CONTACT INFORMATION

Department of Computer Science
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RESEARCH INTERESTS

Graph Theory and Graph Algorithms, Discrete Mathematics and Combinatorics, Combinatorial Optimization, Matroid Theory

BIOGRAPHY

Born September 21, 1976 in the USA, Paul Wollan received a BA in Mathematics with Honors from the University of Chicago in 1999. He completed his PhD in the multi-disciplinary program on Algorithms, Combinatorics, and Optimization at Georgia Institute of Technology working with Prof. Robin Thomas, a world leader in the structural theory of graphs.

ACADEMIC EXPERIENCE

Sapienza University of Rome, Dept. of Computer Science, Italy — Dec 2008 - present

Associate Professor (Professore Associato)

- Assistant Professor (Ricercatore) from Dec 2008 - Oct 2013
- Tenure awarded Feb 2012.
- Habilitation (Abilitazione) for full professor awarded Dec 2014.

University of Hamburg, Dept. of Math, Germany — Jan 2007 - Dec 2008

Humboldt Research Fellow

University of Waterloo, Dept. of Combinatorics and Optimization, Canada — Jan 2006 - Jan 2007

Postdoctoral Research Fellow

Georgia Institute of Technology, USA — Aug 2001 - Dec 2005

Graduate Research Assistant and PhD Candidate

- Ph.D. in Algorithms, Combinatorics, and Optimization, Dec 2005.
- Dissertation title: "Extremal Functions for Graph Linkages and Rooted Minors".
- Advisor: Prof. Robin Thomas.

Los Alamos National Laboratory, Los Alamos, New Mexico USA — Sept 2000 - June 2001

Graduate Research Assistant

FUNDING

ERC Starter Grant: **850,000 €** — Dec 2011 - Nov 2016

Principal Investigator of the ERC project DASTCO, a 5 year project to study structural aspects of signed and directed graphs. Budget includes funding for 2 graduate students and four 1-year post doctoral positions. Awarded by the European Union Research Council.

Humboldt Foundation Research Fellowship: **69,000 €** Jan 2007 - Dec 2008

Recipient of a Humboldt Research Fellowship hosted by Prof. Reinhard Diestel at the University of Hamburg. Originally funded for one year, awarded the maximum extension of 1 year in 2008.

ATENEO Grant: **25,500 €** Jan 2012 - Dec 2013

Principal Investigator for a project on problems in graph theory and aspects of proof complexity. Funded by the internal funding agency of the University of Rome La Sapienza.

TEACHING EXPERIENCE

University of Rome, Rome, Italy

Instructor July 2009 - present

Co-taught the first year introductory programming course. Teaching in Italian. Prepared and taught the first year graduate course in graph theory. Teaching in English.

University of Hamburg, Hamburg, Germany

Lead Instructor Mar - July 2009

Organized and taught a graduate research-oriented course on the theory of Graph Minors. Teaching in English.

University of Waterloo, Waterloo, Canada

Instructor Aug - Dec 2006

Taught one section of a 10-section first year course on linear algebra.

Georgia Institute of Technology, Atlanta, USA

Lead Instructor Jan 2004 - May 2013

Prepared and taught a junior-level computer science course introducing concepts of discrete mathematics in 2004 and again in 2011. Taught graduate course in Combinatorial Optimization as a visiting professor in 2012 and 2013.

SUPERVISED STUDENTS AND POSTDOCS

- Spencer Backman, current *Postdoctoral Researcher*
- Ringi Kim, current *Visiting PhD Student*
- Jan-Oliver Fröhlich, current *Postdoctoral Researcher*
- Tony Huynh, current *Postdoctoral Researcher*
- Irene Muzi, current *PhD*
- Matteo Pontecorvi, 2011 *Laurea Specialistica*
  - Currently PhD Candidate in the University of Austin Department of Computer Science
  - Thesis work published in *J. Combin. Theory Ser B*, entitled "Disjoint cycles intersecting a set of vertices."

INVITED PLENARY PRESENTATIONS

1. *When Are Directed Graphs Well-quasi-ordered*, Colloquia in Combinatoric, London School of Eco-

nomics, May 2014.

2. *A New Proof for the Weak-Structure Theorem with Explicit Bounds*, Dagstuhl Seminar "Bidimensional Structures: Algorithms, Combinatorics and Logic", Germany, March 2013.
3. *Explicit Bounds for the Weak-Structure Theorem*, Workshop on Graphs and Matroids, Maastricht, Netherlands, August 2012.
4. *Excluding a Clique Immersion*, Graph Theory at Georgia Tech, Atlanta, May 2012.
5. *New Proofs in Graph Minors*, Mathematical Foundations of Computer Science (MFCS), Warsaw, Poland, August 2011.
6. *A Shorter Proof of the Unique Linkage Theorem*, Oberwolfach Workshop, Oberwolfach, Germany, March 2010.

OTHER INVITED PRESENTATIONS

1. *When Are Directed Graphs Well-quasi-ordered*, ICM Satellite Conference on Extremal and Structural Graph Theory, Gyongju Korea, August 2014.
2. *Packing Disjoint A-paths With Specified Ends*, SIAM Discrete Mathematics, Minneapolis USA, July 2014.
3. *Packing A-paths With Specified Endpoints*, Bellairs Workshop on Graph Theory, Holetown, Barbados, March 2014.
4. *Immersions in Highly Connected Graphs*, Oberwolfach Workshop, Oberwolfach, Germany, March 2013.
5. *A Short Proof of the Unique Linkage Theorem*, Atlanta Lecture Series in Combinatorics and Discrete Math, Atlanta, April 2011.
6. *A Shorter Proof of the Unique Linkage Theorem*, SIAM Conference on Discrete Mathematics, Austin, June 2010.
7. *Linking Vortices*, Workshop on Graph Theory, Princeton, May 2009.
8. *Non-zero Cycles in Group Labeled Graphs*, Banf Workshop, Banf, Canada, September 2008.
9. *Packing Disjoint Clique Minors*, Sittard, Netherlands, July 2008.
10. *Complete Minors in Large Six Connected Graphs*, Graph Theory 2007, Fredericia, Denmark, December 2007.
11. *Progress on Removable Paths Conjectures*, Oberwolfach Workshop, Oberwolfach, Germany, March 2007.
12. *K_6 Minors in Large Six Connected Graphs*, SIAM Conference on Discrete Mathematics, Victoria, Canada, June 2006.
13. *Extremal Functions for Linkages and Rooted Minors*, ACCOTA, Combinatorial and Computational Aspects of Optimization, Topology, and Algebra, Guanajuato, Mexico, October 2004.
14. *The Extremal Function for 3-linked Graphs*, SIAM Conference on Discrete Mathematics, Nashville, June 2004.

PROFESSIONAL ACTIVITIES

- Program committee: SIAM Symposium on Discrete Algorithms (SODA) 2014, Workshop on Approximation and Online Algorithms (WAOA) 2012.
- Served as referee for numerous discrete mathematics journals and theoretical computer science conferences, including: Journal of Graph Theory, SIAM Journal of Discrete Mathematics, Discrete Mathematics, Combinatorica, Journal of Combinatorial Theory, ser. B, Ars Combinatorica, Graphs and Combinatorics, Electronic Journal of Operations Research, Discrete Optimization, Journal of Combinatorics, Algorithmica, SIAM J. of Computing, Journal of Discrete Algorithms, Symposium on Discrete Algorithms (SODA), Integer Programming and Combinatorial Optimization (IPCO), Scandinavian Workshop on Algorithmic Theory (SWAT), Symposium on the Theoretical Aspects of Computer Science (STACS), European Symposium on Algorithms (ESA), Symposium on the Theory of Computing (STOC).
- Reviewer for various national scientific funding agencies, including the National Science Foundation and National Security Agency (USA), the Australian Research Council, the National Science and Engineering Research Council of Canada, and FONDECYT of Chile.
- Organizer of 5 international conferences and workshops, including Graph Theory at Georgia Tech in Atlanta, USA in May 2012, the Bertinoro Workshop on Algorithms and Graphs in 2009, 2011, and 2013, and the CIRM Workshop on Graph Theory to be held in January 2015.
- Chaired the invited session "Structural Graph Theory and Methods," at the International Symposium on Math Programming (ISMP) in Berlin in Aug 2012. Chair of the invited session "Graph Structure" at the SIAM Conference on Discrete Math held in Minneapolis in June 2014.

HONORS AND AWARDS

- Humboldt Research Fellowship, awarded by the Alexander von Humboldt Foundation and hosted by the University of Hamburg, 2006 - 2007.
- "Graduate Student of the Year" 2004-2005, Department of Mathematics, Georgia Institute of Technology.
- NSF VIGRE research fellowship 2004 - 2005, Department of Mathematics, Georgia Institute of Technology
- Presidential Fellow, Georgia Institute of Technology, 2000 - 2005.
- NSF Graduate Fellowship Honorable Mention, 2001.

REFERENCES

Available upon request.

Most Important Publications

1. M. Grohe, K. Kawarabayashi, D. Marx, and P. Wollan, "Finding Topological Subgraphs is Fixed Parameter Tractable." *Proceedings of the ACM Symposium on Theory of Computing (STOC) 2011*, 479 – 488.

   This article proves a conjecture of Downey and Fellows from 1992 that the problem of testing topological minor containment is fixed parameter tractable; that is, there exists a function f, constant c, and an algorithm which tests whether a graph G contains a graph H as a topological minor in time $f(H)|V(G)|^c$.

2. K. Kawarabayashi and P. Wollan, "A Simpler Algorithm and Shorter Proof for the Graph Minors Decomposition." *Proceedings of the ACM Symposium on Theory of Computing (STOC) 2011*, 451 – 458.

   In this paper, we present a new proof of the graph minor structure theorem which is significantly simpler than the original proof of Robertson and Seymour. The proof is algorithmic and yields an efficient algorithm for finding the decomposition.

3. K. Kawarabayashi and P. Wollan, "A Shorter Proof of the Graph Minors Algorithm - The Unique Linkage Theorem." *Proceedings of the AMS Symposium on the Theory of Computing (STOC) 2010*, 687 – 694.

   The Unique Linkage Theorem is the technical basis of the proof of correctness of Robertson and Seymour's polynomial time algorithm for minor testing and the disjoint paths problem. The theorem is proven in Graph Minors 22 and the proof hinges upon the full power of the graph minor theory. Robertson and Seymour pose as an open problem to give a simpler proof: in this paper, we resolve this problem by giving a simpler proof of the Unique Linkage Theorem which specifically does not rely on the Graph Minor Structure Theorem.

4. H. Bruhn, R. Diestel, M. Kriesell, R. Pevindigh, and P. Wollan, "Axioms for Infinite Matroids." *Advances in Mathematics.* **239** (2013) 18 – 46.

   In 1966, Rado asked if it would be possible to develop a theory of non-finitary infinite matroids which included matroid duality. Numerous models were proposed, however no solution was broadly accepted. In this article, we develop a model of infinite matroids which admits multiple axiomatic formulations mirroring the axiomatic formulations of finite matroids. This formulation contains many of the common matroid features such as duality, minors, and connectivity, and serves as a starting point for a theory of infinite matroids.

5. S. Norine, P. Seymour, R. Thomas, and P. Wollan, "Proper Minor-Closed Families are Small." *J. Combin. Theory, Ser. B* **96**, (2006) 754 – 757.

   This paper resolves an open question of Welsh on the number of distinct labeled graphs in a fixed minor closed class of graphs.

6. R. Thomas and P. Wollan, "An Improved Linear Edge Bound for Graph Linkages." *European J. of Combinatorics* **26**, (2005) 309 – 324.

   This article gives a new proof that linear connectivity suffices to force a graph to be k-linked, improving on a result of Bollobás and Thomason from 1998. The proof is much simpler than the probabilistic proof of Bollobás and Thomason; our proof has been included in it's entirity in the subsequent editions of Reinhard Diestel's standard graduate textbook "Graph Theory".

List of Publications

JOURNAL PUBLICATIONS:

1. R. Thomas and P. Wollan, "An Improved Linear Edge Bound for Graph Linkages." *European J. of Combinatorics* **26**, (2005) 309 – 324.
2. G. Brinkmann, S. Greenberg, C. Greenhill, B. McKay, R. Thomas, and P. Wollan, "Generation of Simple Quadrangulations of the Sphere." *Discrete Math.* **305**, (2005) 33 – 54.
3. K. Kawarabayashi and P. Wollan, "Non-zero Disjoint cycles in Highly Connected Group Labeled Graphs." *J. Combin. Theory, Ser. B* **96**, (2006) 296 – 301.
4. S. Norine, P. Seymour, R. Thomas, and P. Wollan, "Proper Minor-Closed Families are Small." *J. Combin. Theory, Ser. B* **96**, (2006) 754 – 757.
5. P. Wollan, "Extremal Functions for Shortening Sets of Paths." *Combinatorics, Probability, and Computing* **15**, (2006) 927 – 932.
6. R. Thomas and P. Wollan, "The Extremal Function for 3-linked Graphs." *J. Combin. Theory, Ser. B* **98**, (2008) 939 – 971.
7. K. Kawarabayashi, O. Lee, B. Reed, and P. Wollan, "A Weaker Version of Lovász' Path Removal Conjecture." *J. Combin. Theory, Ser. B* **98**, (2008) 972 – 979.
8. P. Wollan, "Extremal Functions for Rooted Minors." *J. Graph Theory* **58** vol. 2, (2008) 159 – 178.
9. P. Wollan, "Packing Non-zero A-paths in an Undirected Model of Group Labeled Graphs." *J. Combin. Theory, Ser. B* **100**, (2010) 141 – 150.
10. D. Berg, S. Norine, F. E. Su, R. Thomas, and P. Wollan, "Voting in Agreeable Societies." *AMS Math. Monthly* **117**, (2010) 27 – 39.
11. P. Wollan, "Bridges in Highly Connected Graphs." *SIAM J. Disc. Math.* **24**, (2010) 1731 – 1741.
12. P. Wollan, "Packing Cycles with Modularity Constraints." *Combinatorica* **31**, (2011) 95 – 126.
13. R. Diestel, K. Kawarabayashi, and P. Wollan, "The Erdős-Pósa Property for Clique Minors in Highly Connected Graphs." *J. Combin. Theory, Ser. B* **102**, (2012) 454 – 469.
14. H. Bruhn and P. Wollan, "Finite Connectivity in Infinite Matroids." *European J. of Combinatorics* **33** (2012) 1900 – 1912.
15. M. Pontecorvi and P. Wollan, "Disjoint Cycles Intersecting a Set of Vertices." *J. Combin. Theory, Ser. B* **102** (2012) 1134 – 1141.
16. R. Diestel, K. Kawarabayashi, T. Müller, and P. Wollan, "On the Excluded Minor Structure Theorem for Graphs of Large Tree-width." *J. Combin. Theory, Ser. B* **102** (2012) 1189 – 1210.
17. B. Guenin, I. Pivotto, and P. Wollan, "Relations Between Pairs of Representations of Signed Binary Matroids." *SIAM J. Disc. Math.* **27** (2013) 329 – 341.
18. H. Bruhn, R. Diestel, M. Kriesell, R. Pevindigh, and P. Wollan, "Axioms for Infinite Matroids." *Advances in Mathematics* **239** (2013) 18 – 46.
19. D. Marx and P. Wollan, "Immersions in highly connected graphs" *SIAM J. of Disc. Math.* **28**(1) (2014) 503 – 520.

20. P. Wollan, "The structure of graphs not admitting a fixed immersion." to appear: *J. Combin. Theory, Ser. B.*

REFEREED CONFERENCE PROCEEDINGS:

21. K. Kawarabayashi and P . Wollan, "A Shorter Proof of the Graph Minors Algorithm - The Unique Linkage Theorem." *Proceedings of the AMS Symposium on the Theory of Computing (STOC) 2010*, 687 – 694.
22. K. Kawarabayashi, B. Reed, and P. Wollan, "The Graph Minor Algorithm with Parity Conditions." *Proceedings of the IEEE Symposium on Foundations of Computer Science (FOCS) 2011*, 27 – 36.
23. K. Kawarabayashi and P. Wollan, "A Simpler Algorithm and Shorter Proof for the Graph Minors Decomposition." *Proceedings of the ACM Symposium on Theory of Computing (STOC) 2011*, 451 – 458.
24. M. Grohe, K. Kawarabayashi, D. Marx, and P. Wollan, "Finding Topological Subgraphs is Fixed Parameter Tractable." *Proceedings of the ACM Symposium on Theory of Computing (STOC) 2011*, 479 – 484.
25. D. Marx, and P. Wollan, "An Exact Characterization of Tractable Demand Patterns for Maximum Disjoint Path Problems." to appear: *Proceedings of the ACM/SIAM Symposium on Discrete Algorithms (SODA) 2015*.

SUBMITTED ARTICLES:

26. K. Kawarabayashi, S. Norine, R. Thomas and P. Wollan, "K_6 Minors in 6-connected Graphs of Bounded Treewidth." submitted to: *J. Combin. Theory, Ser. B.*
27. K. Kawarabayashi, S. Norine, R. Thomas, and P. Wollan, "K_6 Minors in Large 6-connected Graphs." submitted to: *J. Combin. Theory, Ser. B.*
28. B. Guenin, I. Pivotto, and P. Wollan, "Displaying Blocking Pairs in Signed Graphs." submitted to: *Europ. J. Combin.*
29. B. Guenin, I. Pivotto, and P. Wollan, "Stabilizer Theorems for Even Cycle Matroids." submitted to: *J. Combin. Theory, Ser B.*
30. K. Kawarabayashi, R. Thomas, and P. Wollan, "A new proof of the flat wall theorem." submitted to: *J. Combin. Theory, Ser B.*
31. D. Marx, P. Seymour, and P. Wollan, "Rooted grid minors." submitted to: *J. Combin. Theory, Ser B.*
32. Z. Dvorak and P. Wollan, "A structure theorem for strong immersions." submitted to: *J. Graph Theory.*
33. I. Bonacina, N. Galesi, T. Huynh, and P. Wollan, "Space proof complexity for random 3-CNFs via a $(2-\varepsilon)$-Halls Theorem." submitted to: *ACM Symposium on Theory of Computation (STOC 2015).*