Tobias Michael **Fischbach**

Doctoral Researcher · Research Engineer

Interdisciplinary doctoral researcher and research engineer developing optimization systems, scientific software, and reproducible infrastructure. Expertise in quantum circuit optimization, mathematical optimization, search algorithms, ZX-calculus, HPC-scale experimentation, and extensible tooling in Python, C++, and Linux/NixOS ecosystems.

Contact

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Skills

Technical Skills

Languages
Python, C++, Bash, Julia, Nix

Quantum & Scientific Computing
Qiskit, PyZX, NumPy, Pandas, Matplotlib, scikit-learn

Systems & Infrastructure
Linux, NixOS, HPC, OpenMP, MPI, automation, reproducible environments

Research Areas
Quantum Circuit Optimization, Mathematical Optimization, ZX-calculus, Search Algorithms, Monte Carlo Simulation, Computational Physics

Communication
Mentoring, Scientific Writing, Technical Communication, Data Visualization

Languages & Interests

Languages

German (Native)
English (Fluent)
French (Advanced)
Spanish (Intermediate)

Interests

Programming & NixOS
Language Learning
Rugby
Weightlifting
Running

Selected Achievements

- Completed three bachelor's degrees and two master's degrees; currently pursuing a doctorate across institutions in Luxembourg, Germany, and France.
- Executed reproducible HPC experiments at scale across 3200 CPUs.
- Maintains a NixOS-related open-source project with approximately 40,000 Firefox addon derivations.
- Published work in quantum circuit optimization, energy-aware computing, and computational biophysics; recipient of the Young Academics Grant, 2nd place Best Poster Award at PhD Day 2023, and an honorable mention for the EQAI 2025 poster.

Experience

University of Luxembourg

Doctoral Researcher — *2022 - 2026*

Designed and implemented research software for quantum circuit optimization in the Parallel Computing and Optimization Group.

- Designed an extensible ZX-calculus-based optimization framework integrating with existing quantum transpilation pipelines.
- Developed search algorithms targeting two-qubit cost and T-gate reduction and formalized a metric-independent optimization approach.
- Built research tooling and experimental workflows for reproducible evaluation of compiler and optimization strategies.
- Mentored master's students, supervised an intern, and taught discrete mathematics.

University of Luxembourg

Research Assistant — *2020 - 2022*

Built high-performance scientific software for stochastic simulation of chemical reaction networks with rare-event sampling.

- Developed high-performance stochastic simulation software in modern C++.
- Executed reproducible large-scale stochastic simulation experiments across 3200 CPUs on HPC infrastructure.
- Developed automated visualization and analysis pipelines for large-scale simulation outputs.

Selected Projects

Declarative Firefox-Addons with NixOS — *2024 - Present*

- Maintains a NixOS-related open-source project with approximately 40,000 Firefox addon derivations.
- Built scraper-based update tooling to keep addon metadata and derivations current at scale; contributed upstream automation for generating the Zotero derivation.

Quantum Circuit Optimization Framework Using ZX-Calculus — *Exp. 2024-2026*

- Designed a ZX-calculus-based quantum circuit optimization framework integrating with existing transpilation pipelines.
- Implemented search strategies including depth-first search, iterative deepening depth-first search, limited discrepancy search, and lexicographic search.
- Developed a local elimination algorithm targeting T-gates and structured the framework for extensibility, reproducible experimentation, and downstream compiler integration.

Measuring the Energy Consumption of Computation — *2022 - 2024*

- Built an energy-measurement setup by integrating current sensors into standard x86 motherboards.
- Synchronized physical power measurements with `perf`-based software instrumentation and developed a minimal NixOS-based Linux environment to improve measurement reproducibility.

Modern Stochastic Simulation Algorithms — *2020 - 2022*

- Developed Monte Carlo simulation tooling for chemical reaction networks with rare-event sampling.
- Implemented scalable C++ software with OpenMP and MPI support for HPC execution.
- Analyzed non-equilibrium network current and entropy production through reproducible large-scale stochastic simulation experiments across 3200 CPUs on HPC infrastructure.

Selected Publications

Publications in quantum circuit optimization, computational physics, and energy-aware computing.

Exhaustive Search for Quantum Circuit Optimization Using ZX Calculus *2026*
Tobias M. Fischbach, Pierre Talbot, Pascal Bouvry
Research on exhaustive search, pruning, and ZX-calculus-based optimization integrated as a compiler pass with PyZX and Qiskit.

A Review on Quantum Circuit Optimization using ZX-Calculus *2025*
Tobias M. Fischbach, Pierre Talbot, Pascal Bouvry
Survey of ZX-calculus-based optimization methods, target metrics, architectures, and open research problems.

How Protein Hydration Depends on Amino Acid Composition, Peptide Conformation, and Force Fields *2025*
Johanna-Barbara Linse, Tobias M. Fischbach, Jochen S. Hub
Computational biophysics publication combining molecular dynamics simulation with SAXS analysis.

Challenges in Automatic Software Optimization: the Energy Efficiency Case *2023*
Tobias M. Fischbach, Emmanuel Kieffer, Pascal Bouvry
Publication on energy-aware software optimization and measurement challenges in HPC contexts.

Education

Interdisciplinary education spanning physics and computer science across German-, French-, and English-speaking academic systems.

Doctorate

Docteur en Informatique
University of Luxembourg *2022 - Present*
- Doctoral thesis: "End-to-End Quantum Circuit Optimization using ZX-Calculus"
- Focus: ZX-calculus, quantum circuit optimization, search algorithms, and scientific computing; thesis defended, graduation pending

Double Master's Degrees

Master of Science in Physik
Universität des Saarlandes *2019 - 2022*
- Master thesis: "Hydration shell of intrinsically disordered proteins"
- Emphasis on computational biophysics, molecular dynamics simulation, and quantitative analysis

Master of Science in Condensed Matter Physics
University of Luxembourg *2019 - 2022*
- Advanced training in condensed matter physics, computational physics, and scientific computing
- Presented on explainable AI in a seminar focused on theory and current artificial intelligence research

Triple Bachelor's Degrees

Bachelor of Science in Physik
Universität des Saarlandes *2014 - 2019*
- Bachelor thesis: "Molekulardynamik Simulationen von Hydrophobin-Doppelschichten"
- Applied molecular dynamics simulation and data analysis to investigate candidate membrane structures

Bachelor en Science et Ingénierie (académique) - filière physique
University of Luxembourg *2014 - 2019*
- Physics-focused curriculum completed within a multilingual and international academic program
- Built analytical and numerical problem-solving skills across physics and mathematics coursework

Licence Mention Physique-Chimie - (parcours Physique)
Université de Lorraine *2014 - 2019*
- Completed physics and chemistry training in French within a cross-border degree program
- Strengthened adaptability and scientific communication through full academic coursework in French

Selected Talks

End-to-End Quantum Circuit Optimization using ZX-Calculus *2026*
Defense talk presenting an end-to-end ZX-based optimization pipeline that combines metric-agnostic diagram rewriting with extraction-aware optimization and benchmarking.

A Review on Quantum Circuit Optimization using ZX-Calculus *2026*
Invited talk at the international ZX-Seminar giving an overview of the state-of-the-art in ZX-based quantum circuit optimization and presenting the ZX-Benchmark framework.

EQAI 2025: Exhaustive Search for Quantum Circuit Optimization using ZX Calculus *2025*
Poster presentation on exhaustive search of ZX-diagrams and machine-learning directions for optimization.

OLA 2025: Exhaustive Search for Quantum Circuit Optimization using ZX Calculus *2025*
Presented the exhaustive-search framework for ZX-calculus-based quantum circuit optimization.

OLA 2023: Challenges in Automatic Software Optimization: the Energy Efficiency Case *2023*
Conference talk on energy-aware optimization of software using LLVM compiler passes.