Daan **Camps**, PhD

COMPUTATIONAL SCIENTIST · APPLIED MATHEMATICIAN

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Dated: January 11, 2024.

Staff member in Advanced Technologies Group at NERSC working on integrating quantum technologies with future HPC systems. Previously, computational mathematics postdoctoral researcher at Lawrence Berkeley National Laboratory with a broad scientific interest and a passion for problem-solving. Almost 4 years research experience in quantum information and quantum algorithms, 8+ years experience in computational mathematics, and 2+ years experience as project engineer. Recent collaborations resulted in a robust publication record.

Work Experience

NERSC, Lawrence Berkeley National Laboratory
Berkeley, USA

COMPUTER SYSTEMS ENGINEER/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`,
- 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.

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,

Formal training

- 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 (Haussdorff School, 2016)

Personal & Communication

Languages

- Dutch: Native
- English: Fluent
- French: Moderate

Teaching

- 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 ***Efficient Quantum Trace Estimation 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-Commutatitivity 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.

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.

2023 ***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. arXiv:2301.07841.

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 *Explicit Quantum Circuits for Block Encodings of Certain Sparse Matrices*, Camps D., Lin L., Van Beeumen R., Yang C., arXiv:2203.10236. Accepted in SIAM J. Matrix Anal. Appl.

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*, Urbanek 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) — *Leuven, Belgium*
PhD in Computer Science and Applied Mathematics — *Sep. 2015 - Sep. 2019*

- 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.

KU Leuven (University of Leuven) — *Leuven, Belgium*
M.Sc.Eng. in Mathematical Engineering — *Sep. 2011 - Jun. 2013*

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

KU Leuven (University of Leuven) — *Leuven, Belgium*
M.Sc. in Physics: Astronomy and Astrophysics — *Sep. 2009 - Sep. 2011*

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

UHasselt (University of Hasselt) — *Hasselt, Belgium*
B.Sc. in Physics — *Sep. 2006 - Jun. 2010*

Talks

Intel Labs Quantum Seminar Series — *Virtual*
Algebraic Compression of Free Fermionic Quantum Circuits — *September 2023*

10th International Congress on Industrial and Applied Mathematics — *Tokyo, Japan*
FunFact: Tensor Decomposition, Your Way — *August 2023*

IonQ Quantum Seminar Series — *Virtual*
Algebraic Compression of Free Fermionic Quantum Circuits — *May 2023*

Guest lecture at San Francisco State University — *San Francisco, CA, USA*
Algebraic Compression of Free Fermionic Quantum Circuits — *April 2023*

APS March Meeting — *Las Vegas, NV, USA*
Classical and Quantum Strategies to Boost Quantum Subspace Methods — *Mar. 2023*

IEEE International Conference on Quantum Computing and Engineering — *Broomfield, CO, USA*
FABLE: Fast Approximate Quantum Circuits for Block-Encodings — *September 2022*

XXI Householder Symposium on Numerical Linear Algebra — *Selva di Fasano, Italy*
An Algebraic Quantum Circuit Compression Algorithm for Hamiltonian Simulation — *June 2022*

CS Area 3rd Annual Postdoc Symposium — *Berkeley, USA*
FunFact: a Tensor Algebra Language with Applications in Deep Learning — *Feb. 2022*

SIAM Conference on Applied Linear Algebra — *Virtual*
Approximate quantum circuit synthesis using block encodings — *May 2021*

AIDE-QC All-Hands Meeting — *Virtual*
An Algebraic and Scalable Synthesis Algorithm for Computing Dynamic Simulation Constant-Depth Circuits — *Apr. 2021*

APS March Meeting — *Virtual*
Approximate quantum circuit synthesis using block encodings — *Mar. 2021*

SIAM Conference on Computational Science and Engineering — *Virtual*
Understanding the quantum Fourier transform through matrix decompositions — *Mar. 2021*

QIP Conference — *Virtual (Munich, Germany)*
Approximate quantum circuit synthesis using block encodings — *Feb. 2021*

CS Area 2nd Annual Postdoc Symposium — *Berkeley, USA*
Approximate quantum circuit synthesis using block encodings — *Feb. 2021*

Berkeley Lab Seminar — *Berkeley, USA*
Pole swapping methods for the eigenvalue problem – Rational QR algorithms — *Sep. 2019*

ICIAM Conference — *Valencia, Spain*
Pole swapping methods for the eigenvalue problem – Rational QR algorithms — *Jul. 2019*

ETNA25 Conference — *Sardinia, Italy*
Approximate inverse-free rational Krylov methods and the link with FOM and GMRES — *May 2019*

NASCA Conference — *Kalamata, Greece*
A rational QZ method — *Jul. 2018*

SIAM Conference on Applied Linear Algebra — *Hong Kong*
RQZ: A rational QZ method for the generalized eigenvalue problem — *May. 2018*

NUMA Internal Seminar — *Leuven, Belgium*
Rational matrix algorithms for the generalized eigenvalue problem — Iterative and direct methods — *Oct. 2017*

ILAS Conference — *Iowa, USA*
Implicit restart of the rational Krylov method — Chasing algorithms for polynomial, extended and rational Krylov — *Jul. 2017*

ILAS Conference — *Leuven, Belgium*
Towards a computational efficient, implicitly restarted rational Krylov method — *Jul. 2016*

Academic service

Reviewer for

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, IOP New Journal of Physics, ACM Transactions on Quantum Computing