Timon Alexander Hilker

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Research Interests

General Quantum technology, strongly correlated quantum systems, quantum simulations, quantum computing, atomic physics, quantum optics, condensed matter theory

Specific Ultracold neutral atoms, optical lattices, Hubbard models, high-resolution imaging, far-from-equilibrium dynamics

Research

since 2024/06 **Reader**, *Department of Physics*, University of Strathclyde, Glasgow, UK.
In my research, I perform quantum simulations with neutral ultracold atoms in optical lattices to understand and control many-body quantum systems. I work in the Ultracold Matter and Quantum Technologies (UMQT) group and started an independent lab in 2025, where I am building a quantum gas microscope for lithium atoms to study interacting quantum systems at the level of individual particle.

2020/09 – 2024/06 **Group leader**, *Max Planck Institute of Quantum Optics*, Garching, Germany.
I led/co-led three research teams focused on the development and application of quantum simulators with ultracold atoms and molecules in optical lattices. With a quantum gas microscope of fermionic lithium, we are studying strongly correlated phases of the Hubbard model through spin and charge correlations. In a new project, we are advancing this technology via programmable one- and two-atom gates to a scalable quantum computer of neutral atoms. The research is part of the Quantum-Many-Body Division of I. Bloch.

2018/03 – 2020/08 **Postdoc / Marie Skłodowska-Curie fellow**, *Cavendish Laboratory*, University of Cambridge, UK.
In the group of Z. Hadzibabic, I worked with homogeneous Bose-Einstein condensates in box traps and studied quantum hydrodynamics as well as universality far from equilibrium.

2017/11 – 2018/02 **Postdoc**, *Max Planck Institute of Quantum Optics*, Garching, Germany.
In the time following my PhD, I performed hardware and software upgrades of the quantum gas microscope and finished projects on quantum magnetism.

2011/10 – 2017/11 **PhD, Diploma student**, *MPI of Quantum Optics*, Garching, Germany.
Supervised by I. Bloch and C. Gross, I planned and constructed a versatile lattice experiment for fermionic lithium with single-site and single-spin detection. Starting from an empty lab, we developed novel imaging and cooling techniques and conducted quantum simulation experiments. We were among the first to realize antiferromagnetic correlations in Fermi Hubbard systems and with advanced correlation functions we could demonstrate spin-charge separation in one-dimensional doped systems and directly image magnetic polarons in strongly correlated 2d systems.

2009/10 – 2010/08 **Bachelor student**, *Walter Schottky Institut*, Garching, Germany.
In the group of M. Brandt, I characterized phosphorus donors in silicon with electron spin resonance using an ultra-broadband on-chip antenna that we developed.

Teaching

2026	Advanced Topics of Quantum Optics	5th year/Master, *Univ. Strathclyde*, lecture
2025	Topics of Quantum Physics	4th year/Master, *Univ. Strathclyde*, lecture
2024	Topics of Quantum Physics	4th year/Master, *Univ. Strathclyde*, lecture
2023/24	Quantum Comp. and Simulation with Ultracold Matter, Master, *LMU Munich*, seminar	
2022/23	Quantum Comp. and Simulation with Ultracold Matter, Master, *LMU Munich*, seminar	
2021/22	Quantum Comp. and Simulation with Ultracold Matter, Master, *LMU Munich*, seminar	
2020	Quantum Simulations	4th year, *Univ. Cambridge*, supervision
2019	Atomic Physics	4th year, *Univ. Cambridge*, supervision
2019/20	Physics 1B Part B	2nd year, *Univ. Cambridge*, supervision
2019	Quantum Simulations	4th year, *Univ. Cambridge*, supervision
2018	Atomic Physics	4th year, *Univ. Cambridge*, supervision
2018/19	Physics 1A	1st year, *Univ. Cambridge*, supervision
2015/16	Introduction to Quantum Optics	Massive Open Online Course, *Coursera*, tutor
2013	Atomic Physics	2nd year, *LMU Munich*, tutor
2012	Theoretical Physics 1	1st year, *TU Munich*, tutor
2011/12	Experimental Physics 1	1st year, *TU Munich*, tutor
2010	Theoretical Physics 1	1st year, *TU Munich*, tutor
2009/10	Experimental Physics 1	1st year, *TU Munich*, tutor

Education

2012/10 – 2017/11 **Promotion Physik (PhD)**, *MPI of Quantum Optics*, Garching, Germany, – *Summa cum laude*.
Development of a microscope for ultracold lithium with single-atom resolution and experimental quantum simulations of strongly correlated matter in the group of I. Bloch,
Title: *'Spin-resolved microscopy of strongly correlated fermionic many-body states'*

2008/10 – 2012/10 **Diplom Physik (Master)**, *Technische Universität München, Germany*, Grade – 1.0.
Specialization: Quantum optics, Condensed matter theory
Thesis (Group I. Bloch): *'Laser cooling of bosonic and fermionic lithium'*

2007/10 – 2010/08 **Bachelor Engineering Physics**, *Technische Universität München, Germany*, Grade – 1.1.
Specialization: Energy Science, Semiconductor physics
Thesis (Group M. Brandt): *'Broadband detection of magnetic resonances with stripline antennas'*

2006/06 **Abitur**, *Gymnasium Wolbeck*, Münster, Germany, Grade – 1.0.
Major: Mathematics, English

Study Abroad

2010/08 – 2011/05 **Graduate Studies**, *University of Illinois*, Urbana-Champaign, IL, USA.
Advanced physics lectures and lab work supported by a Fulbright scholarship

2003/08 – 2004/06 **High School Year**, *Catholic High School*, Huntsville, AL, USA, GPA – 4.29/4.33.
Year abroad with a host family, graduating with a US High School Diploma

Awards and Scholarships

since 2025 ***ERC Starting Grant*** FOrbQ at University of Strathclyde, Glasgow

2020 – 2021 *Max Planck Harvard Research Center of Quantum Optics* Postdoctoral Fellow at MPQ

2019 – 2020 ***Marie Skłodowska-Curie Fellow*** (EU) at Cavendish Laboratory, Cambridge

2018 – 2021 *Teaching Bye-Fellow* at Fitzwilliam College, Cambridge

2010 – 2011 ***Fulbright Scholarship*** for a year at a US university (Univ. of Illinois at Urbana-Champaign)

2007 – 2012 ***Studienstiftung des deutschen Volkes*** (Fellow of the *German Academic Scholarship Foundation*)

2007 – 2012 *Max-Weber-Program* of the state of Bavaria

Scientific Publications

Nature 2026 *'High-fidelity collisional quantum gates with fermionic atoms'*.
P. Bojović, T. Hilker, S. Wang, J. Obermeyer, M. Barendregt, D. Tell, T. Chalopin, P.M. Preiss, I. Bloch, and T. Franz. *Nature* **651**, 602 (2026).

Opt. Express 2026 *'Tunable optical lattices for the creation of matter-wave lattice solitons'*.
R. Cruickshank, A. La Rooij, E. Kerr, T. Hilker, S. Kuhr, and E. Haller. *Optics Express* **34**, 623-637 (2026).

PRA 2026 *'Quantum-gas microscopy and Talbot interferometry of the Bose-glass phase'*.
L. Koehn, C. Parsonage, C.W. Duncan, P. Kirton, A. Daley, T. Hilker, E. Haller, A. La Rooij, and S. Kuhr. *Physical Review A* **113**, 043303 (2026).

PNAS 2026 *'Observation of emergent scaling of spin-charge correlations at the onset of the pseudogap'*.
T. Chalopin, P. Bojović,S. Wang, T. Franz, A. Sinha, Z. Wang, D. Bourgund, J. Obermeyer, F. Grusdt, A. Bohrdt, L. Pollet, A. Wietek, A. George, T. Hilker and I. Bloch.
Proceedings of the National Academy of Sciences **123**(4), p. e2525539123 (2026).

Nature 2025 *'Formation of individual stripes in a mixed-dimensional cold-atom Fermi–Hubbard system'*.
D. Bourgund, T. Chalopin, P. Bojović, H. Schlömer, S. Wang, T. Franz, S. Hirthe, A. Bohrdt, F. Grusdt, I. Bloch, and T. Hilker. *Nature* **637**, 57 (2025).

PRL 2025 Editor's suggestion *'Experimental Observation of Single- and Multisite Matter-Wave Solitons in an Optical Accordion Lattice'*.
R. Cruickshank, F. Lorenzi, A. La Rooij, E.F. Kerr, T. Hilker, S. Kuhr, L. Salasnich, and E. Haller. *Physical Review Letters* **134**, 053402 (2025).

PRL 2025 *'Optical superlattice for engineering Hubbard couplings in quantum simulation'*.
T. Chalopin, P. Bojović, D. Bourgund, S. Wang, T. Franz, I. Bloch, and T. Hilker.
Physical Review Letters **134**, 053402 (2025).

PRX Quantum 2024 *'Local control and mixed dimensions: Exploring high-temperature superconductivity in optical lattices'*.
H. Schlömer, H. Lange, T. Franz, T. Chalopin, P. Bojović, S. Wang, I. Bloch, T. Hilker, F. Grusdt, and A. Bohrdt. *PRX Quantum* **5**, 040341 (2024).

Nature 2024 *'Ultracold Field-Linked Tetratomic Molecules'*.
X.-Y. Chen, S. Biswas, S. Eppelt, A. Schindewolf, F. Deng, T. Shi, S. Yi, T. Hilker, I. Bloch, and X.-Y. Luo. *Nature* **626**, 283 (2024)

Nature 2023 *'Universal equation of state for wave turbulence in a quantum gas'*.
L. H. Dogra, G. Martirosyan, T. Hilker, J. A. P. Glidden, J. Etrych, A. Cao, C. Eigen, R. P. Smith, and Z. Hadzibabic. *Nature* **620**, 521 (2023).

Comm. Materials 2023 *'Quantifying hole-motion-induced frustration in doped antiferromagnets by Hamiltonian reconstruction'*.
H. Schlömer, T. Hilker, I. Bloch, U. Schollwöck, F. Grusdt, and A. Bohrdt.
Nature Communication Materials **4**, 64 (2023)

Nature 2023 *'Field-linked resonances of polar molecules'*.
X.-Y. Chen*, A. Schindewolf*, S. Eppelt, R. Bause, M. Duda, S. Biswas, T. Karman, T. Hilker, I. Bloch, and X.-Y. Luo. *Nature* **614**, 59 (2023).

Nature 2023 *'Magnetically mediated hole pairing in fermionic ladders of ultracold atoms'*.
S. Hirthe, T. Chalopin, A. Bohrdt, D. Bourgund, P. Bojović, F. Grusdt, E. Demler, I. Bloch, and T. Hilker. *Nature* **613**, 463 (2023).
Presented in a Nature Research Briefing.

Nature 2022 *'Realising the symmetry-protected Haldane phase in Fermi-Hubbard ladders'*.
P. Sompet*, S. Hirthe*, D. Bourgund*, T. Chalopin, J. Bibo, J. Koepsell, P. Bojović, R. Verresen, F. Pollmann, G. Salomon, C. Gross, T. Hilker, and I. Bloch.
Nature **606**, 484 (2022).

PRL 2022 *'First and second sound in a compressible 3D Bose fluid'*.
T. Hilker, L. H. Dogra, C. Eigen, J. A. P. Glidden, R. P. Smith, and Z. Hadzibabic.
Physical Review Letters **128**, 223601 (2022).

Nat. Phys. 2021 *'Bidirectional dynamic scaling in an isolated Bose gas far from equilibrium'*.
J. A. P. Glidden, C. Eigen, L. H. Dogra, T. Hilker, R. P. Smith, and Z. Hadzibabic.
Nature Physics **17**, 457 (2021).

PRL 2021 *'Many-body decay of the gapped lowest excitation of a Bose-Einstein Condensate'*.
J. Zhang, C. Eigen, W. Zheng, J. A. P. Glidden, T. Hilker, S. J. Garratt, R. Lopes, N. R. Cooper, Z. Hadzibabic, and N. Navon. *Physical Review Letters* **126**, 060402 (2021).

PRL 2019 Editor's suggestion *'Can three-body recombination purify a quantum gas?'*.
L. H. Dogra, J. A. P. Glidden, T. Hilker, C. Eigen, E. A. Cornell, R. P. Smith, and Z. Hadzibabic. *Physical Review Letters* **123**, 020405 (2019).

Nature 2019 Cover Figure *'Imaging magnetic polarons in the doped Fermi-Hubbard model'*.
J. Koepsell, J. Vijayan, P. Sompet, F. Grusdt, T. Hilker, E. Demler, G. Salomon, I. Bloch, and C. Gross. Nature *Nature* **572**, 358 (2019).

Nature 2019 *'Direct observation of incommensurate magnetism in Hubbard chains'*.
G. Salomon, J. Koepsell, J. Vijayan, T. Hilker, J. Nespolo, L. Pollet, I. Bloch, and C. Gross.
Nature **565**, 56 (2019).

Science 2017 *'Revealing hidden antiferromagnetic correlations in doped Hubbard chains via string correlators'*.
T. Hilker, G. Salomon, F. Grusdt, A. Omran, M. Boll, E. Demler, I. Bloch, and C. Gross.
Science **357**, 484 (2017).

Science 2016 *'Spin- and density-resolved microscopy of antiferromagnetic correlations in Fermi-Hubbard chains'*.
M. Boll*, T. Hilker*, G. Salomon*, A. Omran, J. Nespolo, L. Pollet, I. Bloch, and C. Gross.
Science **353**, 1257 (2016).

PRL 2015 Editor's suggestion *'Microscopic observation of Pauli blocking in degenerate fermionic lattice gases'*.
A. Omran, M. Boll, T. Hilker, K. Kleinlein, G. Salomon, I. Bloch, and C. Gross. *Physical Review Letters* **115**, 263001 (2015).

PRL 2011 *'Electroelastic hyperfine tuning of Phosphorus donors in silicon'*.
Highlighted in a Viewpoint
L. Dreher, T. Hilker, A. Brandlmaier, S. T. B. Goennenwein, H. Huebl, M. Stutzmann, and M. S. Brandt. *Physical Review Letters* **106**, 037601 (2011).

**Equal contributions*

Preprints

ArXiv 2026 *'Constructing Arbitrary Coherent Rearrangements in Optical Lattices'*.
A. Roth, L. Qiu, T. Hilker, T. Franz, P. M. Preiss. arXiv:2603.04210.

ArXiv 2025 *'Phase-Sensitive Measurements on a Fermi-Hubbard Quantum Processor'*.
A.R. Cavallar, L. Escalera-Moreno, T. Franz, T. Hilker, J.I. Cirac, P.M. Preiss, and B.F. Schiffer. arXiv:2509.01637.

Patents

2024 / 09 *'Apparatus and method for fermionic quantum computing'*
in process T. Hilker, P. Preiss, I. Bloch.

2023 / 10 *'Telecentric imaging of a plurality of light beams into a target area'*
C. Vetter, Y. Sekman, R. Brüning, T. Hilker, P. Preiss, A. von Haaren, R. Groth, I. Bloch.
Patent number: DE102023210480A

2010 / 12 *'Method for manipulating interaction between two electrons in spin quantum computer'*
A. Brandlmaier, M. Brandt, L. Dreher, S. Gönnenwein, T. Hilker, H. Hübl, M. Stutzmann.
Patent number: DE102010053575A1

Talks

International Conferences and Workshops

2025 / 08 **QQQS Workshop**, Cambridge, UK.
'Analogue and digital quantum simulation of strongly correlated electron systems'

2025 / 07 **MAWI Quantum Technology**, St Andrews, UK.
'Quantum simulations of strongly interacting quantum systems'

2025 / 03 **DPG Frühjahrstagung SAMOP**, Mainz, Germany.
'Fermionic quantum gates in optical lattices'

2024 / 10 **WE-Heraeus-Seminar, Galileo Galilei Institute**, Florence, Italy.
'Hole-hole attraction mediated by magnetism in the doped Fermi Hubbard model'

2024 / 05 **Workshop Ultra-cold Fermionic Atoms, Flatiron Institute**, New York, USA.
'Exploring charge- and spin-correlations in quantum simulations of the doped 2d Hubbard model'

2023 / 09 **Quantum Future Academy**, Garching, Germany.
'Quantum simulation and computation with ultraocld atoms'

2023 / 08 **Conference on Impurity Physics**, Aarhus, Denmark.
'Magnetic polarons and hole-hole attraction in mixed-dimensional Hubbard models'

2023 / 08 **Quantinuum IQTN workshop, JILA**, Boulder, CO, USA.
'FermiQP - Towards a hybrid fermionic quantum processor in an optical lattice'

2023 / 07 **Workshop Fermionic Quantum Simulations**, Obermachtal, Germany.
'From hole pairing to stripe formation in doped mixed-dimensional Hubbard models'

2023 / 07 **DESOEQ Conference, Strathclyde University**, Glasgow, United Kingdom.
'Hole pairing mediated by magnetism in mixed-dimensional Hubbard models'

2022 / 12 **Minerva Research Symposium, Weizman Institute**, Tel Avix, Israel.
'Quantum simulation of hole pairing in doped Fermi-Hubbard systems'

2022 / 11 **Harvard ITAMP Workshop**, Cambridge, MA, USA.
'Observation of hole pairing mediated by antiferromagnetic correlations in mixD Hubbard models'

2022 / 07 **Munich Conference on Quantum Science & Technology 2022**, Sonthofen, Germany.
'Quantum gas microscopy of antiferromagnets with and without doping'

2022 / 06 **DAMOP 2022**, Orlando, FL, USA.
'Engineering of lattice models with local control in quantum microscopes'

2022 / 05 **Brasil-German Quantum Symposium**, Garching, Germany.
'Quantum gas microscopy of doped antiferromagnets'

2022 / 03 **DPG Frühjahrstagung SAMOP**, online.
'First and second sound in a compressible 3D Bose fluid'

2022 / 02 **SPIE Photonics West**, San Francisco, CA, USA - online.
'Quantum microscopy of strongly correlated phases in the Fermi-Hubbard model'

2020 / 06 **DAMOP 2020**, Portland, OR, USA - online.
'Observation of self-similar scaling dynamics in a far-from-equilibrium homogeneous Bose gas'

2019 / 09 **DESOEQ Workshop 2019**, Oxford, UK.
'Sound in a homogeneous Bose gas'

2019 / 05 **DAMOP 2019**, Milwaukee, WI, USA.
'Observation of first and second sound in a homogeneous Bose gas'

2018 / 03 **DPG Frühjahrstagung SAMOP**, Erlangen, Germany.
'Microscopic confirmation of a fluctuation relation in Hubbard chains'

2017 / 10 **UQUAM Workshop**, Venice, Italy.
'New possibilities to study many-body problems with single-site-resolved images'

2017 / 07 **Condensed Matter Physics in the City**, London, United Kingdom.
'Introduction to quantum gas microscopes for the simulation of solid-state systems'

2017 / 07 **Condensed Matter Physics in the City**, London, United Kingdom.
'String correlations in doped Hubbard chains of ultracold atoms'

2017 / 03 **DPG Frühjahrstagung SAMOP**, Mainz, Germany.
'Revealing hidden antiferromagnetic correlations in doped Hubbard chains via string correlators'

2016 / 05 **DAMOP 2016**, Providence, RI, USA.
'Spin-resolved observation of antiferromagnetic correlations in Hubbard chains'

2016 / 03 **DPG Frühjahrstagung SAMOP**, Hannover, Germany.
'Microscopic observation of Pauli blocking in degenerate fermionic lattice gases'

2014 / 05 **International UQUAM Workshop**, Venice, Italy.
'Rapid production of a ^{6}Li quantum gas for a Fermi microscope'

Seminars / Colloquia

2026 / 03 **University of Oxford**, Germany, ALP Seminar organized by Axel Kuhn.
'Quantum Simulations in Optical Lattices: From the Hubbard model to quantum gates'

2026 / 03 **University of Strathclyde**, Germany, Physics Colloquium organized by Daniel Oi.
'Quantum Simulations in Optical Lattices: From the Hubbard model to quantum gates'

2023 / 12 **Heidelberg University**, Germany, CQD Colloquium organized by Lauriane Chomaz.
'Hole-hole attraction in quantum simulations of doped antiferromagnets'

2023 / 10 **Leibniz University Hannover**, Germany, Seminar organized by Silke Ospelkaus.
'Quantum Simulation of Fermionic Many-Body Systems'

2023 / 09 **University of Strathclyde**, *Glasgow*, UK, Seminar organized by Stefan Kuhr.
'Quantum Simulation of Fermionic Many-Body Systems'

2023 / 05 **LMU Munich**, Germany, Seminar organized by Christian Hainzl.
'Observation of hole ordering mediated by antiferromagnetic correlations in mixD Hubbard models'

2022 / 11 **Yale University**, USA, Seminar organized by Nir Navon.
'Quantum simulations of many-body systems from turbulent cascades to doped antiferromagnets'

2022 / 11 **Columbia University**, USA, Seminar organized by Sebastian Will.
Quantum gas microscopy of magnetic phases with and without doping'

2022 / 10 **University of Cambridge**, United Kingdom, Seminar organized by Ulrich Schneider.
'Quantum gas microscopy of magnetic phases with and without doping'

2022 / 09 **University of Bonn**, Germany, Seminar organized by Sebastian Hofferberth.
'Quantum gas microscopes -
Observation and manipulation of many-body quantum systems on the single particle level '

2021 / 04 **University of Virginia**, USA, Online seminar organized by Peter Schauss.
'Realizing the Symmetry-Protected Haldane Phase in Fermi-Hubbard Ladders'

2020 / 10 **University of Innsbruck**, Austria, Online seminar organized by Peter Zoller.
'Observation of SPT phases in spin-1/2 ladders'

2020 / 07 **Fitzwilliam College**, Cambridge, UK, Online seminar of the Postdoctoral Society.
'Quantum simulations with the coldest atoms in the world'

2020 / 03 **LMU Munich**, Germany, Seminar organized by Immanuel Bloch.
'Dynamics of a driven Bose gas'

2019 / 01 **Fitzwilliam College**, Cambridge, UK, Seminar organized by Rogier Kievit.
'Quantum collective behaviour of the coldest atoms in the world'

2018 / 08 **ETH Zurich**, Switzerland, Seminar organized by Tilmann Esslinger.
'Spin-resolved microscopy of doped Hubbard systems'

2018 / 07 **LENS**, Florence, Italy, Seminar organized by Giacomo Roati and Francesco Scazza.
'Spin-resolved microscopy of doped Hubbard systems'

2018 / 01 **University of Auckland**, New Zealand, Seminar organized by Maarten Hoogerland.
'Spin-resolved microscopy of doped Hubbard chains'

2018 / 01 **University of Singapore**, Seminar organized by Kai Dieckmann.
'Spin-resolved microscopy of doped Hubbard chains'

2017 / 06 **Princeton University**, NJ, USA, CMP Seminar organized by Waseem Bakr.
'Quantum microscopy of doped spin systems'

2017 / 05 **MPI of Quantum Optics**, Germany, Institute colloquium organized by Stephan Dürr.
'Spin-resolved microscopy of doped Hubbard chain'

2017 / 04 **University of Cambridge**, United Kingdom, AMO Seminar organized by Zoran Hadzibabic.
'Quantum microscopy of doped spin systems'

Glasgow, April 22, 2026