

# Daniel Brosch

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## *Curriculum Vitae*

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### Personal Details

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

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### PhD-Thesis (*Work in Progress*)

title Symmetry Reduction in Convex Optimization  
supervisors *Etienne de Klerk* and *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, extremal combinatorics and geometry.  
expected completion Q3 2022.  
date

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### Education

2018– **PhD-candidate**, *Tilburg University*, the Netherlands  
Symmetry Reduction in Convex Optimization. Under supervision of *Etienne de Klerk* and *Monique Laurent*.  
January 2020 – **Secondment**, *CWI*, Amsterdam, the Netherlands  
March 2020  
October 2019 – **Secondment**, *Ortec*, Zoetermeer, the Netherlands  
December 2019  
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 visit university early in parallel to high school.
- 2008–2015 **Abitur**, *Otto-Hahn-Gymnasium*, Monheim am Rhein  
Abitur in Mathematics, Physics, Latin, Philosophy

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## 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*, awaiting publication, preprint available at <https://arxiv.org/abs/2001.11348>  
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 are convex, thus (partially) solve a problem modeling queueing with redundancies. 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.

### 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 polynomials over the  $k$ -subset-hypercube. This leads on the one hand to computationally more efficient hierarchies equivalent to Razborov's Flag-SOS hierarchies. On the other, it extends their use cases to finite problems, as well as degenerate extremal problems.
- 2021– **Improved bounds for crossing numbers based on semidefinite programming**, joint work with *Sven Polak*  
We reduce SDP-based bounds for the crossing number of complete bipartite graphs, and improve bounds both in the finite case as well as the limit.

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## Software

2021 **SDPSymmetryReduction.jl**

Julia package to numerically reduce an SDP 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 reduced Flag-SOS problems for a variety of combinatorial objects.

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## Talks

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***, Uni 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 **Polynomial optimization reading group**, CWI, Amsterdam  
and March 4, 2020 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.

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## Conferences/Workshops/Summer Schools/Courses

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 3<sup>rd</sup> 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 2<sup>nd</sup> Workshop**, Online

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- May 27–September 16, 2020 **POEMA Online Learning Weeks**, Online
- January 6–10, 2020 **2<sup>nd</sup> MINOA conference**, Aussois, France
- January 6–10, 2020 **24<sup>th</sup> 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 **6<sup>th</sup> International Conference on Continuous Optimization (IC-COPT)**, Berlin, Germany
- June 24–28, 2019 **1<sup>st</sup> MINOA PhD school**, *Mixed-Integer Nonlinear Optimization meets Data Science*, Ischia, Italy
- January 14–16, 2019 **1<sup>st</sup> MINOA conference**, Aussois, France
- January 14–16, 2019 **23<sup>rd</sup> Workshop on Combinatorial Optimization**, Aussois, France
- January 7–11, 2019 **44<sup>th</sup> 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, Sven Polak, CWI, Amsterdam
- 2020–Present **Oberseminar**, *hosted by* Frank Vallentin, Cologne