Daniel Brosch

Curriculum Vitae

Personal Details

Date of birth	November 18, 1996
Place of birth	Leverkusen, Germany
Citizenship	German

PhD-Thesis

title	Symmetry Reduction in Convex Optimization with Applications in Combinatorics
main supervisor	*Etienne de Klerk*
co-supervisor	*Monique Laurent*
summary	We explore different approaches to and applications of symmetry reduction in convex optimization. Using tools from semidefinite programming, representation theory and algebraic combinatorics, we solve or bound hard problems coming from combinatorial optimization, energy minimization, queuing theory, and extremal combinatorics.
defended on	October 19, 2022.

Employment

December 2022 — today	**Postdoc Assistant**, *Department of Mathematics, University of Klagenfurt*, Austria
September 2022 — November 2022	**Senior Scientist**, *Department of Mathematics, University of Klagenfurt*, Austria
November 2018 — July 2022	**PhD-student**, *Tilburg University*, the Netherlands
January 2020 — March 2020	**Secondment**, *Centrum Wiskunde & Informatica*, Amsterdam, the Netherlands
October 2019 — December 2019	**Secondment**, *Ortec*, Zoetermeer, the Netherlands

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Education

2018 — 2022 **PhD in Mathematics**, *Tilburg University*, the Netherlands
Under supervision of *Etienne de Klerk* and *Monique Laurent*, as early stage researcher of the Marie-Curie innovative training network MINOA.

2017 — 2018 **Mathematics MSc**, *University of Cologne*, *cum laude*
Thesis: *Semidefinite Bounds for Unequal Error Protection Codes*, under supervision of *Frank Vallentin*.

2015 — 2017 **Mathematics BSc**, *University of Cologne*, *cum laude*
Thesis: *The Banach-Tarski Paradox*, under supervision of *Alexander Lytchak*.

2012 — 2015 **Project**, *Schülerinnen und Schüler an der Universität*, University of Cologne
Project that allowed me to attend university early in parallel to high school.

2008 — 2015 **Abitur**, *Otto-Hahn-Gymnasium*, Monheim am Rhein
Abitur in Mathematics, Physics, Latin, Philosophy

Papers

Accepted

2021 **Jordan symmetry reduction for conic optimization over the doubly nonnegative cone: theory and software**, *Optimization Methods and Software*, joint work with *Etienne de Klerk*, `https://doi.org/10.1080/10556788.2021.2022146`
We extend the Jordan Reduction method to the doubly nonnegative cone, and describe a Julia software package implementing it.

2021 **Optimizing hypergraph-based polynomials modeling job-occupancy in queueing with redundancy scheduling**, *SIAM Journal on Optimization*, joint work with *Monique Laurent* and *Andries Steenkamp*, `https://doi.org/10.1137/20M1369592`
We show that a family of highly symmetric polynomials is convex, thus (partially) solving a problem coming from queueing with redundancy scheduling. To do this, we exploit the symmetries of the Hessians of the polynomials algebraically.

2020 **Minimum energy configurations on a toric lattice as a quadratic assignment problem**, *Discrete Optimization*, joint work with *Etienne de Klerk*, `https://doi.org/10.1016/j.disopt.2020.100612`
We bound the potential energy of charged particles on an infinite, periodic grid from below, using semidefinite programming and symmetry reduction based on the Jordan Reduction method.

Preprints

2022 **New lower bounds on crossing numbers of $K_{m,n}$ from permutation modules and semidefinite programming**, joint work with *Sven Polak*, `https://arxiv.org/abs/2206.02755`
We symmetry reduce SDP-based bounds for the crossing number of complete bipartite graphs, and improve bounds both in the finite case and in the limit. We also introduce a new, slightly weaker, but computationally more efficient bound for the crossing number of $K_{m,n}$, allowing us to compute bounds for bigger parameters m and n.

Work in progress

2020– **More efficient and flexible flag-SOS hierarchies**
We exploit the symmetries of the SOS and moment hierarchies fully for the class of S_n-invariant polynomials over the k-subset-hybercube. This leads to computationally more efficient hierarchies equivalent to Razborov's Flag-SOS hierarchies, and extends their use case to finite and degenerate problems.

2021– **An efficient decomposition algorithm for quotients of permutation modules**

2021– **Generalized derivatives for extremal combinatorics in the theory of flags**

2022– **Möbius-transform based reductions for error correcting codes**, joint work with *Sven Polak*

2022– **The flag algebra of binary rooted trees**, joint work with *Diane Puges*

2022– **A generalized mixing method**, joint work with *Jan Schwiddessen*

2023– **Improved bounds for the Grothendieck constants**, joint work with *Nando Leijenhorst*, *Fernando Oliveira*, *Frank Vallentin*, *Angelika Wiegele*

2023– **The graph profile of even cycles**, joint work with *Greg Blekherman*

Software

2021 **SDPSymmetryReduction.jl**
Julia package for automatic symmetry reduction of SDPs using the Jordan Reduction method. Available at `https://github.com/DanielBrosch/SDPSymmetryReduction.jl`

Work in Progress

2021– **FlagSOS.jl**
Extendable Julia package for solving fully symmetry-reduced Flag-SOS problems for a variety of combinatorial objects.

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Programming Knowledge

Well familiar with Julia, C/C++, Python, Java and Matlab. Some experience with SageMath, Javascript and C#.

Teaching

University of Klagenfurt

Summer semester 2023 — **Lineare Algebra 2**
Exercise classes

Summer semester 2023 — **Linear Algebra for Engineers**
Exercise classes

Winter semester 2022–2023 — **Computermathematik für das Lehramt**

Winter semester 2022–2023 — **Proseminar Diskrete Mathematik**

Tilburg University

Summer semester 2022 — **Linear Algebra for Data Science**
Tutorials

Winter semester 2021–2022 — **Linear Optimization**
Tutorials and computer labs

Talks

April 15, 2023 — **Meeting on Applied Algebraic Geometry (MAAG) 2023**, Atlanta, USA
The Flag Algebra of Rooted Binary Trees.

April 14, 2023 — **Georgia Tech Graph Theory & Combinatorics Seminar**, Atlanta, USA
New lower bounds on crossing numbers of $K_{m,n}$.

February 22, 2023 — **Semidefinite optimization approaches to classical and quantum combinatorial optimization**, Cologne, Germany
SDPs for Extremal Combinatorics.

December 1, 2022 — **Three days of computational methods for extremal discrete geometry**, Cologne, Germany
New lower bounds on crossing numbers of $K_{m,n}$.

October 23, 2022 — **University of Klagenfurt**, Klagenfurt, Austria
Derivatives in Continuous Combinatorics.

July 26, 2022 — **ICCOPT**, Betlehem, PA, USA
Moebius-Transform Based Symmetry Reduction for Optimization in Binary Variables.

April 12, 2022 **Workshop on Conic Linear Optimization for Computer-Assisted Proofs**, Oberwolfach
The Symmetries of Flag-Algebras.

April 1, 2022 **Discrete Math Seminar**, University of Massachusetts Amherst
Symmetry reduced Flag-hierarchies.

March 23, 2022 **Polynomial optimization reading group**, CWI, Amsterdam
Symmetry reduced Flag-hierarchies.

August 20, 2021 **SIAM AG21**
More efficient and flexible Flag-Algebras coming from polynomial optimization.

July 20–23, 2021 **SIAM OP21**
More efficient and flexible Flag-Algebras coming from polynomial optimization.

February 2021 **Virtual OR seminar**, Tilburg University
More efficient and flexible Flag-Algebras.

January 2021 **Oberseminar Reelle Geometrie und Algebra**, Universität Konstanz
More efficient and flexible flag algebras.

January 2021 **Shared seminar Cologne Oberseminar/CWI reading group**
More efficient and flexible Flag-Algebras.

February 26, 2020 and March 4, 2020 **Polynomial optimization reading group**, CWI, Amsterdam
A two-part introduction to symmetry reduction for SDPs

August 7, 2019 **ICCOPT**, Berlin
Minimum energy configurations on a toric lattice as a quadratic assignment problem.

Conferences/Workshops/Summer Schools/Courses

April 15–16, 2023 **Meeting on Applied Algebraic Geometry (MAAG) 2023**, Atlanta, USA

February 22–23, 2023 **Semidefinite optimization approaches to classical and quantum combinatorial optimization**, Cologne

November 30–December 2 **Three days of computational methods for extremal discrete geometry**, Cologne

September 5–9, 2022 **Final POEMA workshop**, Paris

July 23–28, 2022 **ICCOPT**, Betlehem, PA, USA

June 7–9, 2022 **Nordic Combinatorial Conference (NORCOM)**, Tromsø

April 10–15, 2022 **Workshop on Conic Linear Optimization for Computer-Assisted Proofs**, Oberwolfach

June 21–29, 2021 **MINOA Doctoral School 2021**, Online

April 16, 2021	**General Julia training (POEMA)**, Online
March 4–5, 2021	**Second MINOA ESR days**, Online
March 1–3, 2021	**Annual MINOA Conference 2021**, Online
January—March 2021	**POEMA 3rd Workshop**, Online
December 1, 2020	**Complementary Skills Session on intellectual property rights**, Online
November 23–24, 2020	**First MINOA ESR days**, Online
October–December 2020	**POEMA 2nd Workshop**, Online
May 27–September 16, 2020	**POEMA Online Learning Weeks**, Online
January 6–10, 2020	**2nd MINOA conference**, Aussois, France
January 6–10, 2020	**24th Workshop on Combinatorial Optimization**, Aussois, France
September 9–November 11, 2019	**Interior Point Methods**, *LNMB PhD Course*, Etienne de Klerk, Utrecht, the Netherlands
August 5–8, 2019	**6th International Conference on Continuous Optimization (ICCOPT)**, Berlin, Germany
June 24–28, 2019	**1st MINOA PhD school**, *Mixed-Integer Nonlinear Optimization meets Data Science* , Ischia, Italy
January 14–16, 2019	**1st MINOA conference**, Aussois, France
January 14–16, 2019	**23rd Workshop on Combinatorial Optimization**, Aussois, France
January 7–11, 2019	**44th conference on the mathematics of operations research**, Lunteren, the Netherlands
November 19–February 18, 2019	**Networks and Semidefinite Programming**, *LNMB PhD Course*, Monique Laurent, Utrecht, the Netherlands
2019–Present	**CWI reading group on polynomial optimization**, *hosted by* Monique Laurent *and* Sven Polak, CWI, Amsterdam
2020–Present	**Oberseminar**, *hosted by* Frank Vallentin, Cologne

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