

Georg Hahn

Personal information

Webpage: <http://www.cantab.net/users/ghahn/>
ArXiv: https://arxiv.org/a/hahn_g_1.html
Google scholar: [personal profile](#)
Orcid: <https://orcid.org/0000-0001-6008-2720>
Date of birth: 22 Oct 1985
Place of birth: Mainz, Germany
Nationality: German

Employment

07/2019 – current

Harvard University, Cambridge, USA

- ▷ Research associate in the Department of Biostatistics, Harvard T.H. Chan School of Public Health. Additionally, I hold an *Instructor* appointment in the T.H. Chan School of Public Health.
- ▷ Work on novel multiple testing approaches in large-scale genetic, genomic and imaging data sets.

10/2017 – 04/2019

Lancaster University, United Kingdom

- ▷ Senior Research Associate in the *StatScale* project, a £2.8M EPSRC programme grant between both Lancaster University and the University of Cambridge to develop next generation statistical methods for streaming data.
- ▷ Work on anomaly and changepoint detection methods in online settings: includes methodology development, consistency proofs, simulation studies in *R*.

06/2016 – 09/2017

Imperial College London, United Kingdom

- ▷ Awarded an EPSRC doctoral prize fellowship of the Mathematics Department.
- ▷ Development of algorithms for multiple hypothesis testing, including finite time methods, *R* package release, theoretical work on closure properties of testing procedures, empirical project on gender bias in grant application success rates.

Education

09/2015 – 05/2016

Columbia University, New York, USA

- ▷ Post-doctoral student in the Columbia Statistics Department. Simultaneously external affiliate with Los Alamos National Laboratory for one year.
- ▷ Studies on empirical process theory, development of methodology for *broken-stick* and *broken-plane* regression allowing for superlinear convergence rates.

10/2011 – 05/2015

Imperial College London, United Kingdom

- ▷ Ph.D. in mathematics and statistics (awarded 01 Jul 2015). Doctoral thesis on “Statistical Methods for Monte-Carlo based Multiple Hypothesis Testing” (degree defense on 28 May 2015). *Ph.D. awarded without corrections.*

- ▷ Methodological work on multiple hypothesis testing with Monte Carlo approximated p-values, proof of correctness of developed methods, *R* package release, real data studies in *R*, development of multiple testing heuristics and theoretical frameworks incorporating existing methods, optimality results.

02/2011 – 06/2011

Universidad Complutense de Madrid, Spain

- ▷ Erasmus foreign study in Spain (one semester) as exchange student in physics.
- ▷ Modules in Spanish on algebraic geometry, time series, thermodynamics, atomic and quantum physics.

10/2009 – 06/2010

University of Cambridge, United Kingdom

- ▷ Certificate of Advanced Study in Mathematics/ Part III (awarded 17 Jun 2010, MA.St. awarded in retrospect on 22 Oct 2011): merit (beta+)
- ▷ Modules: commutative algebra, elliptic curves, statistical theory, time series and Monte Carlo inference, mathematics of operational research.
- ▷ Part III essay on block-sorting data compression.

05/2008 – 01/2011

Johannes Gutenberg University, Mainz, Germany

- ▷ M.Sc. in Mathematics (awarded 24 Jan 2011): overall grade 1.0
- ▷ Modules: algebraic number theory, number theory, local fields, algebraic geometry, stochastic calculus, partial differential equations, numerics of partial differential equations, minor: computer science.
- ▷ Master’s thesis on proving primality in polynomial time.

04/2006 – 10/2008

Johannes Gutenberg University, Mainz, Germany

- ▷ Intermediate diploma in Physics (awarded 20 Oct 2008): overall grade 1.4
- ▷ Modules: experimental physics, theoretical physics, mathematics, minor: computer science.

04/2005 – 05/2008

Johannes Gutenberg University, Mainz, Germany

- ▷ B.Sc. in Mathematics (awarded 08 May 2008): overall grade 1.2
- ▷ Modules: algebra, computer algebra, analysis, differential equations and function theory, numerical mathematics, stochastic calculus, topology, numerical solutions of differential equations, minor: computer science.
- ▷ Bachelor’s thesis on parallel integer factorisation using the *Quadratic Sieve*.

Research visits

05/2019 – 06/2019

Los Alamos National Laboratory, New Mexico, USA

- ▷ Invited to Los Alamos to work on the project “Optimizing the spin reversal transform on the D-Wave 2000Q”.
- ▷ Explored ways of increasing the precision of the D-Wave 2000Q annealer through applying a tailored spin reversal to the QUBO/Ising problem under consideration.

08/2018 – 09/2018

Lawrence Livermore National Laboratory, California, USA

- ▷ Invited for a project on scalable neuromorphic computing.
- ▷ Explored suitability of IBM's *TrueNorth* neuromorphic chip for solving quadratic unconstrained binary optimisation (QUBO) problems. Developed methods to transform QUBO connectivity structure and to assess/improve precision.

03/2018 – 04/2018

University of Cambridge (Isaac Newton Institute), United Kingdom

- ▷ Research stay in Cambridge as part of the *StatScale* cooperation.

03/2017 – 04/2017

Los Alamos National Laboratory, New Mexico, USA

- ▷ Invited to Los Alamos for the *LDRD Rapid Response* research project “Preprocessing Methods for Scalable Quantum Annealing”.
- ▷ Explored the use of *persistency* and *roof duality* methods to reduce the number of binary variables in Ising models, thus increasing problem sizes soluble on a quantum annealer. Code written in Python.

08/2016 – 09/2016

Los Alamos National Laboratory, New Mexico, USA

- ▷ Invited to Los Alamos for the *ISTI NSEC* research project “Efficient combinatorial optimization using quantum computing” using one of the world's three available *D-WAVE 2X* quantum annealers.
- ▷ Compared D-Wave to best available heuristics for two NP-hard graph problems in order to demonstrate a *quantum advantage* for the two problem classes.

06/2015 – 08/2015

Los Alamos National Laboratory, New Mexico, USA

- ▷ Selected as one of six participants of the *Information Science and Technology Center (ISTI/ASC) Co-Design Summer School* as a fully funded Ph.D. student.
- ▷ Extended state-of-the-art molecular dynamics software (in C++) with novel graph partitioning methods for faster molecular dynamics simulations.

08/2014 – 09/2014

Columbia University, New York, USA

- ▷ Research visit of the Mailman School of Public Health during my Ph.D.
- ▷ Work on central limit theorems in physics with Professor Ian McKeague, Columbia University. Conducted simulations in *R* and contributed to shortening of proofs.

11/2010 – 01/2011

Max Planck Institute for polymer research, Mainz, Germany

- ▷ Internship: student assistant programmer under the guidance of Dr Christoph Junghans and Dr Victor Rühle.
- ▷ Software development in C++ for the institute's *VOTCA* molecular dynamics package (spline fitting, documentation, php scripts for the *VOTCA* webpage).

Publications

Journal publications:

✉ denotes corresponding author

1. Djidjev, H., Hahn, G.✉, Mniszewski, S., Negre, C. and Niklasson, A. (2019). Using Graph Partitioning for Scalable Distributed Quantum Molecular Dynamics. *Algorithms*, 12(9), 187. *Invited article for the Special Issue on Graph Partitioning: Theory, Engineering, and Applications*.
2. Chapuis, G., Djidjev, H., Hahn, G.✉ and Rizk G. (2019). Finding Maximum Cliques on the D-Wave Quantum Annealer. *J Sign Process Syst*, 91(3–4):363–377.
3. Hahn, G.✉(2018). Closure properties of classes of multiple testing procedures. *AStA Adv Stat Anal*, 102(2):167–178.
4. Ghale, P., Kroonblawd, M., Mniszewski, S., Negre, C., Pavel, R., Pino, S., Sardeshmukh, V., Shi, G. and Hahn, G.✉(2017). Task-based Parallel Computation of the Density Matrix in Quantum-based Molecular Dynamics using Graph Partitioning. *SIAM J Sci Comput*, 39(6):C466–C480.
5. Gandy, A. and Hahn, G.✉(2017). QuickMMCTest: quick multiple Monte Carlo testing. *Stat Comput*, 27(3):823–832.
6. Gandy, A. and Hahn, G.✉(2016). A framework for Monte Carlo based multiple testing. *Scand J Stat*, 43(4):1046–1063.
7. Gandy, A. and Hahn, G.✉(2014). MMCTest – A Safe Algorithm for Implementing multiple Monte Carlo tests. *Scand J Stat*, 41(4):1083–1101.

Other publications:

1. Gandy, A.✉, Noven, R. and Hahn, G. (2018). Does the success of a grant application depend on gender, nationality, or ethnicity? An observational study. *SSRN:3272738*.
2. Djidjev, H., Chapuis, G., Hahn, G. and Rizk, G. (2016). Efficient Combinatorial Optimization Using Quantum Annealing. *Los Alamos Natl Lab Report*. [arXiv:1801.08653](https://arxiv.org/abs/1801.08653).
3. Hahn, G. (2015). Statistical Methods for Monte-Carlo based Multiple Hypothesis Testing. *Doctoral thesis at Imperial College London*.
4. Hahn, G. (2011). Polynomielle Primzahltests mit elliptischen Kurven. *Master thesis at the University of Mainz* (translation: *Polynomial primality tests with elliptic curves*).
5. Hahn, G. (2010). Block-Sorting Data Compression. *Cambridge Part III Essay*.
6. Hahn, G. (2008). Parallelisierte Faktorisierung mit dem Quadratischen Sieb. *Bachelor thesis at the University of Mainz* (translation: *Parallelised factorisation using the quadratic sieve*).

Conference papers:

1. Pelofske, E.✉, Hahn, G. and Djidjev, H. (2019). Solving large Minimum Vertex Cover problems on a quantum annealer. *Proceedings of the Computing Frontiers Conference CF'19* and [arXiv:1904.00051](https://arxiv.org/abs/1904.00051).
2. Pelofske, E.✉, Hahn, G. and Djidjev, H. (2019). Solving large Maximum Clique problems

on a quantum annealer. *Proceedings of the Intl Workshop on Quantum Technology and Optimization Problems QTOP 2019* and [arXiv:1901.07657](https://arxiv.org/abs/1901.07657).

3. Hahn, G. and Djidjev, H. (2017). Reducing Binary Quadratic Forms for More Scalable Quantum Annealing. *IEEE Intl Conference on Rebooting Computing 2017* and [arXiv:1801.08652](https://arxiv.org/abs/1801.08652).
4. Chapuis, G., Djidjev, H., Hahn, G. and Rizk, G. (2017). Finding Maximum Cliques on a Quantum Annealer. *Proceedings of the Computing Frontiers Conference CF'17* and [arXiv:1801.08649v1](https://arxiv.org/abs/1801.08649v1).
5. Pino, S., Kroonblawd, M., Ghale, P., Hahn, G., Sardeshmukh, V., Shi, G., Djidjev, H., Negre, C., Pavel, R., Bergen, B., Mniszewski, S. and Junghans, C. (2015). Task-based parallel computation of the density matrix in quantum-based molecular dynamics using graph partitioning. *Supercomputing sc15* and [poster pdf](#).
6. Djidjev, H., Hahn, G., Mniszewski, S., Negre, C., Niklasson, A. and Sardeshmukh, V. (2015). Graph Partitioning Methods for Fast Parallel Quantum Molecular Dynamics. *SIAM Workshop on Combinatorial Scientific Computing (CSC16)* and [arXiv:1605.01118](https://arxiv.org/abs/1605.01118).

Preprints/ Under review:

1. Hahn, G. and Lange, C. (2019). Implementation of local Jaccard stratification indices in sequencing data of COPD and childhood asthma. *Draft in preparation*.
2. Hahn, G. and Lange, C. (2019). Smoothed LASSO regression for polygenic risk scores. *Draft in preparation*.
3. Pelofske, E.[✉], Hahn, G. and Djidjev, H. (2019). Peering into the Anneal Process of a Quantum Annealer. [arXiv:1908.02691](https://arxiv.org/abs/1908.02691). *Under review*.
4. Pelofske, E.[✉], Hahn, G. and Djidjev, H. (2019). Optimizing the spin reversal transform on the D-Wave 2000Q. [arXiv:1906.10955](https://arxiv.org/abs/1906.10955). *Under review*.
5. Hahn, G.[✉], Fearnhead, P. and Eckley, I. (2019). Online changepoint detection via sequential multiple testing. *Draft in preparation*.
6. Hahn, G.[✉], Fearnhead, P. and Eckley, I. (2019). Fast computation of a projection direction for multivariate changepoint detection. *Under review*.
7. Hahn, G.[✉](2019). Lossless manipulation of QUBO and Ising connectivity structures. *Draft in preparation*.
8. Hahn, G.[✉](2019). Solving NP-complete problems with projections. *Draft in preparation*.
9. Hahn, G.[✉](2018). On the expected runtime of multiple testing algorithms with bounded error. [arXiv:1807.10801](https://arxiv.org/abs/1807.10801). *Under review*.
10. Hahn, G.[✉](2018). Optimal allocation of Monte Carlo simulations to multiple hypothesis tests. [arXiv:1502.07864](https://arxiv.org/abs/1502.07864). *Under review*.
11. Gandy, A., Hahn, G.[✉] and Ding, D. (2018). Implementing Monte Carlo Tests with P-value Buckets. [arXiv:1703.09305](https://arxiv.org/abs/1703.09305). *Under review*.
12. Ding, D., Gandy, A. and Hahn, G.[✉](2018). A simple method for implementing Monte

Carlo tests. [arXiv:1611.01675](https://arxiv.org/abs/1611.01675). *Under review*.

Selected invited talks and posters

1. Invited talk on “Preprocessing a QUBO for Quantum Annealing” at the *D-Wave Users Meeting* in Newport, RI, from 23–25 Sept 2019 funded by Los Alamos National Laboratory.
2. Invited talk on “Preprocessing a QUBO for Quantum Annealing” in the *Information Science and Technology Seminar Speaker Series* of Los Alamos National Laboratory, 04 June 2019.
3. Invited talk on “Computational effort of multiple hypothesis testing” at the *Jerusalem Joint Statistical Event 2018* in Jerusalem, Israel, 20 Dec 2018.
4. Invited talk of equal title in the *Stat/Data/UQ Seminar Series* of the Statistics Department of the University of Manchester, 20 Nov 2018.
5. Invited talk on “Quadratic unconstrained binary optimisation and recent advances in quantum annealing” in the *CQIF Seminar Series* of the Statistical Laboratory of the University of Cambridge, 08 Nov 2018.
6. Talk on “Selected topics in Multiple Hypothesis Testing and Quantum Annealing” in the *ASG Data Sciences Seminar* of Lawrence Livermore National Laboratory, 11 Sept 2018.
7. Invited talk on “Recent Advances in Quantum Annealing and Outlook on its Potential in Statistics” at the Isaac Newton Institute, University of Cambridge, 12 Apr 2018.
8. Invited poster presentation at the Salishan Conference on High-Speed Computing 2017 at the Salishan Lodge in Gleneden Beach, Oregon, USA from 24–27 Apr 2017.
9. Invited talk for the contributed session *High and infinite dimensional time series analysis* at *ERCIM 2016 (CMStatistics)* in Seville, Spain, from 09–11 Dec 2016.
10. Invited talk at the *Spotify* headquarters in New York on “Monte Carlo based Multiple Testing”, 20 Oct 2016.
11. Lecture in the *CCS-6 Statistical Sciences Seminar Series* of Los Alamos National Laboratory on “A Framework for Monte Carlo based Multiple Testing”, 22 Sep 2016.

Software packages

1. Author of the `BayesCpt` *R*-package on CRAN (to be submitted).
2. Co-author of the `simctest` *R*-package on CRAN, specifically author of the class `mmctest`. Written in *R*. Total of 13k downloads as of Nov 2018.
3. Author of the `ecpp` package for SAGE. Written in SAGE/Python.
4. Contributor to the `VOTCA` package for molecular dynamics simulation (modules for spline fitting, maintenance of analysis modules, documentation, php scripts for webpage) of the Max Planck Institute for polymer research, Germany. Written in *C++*. Total of 47 downloads as of Nov 2017.
5. Contributor to the *PROGRESS* package for quantum molecular dynamics at Los Alamos (specifically graph partitioning methods of the density matrix to speed up computations).

Written in C++. Internal use at Los Alamos National Laboratory only.

6. The `MMCTest` algorithm (see publications) has been made available for `MathWorks` by independent author Dylan Muir. Written in Matlab.

Scholarship awards, Travel grants, Prizes

Academic scholarships and awards:

1. Extension of my EPSRC doctoral prize fellowship for a two month teaching commitment at Imperial College London in Jan and Feb 2017 (£4,300).
2. EPSRC post-doctoral prize fellowship of £47,094 to continue research at Imperial College London for one year (06 Jun 2016 to 30 Sept 2017).
3. Roth scholarship to cover living expenses in London (academic years 2012–15): £15,590 (per annum) for a period of 2.5 years (total £38,975).
4. DAAD scholarship: external funding of €12,000 (academic year 2011–12) provided by the German Academic Exchange Service DAAD.
5. EPSRC (*Engineering and Physical Sciences Research Council*) scholarship to cover university fees at Imperial College London from 2011–15: £3,732 (per annum) for 3.5 years (total £13,062).
6. Erasmus scholarship for one exchange semester in Spain in 2011 (€2,000).

Research grants:

1. *Faculty Researcher Guest Agreement* invite to Los Alamos National Laboratory from 05 May to 08 June 2019 to participate in research on D-Wave’s spin reversal (\$7,500).
2. VSP (visiting scientists and professionals) invite to Lawrence Livermore National Laboratory from 06 Aug to 15 Sept 2018 to participate in current laboratory research (\$16,500).
3. Award of a *Research Impulse* grant by Imperial College London for a talk at the *10th International Conference on Multiple Comparison Procedures* from 20–23 Jun 2017 (£850).
4. Grant for a two-month research project (May and Jun 2017) on *Gender bias in grant application success rates* at Imperial College London (£4,300).
5. *LDRD Rapid Response* project funding for “Preprocessing Methods for Scalable Quantum Annealing” at Los Alamos National Laboratory in Mar and Apr 2017 (\$8,000).
6. *ISTI NSEC* project funding for “Efficient combinatorial optimization using quantum computing” at Los Alamos National Laboratory in Aug and Sept 2016 (\$10,000).
7. Invitation by Los Alamos National Laboratory, USA, to participate at its IS&T Co-Design Summer School from May to Aug 2015 (\$12,000 stipend and \$1,300 travel grant).

Other awards:

1. Travel grant by Los Alamos National Laboratory to present at the *D-Wave Users Meeting* in Newport, RI, from 23–25 Sept 2019 (\$700).
2. Travel grant by Los Alamos National Laboratory to present at the *Computing Frontiers*

- Conference CF'19* in Alghero, Sardinia, Italy, from 30 April to 02 May 2019 (\$1,400).
3. Travel grant by Los Alamos National Laboratory to present at the *IEEE Conference on Rebooting Computing* in Washington, DC, USA, from 06–07 Nov 2017 (\$500).
 4. Invitation to the *Salishan Conference on High-Speed Computing 2017* from 24–27 Apr 2017 which included flights, rental car and accommodation (total \$890).
 5. Travel grant by Los Alamos National Laboratory to participate in the *D-Wave “Qubits” Users Conference* in Santa Fe, New Mexico, USA, from 27–29 Sep 2016 (\$300).
 6. Winner in category *Materials Science* and *Spot Award* (\$250) for best interdisciplinary work at the *2015 Student Symposium* poster competition, Los Alamos, Aug 2015.
 7. EPSRC travel grant for the JSM2014 (Joint Statistical Meeting) conference in Boston, USA, and a research visit at Columbia University, New York, in Aug 2014 (total £2,300).
 8. Imperial College London yearly travel grants: £500 (per annum) for a period of 3.5 years from 2011 to 2015 (total £1,750).
 9. Winner of best statistics poster (£200) twice during internal poster competitions of the Mathematics Department of Imperial College London, 13 Mar 2012 and 07 Mar 2014.

Additional information

▷ Language skills:

1. German (native speaker)
2. English (IELTS score of 8.0 in 2010, lived in the U.K. and the USA for 7 years)
3. Spanish (advanced level C.1)
4. French (advanced level 5 out of 6)

▷ Computing skills:

1. daily use: R and L^AT_EX(at Imperial College and Lancaster), Python (at Los Alamos)
2. proficient: Java, Borland Delphi, SAGE, Matlab, Maple, MuPAD
3. other: C++, Singular, Pascal, Logo, text processing.

▷ Promoted to become a member of the German Physical Society DPG (*Deutsche Physikalische Gesellschaft*) in 2005 after having achieved the best Abitur result in physics at my high school.

▷ Lifelong member and *Scholar* (admitted as a Scholar in a ceremony on 01 Dec 2010 based on exam results) of Churchill College, University of Cambridge.

▷ Lifelong member of the International House community and residential member of the first International House in New York City (“i-house”) in 2015/6.

▷ Peer reviewer for the following journals: *Biometrika*, *Computational Statistics and Data Analysis*, *Statistics and Probability Letters*, *Journal of Statistical Planning and Inference*, *Statistics*, *Estudios de Economia*, *Pattern Recognition Letters*. Regular contributor to the *AMS Mathematical Reviews*.

▷ Member of the Royal Statistical Society of Great Britain (RSS) and attendee of various meetings in London.

Organised conferences

- ▷ *Young Statisticians' Meeting* YSM2013 at Imperial College London from 04–05 Jul 2013: Organiser (and head of the organising committee) of YSM, a yearly conference with around 100 participants from the United Kingdom and Europe. The invited guests included the current president and the immediate past-president of the Royal Statistical Society.

Selected contributed talks and posters

1. *Joint Statistical Meeting* JSM2019 in Denver, USA, from 27 Jul to 01 Aug 2019.
2. *International Conference on Computing Frontiers* ACM 2019 in Alghero, Sardinia, Italy from 30 April to 02 May 2019.
3. *IEEE Conference on Rebooting Computing* in Washington DC from 06–07 Nov 2017.
4. *Joint Statistical Meeting* JSM2017 in Baltimore, USA, from 29 Jul to 03 Aug 2017.
5. *10th International Conference on Multiple Comparison Procedures* MCP2017 at the University of California in Riverside, USA, from 20–23 Jun 2017.
6. *Joint Statistical Meeting* JSM2016 in Chicago, USA, from 30 Jul to 04 Aug 2016.
7. *Joint Statistical Meeting* JSM2015 in Seattle, USA, from 08–13 Aug 2015.
8. *Joint Statistical Meeting* JSM2014 in Boston, USA, from 02–07 Aug 2014.
9. *11th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC2014)* in Leuven, Belgium, from 06–11 Apr 2014.
10. *German Probability and Statistics Days* in Ulm, Germany, from 04–07 Mar 2014.
11. *8th International Conference on Multiple Comparison Procedures* MCP2013 at the University of Southampton from 09–11 Jul 2013.
12. *DAGStat2013* conference in Freiburg, Germany, from 18–23 Mar 2013.
13. Seminar series of the Neurotechnology Section in the Department of Bioengineering of Imperial College London on 13 Mar 2013.
14. *German Probability and Statistics Days* in Mainz, Germany, from 06–09 Mar 2012.
15. Presentation of my Part III essay topic *data compression* during the Students' Part III Seminar Series, Department of Mathematics, University of Cambridge, on 10 Mar 2010.

Teaching

1. Teaching at Imperial College London from 2011 to 2019:
 - ▷ Quarterly demonstration for various courses: M1M(Comp) Matlab, Civil Eng Year 1, Electrical Eng Year 2 Stats, M2S2 Statistical Modelling I, M1M(Comp) Maple, M1S Probability & Statistics I, M2S1 Probability & Statistics II, M4SC Scientific Computation.
 - ▷ Taught the two day course *LaTeX, R, and Sweave* for new masters students at Imperial College London on 06 and 07 Oct 2016.

- ▷ Personal tutoring for SAT examinations while at Imperial College London in 2013 and personal tutoring for statistics courses while at Columbia University in 2015–16.
 - ▷ Lecturer of the course *M5MS11 Statistics for Extreme Events* in the Spring term of 2017. This course is a module in the statistics master programme of Imperial College London. Since I had full lecturing responsibilities I also ran weekly office hours, offered regular problem classes and problem sheet grading, set the exam, supervised the examination, graded all exam papers and approved the final marking scheme.
 - ▷ June 2016 to Spring 2019: Co-supervision of a Ph.D. student in the Mathematics Department of Imperial College London (of Professor Axel Gandy). This includes giving assistance and feedback on publication writing, cross-checking of proofs and help with paper submissions.
2. Teaching at the T.H. Chan School of Public Health of Harvard University in 2019:
- ▷ Instructor for the course BST 234 together with Professor Christoph Lange.