Alexander Kolpakov

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Associate Professor of Mathematics

Research Interests

- Combinatorics: circle packing and sphere packing, geometric codes.
- Semidefinite optimization: applications to geometric combinatorics.
- Riemannian geometry: low–dimensional manifolds, transformation groups, geometry of data.
- Computer vision: fast and robust feature matching, optimization of convolutional neural networks.
- Experimental mathematics: enumerative problems in geometry and combinatorics, computational experiments.

Employment and Affiliations

- Associate Professor of Mathematics, The University of Austin – UATX

Education

- 2012: Ph.D. in Mathematics, University of Fribourg, Switzerland
- 2008: B.Sc. in Mathematics (cum laude), Novosibirsk State University, Russia

Positions Held

- 2017 – 2023: Assistant Professor, University of Neuchâtel, Switzerland
- 2015 – 2017: Post–Doctoral Fellow, University of Toronto, Canada
- 2014: JSPS Visiting Assistant Professor, Waseda University, Tokyo, Japan
- 2013 – 2014: SNSF Post–Doctoral Fellow, Vanderbilt University, USA
- 2009 – 2013: Assistant Diplômé, University of Fribourg, Switzerland

Academic Distinctions

- 2017 – 2023: SNSF Research Chair, projects PP00P2-170560 and PP00P2-202667
- 2016: Research Visitor at the ICTP, Trieste, Italy, supported by the ICTP/UNESCO visitor program
- 2014 – 2015: SNSF Advanced Post-Doc Mobility Fellowship, project P300P2-151316
- 2013 – 2014: SNSF Early Post-Doc Mobility, PBFRP2-145885

Research Funding

- 2021 – 2023: SNSF Professorship Grant, PP00P2-202667 (778'051 CHF)
- 2017 – 2021: SNSF Professorship Grant, PP00P2-170560 (1'589'948 CHF)
- 2014 – 2015: SNSF Advanced Post–Doc Mobility, P300P2-151316 (46'900 CHF)
- 2014: Japan Society for the Promotion of Science Fellowship, S-14021 (1'100'000 JPY)
- 2013 – 2014: SNSF Early Post-Doc Mobility, PBFRP2-145885 (46'500 CHF)

Post–Docs Mentored

- 2022 – 2023: Peter Zeman (Ph.D. University of West Bohemia; now a postdoc at the Technical University of Denmark)
- 2021 – 2022: Leonardo Ferrari (Ph.D. University of Pisa; now an Assistant Professor at IMPAN, Poland)
- 2021: Edoardo Dotti (Ph.D. University of Fribourg; now at the Swiss National Science Foundation, Bern)
- 2018 – 2020: Stefano Riolo (Ph.D. University of Pisa; now an Assistant Professor at the University of Bologna)

Theses Supervised

- 2018 – 2021: Rémi Bottinelli (M.Sc. EPF Lausanne; now Teaching Assistant, University of Neuchâtel, Switzerland); University of Neuchâtel, Thesis: "On computational aspects of hyperbolic reflection groups, and two homology theories for graphs"
- 2018 – 2021: Laura Grave de Peralta (M.Sc. Université de Genève, now Teaching Assistant, University of Neuchâtel, Switzerland); University of Neuchâtel, Thesis: "Some application of combinatorics: from group theory to mathematical ecology"

Conferences and Workshops Organized

- The Vinberg Distinguished Lecture Series (online), since October 2021
- Swiss Mathematical Society Annual Conference 2019, University of Neuchâtel, June 2019
- CUSO summer school "Géométrie, topologie et arithmétique de façon hyperbolique", June 2019
- Series of workshops "Hyperbolic Geometry Beyond Dimension Three", American Institute of Mathematics, San Jose CA, July, 2015; July, 2016; July, 2017
- "Journées de Géométrie Hyperbolique", Université de Fribourg, November, 2012

Professional Membership

- Association for Mathematical Research
- Swiss Mathematical Society

Editorial Boards

- Journal of Experimental Mathematics, Managing Editor (2023 – 2025)
- Experimental Results, Section Editor (2020 – 2023)

Refereeing Work

International Mathematical Research Notices; Geometry & Topology; Algebraic and Geometric Topology; Proceedings of the AMS; Transactions of the AMS; European Journal of Combinatorics; Journal of Geometry; Tokyo Journal of Mathematics; Rocky Mountain Journal of Mathematics; Advances in Geometry; Journal of the Mathematical Society of Japan; Quantum Topology; Kyoto Mathematical Journal; Geometriae Dedicata; Crelle's Journal; Groups, Geometry, and Dynamics

Publications

Pre-prints

49. "A ripple in time: a discontinuity in American history", arXiv:2312.01185 (with I. Rivin)
48. "Thin hyperbolic reflection groups", arXiv:2112.14642 (with N. Bogachev)
47. "Subspace stabilisers in hyperbolic lattices", arXiv:2105.06897 (with M. Belolipetsky, N. Bogachev, and L. Slavich)
46. "Space vectors forming rational angles", arXiv:2011.14232 (with K. S. Kedlaya, B. Poonen, and M. Rubinstein)

Accepted and Published

45. "Discovering temporal and personality aspects in meager and highly variable text samples", NLPIR 2024, Okayama, Japan (with I. Rivin)
44. "Expansion properties of Whitehead moves on cubic graphs", Comptes Rendus Mathématique, 2024; arXiv:2303.13923 (with L. G. de Peralta)
43. "Robust affine point matching via quadratic assignment on Grassmannians", Pattern Recognit. Lett., 2024; arXiv:2303.02698 (with M. Werman)
42. "The information geometry of UMAP", Le Matematiche, 2024; arXiv:2309.01237 (with A. Rocke)
41. "Machine learning of the prime distribution", PLOS ONE, 2024; arXiv:2403.12588 (with A. Rocke)
40. "Euclidean volumes of hyperbolic knots", Proc. Amer. Math. Soc., 2024; arXiv:2107.03275 (with N. Abrosimov and A. Mednykh)
39. "Kleinian sphere packings, reflection groups, and arithmeticity", Math. Comp., 2024; arXiv:2203.01973 (with N. Bogachev and A. Kontorovich)
38. "An approach to robust ICP initialization", IEEE Trans. Patt. Anal. Mach. Intell. 2023; arXiv:2212.05332 (with M. Werman)

37. "Infinitely many arithmetic hyperbolic rational homology 3–spheres that bound geometrically", Trans. Amer. Math. Soc. **376**, 1979–1997 (2023); arXiv:2203.01997 (with L. Ferrari and A. W. Reid)

36. "The signature of cusped hyperbolic 4-manifolds", Int. Math. Res. Notices **2023** (9), 7961–7975 (2023); arXiv:2006.12095 (with S. Riolo and S. Tschantz)

35. "Packable surfaces with symmetries", Canadian Math. Bull. **66**, 103–113 (2023); arXiv:2010.12028 (with M. Dostert)

34. "Graph-based nearest neighbor search in hyperbolic spaces", Proceedings of ICLR 2022, accessible via OpenReview (with L. Prokhorenkova, D. Baranchuk, N. Bogachev and Yu. Demidovich)

33. "Infinitely many quasi-arithmetic maximal reflection groups", Proc. Amer. Math. Soc. **150**, 4203–4211 (2022); arXiv:2109.03316 (with E. Dotti)

32. "On free semigroups of affine maps on the real line", Proc. Amer. Math. Soc. **150**, 2301–2307 (2022); arXiv:2105.09387 (with A. Talambutsa)

31. "Semidefinite programming bounds for the average kissing number", Israel J. Math. **247**, 635–659 (2022); arXiv:2003.11832 (with M. Dostert and F. M. de Oliveira)

30. "Growth rates of Coxeter groups and Perron numbers", Int. Math. Res. Notices **2022** (19), 14675–14696 (2022); arXiv:1912.05608 (with A. Talambutsa)

29. "Three-dimensional maps and subgroup growth", Manuscripta Math. **168**, 549–570 (2022); arXiv:1712.01418 (with R. Bottinelli and L. Ciobanu)

28. "Cusps of hyperbolic 4-manifolds and rational homology spheres", Proc. London Math. Soc. **123** (6), 636–648 (2021); arXiv:2009.09995 (with L. Ferrari and L. Slavich)

27. "Kissing number in non-Euclidean spaces of constant sectional curvature", Math. Comp. **90**, 2507–2525 (2021); arXiv:2003.05547 (with M. Dostert)

26. "Kissing number in non-Euclidean spaces of constant sectional curvature", Proceedings of EUROCOMB 2021, in: CRM Research Perspectives (with M. Dostert)

25. "On faces of quasi-arithmetic Coxeter polytopes", Int. Math. Res. Notices **2021** (4), 3078–3096 (2021); arXiv:2002.11445 (with N. Bogachev)

24. "Embedding non-arithmetic hyperbolic manifolds", Math. Res. Lett. (2020), to appear; arXiv:2003.01707 (with S. Riolo and L. Slavich)

23. "A hyperbolic counterpart to Rokhlin's cobordism theorem", Int. Math. Res. Notices (2020), to appear; arXiv:1905.04774 (with M. Chu)

22. "Telescopic groups and symmetries of combinatorial maps" Alg. Combin. **3** (2): 483–508 (2020); arXiv:1901.05710 (with R. Bottinelli and L. Grave de Peralta)

21. "Spherical and geodesic growth rates of right-angled Coxeter and Artin groups are Perron numbers" Discrete Math. **343** (3): no. 111763 (2020); arXiv:1809.09591 (with A. Talambutsa)

20. "Spherical Pythagorean triples, and volume rationality of spherical tetrahedra", Math. Comp. **89**: 2031–2046 (2020); arXiv:1811.06598 (with S. Robins)

19. "Counting cusped hyperbolic three-manifolds that bound geometrically", Trans. Amer. Math. Soc. **373**: 229–247 (2020); arXiv:1808.05681 (with S. Riolo)

18. "Many cusped hyperbolic 3-manifolds do not bound geometrically", Proc. Amer. Math. Soc. **148**: 2233–2243 (2020); arXiv:1811.05509 (with A. Reid and S. Riolo)

17. "Free subgroups of free products and combinatorial hypermaps", Discrete Math., **342** (5): 1415–1433 (2019); arXiv:1708.03842 (with L. Ciobanu)

16. "Embedding arithmetic hyperbolic manifolds", Math. Res. Lett. **25** (4): 1305–1328 (2018); arXiv:1703.10561 (with A. Reid and L. Slavich)

15. "Volume formulae for fibred cone-manifolds with spherical geometry", Sbornik: Mathematics **207** (12): 1693–1708 (2016). Issue dedicated to the 150th anniversary of the Journal.

14. "Combinatorial decompositions, Kirillov-Reshetikhin invariants and the Volume Conjecture for hyperbolic polyhedra", Experimental Math., **27** (2): 193–207 (2016); arXiv:1603.02380 (with J. Murakami)

13. "Hyperbolic four-manifolds, colourings and mutations", Proc. London Math. Soc. **113** (2): 163–184 (2016); arXiv:1507.02747 (with L. Slavich)

12. "Symmetries of hyperbolic 4-manifolds", Int. Math. Res. Not. **2016** (9): 2677–2716 (2016); arXiv:1409.1910 (with L. Slavich)

11. "The dual Jacobian of a generalised tetrahedron, and volumes of prisms", Tokyo J. of Math. **39** (1): 45–67 (2016); arXiv:1409.3355 (with J. Murakami)

10. "Geodesic growth of right-angled Coxeter groups based on trees", J. Alg. Combin. **44** (2): 249–264 (2015); arXiv:1504.02774 (with L. Ciobanu)

9. "Some hyperbolic three-manifolds that bound geometrically", Proc. Amer. Math. Soc. **143**: 4103–4111 (2015); arXiv:1311.2993 (with B. Martelli and S. Tschantz)

8. "Hyperbolic four-manifolds with one cusp", Geom. and Funct. Anal. **23**: 1903–1933 (2013); arXiv:1303.6122 (with B. Martelli)

7. "The minimal growth rate of cocompact Coxeter groups in hyperbolic 3-space", Canad. J. Math. **66**: 354–372 (2014); (with R. Kellerhals)

6. "Examples of rigid and flexible Seifert fibred cone-manifolds", Glasgow Math. J. **55** (2): 411–429 (2013); arXiv:1004.2376

5. "On the optimality of the ideal right-angled 24-cell", Alg. Geom. Topol., **12**: 1941–1960 (2012); arXiv:1211.2944

4. "Volume of a doubly truncated hyperbolic tetrahedron", Aequationes Math. **85** (3): 449–463 (2013); arXiv:1203.1061 (with J. Murakami)

3. "Deformation of finite-volume hyperbolic Coxeter polyhedra, limiting growth rates and Pisot numbers", European J. Combin. **33** (8): 1709–1724 (2012); arXiv:1105.6267

2. "Volume formula for a Z_2-symmetric spherical tetrahedron through its edge lengths", Arkiv för Matematik **51** (1): 99–123 (2013); arXiv:1007.3948 (with A. Mednykh and M. Pashkevich)

1. "Spherical structures on torus knots and links", Siberian Math. J. **50** (5): 856–866 (2009); arXiv:1008.0312 (with A. Mednykh)

Activities and Talks

60. "Machine Learning of the Prime Distribution", DANGER: Data, Numbers and Geometry, August 2024

59. "Sphere packing and semidefinite programming", invited minicourse, CMS Winter Meeting, December 2022

58. "Subspace stabilisers in hyperbolic lattices", CMS Winter Meeting, December 2022

57. "Three–dimensional maps and subgroup growth", 44th Australasian Combinatorics Conference, December 2022

56. "Subspace stabilisers in hyperbolic lattices", Oberseminar Geometrie, Université de Fribourg, October 2022

55. "Subspace stabilisers in hyperbolic lattices", Swiss Mathematical Society Autumn Workshop "Dynamics and Groups", September 2022

54. "Space vectors forming rational angles", CMS Summer Meeting, June 2022

53. "The signature of cusped hyperbolic 4–manifolds", AMS Spring Western Virtual Sectional Meeting, May 2022

52. "Semidefinite programming bounds for the average kissing number", 43th Australasian Combinatorics Conference, December 2021

51. "Kissing number in non–Euclidean spaces of constant sectional curvature", EuroComb 2021, September 2021

50. "Kissing number in non–Euclidean spaces", SIAM Conference on Discrete Mathematics, July 2021

49. "Computing reflection centralisers in hyperbolic reflection groups", ICERM Workshop "Computational Aspects of Discrete Subgroups of Lie Groups", June 2021

48. "Semidefinite programming bounds for the average kissing number", Workshop on Distance Geometry, Semidefinite Programming and Applications, Fields Institute, May 2021

47. "Space vectors forming rational angles", CanaDAM 2021, May 2021

46. "Kissing number in non–Euclidean spaces of constant sectional curvature", CanaDAM 2021, May 2021

45. "Space vectors forming rational angles", Oberseminar Geometrie, Univesrité de Fribourg, May 2021

44. "Semidefinite programming bounds for the average kissing number", SIAM Conference on Computational Science and Engineering, March 2021

43. Invited participant at AIM Workshop "Arithmetic reflection groups and crystallographic packings", December 2020

42. "Space vectors forming rational angles: on a question of J.H. Conway", Conference: "Combinatorics and Geometry Days III" at Moscow Institute of Physics and Technology, December 2020

41. "Growth of Coxeter groups and Perron numbers", Oberseminar Geometrie, Univesrité de Fribourg, November 2020

40. “Packing surfaces with symmetries”, ICERM Workshop “Circle Packings and Geometric Rigidity”, July 2020

39. “Growth rates of RACG’s and RAAG’s are Perron numbers”, Séminaire "Groupes et Géométrie", Université de Genève, September 2019

38. “A hyperbolic counterpart to Rokhlin’s cobordism theorem”, Oberwolfach Mini-Workshop: “Reflection Groups in Negative Curvature”, April 2019

37. Invited participant at the Fields Institute Program on Teichmüller theory, November 2018

36. “Growth rates of RACG’s and RAAG’s are Perron numbers”, Oberseminar Geometrie, Université de Fribourg, October 2018

35. Invited participant at AIM Workshop “Discrete Geometry and Automorphic Forms”, September 2018

34. “Super–exponential families of hyperbolic manifolds”, Colloquium in Mathematics, Université de Fribourg, May 2018

33. “Combinatorics of subgroup counting in free products of cyclic groups”, Intercity Seminar: Bern, May 2018

32. “Combinatorics of subgroup counting in free products of cyclic groups, and other stories”, Geometry Seminar, ETH Zürich, April 2018

31. Graduate course “Reflection Groups and Coxeter Groups”, CUSO Network, University of Bern, February – May 2018

30. “Counting subgroups and cellular complexes”, EGG Seminar, EPF Lausanne, November 2017

29. “Counting subgroups and cellular complexes”, Colloquium, Department of Mathematics, University of Neuchâtel, November 2017

28. “Counting subgroups and hypermaps: common points”, Séminaire LaCIM, Université de Quebec à Montréal, October 2017

27. “Triangulations of surfaces and conjugacy classes in the modular group”, CanaDAM 2017, June 2017

26. “On the number of non-isomorphic surface triangulations”, Combinatorics and Optimization Seminar, University of Waterloo, November 2016

25. “Around volumes of Coxeter polytopes, scissors congruence and related conjectures”, Workshop on Volume Conjecture and Quantum Topology, Waseda University, Tokyo, September 2016 (video of the talk)

24. “Volumes of Coxeter polytopes and scissors congruence”, Oberseminar Geometrie, Université de Fribourg, June 2016

23. “Combinatorial tools for geometry of hyperbolic four–manifolds”, Séminaire Groupes et Analyse, University of Neuchâtel, June 2016

22. “Constructions combinatoires de variétés hyperboliques en dimension quatre”, CIRGET Seminar, Université de Québec à Montréal, October 2015

21. “Symmetries of hyperbolic four–manifolds”, Geometry & Topology Seminar, University of Toronto, January 2015

20. "Symmetries of hyperbolic four–manifolds and combinatorics of simplicial complexes", RIKO Topology Seminar, Waseda University, Tokyo, October 2014

19. "Higher–dimensional hyperbolic manifolds: constructions, new questions and examples", Colloquium, Department of Mathematics, Tokyo Institute of Technology, September 2014

18. "Colourings of polytopes and hyperbolic 4–manifolds", GEAR Junior Retreat, University of Michigan, Ann Arbor, May 2014

17. "Hyperbolic manifolds with one cusp", Wasatch Topology Conference, University of Utah, Salt Lake City, November 2013

16. "On hyperbolic polytopes", RIKO Topology Seminar, Waseda University, Tokyo, July 2013

15. "Cusp structure of hyperbolic four–dimensional manifolds", Workshop and Conference The topology of 3-dimensional manifolds, CRM/University of Montreal, May 2013

14. "Hyperbolic ideal right–angled polytopes, octahedrites and dimension bounds", AMS Spring Sectional meeting, Boston College, April 2013

13. "Hyperbolic 4–manifolds with one cusp", Geometry & Topology Seminar, University of Toronto, February 2013

12. "Les polyèdres hyperboliques rectangulaires idéaux en dimension quatre et leurs propriétés optimales", Séminaire "Géométrie Dynamique", Université Lille-1, December 2012

11. "Ideal right-angled polytopes in H^4 and octahedrites", Seminario di Geometria, Università di Pisa, November 2012

10. "Growth rates of Coxeter groups acting in hyperbolic plane and space, algebraic integers and co-volumes", Séminaire "Groupes et géométrie", Université de Genève, October 2012

9. "Dimension constraints for hyperbolic Coxeter polytopes", Workshop Algebra and Geometry, Universität Bern, September 2012

8. "On the optimality of the ideal right-angled 24–cell", Lie Groups and Algebraic Groups, Universität Bielefeld, July 2012

7. "Geometry of polyhedra and cone–manifolds in negative and positive curvature", RIKO Topology Seminar, Waseda University, Tokyo, December 2011

6. "The 24–cell: geometric and combinatorial optimality", Oberseminar Geometrie, Université de Fribourg, November 2011

5. "Growth of hyperbolic reflection groups", Parole aux jeunes chercheurs, Institut de Mathématiques de Jussieu, Paris, October 2011

4. "Growth of finite covolume hyperbolic Coxeter groups and algebraic integers", Oberseminar Geometrie, Université de Fribourg, November 2010

3. "Coxeter groups and algebraic integers", Geometry and Ergodic Theory Seminar, EPF Lausanne, October 2010

2. "Volume formula for Z_2–symmetric spherical tetrahedron through its edges", Oberseminar Geometrie, Université de Fribourg, October 2009

1. "Spherical structures on torus knots and links", ICTP, Trieste, May 2008