction of each point is compact. Let f be a parabolic isometry of X, and consider the set of fixed points of f, $X_f(\infty)$, in the Tits ideal boundary of X. We show that the radius of $X_f(\infty)$ is at most $\pi/2$, so that it is contractible. This was known for Hadamard manifolds. As an example, we may discuss the symmetric space for $SL(3, \mathbf{R})$.

Światosław R. Gal

Real-rootednes of h-polynomials

A simplicial complex L with the vertex set S is called *flag* if for any $T \subset S$ such that T is a *clique* (i.e., any two distinct vertices of T are joined by an edge), T is a face of L.

Let f_L be the generating function for the numbers of simplices of L of each dimension.

It was conjectured that f_L has only real roots when L is a flag triangulation of a sphere. This conjecture in particular would imply the Charney-Davis conjecture (special case of a Hopf conjecture on a sign of Euler Characteristic of a compact aspherical manifold).

We prove it when the dimension of L is less then five and construct a flag triangulation of S^5 that fail the conjecture.

We also find a property weaker than real-rootedness (but still stronger than the one conjectured by Charney and Davis) and give some evidence, that it may by satisfied by flag triangulation of spheres.

Ross Geoghegan

A new understanding of the Bieri-Neumann-Strebel invariant

I will describe the recent thesis of my student Nicholas Koban. His result, proving a conjecture of Robert Bieri, throws new light on the relationship between the Bieri-Neumann-Strebel (BNS) invariant, as well as its higher dimensional analogues due to Bieri-Renz (BR), and "controlled topology" as it arises in the study of high-dimensional manifolds.

The BNS and BR invariants of a suitable group G detect properties of normal subgroups containing the commutator subgroup by considering the maximal action of G by translations on a vector space. The so-called "Sigma invariants" are the (open) sets of points in the sphere at infinity (i.e. directions in that vector space) over which the group is topologically well-behaved. Behavior "over" a direction has been always interpreted in terms of half-spaces (= horoballs) rather than the more topologically natural "cone topology" neighborhoods of points in the sphere at infinity. Koban's theorem explains the exact relationship between the two approaches - half spaces versus cone topology neighborhoods. The result is quite elegant and may facilitate future computations.

It should be possible to get a similar theorem for general isometric actions over $CAT(0)$ spaces in the spirit of my recent work with Bieri, but this remains to be done.

Olivier Guichard

Quasi isometric embendings in Lie groups

Let Γ be a finite type group and G a real semi-simple group.

We first give a simple criterium for Γ to be quasi isometrically embended in G, namely a well-suited "tennis-table" lemma.

We apply this criterium to prove the following :

- suppose that Γ is quasi isometrically embended in G^*, a rank-one subgroup of G and call ι this morphism of Γ in G,

then there exist a neighborhood of ι in which any morphism is a quasi isometric embending.

We finish by giving an exemple of a quasi ismetrically embended F_2 in $SL_2(\mathbb{R})^2$ with no such neighborhood. (F_2 is the free group on two generators)

link (in french):

http://www.dma.ens.fr/ oguichar/

Vincent Guirardel

Intersections space for splittings and group actions on R-trees

The goal of this talk is to present the construction of some kind of *convex core* in the product of two actions of a group on trees. This geometric construction allows to generalize and unify the intersection number of two curves, or two measured foliations on a surface, Scott-Swarup's intersection number, and the apparition of surfaces in Fujiwara-Papasoglu's construction of the JSJ splitting. In particular, this construction allows a topological interpretation of the intersection number analog to the definition for curves in surfaces.

As a corollary, we can deduce that an iwip automorphism of the free group whose stable and unstable trees are geometric, is actually induced a pseudo-Anosov homeomorphism on a surface.

Ursula Hamenstaedt

Mapping class groups are biautomatic

Let S be a surface of genus g with m punctures. If $3g - 3 + 2m$ is at least two, then the mapping class group of all isotopy classes of orientation preserving homeomorphisms of S admits a biautomatic structure. The proof of this result uses a geometric model for the mapping class group which is a directed graph whose vertices consist of all complete train tracks on S.

James Harris

Polytopes and the homology of Coxeter groups

A free resolution for arbitrary Coxeter groups will be presented and it's use in calculating the group homology will be discussed. The construction involves certain convex polytopes, known as generalised permutahedra, which are associated to finite Coxeter groups. The method used to construct the above free resolution can be extended to the class of all finite groups.

Aleksander Iwanow

Non-nesting actions on pretrees

The research is motivated by the question when group actions on generalized trees can be obtained from isometric actions on real trees. We axiomatize the situation when a group acts on a tree T by automorphisms of the corresponding betweenness relation $B(x;y,z)$ (then the structure (T,B) is called a *pretree*). We obtain an axiomatizable class of structures $(G,T,*)$ which satisfy some typical properties of isometric actions on real trees. In particular the action is *non-nesting*: no g from G maps an arc properly into itself [L]. We show that the basic theory of isometric actions on $\mathbf{R}$-trees can be carried out in the obtained class of actions (called *classical* non-nesting actions).

The central problem of the research is if the class of classical non-nesting actions is the minimal axiomatizable class containing isometric actions on real trees (the positive answer can be interpreted as the statement that any classical non-nesting action is induced by an isometric action on a real tree). We obtain a partial confirmation when the group fixes an end of the pretree.
The main technical problem is as follows. Let $(G,T,*)$ be a *countable* structure of a non-nesting action on a pretree. Is there an $\mathbf{R}$-tree $\hat{T}$ extending T such that the action of G on T extends to an action of G on $\hat{T}$? We describe several cases when the answer is positive. In these cases we use *flows* [B].
The text is available at **http://www.math.uni.wroc.pl/~ivanov/nnsts2.ps**

References

[B] B.H.Bowditch, Treelike structuresarising from continua and convergence groups, Memoirs Amer. Math. Soc., 662. Providence, Rhode Island: AMS (1999).
[L] G.Levitt, Non-nesting actions on real trees, Bull. London Math. Soc. 30(1998), 46 – 54.

Craig Jensen

Automorphisms of free groups with boundary

The automorphisms of free groups with boundaries form a family of groups $A_{n,k}$ closely related to mapping class groups, with the standard automorphisms of free groups as $A_{n,0}$ and (essentially) the symmetric automorphisms of free groups as $A_{0,k}$. We give a presentation of the groups and calculate their first homology group. In addition, we construct a contractible space $L_{n,k}$ on which $A_{n,k}$ acts with finite stabilizers and finite quotient space and deduce a range for their virtual cohomological dimension.

Bruce Kleiner

Analysis on boundaries of hyperbolic groups, and rigidity

Let G be a hyperbolic group. If the boundary of G admits a metric satisfying a Poincare inequality, then it turns out that one can associate, in a canonical fashion, a "conformal" group (a certain group of homeomorphisms of Bdy(G) containing the original group), and a form of Mostow rigidity holds. When G is a uniform lattice in the isometry group of a rank 1 symmetric space X, this result reduces to the usual Mostow rigidity, i.e. the conformal group associated to G is precisely the isometry group of X. I will explain this, and discuss what is currently known about finding metrics satisfying a Poincare inequality.

Peter Kropholler

On rational cohomological dimension of elementary amenable groups

Elementary amenable groups of finite rational homological dimension are (locally finite) by (soluble of finite rank) by finite. The homological dimension of such a group is equal to its Hirsch rank or Hirsch length. There are several open problems concerning the precise cohomological dimension (over the rationals!). For example it is not known when the cohomological dimension is finite. If the group is countable the rational cd is finite and takes one of the two values hG or hG+1. Which of these values is correct for a given group turns out to be a hard question in many interesting cases. We contribute to the present state of knowledge by answering the question for residually finite groups in which the locally finite normal subgroup has a complement. The technique is based on a study of Kummer duals and computing cohomology with coefficients in carefully chosen infinite direct sums of modules.

Jon McCammond

Garside-like structures for Artin groups

In this talk I will report on recent progress in defining Garside-like structures for arbitrary Artin groups. Joint work with Noel Brady, John Crisp, and Anton Kaul.

Bernhard Mühlherr

Isomorphisms of Coxeter Groups

Coxeter groups are groups which admit a particularly nice presentation using a set of involutory generators. This presentation is given by a symmetric matrix whose entries are natural numbers or a symbol which represents infinity.

Since the 1980's the automorphism groups of Coxeter groups had been investigated. It turned out that in order to determine these groups it is more natural to solve the isomorphism problem for Coxeter groups.

In my talk I will give an overview about several contributions to the isomorphism problem. The main result of my talk is the solution of the isomorphism problem for 2-spherical Coxeter groups. This means that there are no infinities in the matrix. I describe the two main steps of its proof and indicate to which extent the results generalize to arbitrary matrices.

The first step is to characterize reflections in abstract Coxeter groups. This is joint work with W. Franzsen, F. Haglund and R. Howlett. The second step is to show reflection rigidity. This is joint work with P.-E. Caprace.

Igor Mineyev

The flows and joins of metric spaces

I would like to propose the notion of *symmetric join* of a topological or metric space X. Topologically it is the "obvious" union of closed intervals connecting pairs of points in X; the interval connecting a point to itself is required to degenerate. The *open symmetric join* of X is the union of open intervals. Any metric on X canonically determines a metric d_* on its symmetric join.

When X is a hyperbolic complex, for example a Cayley graph of a hyperbolic group or the universal cover of a closed manifold with hyperbolic fundamental group, consider the metric $\hat{d}$ on X defined in our joint work with G. Yu. Then the symmetric join of the compactification $\bar{X}$ and a metric d_* on it are canonically defined. The symmetric join admits isometric actions by $Isom(X)$ and $\mathbb{Z}_2$ and a bi-Lipschitz action by $\mathbb{R}$.

M. Gromov and others gave constructions of geodesic flows for hyperbolic groups. A part of our symmetric join is the open join of the boundary ∂X, denoted $\mathcal{F}(X)$. It should be called the geodesic flow of X. It has sharp properties, stronger than in the previously known constructions. For example $\mathbb{R}$ acts on it by bi-Lipschitz homeomorphisms, and isometrically on each $\mathbb{R}$-orbit; $\mathbb{R}$-orbits converge synchronously and uniformly exponentially.

A cross-ratio and horofunctions in $\bar{X}$ are constructed. Both are $Isom(X)$-invariant and continuous.

Graham A. Niblo

Hilbert space compression and exactness for groups acting on $CAT(0)$ cube complexes

In this talk we will discuss Gromov's notion of the Hilbert space compression of an unbounded metric space, which measures the large scale distortion required to embed the space into a Hilbert space. Following an idea of Guentner and Kaminker (who computed the Hilbert space compression of a tree) we will show how to compute the Hilbert space compression for any finite dimensional $CAT(0)$ cube complex using the normal cube paths in the complex . As an application we will examine the implications for the reduced C^*-algebra of a group which acts properly and co-compactly on such a complex. This is based on joint work with Sarah Campbell.

Anna Pratoussevitch

Traces in Complex Hyperbolic Triangle Groups

We present several formulas for the traces of elements in complex hyperbolic triangle groups generated by complex reflections.

The space of such groups of fixed signature is of real dimension one. We parameterize this space by a real invariant alpha of triangles in the complex hyperbolic plane. The main result of the paper is a formula, which expresses the trace of an element of the group as a Laurent polynomial in $\exp(i\alpha)$ with coefficients independent of alpha and computable using a certain combinatorial winding number. We also give a recursion formula for these Laurent polynomials and generalize the trace formulas for the groups generated by complex mu-reflections.

We apply these formulas to prove some discreteness and some non-discreteness results for complex hyperbolic triangle groups.

Bertrand Rémy

Compactifications of buildings

This is a joint work in progress with Y. Guivarc'h. We wish to define and study several compactifications of Euclidean buildings, in analogy with the case of symmetric spaces. In other words, passing to the isometry groups, we replace semisimple real Lie groups by semisimple groups over local fields.

One compactification is well-known since it is obtained by gluing the asymptotic boundary of the building. The other considered compactifications are obtained by embedding (the vertices of) the building, say X, into some compact metrizable space. For instance, when the compact space is the space of probability measures on a flag variety (equivalently, on a Furstenberg boundary) of the isometry group G, we obtain analogues of the Furstenberg compactifications. Moreover, Bruhat-Tits fixed point lemma provides a dictionary between maximal compact subgroups of G and vertices in X. This allows to take as compact target of the embedding map, the space of closed subgroups in G, endowed with the Chabauty topology. This raises the question of characterizing the groups appearing when taking the closure of the so-embedded vertices. Another group-theoretic consequence is a geometric parametrization of the maximal (Zariski connected) amenable subgroups of G as the point-stabilizers of the maximal Furstenberg compactification of X, thus providing an extension of the Bruhat-Tits dictionary.

Michah Sageev

A flat closing theorem for CAT(0) cubical complexes

We prove that if G acts freely and cocompactly on a CAT(0) cubical complex for which every facing triple of hyperplanes (the analog of tripod in a tree) has a cyclic or trivial stabilizer, then either G has a Z+Z subgroup or G is Gromov hyperbolic. (joint with Dani Wise.)

Mark Sapir

Tree-graded spaces and relatively hyperbolic groups

This is a joint work with Cornelia Drutu. We introduce a concept of tree-graded metric spaces and use it to show quasi-isometry invariance of certain classes of relatively hyperbolic groups, to obtain a characterization of relatively hyperbolic groups in terms of their asymptotic cones, to find geometric properties of Cayley graphs of relatively hyperbolic groups, and to construct the first example of a finitely generated group with continuum non-quasi-isometric asymptotic cones. Note that by a result of Kramer, Shelah, Tent, and Thomas, continuum is the maximal possible number of different asymptotic cones provided the Continuum Hypothesis is true.

Viktor Schroeder

Embedding of right angled Coxeter groups into a product of trees

We prove that a right angled Coxeter group with chromatic number n can be embedded in a bilipschitz way into the product of n locally finite trees. We give applications of this result to various embedding problems in particular we obtain bilipschitz embeddings of the real hyperbolic space into the product of locally compact trees. We use this result to determine the hyperbolic rank of products of exponentially branching trees. This is joint work with Alexander Dranishnikov.

Zbigniew Szaszkowski

On normal structure of the automorphism group of a sphericaly homogenous rooted tree

It is join work with Ye. Muntian and V. Sushchansky. Let $\kappa = (n_i)_{i\in\mathbb{N}}$ be a sequences of positive integer, $n_i \geq 2$, $i \in \mathbb{N}$. Denote by T_κ an homogenous rooted tree of the spherical index κ [1], and let $AutT_\kappa$ be the automorphism group of T_κ. The group AutT_κ is isomorphic to infinite iterated wreath product of symmetric groups $S_{n_1}, S_{n_2}, \ldots$:

$$AutT_\kappa = \mathop{\wr}_{i=1}^{\infty} S_{n_i}.$$

Closed in the profinite topology normal subgroups of AutT_κ is described in [1], [2]. In the talk we characterize the lattice of all normal subgroups in AutT_κ and lattices of normal subgroups in so called large subgroup of AutT_κ. A subgroup H of AutT_κ is called *large subgroup*, if for every k there exists $H' < H$ such that $H = H' \wr S_{n_k} \wr \ldots \wr S_{n_1}$. Let $G < \mathrm{AutT}_\kappa$ and $k \in \mathbb{N}$, then we denote by $\mathrm{Stab_i(G)}$ the set of all automorphisms f of G such that f acts trivially on first i levels of T_κ. The lattice L_G of normal subgroups in a large subgroup $G < AutT_\kappa$ is disjoin union of the subsemilattice $L_G^{(i)}$ of subgroups U such that $U < \mathrm{Stab_i(G)}$ and $U \not< \mathrm{Stab_{i+1}(G)}$. The semilattice $L_G^{(i)}$ is a lattice if and only if $n_i \neq 2$. For all $i \in \mathbb{N}$ the semilattice $L_G^{(i)}$ is isomorphic to a special subgroup (semi)lattice of an elementaire abelian 2-group of cardinality c. Some other properties of lattice L_G and (semi)lattice $L_G^{(i)}$ is characterized. Because many standard subgroups of $AutT_\kappa$ (the finitary automorphism subgroup, the algebraic automorphism subgroup and others [3]) are large subgroups we obtain the characterization of the normal structure for this standard subgroups of AutT_κ.

References

[1] H. Bass, M.V. Otero-Espinar, D.N. Rockmore, C.P.G. Tresser. *Cyclic Renormalisation and Automorphism Groups of Rooted trees.* Springer. Berlin etc. 1996, 163p.

[2] V.I. Sushchansky. *Normal structure of isometry groups of semifinite Baire metrics.* In: Infinite Groups and Similar Objects. Kyiv: Institute of Mathematics NAS Ukraine 1993, p.269-289. (in Russian)

[3] R.I. Grigorchuk, V.V. Nekrashevich, V.I. Sushchansky. *Automata, dynamical systems and groups.* Proceedings of the Steklov Institute of Mathematics Vol. 231, 2000, p.128-203.

Witali Suszczański

Automorphisms of Homogeneous Symmetric Groups and Hierarchomorphisms of Rooted Trees

A representation of homogeneous symmetric groups by hierarchomorphisms of spherically homogeneous rooted trees are considered. We show that every automorphism of a homogeneous symmetric group is locally inner and that the group of all automorphisms contains Cartesian products of arbitrary finite symmetric groups.

The structure of orbits on the boundary of the tree where investigated for the homogeneous symmetric group and for its automorphism group. The automorphism group acts highly transitive on the boundary, and the homogeneous symmetric group acts faithfully on every its orbit. All orbits are dense, the actions of the group on different orbits are isomorphic as permutation groups.

Alina Vdovina

Surface groups acting on buildings

We consider hyperbolic polyhedra whose faces are regular $2k$-gones and whose links are generalized m-gones with $km > m + k$. The universal coverings of such polyhedra are hyperbolic buildings. We say that a tesselated plane is periodic if there exists a genus $g > 1$ surface group on it uniformly.

Theorem 1. Let I be a right-angled hyperbolic building which apartments are hyperbolic planes tesselated by $2k$-gones with $k \geq 3$. Then I contains a periodic plane under the action of genus $g = 2k-4$ surface group.

Theorem 2. Let I be a hyperbolic building obtained from a hyperbolic p polyhedron with 4-gonal faces and a generalized m-gon as a link at each vertex, $m = 3, 4, 6, 8$. Then I contains a periodic plane under the action of genus $g = m - 1$ surface group.

Richard Weidmann

The rank of Fuchsian groups

In this talk we discuss minimal generating set of Fuchsian groups, i.e. of discrete subgroups of Isom $\mathbb{H}^2$. The case of Fuchsian groups not containing reflections has been settled by Zieschang, Rosenberger and Peczynski in the early 70s. For the general case the only substantial result is due to Klimenko and Sakuma who give a complete classification of Fuchsian groups that are 2-generated.

In this talk we discuss the general case. We start by analyzing a mistake in the original paper of Zieschang and show how it propagates and yields generating sets that are significantly smaller than the standard generating sets obtained by using Poincare's theorem. The main problem in the proof is to show that this is essentially the only pathology that occurs.

The proof uses decompositions of Fuchsian groups as fundamental groups of graphs of groups and folding sequences that approximate these splittings. It is modelled after the proof of Grushko's theorem and its generalizations.

Anna Wienhard

Group actions on Hermitian symmetric spaces

(Joint work with M.Burger and A.Iozzi)

An action of a group Γ on a Hermitian symmetric space of noncompact type X by isometries is given by a representation of Γ into the group G of isometries of X, i.e. a homomorphism $\rho : \Gamma \to G$. The G-invariant Kähler form on X defines (by integration) a continuous bounded 2-cocycle on G, hence a bounded cohomology class $k_b^X \in H_{cb}^2(G, \mathbb{R})$. The pull back of k_b^X via ρ is an invariant for the representation ρ with values in the second bounded cohomology group $H_b^2(\Gamma, \mathbb{R})$. This invariant contains information about geometric and dynamical properties of the action of Γ via ρ on X. In certain cases it determines ρ up to conjugation. We use the invariant to define the class of "tight homomorphisms", leading to interesting totally geodesic embeddings of Hermitian symmetric spaces. We discuss an application to actions of surface groups on X. If Γ is a surface group, the evaluation of $\rho^*(k_b^X)$ on the fundamental class defines a bounded real valued invariant, known as Toledo invariant. In rank one, representations with maximal Toledo invariant correspond to points in Teichmüller space. We show that, even for higher rank, actions given by representations with maximal Toledo invariant are properly discontinuous without fixed points. They have interesting dynamical properties and a rectifiable curve as limit set.

Daniel Wise

Coherent Groups

A group G is "coherent" if each finitely generated subgroup of G is finitely presented. Finite groups are obviously coherent, but there are more interesting examples such as the fundamental group of any 3-manifold. In this talk we will describe the known classes of coherent groups, and survey the geometric methods for proving that groups are coherent.

Kevin Wortman

Quasi-isometric rigidity of non-cocompact S-arithmetic lattices

In joint work with Taback and Whyte, we complete the quasi-isometric classification of irreducible non-cocompact S-arithmetic lattices. Combined with results of Eskin, Farb, Schwartz, Taback, and myself, we have that a quasi-isometry of any such lattice Γ is a bounded distance from a commensurator, as long as Γ is not abstractly commensurable to $SL_2(\mathbb{Z})$. As a consequence, any finitely generated group which is quasi-isometric to Γ is actually isomorphic to Γ "up to finite groups".

Examples of Γ as above include $SL_n(\mathbb{Z}[1/m])$ where $m \in \mathbb{N}$.

Adam Woryna

On groups generated by time-varying Mealy automata

There are three methods in describing groups acting on level homogeneous rooted trees: geometrical by using the language of graphs and operations on them, topological which regards the groups as metric spaces and the combinatorial approach in case of regular tree uses the language of Mealy automata. The idea of an automaton with a changing alphabet and a changing set of its inside states is a generalization which allows to represent groups acting on level homogeneous rooted trees which may be not homogeneous.

Let A be a given time-varying automaton. Any state q from the set Q_0 of its inside states defines a transformation f_q on the set of words over the changing alphabet. The group $\langle f_q \colon q \in Q_0 \rangle$ is called the group generated by automaton A or the automaton transformation group defined by A. If the sets of letters in the changing alphabet are finite any such group is residually finite.

Theorem *For every k-generated residually finite group G there exist a time varying automaton A with a k-element set of inside states such that $G \simeq G(A)$.*

Hence the class of groups generated by time-varying Mealy automata includes strongly the class of groups generated by ordinary Mealy automata (see [1]). We present different examples of residually finite groups generated by time-varying Mealy automata.

References

[1] R.I.Grigorchuk, V. V. Nekrashevich, V. I. Sushchansky, *Automata, Dynamical Systems and Groups*,

Proseedings of Steklow Institute of Mathematics, 231: 128-203, 2000. [2] B. Mikolajczak, *Algebraic and structural automata theory.* Translated from the Polish Annals of Discrete Mathematics, 44, North-Holland Publishing Co., Amsterdam, 1991, 402 pp.

[3] A. Woryna, *On permutation groups generated by time-varying Mealy automata*, to appear in Publ. Math. Debrecen

POSTERS

Waldemar Hołubowski

Subgroups of infinite unitriangular matrices

In our talk we give a survey of recent results on subgroups of the group of infinite upper unitriangular $\mathbb{N}\times\mathbb{N}$ matrices $G = UT(\infty, R)$ over any associative ring R. The set N_m of all matrices a from G such that first m columns of a are the same as those in the unit matrix e is a normal subgroup of G. Clearly, the group $G/N_m \simeq UT(m, R)$ is nilpotent and G is a pro-nilpotent group as an inverse limit of finite dimensional unitriangular groups G/N_m.

The lattice of subgroups of G is not well understood, in the contrast to the stable unitriangular group $UT_\omega(R)$ (direct limit of groups $UT(m, R)$ under natural diagonal embeddings). In the case of finite field K (of order p^s), the group $UT_\omega(K)$ is countable while $UT(\infty, K)$ is uncountable, because it contains, for example, infinite cartesian product $UT(2, K)\times UT(2, K)\times \ldots$. Moreover, $UT_\omega(K)$ is locally finite and does not contain a nonabelian free subgroup while explicit examples of free subgroups in $UT(\infty, K)$ were given in [OS] for $char(K) = 2$ and [Hol2] for $Char(K) = 0$ and $p > 2$. In [Hol3] it was proved that, in a suitable sense, almost all $k-$generator subgroups of $UT(\infty, K)$ are free groups of rank k (here k can be finite or countable).

This shows the importance of the problem of finding explicit generators of the non-free subgroups in $UT(\infty, K)$. We note here that the famous Nottingham group $\mathcal{N}$ [Cam] and first Grigorchuk's group are contained in $UT(\infty, K)$ (recently A. G. Leonov announced that he found explicit generators of the first Grigorchuk's group as subgroup of $UT(\infty, K)$). It is known that every countably-based pro-p-group can be embedded in $\mathcal{N}$, and so in $UT(\infty, K)$. In particular, every finitely generated residually finite p-group can be embedded in $UT(\infty, K)$. Moreover, $UT(\infty, K)$ can be viewed as a subgroup of automata permutations group.

In talk we survey results on free subgroups of $UT(\infty, K)$, we describe a family of normal subgroups of $UT(\infty, R)$ corresponding to the nets of ideals and give the sets of generators for some natural subgroups.

References

[Cam] R. Camina, *Some natural subgroups of the Nottingham group*, J. Algebra 196 (1997) 101-113.

[Hol3] W. Holubowski, *ost finitely generated subgroups of infinite unitriangular matrices are free.* Bull. Austral. Mat. Soc. 66 (2002), 419-423.

[Hol2] W. Holubowski, *Free subgroups of the group of infinite unitriangular matrices.* Internat. J. of Algebra and Computation , 13, No 2, 81-86.

[OS] A. Olijnyk and V. S. Sushchansky, *Free group of infinite unitriangular matrices*, Math. Notes 67 (2000), No. 3-4, 320-324.

Andreas Zastrow

On group-theoretical results obtained by the method of word sequences

Word sequences are infinite combinatorial objects that have been constructed in order to mimick the structure of the fundamental group of the Hawaiian Earrings. The have been used in proving that certain subgroups of the fundamental group of the Hawaiian Earrings are or are not free and thus helped to understand why the fundamental group of such a graph-like space could be not free [1,2]. The talk might also indicate how this concept was generalized in order to combinatorially understand the possible bahaviour of paths in wild subsets of the plane [3,Thm.16 of 4], and to make the concept of covering spaces (as concept that associates a faithful represention to some group) available also to spaces that do not fulfill the classical criterion for the existence of covering spaces [5].

References

[1] "The non-abelian Specker-group is free" J. Algebra 229 (2000), no. 1, 55–85, electronically available (article) via ScienceDirect at "http://www.sciencedirect.com/science/math/home" or as preprint at "http://at.yorku.ca/i/d/e/b/14.htm".

[2] "Free and non-free subgroups of the fundamental group of the Hawaiian earrings" Cent. Eur. J. Math. 1 (2003), electronically available (article) via "http://www.cesj.com/mathematics.html"

[3] "Planar sets are aspherical", Habilitationsscrift, Ruhr-Uni-Bochum (Bochum, Germany), 1997/98, electronically available at "http://at.yorku.ca/i/d/e/b/15.htm"

[4] "The fundamental groups of subsets of closed surfaces inject into their first shape groups" (joint with Hanspeter Fischer), submitted for publication, available at "http://www.cs.bsu.edu/homepages/fischer/article9.ps"

[5] "On the existence of universal covering fibrations" (joint with Hanspeter Fischer), in progress.

PARTICIPANTS

Sebastian Agata, Gdańsk
Javier Aramayona, Southampton
Goulnara Arjantseva, Geneva
Marek Badura, Łódź
Werner Ballmann, Bonn
Gregory C. Bell, Penn State
Mladen Bestvina, U of Utah
Oleg Bogopolski, Novosibirsk
Agnieszka Bojanowska, Warszawa
Marc Bourdon, Lille
Brian Bowditch, Southampton
Martin Bridson, London
Nikolay Brodskiy, Knoxville
Inna Bumagin, McGill
Kai Uwe Bux, Cornell
John Crisp, Dijon
Maciej Czarnecki, Łódź
Francois Dahmani, ETH Zurich
Thomas Delzant, Strasbourg
Martin Dunwoody, Southampton
Jan Dymara, Wrocław
Murray Elder, St Andrews
Tomasz Elsner, Wrocław
Mark Feighn, Rutgers Newark
Koji Fujiwara, Tohoku
Światosław R. Gal, Wrocław
Ross Geoghegan, Binghamton
Renata Gruszka, Warszawa
Olivier Guichard, ENS Paris
Ursula Hamenstaedt, Bonn
James Harris, Galway
Mohamad Hindawi, UPenn
Waldemar Hołubowski, Gliwice
Aleksander Iwanow, Wrocław
Tadeusz Januszkiewicz, Wrocław
Craig Jensen, New Orleans
Jarek Kędra, Szczecin
Bruce Kleiner, Ann Arbor
Danuta Koodziejczyk, Warszawa
Peter Kropholler, Glasgow
Gabrielle Link, Palaiseau
Gilbert Levitt, Caen
Jon McCammond, Santa Barbara
John Meier, Lafayette
Mike Mihalik, Vanderbilt
Igor Mineyev, Urbana-Champaign
Bernhard Mühlherr, Bruxelles
Andrzej Nagórko, Warszawa
Graham Niblo, Southampton
Boris Okuń, Milwaukee
Damian Osajda, Wrocław
Leszek Pacholski, Wrocław
Pierre Pansu, Orsay
Panos Papasoglu, Athens
Leonid Potyagailo, Lille
Anna Pratoussevitch, Bonn
Anton Prowse, Southampton
Bartosz Putrycz, Gdańsk
Bertrand Rémy, Grenoble
Michah Sageev, Haifa
Mark Sapir, Vanderbilt
Marcin Sawicki, Warszawa
Viktor Schroeder, Zuerich
Zlil Sela, Jerusalem
Ken Shackleton, Southampton
Stanisław Spież, Warszawa
Michał Stukow, Gdańsk
Witalis Suszczański, Gliwice
Eric Swenson, BYU
Jacek Świątkowski, Wrocław
Zbigniew Szaszkowski, Gliwice
Andrzej Szczepański, Gdańsk
Błażej Szepietowski, Gdańsk
Henryk Toruńczyk, Warszawa
Michael Tweedale, London
Alina Vdovina, Bonn
Roger Vogeler, Helsinki and OSU
Olga Weber, Warszawa
Richard Weidmann, Bochum
Anna Wienhard, Bonn
Henry Wilton, London
Dani Wise, McGill
Paweł Witkowski, Warszawa
Kevin Wortman, Cornell
Adam Woryna, Gliwice
Asli Yaman, Bonn
Roland Zarzycki, Wrocław
Andreas Zastrow, Gdańsk
Paweł Zawiślak, Wrocław

LECTURES SCHEDULE

Monday

9^{00} – 10^{00}	Ursula Hamenstaedt
10^{30} – 11^{30}	Igor Mineyev
11^{45} – 12^{30}	Jan Dymara
16^{00} – 16^{45}	Viktor Schroeder vs. Kevin Wortman
17^{15} – 17^{50}	Bernhard Mühlherr vs. Anna Pratoussevitch

Tuesday

9^{00} – 10^{00}	Bruce Kleiner
10^{30} – 11^{30}	Thomas Delzant
11^{45} – 12^{30}	Anna Wienhard vs. Jon McCammond
16^{00} – 16^{35}	Olivier Guichard vs. Alina Vdovina
17^{00} – 17^{35}	Ross Geoghegan vs. Richard Weidmann

Wednesday

8^{30} – 9^{05}	Goulnara Arjantseva vs. Murray Elder
9^{15} – 9^{50}	Kai-Uwe Bux vs. Peter Kropholler
10^{20} – 10^{55}	Francois Dahmani vs. Oleg Bogopolski
11^{05} – 11^{40}	John Crisp vs. Inna Bumagin
11^{50} – 12^{25}	James Harris vs. Craig Jensen

Thursday

9^{00} – 10^{00}	Mark Sapir
10^{30} – 11^{15}	Graham Niblo vs. Aleksander Iwanow
11^{30} – 12^{15}	Gregory Bell vs. Martin Dunwoody
15^{00} – 16^{00}	Bruce Kleiner – special lecture on Poincaré conjecture
16^{30} – 17^{05}	Świątosław R. Gal vs. Adam Woryna

Friday

9^{00} – 10^{00}	Daniel Wise
10^{30} – 11^{30}	Martin Bridson
11^{45} – 12^{30}	Bertrand Rémy vs. Koji Fujiwara
16^{00} – 16^{45}	Mark Feighn vs. Witali Suszczański
17^{15} – 17^{50}	Michah Sageev vs. Zbigniew Szaszkowski