

Daan Camps, PhD

COMPUTATIONAL SCIENTIST · APPLIED MATHEMATICIAN

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Dated: December 1, 2024.

Quantum computing and high performance computing (HPC) engineer in the Advanced Technologies Group at the National Energy Research Scientific Computing Center (NERSC) at Lawrence Berkeley National Laboratory. Working on the leading edge of technology, integrating quantum technologies with future HPC systems, and developing a quantum computing program at NERSC. Over 5 years research experience in quantum information and quantum algorithms, 9+ years experience in computational mathematics, and 2+ years experience as project engineer. Recent collaborations resulted in a robust publication record of 20 journal articles and 5 conference papers.

Work Experience

National Energy Research Scientific Computing Center (NERSC), Lawrence Berkeley National Laboratory

Berkeley, USA

QUANTUM COMPUTING AND HPC ARCHITECTURE AND PERFORMANCE ENGINEER IN
ADVANCED TECHNOLOGIES GROUP

Apr. 2022 - Current

- Working on integrating HPC with future quantum technologies,
- Benchmarking of heterogeneous quantum-classical systems,
- Developing and driving NERSC's quantum computing program and strategy,
- Research on quantum algorithms for scientific computing.

Lawrence Berkeley National Laboratory

Berkeley, USA

POSTDOCTORAL RESEARCHER IN COMPUTATIONAL MATHEMATICS

Nov. 2019 - Apr. 2022

- Research on quantum information and quantum algorithms with a focus on circuit compilation and synthesis,
- Completed projects on Hamiltonian simulation, quantum chemistry, quantum linear algebra, and quantum image processing,
- Software engineering of nonlinear tensor factorization package,
- Developed QCLAB, QCLAB++, F3C, F3C++, QPIXL++ and FunFact, FABLE,
- Team scientist.

KU Leuven

Leuven, Belgium

TEACHING ASSISTANT

Sep. 2015 - Jun. 2019

- Exercise sessions for courses on numerical modeling and approximation, numerical mathematics,
- Mentor of master student projects.

IPCOS NV

Leuven, Belgium

PROJECT ENGINEER IN DIGITAL OILFIELD TEAM

Aug. 2013 - Sep. 2015

- Deployment and maintenance of upstream production monitoring models based on real-time process data,
- Development and deployment of new data-driven pipeline leak detection models,
- Customer-oriented role: presenting on-site training sessions and providing end user support.

Skills, Competencies & Training

Programming

- MATLAB, C++, Python, Fortran 90.
- OpenMP and MPI.
- git, CMake

Open source projects

- QCLAB and QCLAB++: quantum circuit development, analysis and simulation.
- F3C and F3C++: fast and scalable quantum circuit compilation for Hamiltonian simulation.
- QPIXL++: efficient and compressible representations for quantum images.
- FunFact: tensor algebra and deep learning via Einstein notations.
- FABLE: generate quantum circuits for block encodings.

- Research interests** Quantum algorithms, Scalable quantum benchmarking, Quantum circuit synthesis, Numerical linear algebra, Tensor decomposition techniques, Manifold optimization, Eigenvalue problems, Randomized algorithms, Scientific machine learning,
- Communications Excellence (Haas Business School, UC Berkeley, 2023)
 - Mathematics of Big Data: Sketching and (Multi-)Linear Algebra (MSRI Graduate Summer School, 2021)
 - Fundamentals of Machine Learning (SOCN Graduate School, 2018)
 - Low-Rank Tensor Techniques (Hausdorff School, 2016)
- Formal training**

Personal & Communication

- Languages**
- Dutch: Native
 - English: Fluent
 - French: Moderate
- Teaching & Mentorship**
- TA for B.Sc. courses on numerical modeling and approximation, numerical mathematics at KU Leuven.
 - Mentor of M.Sc. thesis projects at KU Leuven.
 - Mentor of summer interns at Lawrence Berkeley National Laboratory.
 - Mentor of postdoctoral researchers at Lawrence Berkeley National Laboratory.

Publications & Preprints

- 2024 *The RQR algorithm*, Camps D., T. Mach, R. Vandebril, D. S. Watkins, arXiv:2411.17671.
- 2024 *Long-lived oscillations of metastable states in neutral atom systems*, Darbha S., Kornjača M., Liu F., Balewski J., Hirsbrunner M. R., Lopes P., Wang S., Van Beeumen R., Klymko K., Camps D., Phys. Rev. B 110, 155114, arXiv:2404.12371.
- 2024 *False vacuum decay and nucleation dynamics in neutral atom systems*, Darbha S., Kornjača M., Liu F., Balewski J., Hirsbrunner M. R., Lopes P., Wang S., Van Beeumen R., Camps D., Klymko K., Phys. Rev. B 110, 155103, arXiv:2404.12360.
- 2024 *Efficient Measurement-Driven Eigenenergy Estimation with Classical Shadows*, Shen Y., Buzali A., Hu H.-Y., Klymko K., Camps D., Yelin S. F., Van Beeumen R., arXiv:2409.13691.
- 2024 *Non-Clifford diagonalization for measurement shot reduction in quantum expectation value estimation*, Sawaya N., Camps D., Tubman N., Rotskoff G., LaRose R., arXiv:2408.11898.
- 2024 *Quantum Rational Transformation Using Linear Combinations of Hamiltonian Simulations*, Shen Y., Van Buggenhout N., Camps D., Klymko K., Van Beeumen R., arXiv:2408.07742.
- 2024 *Quantum-centric supercomputing for materials science: A perspective on challenges and future directions*, Future Generation Computer Systems, DOI:10.1016/j.future.2024.04.060
- 2024 *Evaluation of the classical hardware requirements for large-scale quantum computations*, Camps D., Rrapaj E., Klymko K., Austin B., Wright N.J. Proceedings of ISC-HPC24 Conference, DOI:10.23919/ISC.2024.10528937
- 2024 *Engineering quantum states with neutral atoms*, Balewski J., Kornjača M., Klymko K., Darbha S., Hirsbrunner M. R., Lopes P., Liu F., Camps D. arXiv:2404.04411.
- 2024 *Explicit Quantum Circuits for Block Encodings of Certain Sparse Matrices*, Camps D., Lin L., Van Beeumen R., Yang C., SIAM J. Matrix Anal. Appl. 45(1)DOI:10.1137/22M1484298, arXiv:2203.10236.
- 2024 *Quantum-parallel vectorized data encodings and computations on trapped-ions and transmon QPUs*, Balewski J., Amankwah M., Van Beeumen R., Bethel E., Perciano T., Camps D. Scientific Reports, DOI: 10.1038/s41598-024-53720-x, arXiv:2301.07841.
- 2024 *Simple Diagonal Designs with Reconfigurable Real-Time Circuits*, Shen Y., Klymko K., Rabani E., Camps D., Van Beeumen R., Lindsey M. arXiv:2401.04176.
- 2024 *Simulating dirty bosons on a quantum computer*, Bassman Oftelie L., Van Beeumen R., Camps D., de Jong W., Dupont M., New Journal of Physics, DOI:10.1088/1367-2630/ad1a2d, arXiv:2210.08386.
- 2023 *k-Commutativity and Measurement Reduction for Expectation Values*, Delfavero B., Sarkar R., Camps D., Sawaya N., LaRose R. arXiv:2312.11840.
- 2023 *Quantum-centric Supercomputing for Materials Science: A Perspective on Challenges and Future Directions*, arXiv:2312.09733.

- 2023 *A Performance Model for Estimating the Cost of Scaling to Practical Quantum Advantage*, Camps D., Klymko K., Austin B., Wright N. J., A, Proceedings of the SC '23 Workshops of The International Conference on High Performance Computing, Network, Storage, and Analysis, DOI:10.1145/3624062.3625533.
- 2023 *Efficient Quantum Counting and Quantum Content-Addressable Memory for DNA similarity*, Balewski J., Camps D., Klymko K., Tritt A, 2023 IEEE International Conference on Quantum Computing and Engineering (QCE), DOI:10.1109/QCE57702.2023.00050, arXiv:2308.00699.
- 2023 *HamLib: A library of Hamiltonians for benchmarking quantum algorithms and hardware*, Sawaya N., Marti-Dafcik D., Ho Y., Tabor D., Bernal D., Magann A., Premaratne S., Dubey P., Matsuura A., de Jong W., Benjamin S., Parekh O., Tubman N., Klymko K., Camps D. arXiv:2306.13126. Accepted in Quantum.
- 2023 *Estimating Eigenenergies from Quantum Dynamics: A Unified Noise-Resilient Measurement-Driven Approach*, Shen Y., Camps D., Darbha S., Szasz A., Klymko K., Williams-Young D., Tubman N., Van Beeumen R. arXiv:2306.01858.
- 2023 *Algebraic Compression of Free Fermionic Quantum Circuits: Particle Creation, Arbitrary Lattices and Controlled Evolution*, Kökcü E., Camps D., Bassman Oftelie L., de Jong W., Van Beeumen R., Kemper A. arXiv:2303.09538.
- 2023 *QCLAB++: Simulating Quantum Circuits on GPUs*, Van Beeumen R., Camps D., Mehta N. arXiv:2303.00123.
- 2023 *Exploring Finite Temperature Properties of Materials with Quantum Computers*, Powers C., Bassman Oftelie L., Camps D., de Jong W. A., Scientific Reports, DOI: 10.1038/s41598-023-28317-5, arXiv:2205.00081.
- 2022 *FABLE: Fast Approximate Quantum Circuits for Block-Encodings*, Camps D., Van Beeumen R. IEEE International Conference on Quantum Computing and Engineering (QCE), DOI: 10.1109/QCE53715.2022.00029, arXiv:2205.00081.
- 2022 *Quantum pixel representations and compression for N-dimensional images*, Amankwah M. G., Camps D., Bethel E.W., Van Beeumen R., Perciano T. Scientific Reports, DOI: 10.1038/s41598-022-11024-y.
- 2022 *Algebraic compression of quantum circuits for Hamiltonian evolution*, Kökcü E., Camps D., Bassman L., Freericks J.K., de Jong W.A., Van Beeumen R., Kemper A.F., Phys. Rev. A, DOI:10.1103/PhysRevA.105.032420.
- 2021 *An algebraic quantum circuit compression algorithm for Hamiltonian simulation*, Camps D., Kökcü E., Bassman L., de Jong W.A., Kemper A.F., Van Beeumen R., SIAM J. Matrix Anal. Appl. 43(3), DOI:10.1137/21M1439298, arXiv:2108.03283.
- 2021 *A multishift, multipole rational QZ method with aggressive early deflation*, Steel T., Camps D., Meerbergen K., Vandebril R., SIAM J. Matrix Anal. Appl. 42(2), 753–774. DOI: 10.1137/19M1249631
- 2020 *Approximate quantum circuit synthesis using block encodings*, Camps D., Van Beeumen R., Phys. Rev. A 102, 052411. DOI: 10.1103/PhysRevA.102.052411
- 2020 *Chemistry on quantum computers with virtual quantum subspace expansion*, Urbaneck M., Camps D., Van Beeumen R., de Jong W. A., J. Chem. Theory Comput. 16(9), 5425–5431. DOI: 10.1021/acs.jctc.0c00447
- 2020 *Quantum Fourier transform revisited*, Camps D., Van Beeumen R., Yang C., Numer. Linear Algebra Appl. 28(1). DOI: 10.1002/nla.2331
- 2020 *On pole-swapping algorithms for the eigenvalue problem*, Camps D., Mach T., Vandebril R., Watkins D. S., Electron. Trans. Numer. Anal. 52, 480–508. DOI: 10.1553/etna_vol52s480
- 2019 *Swapping 2x2 blocks in the Schur and generalized Schur form*, Camps D., Mastronardi N., Vandebril R., Van Dooren P., J. Comput. Appl. Math. 373. 112274. DOI: 10.1016/j.cam.2019.05.022
- 2019 *A rational QZ method*, Camps D., Meerbergen K., Vandebril R., SIAM J. Matrix Anal. Appl. 40(3), 943–972. DOI: 10.1137/18M1170480
- 2019 *An implicit filter for rational Krylov using core transformations*, Camps D., Meerbergen K., Vandebril R., Linear Algebra and its Applications, DOI: 10.1016/j.laa.2018.09.021
- 2014 *Block term decomposition for modelling epileptic seizures*, Hunyadi B., Camps D., Sorber L., Van Paesschen W., De Vos M., Van Huffel S., De Lathauwer L., EURASIP Journal on Advances in Signal Processing, DOI: 10.1186/1687-6180-2014-139

Education

KU Leuven (University of Leuven)

PHD IN COMPUTER SCIENCE AND APPLIED MATHEMATICS

- Thesis: *Pole swapping methods for the eigenvalue problem — Rational QR algorithms.*
- Generalized dense QR eigenvalue algorithms to rational QR methods.
- Implicitly restarted rational Krylov methods for large-scale, sparse eigenvalue problems.
- Focus on theory, numerical stability and efficient implementations.

Leuven, Belgium
Sep. 2015 - Sep. 2019

KU Leuven (University of Leuven)

M.SC.ENG. IN MATHEMATICAL ENGINEERING

- Thesis: 'Epileptic seizure monitoring using tensor decomposition techniques'.

Leuven, Belgium
Sep. 2011 - Jun. 2013

KU Leuven (University of Leuven)

M.SC. IN PHYSICS: ASTRONOMY AND ASTROPHYSICS

- Thesis: 'Herschel/PACS observations of water in the carbon-rich AGB star V Hya'.

Leuven, Belgium
Sep. 2009 - Sep. 2011

UHasselt (University of Hasselt)

B.SC. IN PHYSICS

Hasselt, Belgium
Sep. 2006 - Jun. 2010

Talks

Teratec Workshop

From HamLib to HamPerf: A Hamiltonian-Oriented Approach to Quantum Benchmarking

Reims, France
June 2024

ISC High Performance 2024

Evaluation of the classical hardware requirements for large-scale quantum computations

Hamburg, Germany
May 2024

DW75 Workshop

On Block Encodings of Matrices

Leuven, Belgium
May 2024

APS March Meeting

Exploring the Lieb lattice phase diagram using Rydberg atom quantum simulators

Minneapolis, MN, USA
March 2024

SC23 – The International Conference for High Performance Computing, Networking, Storage, and Analysis

A Performance Model for Estimating the Cost of Scaling to Practical Quantum Advantage

Denver, CO
November 2023

Intel Labs Quantum Seminar Series

Algebraic Compression of Free Fermionic Quantum Circuits

Virtual
September 2023

10th International Congress on Industrial and Applied Mathematics

FunFact: Tensor Decomposition, Your Way

Tokyo, Japan
August 2023

IonQ Quantum Seminar Series

Algebraic Compression of Free Fermionic Quantum Circuits

Virtual
May 2023

Guest lecture at San Francisco State University

Algebraic Compression of Free Fermionic Quantum Circuits

San Francisco, CA, USA
April 2023

APS March Meeting

Classical and Quantum Strategies to Boost Quantum Subspace Methods

Las Vegas, NV, USA
March 2023

IEEE International Conference on Quantum Computing and Engineering

FABLE: Fast Approximate Quantum Circuits for Block-Encodings

Broomfield, CO, USA
September 2022

XXI Householder Symposium on Numerical Linear Algebra

An Algebraic Quantum Circuit Compression Algorithm for Hamiltonian Simulation

Selva di Fasano, Italy
June 2022

CS Area 3rd Annual Postdoc Symposium

FunFact: a Tensor Algebra Language with Applications in Deep Learning

Berkeley, USA
Feb. 2022

SIAM Conference on Applied Linear Algebra

Approximate quantum circuit synthesis using block encodings

Virtual
May 2021

AIDE-QC All-Hands Meeting An Algebraic and Scalable Synthesis Algorithm for Computing Dynamic Simulation Constant-Depth Circuits	<i>Virtual</i> Apr. 2021
APS March Meeting Approximate quantum circuit synthesis using block encodings	<i>Virtual</i> Mar. 2021
SIAM Conference on Computational Science and Engineering Understanding the quantum Fourier transform through matrix decompositions	<i>Virtual</i> Mar. 2021
QIP Conference Approximate quantum circuit synthesis using block encodings	<i>Virtual (Munich, Germany)</i> Feb. 2021
CS Area 2nd Annual Postdoc Symposium Approximate quantum circuit synthesis using block encodings	<i>Berkeley, USA</i> Feb. 2021
Berkeley Lab Seminar Pole swapping methods for the eigenvalue problem – Rational QR algorithms	<i>Berkeley, USA</i> Sep. 2019
ICIAM Conference Pole swapping methods for the eigenvalue problem – Rational QR algorithms	<i>Valencia, Spain</i> Jul. 2019
ETNA25 Conference Approximate inverse-free rational Krylov methods and the link with FOM and GMRES	<i>Sardinia, Italy</i> May 2019
NASCA Conference A rational QZ method	<i>Kalamata, Greece</i> Jul. 2018
SIAM Conference on Applied Linear Algebra RQZ: A rational QZ method for the generalized eigenvalue problem	<i>Hong Kong</i> May. 2018
NUMA Internal Seminar Rational matrix algorithms for the generalized eigenvalue problem — Iterative and direct methods	<i>Leuven, Belgium</i> Oct. 2017
ILAS Conference Implicit restart of the rational Krylov method — Chasing algorithms for polynomial, extended and rational Krylov	<i>Iowa, USA</i> Jul. 2017
ILAS Conference Towards a computational efficient, implicitly restarted rational Krylov method	<i>Leuven, Belgium</i> Jul. 2016

Academic service

Reviewer for

IOP New Journal of Physics, ACM Transactions on Quantum Computing, IEEE Transactions on Quantum Engineering, npj Quantum Information, Quantum – the open journal for quantum science, Quantum Information & Computation, Journal of Computational Physics, Applied Mathematics and Computation, SIAM Journal on Matrix Analysis and Applications, Linear and Multilinear Algebra, Electronic Transactions on Numerical Analysis, IEEE International Conference on Quantum Computing and Engineering, The Journal of Supercomputing

Program Committee for

IEEE International Conference on Quantum Computing and Engineering 2022 & 2024

Honors & Awards

2024	1st Place Best Research Paper in Quantum Technologies and Systems Engineering (QTEM) track , IEEE International Conference on Quantum Computing and Engineering (QCE24).	<i>Montreal, Canada</i>
2024	Hans Meuer Award for Best Research Paper , ISC High Performance.	<i>Hamburg, Germany</i>
2018	SIAM Student Travel Award , SIAM Conference on Applied Linear Algebra.	<i>Hong Kong</i>