

Preface

This book contains the joint proceedings of the workshop on **Boundaries** that took place in Graz, from June 29–July 3, and the **Alp-Workshop** that was held immediately afterwards in Sankt Kathrein am Offenegg, on the weekend July 4–5, 2009.

The two events were dedicated to related subjects.

The aim of the **Boundaries** workshop was to bring together mathematicians working on groups, graphs, manifolds, etc., in the context of probability (random walks, Brownian motion), harmonic analysis, potential theory, ergodic theory, geometric group theory and related topics. The title indicates a central topic but was not to be considered the exclusive theme.

The scientific committee of the meeting consisted of Tatiana Nagnibeda-Smirnova (Geneva), Christophe Pittet (Marseille), Hamish Short (Marseille), and Wolfgang Woess (Graz).

The local organisation rested on the shoulders of Ecaterina Sava and Wolfgang Woess at Graz University of Technology in the capital of Styria, southeastern province of Austria.

Three special guests were particularly featured in view of their “milestone birthdays” taking place in 2009:

- Donald I. Cartwright (Sydney; 60th birthday)
- Vadim A. Kaimanovich (Bremen; 50th birthday)
- Massimo Picardello (Rome; 60th birthday)

Each of these three has given substantial contributions to the mathematical subject of the workshop, and to each of them, a half-day session was dedicated, featuring in particular their own (respective) invited talks. In the present volume, we display their lists of publications (state of September, 2010).

The **Alp-Workshop 2009** was devoted to “Spectral and probabilistic properties of random walks on random graphs”. The aim was a discussion between experts from spectral theory, ergodic theory and probability theory about the special topics of random walk theory in which the methods from group theory and harmonic analysis fail: Discrete structures with much irregularity, such as Percolation, Random Graphs, or Branching Processes were the main focus. Instead of a detailed discussion of each talk we refer to the attached programme. During the

first afternoon-session, there were six twenty-minutes talks by young researchers of whom several have contributed to the proceedings.

The Alp-Workshop was organised by Florian Sobieczky with the budget of project P18703 (“Random Subgraphs of Transitive Graphs”) of the Austrian Science Foundation (FWF). Furthermore, the main part of the publication cost of these proceedings was carried by the budget of this research project.

The “Almenland” in the mountains east of Graz provided a picturesque environment for the interdisciplinary discussion about random walks. Its remoteness allowed inviting more people with the given budget while keeping a high standard of the venue.

The editing of the proceedings contributed by the Alp-Workshop’s participants was undertaken by Daniel Lenz and Florian Sobieczky. The contributions from the Boundaries-Workshop were edited by Wolfgang Woess. All articles underwent anonymous refereeing by experts from the respective field.

We would like to thank everyone who was directly or indirectly involved in helping to organise these meetings.

This volume is dedicated to



Donald I. Cartwright



Massimo A. Picardello



Vadim A. Kaimanovich

October 2010,

Daniel Lenz
Florian Sobieczky
Wolfgang Woess

Programme of the Workshop on “Boundaries”

June 29th (Mon.)

- 09:00–09:10 Opening
- 09:10–10:10 **Francois Ledrappier**, University of Notre Dame
Linear drift for the Brownian motion on covers
- 10:10–10:40 Coffee & Registration
- 10:40–11:10 **Martin Dunwoody**, University of Southampton
An inaccessible graph
- 11:20–11:50 **Panos Papazoglou**, University of Athens
Topology of boundaries and splittings
- 12:00–12:20 **Barbara Bobikau**, University of Wroclaw
Spectral properties of a class of random walks on locally finite groups
- 12:20–14:30 Lunch
- 14:30–15:20 **Massimo Picardello**, Tor Vergata University in Rome
Harmonic functions on homogeneous trees and buildings
- 15:30–16:00 **Sara Brofferio**, University of Paris-Sud 11
Poisson boundary of matrix groups with rational coefficients
- 16:10–16:40 Coffee
- 16:40–17:30 **Yves Guivarc’h**, University of Rennes
Random walk in a random medium on Z , and random walks on homogeneous spaces
- 17:40–18:00 **Daniele D’Angeli**, University of Geneva
The boundary action of the Basilica group

June 30th (Tue.)

- 09:30–09:50 **Tim Riley**, Cornell University
How wild can a group with a quadratic Dehn function be?
- 10:00–10:30 Coffee
- 10:40–11:11 **Anton Thalmaier**, University of Luxembourg
The Poisson boundary of certain Cartan-Hadamard manifolds of unbounded curvature
- 11:20–11:50 **Alexander Gnedin**, Utrecht University
Boundaries of the generalised Pascal triangles and larger graded graphs
- 12:00–12:20 **Jeremy Macdonald**, McGill University
Compressed words and automorphisms in fully residually free groups
- 12:20–14:30 Lunch
- 14:30–15:20 **Tim Steger**, University of Sassari
Background on fake planes
- 15:30–16:00 **Jean Lécureux**, Claude Bernard University Lyon 1
Combinatorial boundaries of buildings

- 16:10–16:40 Coffee
 16:40–17:30 **Donald Cartwright**, University of Sidney
The 50 fake projective planes
 17:40–18:00 **Bernhard Krön**, University of Vienna
Vertex cuts, ends and group splittings

July 1st (Wed.)

- 09:00–09:50 **Anna Erschler**, University of Paris-Sud 11
Boundaries of amenable groups
 10:00–10:50 **Poster Session & Coffee**
 Poster: Elisabetta Candellero, Lorenz Gilch, Motoko Kotani,
 Jeremy Macdonald, Sebastian Müller, Svetla Vassileva
 10:50–11:20 **Matthias Keller**, Universität Jena
Heat transfer to the boundary on discrete graphs
 11:30–12:00 **Erin Pearse**, University of Iowa & University of Oklahoma
Resistance analysis of infinite networks
 Afternoon Excursion

July 2nd (Thu.)

- 09:00–09:50 **James Parkinson**, University of Sydney
Random walks on p -adic groups and affine buildings
 10:00–10:30 Coffee
 10:40–11:10 **Agelos Georgakopoulos**, Graz University of Technology
Uniqueness of currents in an electrical network of finite total resistance
 11:20–11:50 **Jörg Schmeling**, Lund University
Large dimension of limit sets of Kleinian groups and transience of critical random walks
 12:00–12:20 **Riddhi Shah**, Jawaharlal Nehru University
Distal actions on locally compact groups
 12:20–14:30 Lunch
 14:30–15:20 **Vadim Kaimanovich**, University of Ottawa
Random graphs, stochastic homogenization and equivalence relations
 15:30–16:00 **Alexander Bendikov**, University of Wrocław
On a class of random walks on groups with infinite number of generators
 16:00–16:40 Coffee
 16:40–17:30 **Volodymyr Nekrashevych**, Texas A& M University
Hyperbolic duality
 17:40–18:00 **Frédéric Mathéus**, LMAM University of South-Brittany
Poisson boundary of free-by-cyclic groups

July 3rd, (Fri.)

- 09:00–09:50 **Klaus Schmidt**, University of Vienna
Sandpiles and the harmonic model
- 10:00–10:40 Coffee
- 10:40–11:10 **Tatiana Smirnova-Nagnibeda**, University of Geneva
Sandpiles and self-similar groups
- 11:20–11:50 **Markus Neuhauser**, RWTH Aachen
Further examples to a question of Atiyah
- 11:50–13:30 Lunch
- 13:30–14:00 **Michael Björklund**, Hebrew University
Sharp sumset inequalities for Bohr sets
- 14:10–15:00 **Anatoly Vershik**, St.Petersburg State University
Adjoint dynamics to a question of Atiyah

Programme of the Alp-Workshop 2009

July 4th (Sat.)

- 09:15–09:30 Welcome
- 09:30–10:15 **Christoph Pittet**, University of Aix-Marseille 1
Return probabilities and spectral distribution of Laplace operators
- 10:20–11:05 **Peter Müller**, Ludwigs Maximilians University Munich
Ergodic properties of randomly coloured aperiodic point sets
- 11:05–11:20 Coffee
- 11:20–12:05 **Tatyana Turova**, Lund University
Asymptotic size of the largest cluster in inhomogeneous random graphs: sub-critical and critical phases
- 12:10–12:55 **Vadim Kaimanovich**, Jacobs University Bremen
Stochastic homogenization of graphs: case studies
- 12:55–14:00 Lunch
- 14:00–16:30 **Short Talks-Session & Coffee**
Wolfgang Spitzer, Bernt Metzger, Radoslaw Wojciechowski,
Matthias Keller, Sebastian Müller, Erin Pearce
- Evening **Hike and Dinner** at Mountain Cabin

July 5th (Sun.)

- 10:00–10:45 **Daniel Lenz**, Universität Jena
Amenability of Horocyclic Products of uniformly growing trees
- 10:45–11:00 Coffee
- 11:00–11:45 **Tatiana Smirnova-Nagnibeda**, Geneva University
Amenability and percolation

- 11:50–12:35 **Jörg Schmeling**, Lund University
*Random trees generated by a dynamical system
 and the structure of typical orbits*
- 12:35–14:00 Lunch
- 14:00–14:45 **Franz Lehner**, Graz University of Technology
*On the Eigenspaces of Lamplighter Random Walks and
 Percolation Clusters on Graphs*
- 14:50–15:55 **Poster-Session** & Coffee
 Erin Pearse, Lorenz Gilch, Ecaterina Sava,
 Wilfried Huss, Seon Hee Lim, Michael Matter,
 Uta Freiberg, Elisabetta Candellero
- 16:00–16:45 **Peter Mörters**, University of Bath
*Simultaneous multifractal analysis of branching and
 visibility measure on a Galton-Watson tree*
- 17:00–17:45 **Ivan Veselić**, TU Chemnitz
Percolation clusters on Caley graphs and their spectra
- 18:00–18:45 **Tyll Krüger, Rainer Siegmund-Schultze**, TU Berlin
Epidemic processes on networks and generalisations



A Steyr 480a “Postbus” waiting for its passengers to board before taking them to St. Kathrein am Offenegg, the venue of the Alp-Workshop 2009.

Donald I. Cartwright

Research Publications

- [1] The order completeness of some spaces of vector-valued functions. *Bull. Austral. Math. Soc.* **11** (1974), 57–61. MR50#14207.
- [2] Extensions of positive operators between Banach lattices. *Mem. Amer. Math. Soc.* **3** (1975), no. 164, iv + 48 pp. MR52#3913.
- [3] (with Lotz, Heinrich P.) Some characterizations of AM - and AL -spaces. *Math. Z.* **142** (1975), 97–103. MR52#3912.
- [4] (with Lotz, Heinrich P.) Disjunkte Folgen in Banachverbänden und Kegel-absolut-summierende Operatoren. *Arch. Math. (Basel)* **28** (1977), 525–532. MR58#2442.
- [5] (with McMullen, John R.) A note on the fractional calculus. *Proc. Edinburgh Math. Soc.* (2) **21** (1978/79), 79–80. MR57#16488.
- [6] (with Field, M.J.) A refinement of the arithmetic mean–geometric mean inequality. *Proc. Amer. Math. Soc.* **71** (1978), 36–38. MR57#16516.
- [7] (with Howlett, Robert B.; McMullen, John R.) Extreme values for the Sidon constant. *Proc. Amer. Math. Soc.* **81** (1981), 531–537. MR#82c:43005.
- [8] (with McMullen, John R.) A structural criterion for the existence of infinite Sidon sets. *Pacific J. Math.* **96** (1981), 301–317. MR#83c:43009.
- [9] (with McMullen, John R.) A generalized universal complexification for compact groups. *J. Reine Angew. Math.* **331** (1982), 1–15. MR#84d:22009.
- [10] L_p -norms of characters on the exceptional compact Lie groups. *Boll. Un. Mat. Ital. B* (6) **2** (1983), 339–351. MR#84i:22014.
- [11] (with Soardi, Paolo M.) Best conditions for the norm convergence of Fourier series. *J. Approx. Theory* **38** (1983), 344–353. MR#85a:42017.
- [12] Lebesgue constants for Jacobi series. *Proc. Amer. Math. Soc.* **87** (1983), 427–433. MR#84b:42019.
- [13] (with Brown, Timothy C.; Eagleson, G.K.) Characterizations of invariant distributions. *Math. Proc. Cambridge Philos. Soc.* **97** (1985), 349–355. MR#86i:60023.
- [14] (with Barbour, A.D.; Donnelly, J.B.; Eagleson, G.K.) A new rank test for the k -sample problem. *Comm. Statist. A – Theory Methods* **14** (1985), 1471–1484.
- [15] (with Brown, Timothy C.; Eagleson, G.K.) Correlations and characterizations of the uniform distribution. *Austral. J. Statist.* **28** (1986), 89–96. MR#87i:62032.
- [16] (with Soardi, Paolo M.) Harmonic analysis on the free product of two cyclic groups. *J. Funct. Anal.* **65** (1986), 147–171. MR#87m:22015.
- [17] (with Soardi, Paolo M.) Random walks on free products, quotients and amalgams. *Nagoya Math. J.* **102** (1986), 163–180. MR#88i:60120a.
- [18] (with Soardi, Paolo M.) A local limit theorem for random walks on the cartesian product of discrete groups. *Boll. Un. Mat. Ital.* (7) **1-A** (1987), 107–115. MR#89a:60159.
- [19] Some examples of random walks on free products of discrete groups. *Annali di Matematica pura ed applicata* **106** (1988), 1–15. MR#90f:60018.
- [20] (with Kucharski, Krzysztof) Jackson’s theorem for compact connected Lie groups. *J. Approx. Theory* **55** (1988), 352–359. MR#89j:43008.

- [21] Random walks on direct sums of discrete groups. *J. Theoretical Probability* **1** (1988), 341–356. MR#89j:60013.
- [22] (with P.M. Soardi) Convergence to ends for random walks on the automorphism group of a tree. *Proc. Amer. Math. Soc.* **107** (1989), 817–823. MR#90f:60137.
- [23] On the asymptotic behaviour of convolution powers of probabilities on discrete groups. *Monatshefte für Mathematik* **107** (1989), 287–290. MR#91a:60024.
- [24] (with S. Sawyer) The Martin boundary for general isotropic random walks on a tree. *J. Theoretical Probability* **4** (1991), 111–136.
- [25] (with Wolfgang Woess) Infinite graphs with nonconstant Dirichlet finite harmonic functions. *SIAM J. Discrete Math.* **5** (1992), 380–385.
- [26] Singularities of the Green function of a random walk on a discrete group. *Monatshefte für Mathematik* **113** (1992), 183–188.
- [27] (with P.M. Soardi, Wolfgang Woess) Martin and end compactifications of non locally finite graphs. *Trans. Amer. Math. Soc.* **338** (1993), 679–693.
- [28] (with Anna Maria Mantero, Tim Steger and Anna Zappa) Groups acting simply transitively on the vertices of a building of type \tilde{A}_2 I, *Geom. Ded.* **47** (1993), 143–166.
- [29] (with Anna Maria Mantero, Tim Steger and Anna Zappa) Groups acting simply transitively on the vertices of a building of type \tilde{A}_2 II: the cases $q = 2$ and $q = 3$, *Geom. Ded.* **47** (1993), 167–226.
- [30] (with Wojciech Młotkowski and Tim Steger) Property (T) and \tilde{A}_2 -groups. *Annales de l'Institut Fourier* **44** (1994), 213–248.
- [31] (with Wojciech Młotkowski) Harmonic analysis for groups acting on triangle buildings. *J. Aust. Math. Soc.* **56** (1994), 345–383.
- [32] (with Vadim A. Kaimanovich and Wolfgang Woess) Random walks on the affine group of local fields and homogeneous trees. *Annales de l'Institut Fourier* **44** (1994), 1243–1288.
- [33] Groups acting simply transitively on the vertices of a building of type \tilde{A}_n . Proceedings of the 1993 Como conference “Groups of Lie type and their geometries”, pp. 43–76, W.M. Kantor, L. Di Martino, editors, London Mathematical Society Lecture Note Series 207, Cambridge University Press, 1995.
- [34] (with Michael Shapiro) Hyperbolic buildings, affine buildings and automatic groups. *Mich. Math. J.*, **42** (1995), 511–523.
- [35] A brief introduction to buildings, *Contemp. Math.* **206** (1997), 45–77.
- [36] (with Tim Steger) A family of \tilde{A}_n -groups. *Israel J. Math.*, **103** (1998), 125–140.
- [37] (with Tim Steger) Application of the Bruhat-Tits tree of $SU_3(h)$ to some \tilde{A}_2 groups. *J. Aust. Math. Soc.*, **64** (1998), 329–344.
- [38] Harmonic functions on buildings of type \tilde{A}_n . Proceedings of the 1997 Cortona conference “Random Walks and Discrete Potential Theory”, pp. 104–138, Massimo Picardello and Wolfgang Woess, editors, Symposia Mathematica, vol XXXIX, Cambridge University Press, 1999.
- [39] (with Gabriella Kuhn and Paolo M. Soardi) A product formula for spherical representations of a group of automorphisms of a homogeneous tree, I. *Trans. Amer. Math. Soc.*, **353** (2001), 349–364.

- [40] (with Gabriella Kuhn) A product formula for spherical representations of a group of automorphisms of a homogeneous tree, II. *Trans. Amer. Math. Soc.* **353** (2001), 2073–2090.
- [41] Spherical harmonic analysis on buildings of type \tilde{A}_n . *Monatshefte für Mathematik* **133** (2001), 93–109.
- [42] (with Tim Steger) Elementary symmetric polynomials in numbers of modulus 1. *Canadian J. Math.* **54** (2002), 239–262.
- [43] (with Joseph Kupka) When factorial quotients are integers. *Gazette Aust. Math. Soc.* **29** (2002), 19–26.
- [44] (with Gabriella Kuhn) Restricting cuspidal representations of the group of automorphisms of a homogeneous tree. *Boll. Un. Mat. Ital.* (8) **6-B** (2003), 353–379.
- [45] (with Patrick Solé and Andrzej Żuk) Ramanujan geometries of type \tilde{A}_n . *Discrete Mathematics* **269** (2003), 35–43.
- [46] (with Wolfgang Woess) Isotropic random walks in a building of type \tilde{A}_d . *Math. Zeitschrift.* **247** (2004), 101–135.
- [47] (with Bernhard Krön) On Stallings’ unique factorization groups. *Bulletin Austral. Math. Soc.* **73** (2006), 27–36.
- [48] (with Wolfgang Woess) The spectrum of the averaging operator on a network (metric graph). *Illinois J. Math.* **51** (2007), 805–830.
- [49] (with Tim Steger) Enumeration of the 50 fake projective planes. *C. R. Acad. Sci. Paris, Ser. I* **348** (2010), 11–13.

Massimo A. Picardello

Research Publications

- [1] A. Figà-Talamanca, M.A. Picardello, *Multiplicateurs de $A(G)$ qui ne sont pas dans $B(G)$* , C. R. Acad. Sci. Paris **277** (1973), 117–119.
- [2] M.A. Picardello, *Lacunary sets in discrete noncommutative groups*, Boll. Un. Mat. It. **8** (1973), 494–508.
- [3] M.A. Picardello, *Random Fourier series on compact noncommutative groups*, Canad. J. Math. **27** (1975), 1400–1407.
- [4] A. Figà-Talamanca, M.A. Picardello, *Functions that operate on the algebra $B_0(G)$* , Pacific J. Math. **74** (1978), 57–61.
- [5] M.A. Picardello, *Locally compact unimodular groups with atomic dual*, Rend. Sem. Mat. Fis. Milano **48** (1978), 197–216.
- [6] M.A. Picardello, *A unimodular non-type I group with purely atomic regular representation*, Boll. Un. Mat. It. **16-A** (1979), 331–334.
- [7] G. Mauceri, M.A. Picardello, *Noncompact unimodular groups with purely atomic Plancherel measures*, Proc. Amer. Math. Soc. **78** (1980), 77–84.
- [8] M.A. Picardello, *Unimodular Lie groups without discrete series*, Boll. Un. Mat. It. **1-C** (1980), 61–80.
- [9] G. Mauceri, M.A. Picardello, F. Ricci, *Hardy spaces associated with twisted convolution*, Advances Math. **39** (1981), 270–288.
- [10] G. Mauceri, M.A. Picardello, F. Ricci, *Twisted convolution, Hardy spaces and Hörmander multipliers*, Rend. Circ. Mat. Palermo (Suppl. 1) (1981), 191–203.
- [11] A. Figà-Talamanca, M.A. Picardello, *Spherical functions and harmonic analysis on free groups*, J. Functional Anal. **47** (1982), 281–304.
- [12] M.A. Picardello, *Spherical functions and local limit theorems on free groups*, Ann. Mat. Pura Appl. **133** (1983), 177–191.
- [13] A. Iozzi, M.A. Picardello, *Graphs and convolution operators*, in “Topics in Modern Harmonic Analysis” **1**, Ist. Naz. Alta Matem., Roma (1983), 187–208.
- [14] A. Iozzi, M.A. Picardello, *Spherical functions on symmetric graphs*, Lecture Notes in Math. **993**, Springer, New York–Berlin (1983), 344–386.
- [15] A. Figà-Talamanca, M.A. Picardello, *Restriction of spherical representations of $PGL_2(Q_p)$ to a discrete subgroup*, Proc. Amer. Math. Soc. **91** (1984), 405–408.
- [16] J. Faraut, M.A. Picardello, *The Plancherel measures for symmetric graphs*, Ann. Mat. Pura Appl. **138** (1984), 151–155.
- [17] M.A. Picardello, W. Woess, *Random walks on amalgams*, Monatshefte Math. **100** (1985), 21–33.
- [18] M.A. Picardello, *Positive definite functions and L^p -convolution operators on amalgams*, Pacific J. Math. **123** (1986), 209–221.
- [19] A. Korányi, M.A. Picardello, *Boundary behaviour of eigenfunctions of the Laplace operator on trees*, Ann. Sci. Sc. Norm. Sup. Pisa **13** (1986), 389–399.
- [20] M.A. Picardello, W. Woess, *Martin boundaries of random walks: ends of trees and groups*, Trans. Amer. Math. Soc. **302** (1987), 285–305.

- [21] A. Korányi, M.A. Picardello, M.H. Taibleson, *Hardy spaces on non-homogeneous trees*, Symp. Math. **29** (1987), 205–265.
- [22] M.A. Picardello, P. Sjögren, *The minimal Martin boundary of a cartesian product of trees*, Proc. Centre Math. Anal. Austral. Nat. Univ. **16** (1988), 226–246.
- [23] M.A. Picardello, W. Woess, *Harmonic functions and ends of graphs*, Proc. Edinburgh Math. Soc. **31** (1988), 457–461.
- [24] M.A. Picardello, T. Pytlik, *Norms of free operators*, Proc. Amer. Math. Soc. **104** (1988), 257–261.
- [25] J.M. Cohen, M.A. Picardello, *The 2-circles and 2-discs problems on trees*, Israel J. Math. **64** (1988), 73–86.
- [26] M.A. Picardello, W. Woess, *A converse to the mean value property on homogeneous trees*, Trans. Amer. Math. Soc. **311** (1989), 209–225.
- [27] M.A. Picardello, W. Woess, *Ends of graphs, potential theory and electric networks*, in “Cycles and Rays”, NATO ASI Ser. C, Kluwer Academic Publishers, Dordrecht (1990), 181–196.
- [28] C.A. Berenstein, E. Casadio Tarabusi, J.M. Cohen, M.A. Picardello, *Integral geometry on trees*, Amer. J. Math. **113** (1991), 441–470.
- [29] M.A. Picardello, M.H. Taibleson, *Substochastic transition operators on trees and their associated Poisson integrals*, Coll. Math. **59** (1990), 279–296.
- [30] M.A. Picardello, M.H. Taibleson, *Degeneracy of Hardy spaces on a two-sheeted graph: a sandwich of trees*, Ars Combinatoria **29B** (1990), 161–174.
- [31] M.A. Picardello, W. Woess, *Examples of stable Martin boundaries of Markov chains in “Potential Theory”*, De Gruyter & Co., Berlin – New York (1991), 261–270.
- [32] M.A. Picardello, M.H. Taibleson, W. Woess, *Harmonic functions on cartesian products of trees with finite graphs*, J. Functional Anal. **102** (1991), 379–400.
- [33] M.A. Picardello, P. Sjögren, *Boundary behaviour of eigenfunctions of the Laplacian in a bi-tree*, J. Reine Angew. Math. **424** (1992), 133–144.
- [34] M.A. Picardello, M.H. Taibleson, W. Woess, *Harmonic measure on the planar Cantor set from the viewpoint of graph theory*, Discrete Math. **109** (1992), 193–202.
- [35] C.A. Berenstein, E. Casadio Tarabusi, M.A. Picardello, *Radon transforms on hyperbolic spaces and their discrete counterparts*, in “Proceedings of the Conference in Radon Transforms”, Rende (1991).
- [36] M.A. Picardello, W. Woess, *Martin boundaries of Cartesian products of Markov chains*, Nagoya Math. J. **128** (1992), 153–169.
- [37] E. Casadio Tarabusi, J.M. Cohen, M.A. Picardello, *The horocyclical Radon transform on trees*, Israel J. Math. **78** (1992), 363–380.
- [38] M. Bozejko, M.A. Picardello, *Weakly amenable groups and amalgamated products*, Proc. Amer. Math. Soc. **117** (1993), 1039–1046.
- [39] E. Casadio Tarabusi, J.M. Cohen, F. Colonna, M.A. Picardello, *Characterization of the range and functional analysis of the X-ray transform on trees*, C. R. Acad. Sci. Paris **316** (1993), 559–564.
- [40] E. Casadio Tarabusi, J.M. Cohen, M.A. Picardello, *The range of the X-ray transform on trees*, Adv. Math. **109** (1994), 143–156.

- [41] M.A. Picardello, W. Woess, *The full Martin boundary of the bi-tree*, Ann. Prob. **22** (1994), 2203–2222.
- [42] F. Di Biase, M.A. Picardello, *The Green formula and H^p spaces on trees*, Math. Zeitsch. **218** (1995), 253–272.
- [43] M. Pagliacci, M.A. Picardello, *Heat diffusion on homogeneous trees*, Adv. Math **100** (1995), 175–190.
- [44] J. Cohen, F. Colonna, M.A. Picardello, *Image reconstruction from exponential blurring*, Circuits, Systems, Signal Process. **15** (1996), 261–274.
- [45] M.A. Picardello, *Characterizing harmonic functions by mean value properties on trees and symmetric spaces*, Contemp. Math. **206** (1997), 161–163.
- [46] E. Casadio-Tarabusi, J.M. Cohen, A. Korányi, M.A. Picardello, *Converse mean value theorems on trees and symmetric spaces*, Jour. Lie Theory **8** (1998), 229–254.
- [47] M.A. Picardello, *The geodesic Radon transform on trees*, in “Harmonic Analysis and Integral Geometry”, CRC/Chapman Hall (2000).
- [48] E. Casadio-Tarabusi, S.G. Gindikin, M.A. Picardello, *The circle Radon transform on trees*, Diff. Geom. and Applications **19** (2003), 295–305.
- [49] N. Arcozzi, E. Casadio-Tarabusi, F. Di Biase, M.A. Picardello, *A potential theoretic approach to twisting*, in “New Trends in Potential Theory”, The Theta Foundation, Bucharest (2005), 3–15.
- [50] N. Arcozzi, E. Casadio-Tarabusi, F. Di Biase, M.A. Picardello, *Twist points of planar domains*, Trans. Amer. Math. Soc. **358** (2006), 2781–2798.
- [51] E. Casadio-Tarabusi, M.A. Picardello, *The algebras generated by the Laplace operators in a semi-homogeneous tree*, preprint.
- [52] L. Atanasi, M.A. Picardello, *The Lusin area function and local admissible convergence of harmonic functions on homogeneous trees*, Trans. Amer. Math. Soc. **360** (2008), 3327–3343.
- [53] J.M. Cohen, M. Pagliacci, M.A. Picardello, *Radial heat diffusion from the root of a semi-homogeneous tree and the combinatorics of paths*, Boll. Un. Mat. It. **1** (3) (2008), 619–628.
- [54] F. Andreano, M.A. Picardello, *Approximate identities on some homogeneous Banach spaces*, Monashefte Math. **158** (2009), 235–246.
- [55] M.A. Picardello, *Local admissible convergence of harmonic functions on non-homogeneous trees*, in print in Colloquium Math.

Books

- [1] A. Figà-Talamanca, M.A. Picardello, “Harmonic Analysis on Free Groups”, Lecture Notes in Pure and Appl. Math. **87**, M. Dekker, New York–Basel, 1983.
- [2] S. Campi, M.A. Picardello, G. Talenti, “Analisi Matematica e Calcolatori”, Borighieri, Torino, 1990.
- [3] M.A. Picardello (ed.), “Harmonic Analysis and Discrete Potential Theory”, Plenum Publishing Co. 1992.
- [4] W. Baldoni, M.A. Picardello (eds.), “Representation Theory of Lie Groups and Quantum Groups”, Pitman Research Notes in Math. **311**, Longman, Harlow, Essex, 1994.

- [5] E. Casadio Tarabusi, M.A. Picardello, G. Zampieri (eds.), “Integral Geometry, Radon Transforms and Complex Analysis”, Lecture Notes in Math. **1684**, Springer, Berlin, Heidelberg, New York, 1998.
- [6] M.A. Picardello, W. Woess (eds.), “Random Walks and Discrete Potential Theory”, Cambridge University Press Symp. Math., Cambridge University Press, Cambridge, 1999.
- [7] M.A. Picardello (ed.), “Harmonic Analysis and Integral Geometry ”, CRC/Chapman Hall, 2000.
- [8] A. D’Agnolo, E. Casadio Tarabusi, M.A. Picardello (eds.), “Representation Theory and Complex Analysis”, Lecture Notes in Math. **1931** (2006), Springer, Berlin, Heidelberg, New York.
- [9] M.A. Picardello, “Analisi di Fourier e trattamento numerico dei segnali”,
www.mat.uniroma2.it/~picard/SMC/didattica/materiali_did/An.Arm./LIBRO.pdf
- [10] M.A. Picardello, L. Zsidó, “Appunti di Algebra Lineare”,
http://www.mat.uniroma2.it/~picard/SMC/didattica/materiali_did/Alg.Lin./AlgLin.pdf
- [11] M.A. Picardello, “Algoritmi e metodi numerici, analitici e statistici in Computer Graphics”,
www.mat.uniroma2.it/~picard/SMC/didattica/materiali_did/Comp.Graph./Note_di_Computer_Graphics.pdf
- [12] M.A. Picardello, “Elaborazione digitale di immagini con Adobe Photoshop”,
www.mat.uniroma2.it/~picard/SMC/didattica/materiali_did/Photoshop/Libro_Photoshop.pdf
- [13] M.A. Picardello, “Il linguaggio Java”,
www.mat.uniroma2.it/~picard/SMC/didattica/materiali_did/Java/Matematica_Computazionale/Matem_Computazionale.pdf
- [14] A. Pantano, M.A. Picardello, “Rappresentazioni di $SL_2(\mathbb{R})$ ”, in preparation.

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Research Publications

- [1] A.M. Vershik, V.A. Kaimanovich, *Random walks on groups: boundary, entropy and uniform distribution*, Dokl. Akad. Nauk SSSR, **249** (1979), 15–18 (Russian); English translation: Soviet Math. Dokl., **20** (1979), 1170–1173.
- [2] V.A. Kaimanovich, *Spectral measure of the transition operator and harmonic functions connected with random walks on discrete groups*, Zapiski Nauchn. Sem. LOMI, **97** (1980), 102–109 (Russian); English translation: J. Soviet Math., **24** (1984), 550–555.
- [3] V.A. Kaimanovich, *Boundaries of random walks on discrete groups*, Diploma (MSc) Thesis, Leningrad University, 1980 (Russian).
- [4] V.A. Kaimanovich, *Boundaries of random walks on discrete groups*, Teoriya Veroyatn. i ee Prim., **26:3**(1981), 637–639 (Russian); English translation: Theory Probab. Appl., **26:3**(1981), 624–625.
- [5] V.A. Kaimanovich, *A topological model of the boundary for random walks on groups*, VINITI publ. 5052–81, 1981 (Russian).
- [6] V.A. Dymshits, V.A. Kaimanovich, *On the problem of the genetic code structure*, Proceedings of the Annual Conference of Young Scientists, Tartu University, 1981 (Russian).
- [7] V.A. Kaimanovich, *Examples of non-commutative groups with non-trivial exit boundary*, Zapiski Nauchn. Sem. LOMI, **123** (1983), 167–184 (Russian); English translation: J. Soviet Math., **28** (1985), 579–591.
- [8] V.A. Kaimanovich, *The differential entropy of the boundary of a random walk on a group*, Uspekhi Mat. Nauk, **38:5**(1983), 187–188 (Russian); English translation: Russian Math. Surveys, **38:5**(1983), 142–143.
- [9] V.A. Kaimanovich, A.M. Vershik, *Random walks on discrete groups: boundary and entropy*, Ann. Probab., **11** (1983), 457–490.
- [10] V.A. Kaimanovich, *A complete description of the tail sigma-algebra of random walks and related problems*, Teoriya Veroyatn. i ee Prim., **30:1**(1985), 189–190 (Russian); English translation: Theory Probab. Appl., **30:1**(1985), 207–208.
- [11] V.A. Kaimanovich, *An entropy criterion for maximality of the boundary of random walks on discrete groups*, Dokl. Akad. Nauk SSSR, **280** (1985), 1051–1054 (Russian); English translation: Soviet Math. Dokl., **31** (1985), 193–197.
- [12] V.A. Kaimanovich, *The uniform distribution on compact homogeneous spaces and the Kantorovich-Rubinshtein metric*, Teoriya Veroyatn. i ee Prim., **30:4**(1985), 779–782 (Russian); English translation: Theory Probab. Appl., **30:4**(1985), 828–831.
- [13] V.A. Kaimanovich, *A global law of large numbers for the Lie groups*, Fourth International Vilnius Conference on Probability Theory and Mathematical Statistics, Abstracts of Communications, Akad. Nauk Litovsk. SSR, Vilnius, 1985, **2**, 9–11 (Russian).
- [14] V.A. Kaimanovich, *Boundaries of random walks on discrete groups*, Candidate of Sciences (Ph. D.) Thesis, Leningrad University, 1985 (Russian).
- [15] V.A. Kaimanovich, *Brownian motion and harmonic functions on covering manifolds. An entropy approach*, Dokl. Akad. Nauk SSSR, **288** (1986), 1045–1049 (Russian); English translation: Soviet Math. Dokl., **33** (1986), 812–816.

- [16] V.A. Kaimanovich, *Boundaries of random walks on polycyclic groups and the law of large numbers for solvable Lie groups*, Vestnik Leningrad. Univ. Mat. Mekh. Astronom., 1987, vyp. 4, 93–95 (Russian); English translation: Vestnik Leningrad University: Mathematics, **20**:4(1987), 49–52.
- [17] V.A. Kaimanovich, *Lyapunov exponents, symmetric spaces and a multiplicative ergodic theorem for semi-simple Lie groups*, Zapiski Nauchn. Sem. LOMI, **164** (1987), 30–46 (Russian); English translation: J. Soviet Math., **47** (1989), 2387–2398.
- [18] V.A. Kaimanovich, *Brownian motion on manifolds and Markov chains*, Abstracts of Communications at the Leningrad Probability Seminar, 1987 (Russian).
- [19] V.A. Kaimanovich, *Brownian motion on foliations: entropy, invariant measures, mixing*, Funktsional. Anal. i Prilozhen., **22**:4(1988), 82–83 (Russian); English translation: Funct. Anal. Appl., **22**:4(1988), 326–328.
- [20] V.A. Kaimanovich, *Boundary and entropy of random walks in random environment*, Fifth International Vilnius Conference on Probability Theory and Mathematical Statistics, Abstracts of Communications, Akad. Nauk Litovsk. SSR, Vilnius, 1989, **1**, 234–235.
- [21] V.A. Kaimanovich, *The entropy and the Liouville property of Riemannian manifolds*, Uspekhi Mat. Nauk, **44**:4(1989), 225–226 (Russian); English translation: Russian Math. Surveys, **44**:4(1989), 195–196.
- [22] V.A. Kaimanovich, *Harmonic and holomorphic functions on coverings of complex manifolds*, Mat. Zametki, **46**:5(1989), 94–96 (Russian).
- [23] V.A. Kaimanovich, E.M. Krupitski, A.V. Spirov, *The possible contribution of intracellular electric fields to oriented assemblage of microtubules*, Journal of Bioelectricity, **8** (1989), 243–245.
- [24] V.A. Kaimanovich, *Boundary and entropy of random walks in random environment*, Probability Theory and Mathematical Statistics, Fifth International Conference, Vilnius, 1989 (B. Grigelionis, Yu.V. Prohorov, V.V. Sazonov, V. Statulivicius eds.), Mokslas-VSP, Vilnius-Utrecht, 1990, **1**, 573–579.
- [25] V.A. Kaimanovich, *Invariant measures of the geodesic flow and measures at infinity on negatively curved manifolds*, Ann. Inst. H. Poincaré, Phys. Théor., **53** (1990), 361–393.
- [26] V.A. Kaimanovich, E.M. Krupitski, A.V. Spirov, *Possible role of intracellular electric fields in microtubule assembly orientation*, Biofizika, **35** (1990), 603–604 (Russian).
- [27] V.A. Kaimanovich, *Bowen-Margulis and Patterson measures on negatively curved compact manifolds*, Dynamical Systems and Related Topics, Nagoya, 1990 (K. Shiraiwa ed.), World Sci. Publishing, River Edge, NJ, 1991, 223–232.
- [28] V.A. Kaimanovich, *Poisson boundaries of random walks on discrete solvable groups*, Probability Measures on Groups X, Oberwolfach, 1990 (H. Heyer ed.), Plenum, New York, 1991, 205–238.
- [29] V.A. Kaimanovich, *Dirichlet norms, capacities and generalized isoperimetric inequalities for Markov operators*, Potential Anal., **1** (1992), 61–82.
- [30] V.A. Kaimanovich, W. Woess, *The Dirichlet problem at infinity for random walks on graphs with a strong isoperimetric inequality*, Probab. Theory Related Fields, **91** (1992), 445–466.

- [31] V.A. Kaimanovich, *Bi-harmonic functions on groups*, C. R. Acad. Sci. Paris Sér. I Math., **314** (1992), 259–264.
- [32] V.A. Kaimanovich, *Discretization of bounded harmonic functions on Riemannian manifolds and entropy*, Potential Theory, Nagoya, 1990 (M. Kishi ed.), de Gruyter, Berlin, 1992, 213–223.
- [33] V.A. Kaimanovich, *Measure-theoretic boundaries of Markov chains, 0-2 laws and entropy*, Harmonic Analysis and Discrete Potential Theory, Frascati, 1991 (M.A. Picardello ed.), Plenum, New York, 1992, 145–180.
- [34] V.A. Kaimanovich, O.V. Narvskaya, V.V. Babkov, L.A. Kaftyreva, *Computer-aided statistical analysis of the biological properties of Salmonella Typhimurium*, J. Microbiol., 1992, no. 1, 70 (Russian).
- [35] V.A. Kaimanovich, *The Poisson boundary of hyperbolic groups*, C. R. Acad. Sci. Paris Sér. I Math., **318** (1994), 59–64.
- [36] V.A. Kaimanovich, E.M. Krupitski, A.V. Spirov, *Electrical activity of biomembranes and vectorization of intracellular processes*, Electro- and Magnetobiology, **13** (1994), 149–158.
- [37] V.A. Kaimanovich, *Ergodicity of harmonic invariant measures for the geodesic flow on hyperbolic spaces*, J. Reine Angew. Math., **455** (1994), 57–103.
- [38] D. Cartwright, V.A. Kaimanovich, W. Woess, *Random walks on the affine group of local fields and of homogeneous trees*, Ann. Inst. Fourier (Grenoble), **44** (1994), 1243–1288.
- [39] V.A. Kaimanovich, *The Poisson boundary of covering Markov operators*, Israel J. Math., **89** (1995), 77–134.
- [40] V.A. Kaimanovich, *The Poisson boundary of polycyclic groups*, Probability measures on groups and related structures, XI, Oberwolfach, 1994 (H. Heyer ed.), World Sci. Publishing, River Edge, NJ, 1995, 182–195.
- [41] V.A. Kaimanovich, W. Woess, *Construction of discrete, non-unimodular hypergroups*, Probability measures on groups and related structures, XI, Oberwolfach, 1994 (H. Heyer ed.), World Sci. Publishing, River Edge, NJ, 1995, 196–209.
- [42] V.A. Kaimanovich, *Boundaries of invariant Markov operators: the identification problem*, Ergodic Theory of \mathbf{Z}^d actions, Warwick, 1993–1994 (M. Pollicott, K. Schmidt eds.), London Math. Soc. Lecture Note Ser. **228** (1996), 127–176.
- [43] V.A. Kaimanovich, H. Masur, *The Poisson boundary of the mapping class group*, Invent. Math., **125** (1996), 221–264.
- [44] V.A. Kaimanovich, E.M. Krupitski, A.V. Spirov, *Electrical activity of biomembranes and oriented assemblage of microtubules in neurones*, Suppl. “Consciousness Research Abstracts”, J. Consciousness Studies, **3** (1996), 73.
- [45] V.A. Kaimanovich, *Harmonic functions on discrete subgroups of semi-simple Lie groups*, Contemp. Math., **206** (1997), 133–136.
- [46] V.A. Kaimanovich, *Hopf-Tsuji-Sullivan theorem*, Encyclopedia of Mathematics, Kluwer, Dordrecht, 1997, 300–301.
- [47] V.A. Kaimanovich, *Gromov hyperbolic space*, Encyclopedia of Mathematics, Kluwer, Dordrecht, 1997, 277–278.
- [48] V.A. Kaimanovich, *Hopf alternative*, Encyclopedia of Mathematics, Kluwer, Dordrecht, 1997, 294–296.

- [49] V.A. Kaimanovich, *Amenability, hyperfiniteness and isoperimetric inequalities*, C. R. Acad. Sci. Paris, Sér. I **325** (1997), 999–1004.
- [50] V.A. Kaimanovich, H. Masur, *The Poisson boundary of Teichmüller space*, J. Funct. Anal. **156** (1998), 301–332.
- [51] V.A. Kaimanovich, *Hausdorff dimension of the harmonic measure on trees*, Ergodic Theory Dynam. Systems **18** (1998), 631–660.
- [52] V.A. Kaimanovich, A. Fisher, *A Poisson formula for harmonic projections*, Ann. Inst. H. Poincaré Prob. Stat. **34** (1998), 209–216.
- [53] V.A. Kaimanovich, *A discrete time Harnack inequality and its applications*, Random Walks and Discrete Potential Theory, Cortona, 1997 (M. Picardello, W. Woess eds.), Cambridge Univ. Press, Symposia Mathematica **29** (1999), 214–230.
- [54] V.A. Kaimanovich, *Ergodicity of the horocycle flow*, Dynamical Systems, Luminy-Marseille, 1998, World Sci. Publishing River Edge, NJ, 2000, 274–286.
- [55] V.A. Kaimanovich, *Ergodic properties of the horocycle flow and classification of Fuchsian groups*, J. Dynam. Control Systems **6** (2000), 21–56.
- [56] V.A. Kaimanovich, *The Poisson formula for groups with hyperbolic properties*, Ann. of Maths. **152** (2000), 659–692.
- [57] V.A. Kaimanovich, *Equivalence relations with amenable leaves need not be amenable*, Topology, Ergodic Theory, Real Algebraic Geometry, Amer. Math. Soc. Transl. (Ser. 2) **202** (2001), 151–166.
- [58] V.A. Kaimanovich, W. Woess, *Boundary and entropy of space homogeneous Markov chains*, Ann. Probab. **30** (2002), 323–363.
- [59] V.A. Kaimanovich, *Non-Euclidean affine laminations*, Foliations: geometry and dynamics (Warsaw, 2000), World Sci. Publishing, River Edge, NJ, 2002, 333–349.
- [60] V.A. Kaimanovich, K. Schmidt, *Ergodicity of cocycles. I: General theory*, preprint, 2000.
- [61] V.A. Kaimanovich, Y. Kifer, B.-Z. Rubshtein, *Boundaries and harmonic functions for random walks with random transition probabilities*, J. Theoret. Probab. **17** (2004), 605–646.
- [62] V.A. Kaimanovich, *SAT actions and ergodic properties of the horosphere foliation*, Rigidity in Dynamics and Geometry (Cambridge, 2000), Springer, Berlin, 2002, 261–282.
- [63] V.A. Kaimanovich, *The Poisson boundary of amenable extensions*, Monatsh. Math. **136** (2002), 9–15.
- [64] V.A. Kaimanovich, *Random walks on Sierpinski graphs: hyperbolicity and stochastic homogenization*, in: Fractals in Graz 2001, Birkhäuser, Basel, 2002, 145–183.
- [65] S. Kh. Aranson, V.Z. Grines, V.A. Kaimanovich, *Classification of supertransitive 2-webs on surfaces*, J. Dynam. Control Systems **9** (2003), 455–468.
- [66] V.A. Kaimanovich, *Double ergodicity of the Poisson boundary and applications to bounded cohomology*, GAFA, **13** (2003), 852–861.
- [67] V.A. Kaimanovich, *Boundary amenability of hyperbolic spaces*, Contemp. Math., **347** (2004), 83–111.
- [68] V.A. Kaimanovich, *Amenability and the Liouville property*, Israel J. Math., **149** (2005), 45–85.
- [69] V.A. Kaimanovich, *“Münchhausen trick” and amenability of self-similar groups*, Internat. J. Algebra Comput. **15** (2005), 907–937.

- [70] V.A. Kaimanovich, I. Kapovich, P. Schupp, *Generic stretching factors for free group automorphisms*, Israel J. Math. **157** (2007), 1–46.
- [71] V.A. Kaimanovich, *Self-similarity and random walks*. In: Fractal Geometry and Stochastics IV. Progress in Probability 61, Birkhäuser, 2009, pp. 45–70.
- [72] V.A. Kaimanovich, F. Sobieczky, *Stochastic homogenization of horospheric tree products*. In: Probabilistic Approach to Geometry. Advanced Studies in Pure Mathematics 57, Mathematical Society of Japan, 2010, pp. 199–229.
- [73] L. Bartholdi, V.A. Kaimanovich, V. Nekrashevych, *On amenability of automata groups*, Duke Math. J., to appear (2010); available at arXiv:0802.2837 (February 2008).
- [74] V.A. Kaimanovich, *Hopf decomposition and horospheric limit sets*, Ann. Acad. Sci. Fenn. Math., to appear (2010); available at arXiv:0807.0995 (July 2008).
- [75] V.A. Kaimanovich, V. Le Prince, *Matrix random products with singular harmonic measure*, Geom. Dedicata, to appear (2010); available at arXiv:0807.1015 (July 2008).
- [76] R.I. Grigorchuk, V.A. Kaimanovich, T. Nagnibeda, *Ergodic properties of boundary actions and Nielsen-Schreier theory*, arXiv:0901.4734 (January 2009).

In preparation:

- [77] T. Bühler, V.A. Kaimanovich, *Markov operators on groupoids and amenability*.
- [78] P. Freitas, V.A. Kaimanovich, *Compactifications of symmetric spaces*.
- [79] V.A. Kaimanovich, *Boundary behaviour of Thompson's group*.
- [80] V.A. Kaimanovich, *Differential properties of Gibbs measures on negatively curved manifolds*.
- [81] V.A. Kaimanovich, *Poisson boundary of discrete groups: a survey*.
- [82] V.A. Kaimanovich, V. Le Prince, *Random walks with maximal entropy on free products*.
- [83] V.A. Kaimanovich, K. Schmidt, *Ergodicity of cocycles. II. Geometric applications*.
- [84] V.A. Kaimanovich, F. Sobieczky, *Horospheric products of random trees*.

Books

- [1] N. Martin, J. England, *Mathematical Theory of Entropy*, Mir, Moscow, 1988, translation into Russian and editorial comments.
- [2] V.A. Kaimanovich (ed.) *Random walks and geometry* (Vienna, 2001), de Gruyter, 2004.
- [3] V.A. Kaimanovich, M. Lyubich, *Conformal and harmonic measures on laminations associated with rational maps*, AMS, 2005.
- [4] V.A. Kaimanovich, A.A. Lodkin (eds.), *Representation Theory, Dynamical Systems, and Asymptotic Combinatorics*, AMS, 2006.

In preparation:

- [5] V.A. Kaimanovich, B.-Z. Rubshtein, *Partitions in ergodic theory and probability*.
- [6] V.A. Kaimanovich, *Boundary and entropy of random walks on countable groups*.
- [7] V.A. Kaimanovich, *Amenability beyond groups*.

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