



Patrick M. Lenggenhager

Personal Data

E-Mail plengg@pks.mpg.de
Website patrick-lenggenhager.github.io
LinkedIn [patrick-m-lenggenhager](https://www.linkedin.com/in/patrick-m-lenggenhager)

Academic Experience

- 11.2023–present **Postdoctoral fellow**, *Max Planck Institute for the Physics of Complex Systems*, Germany
Nonequilibrium Quantum Dynamics Group, Dr. Marin Bukov
- 10.2023–10.2023 **Postdoctoral researcher**, *Physics Institute, University of Zurich*, Switzerland
Theory of Topological Matter Group, Prof. Dr. Tomáš Bzdušek
- 2.2018–9.2023 **Teaching Assistant**, *Institute of Theoretical Physics, ETH Zürich*, Switzerland

Higher Education

- 11.2019–9.2023 **Doctor of Sciences of ETH in Physics**, *ETH Zürich and Laboratory for Theoretical and Computational Physics, Paul Scherrer Institute*, Switzerland
Thesis advisors: Prof. Dr. Tomáš Bzdušek and Prof. Dr. Manfred Sgrist
Title: *Emerging avenues in band theory: multigap topology and hyperbolic lattices*
- 11.2019–9.2023 **Associated PhD Student**, *Physics Institute, University of Zurich*, Switzerland
Condensed Matter Theory Group, Prof. Dr. Titus Neupert
- 9.2016–9.2019 **Master of Science ETH in Physics**, *ETH Zürich*, Switzerland
Thesis (at Caltech): *Quantum Control of Dynamically Induced Topology* (thesis advisors: Prof. Dr. Gil Refael, Caltech, USA and Prof. Dr. Gianni Blatter)
- 9.2018–4.2019 **Caltech Visiting Student**, *Institute for Quantum Information and Matter*, USA
- 9.2012–9.2015 **Bachelor of Science ETH in Physics**, *ETH Zürich*, Switzerland
Thesis: *Low Frequency Resonators on Superconducting Chips* (thesis advisors: Prof. Dr. Andreas Wallraff and Dr. Anton Potočnik)

Languages

German	Native language	<i>Matura (Grade 6)</i>
English	European Language Level C2	<i>Bilingual Matura, Cambridge Advanced English (Grade A)</i>
Italian	European Language Level B2	<i>Matura (Grade 5.5)</i>

Selected Awards, Distinctions, and Scholarships

- 2024 **Swiss Physical Society Award in Condensed Matter Physics**, *sponsored by IBM Research Rüschlikon, Switzerland*, for excellent work in the context of the PhD thesis
- 2023 **ETH Silver Medal for outstanding PhD thesis**, *ETH Zürich, Switzerland*
- 2012–2021 **The Swiss Study Foundation**, *Member/supported student*
- 2019 **Master's Degree in Physics "with distinction"**, *ETH Zürich, Switzerland*
- 2016 **International Young Physicists' Tournament**, *Ekaterinburg, Russia*, Gold medal
Teamleader and coach of the Swiss national team
- 2012 **International Young Physicists' Tournament**, *Bad Saulgau, Germany*, Silver medal
- 2011/2012 **Swiss Young Physicists' Tournament**, *Switzerland*, First place

Past Research Projects

- 11.2020–present **Hyperbolic lattices**
Hyperbolic lattices are networks that emulate negatively curved space. My research has contributed to their experimental realization and measurement in electrical circuits, the development of analytical and computational methods to study them, and the exploration of their properties. In particular, I have investigated hyperbolic spin liquids, which have potential applications in quantum error correction.
- 11.2019–08.2022 **Topological semimetals**
Topological materials exhibit properties that are robust to imperfections. Using analytical models, symmetry analysis, and material database scraping, I have contributed to bridging the gap between easily observable features in simulations and the underlying topological properties.
- 09.2018–04.2019 **Quantum control of dynamically induced topology**
Periodic driving of electronic materials, such as irradiation with light, can drastically alter their properties. In this work, I have studied how to counteract unwanted effects that arise when varying the driving parameters.
- 01.2018–12.2019 **Real-space mutual information coarse-graining algorithm**
The renormalization group is a fundamental framework in condensed matter physics, linking microscopic and macroscopic properties of a system. In this project, I have demonstrated that an optimal coarse graining is achieved by maximizing the long-range mutual information retained.
- 02.2015–09.2015 **Superconducting quantum computing (experimental)**
Inspired by optomechanics, we designed, optimized, and measured space-efficient coplanar waveguide resonators with low eigenfrequencies, with potential applications in active cooling. During a prior project in Prof. Wallraff's group, I gained insights into the fundamentals of superconducting qubit calibration, control, and readout.

Developed Scientific Software

- 2023–present **HyperCells**, *A GAP package for constructing primitive cells and supercells of hyperbolic lattices based on triangle groups and quotients with normal subgroups*, <https://github.com/patrick-lenggenhager/HyperCells>
- 2023–present **HyperBloch**, *A Mathematica package for constructing tight-binding models on hyperbolic lattices and calculating their band structures using the supercell method*, <https://github.com/patrick-lenggenhager/HyperBloch>

Computing/IT Knowledge and Experience

Scientific	Wolfram Language / Mathematica	Exceptional knowledge and experience
Programming	GAP, C++, Python, Julia	Advanced knowledge and experience
Computing	Linux, Bash, SSH, Slurm, Git, Github	Knowledge and experience
Word processing	LaTeX	Advanced knowledge and experience

Supervision and Teaching Activities

Master Students and Interns

- 2.2024–6.2024 **Benoît Fanton**, *École Normale Supérieure - PSL*, France, with Dr. Marin Bukov
Title: *Scaling of excitations when crossing phase transitions in the Kitaev honeycomb model*
- 7.2023–6.2024 **Marcelo Looser**, *University of Zurich*, Switzerland, with Prof. Dr. Tomáš Bzdušek
Title: *Supercell-based characterization of hyperbolic tight-binding models*

Teaching Assistant

- 2022 **Solid State Theory**, by Prof. Dr. Eugene Demler at *ETH Zürich*
- 2021 **Mechanics of Continua**, by Prof. Dr. Manfred Sigrist at *ETH Zürich*
- 2020 **Solid State Theory**, by Prof. Dr. Manfred Sigrist at *ETH Zürich*
- 2018 **Theory of Heat**, by Prof. Dr. Gianni Blatter at *ETH Zürich*

Service to the Scientific Community

- 2024–present Referee for *Nature Communications*, *Nature Portfolio*
- 2024–present Referee for *Communications Physics*, *Nature Portfolio*
- 2023–present Referee for *Physical Review B*, *American Physical Society*

Outreach and Science Communication

Swiss/International Young Physicists' Tournament (SYPT/IYPT)

- 1.2013–3.2024 **Board Member, Coach and Juror at the SYPT**, *Pro IYPT-CH*, Switzerland
- 4.2016–7.2016 **Teamleader and Coach of the Swiss IYPT Team and Juror at the IYPT 2016**, *Pro IYPT-CH*, Zurich, Switzerland / Ekaterinburg, Russia
- 7.2016–9.2016 **Webdeveloper and -designer**, *Pro IYPT-CH*, Switzerland

Publications

- [1] **P. M. Lenggenhager**, S. Dey, T. Bzdušek, and J. Maciejko. *Hyperbolic spin liquids*. Phys. Rev. Lett. **135**, 076604 (2025). DOI:10.1103/s25y-s4fj.
- [2] S. Dey, A. Chen, P. Basteiro, A. Fritzsche, M. Greiter, M. Kaminski, **P. M. Lenggenhager**, R. Meyer, R. Sorbello, A. Stegmaier, R. Thomale, J. Erdmenger, and I. Boettcher. *Simulating holographic conformal field theories on hyperbolic lattices*. Phys. Rev. Lett. **133**, 061603 (2024). (Editors' Suggestion) DOI:10.1103/PhysRevLett.133.061603.
- [3] T. Tummuru*, A. Chen*, **P. M. Lenggenhager***, T. Neupert, J. Maciejko, and T. Bzdušek. *Hyperbolic non-Abelian semimetal*. Phys. Rev. Lett. **132**, 206601 (2024). DOI:10.1103/PhysRevLett.132.206601.
- [4] **P. M. Lenggenhager**, J. Maciejko, and T. Bzdušek. *Non-Abelian hyperbolic band theory from supercells*. Phys. Rev. Lett. **131**, 226401 (2023). DOI:10.1103/PhysRevLett.131.226401.
- [5] A. Chen, Y. Guan, **P. M. Lenggenhager**, J. Maciejko, I. Boettcher, and T. c. v. Bzdušek. *Symmetry and topology of hyperbolic haldane models*. Phys. Rev. B **108**, 085114 (2023). DOI:10.1103/PhysRevB.108.085114.
- [6] **P. M. Lenggenhager**, X. Liu, T. Neupert, and T. Bzdušek. *Triple nodal points characterized by their nodal-line structure in all magnetic space groups*. Phys. Rev. B **106**, 085128 (2022). (Editors' Suggestion) DOI:10.1103/PhysRevB.106.085128.
- [7] **P. M. Lenggenhager**, X. Liu, T. Neupert, and T. Bzdušek. *Universal higher-order bulk-boundary correspondence of triple nodal points*. Phys. Rev. B **106**, 085129 (2022). DOI:10.1103/PhysRevB.106.085129.
- [8] D. M. Urwyler, **P. M. Lenggenhager**, I. Boettcher, R. Thomale, T. Neupert, and T. Bzdušek. *Hyperbolic topological band insulators*. Phys. Rev. Lett. **129**, 246402 (2022). DOI:10.1103/PhysRevLett.129.246402.
- [9] **P. M. Lenggenhager**, A. Stegmaier, L. K. Upreti, T. Hofmann, T. Helbig, A. Vollhardt, M. Greiter, C. H. Lee, S. Imhof, H. Brand, T. Kießling, I. Boettcher, T. Neupert, R. Thomale, and T. Bzdušek. *Simulating hyperbolic space on a circuit board*. Nat. Commun. **13**(1), 4373 (2022). DOI:10.1038/s41467-022-32042-4.
- [10] **P. M. Lenggenhager**, X. Liu, S. S. Tsirkin, T. Neupert, and T. Bzdušek. *From triple-point materials to multiband nodal links*. Phys. Rev. B **103**, L121101 (2021). DOI:10.1103/PhysRevB.103.L121101.
- [11] **P. M. Lenggenhager**, D. E. Gökmen, Z. Ringel, S. D. Huber, and M. Koch-Janusz. *Optimal renormalization group transformation from information theory*. Phys. Rev. X **10**, 011037 (2020). DOI:10.1103/PhysRevX.10.011037.

Talks and Posters

Invited Talks

- 10.09.2024 Annual Meeting of the Swiss Physical Society, ETH Zurich, Zurich, Switzerland
Plenary Session
Title: *Hyperbolic lattices: from table-top simulators to non-Abelian band theory*

Invited Seminars

- 02.07.2025 Theoretical Physics Institute, University of Alberta, Edmonton, Canada
Host: Prof. Dr. Joseph Maciejko
Title: *Lattice vs. long-wavelength physics in variants of quantum mutual information*
- 12.06.2025 Applied Quantum Algorithms Lab, Leiden University, Leiden, The Netherlands
Host: Dr. Anastasiia Skurativska
Title: *Lattice vs. long-wavelength physics in variants of quantum mutual information*
- 05.12.2024 IBM Quantum, IBM Research Zurich, Rüschlikon, Zürich
Host: Dr. Stefan Woerner
Title: *Real-space quantum mutual information - lattice effects and continuum limit*
- 03.02.2023 Theoretical Physics Institute, University of Alberta, Edmonton, Canada
Host: Prof. Dr. Joseph Maciejko
Title: *Classification and higher-order topology of triple nodal points*
- 04.11.2022 Theoretical Solid State Physics, Technische Universität Dresden, Dresden, Germany
Host: Prof. Dr. Matthias Vojta
Title: *From a hyperbolic drum towards hyperbolic topological insulators*
- 27.10.2022 Max Planck Institute for the Physics of Complex Systems, Dresden, Germany
Host: Dr. Marin Bukov
Title: *From a hyperbolic drum towards hyperbolic topological insulators*
- 11.10.2022 The Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom
Host: Dr. Robert-Jan Slager
Title: *From a hyperbolic drum towards hyperbolic topological insulators*
- 17.11.2021 Institute for Theoretical Physics, Julius-Maximilians-University of Würzburg, Würzburg, Germany
Host: Prof. Dr. Ronny Thomale
Title: *Classification and higher-order topology of triple nodal points*
- 25.06.2019 Institute of Physics, University of Zurich, Zurich, Switzerland
Host: Prof. Dr. Titus Neupert
Title: *Optimal Renormalization Group from Information Theory*
- 04.06.2019 Laboratory for Scientific Computing and Modelling, Paul Scherrer Institute, Villigen, Switzerland
Host: Prof. Dr. Christopher Mudry
Title: *Optimal Renormalization Group from Information Theory*
- 30.01.2019 Institute for Quantum Information and Matter, Caltech, Pasadena, USA
Host: Dr. Evert van Nieuwenburg
Title: *Optimal Renormalization Group from Information Theory*

Contributions to Conferences/Workshops

- 24.07.2025 Advances in Quantum Control: Techniques, Applications and Challenges, Dresden, Germany, poster
Title: *Non-adiabatic manipulation of non-Abelian anyons in the Kitaev model*
- 21.05.2025 QuantuMatter 2025, Grenoble, France, talk
Title: *Access to lattice vs. long-wavelength physics in quantum mutual information variants*

- 23.09.2024 CT.QMAT International Conference 2024, Dresden, Germany, poster
Title: *Hyperbolic spin liquids*
- 08.07.2024 Workshop on Topological Quantum Matter in Magnetic and Synthetic Platforms, Dresden, Germany, poster
Title: *Non-Abelian hyperbolic bloch states: effects on spectrum and topology*
- 25.03.2024 CT.QMAT Retreat, Weimar, Germany, poster
Title: *Non-Abelian hyperbolic nand theory from supercells*
- 21.03.2024 DPG Meeting, Berlin, Germany, talk
Title: *HyperCells and HyperBloch: open-source software packages for studying hyperbolic lattices based on triangle groups*
- 06.03.2024 APS March Meeting, Minneapolis, USA, talk
Title: *HyperCells and HyperBloch: open-source software packages for studying hyperbolic lattices based on triangle groups*
- 16.03.2023 APS March Meeting, Las Vegas, USA, talk
Title: *Supercell construction and non-Abelian Bloch states in hyperbolic lattices*
- 30.08.2022 Swiss Workshop on Materials with Novel Electronic Properties SWM 22, Les Diablerets, Switzerland, poster
Title: *Classification and higher-order topology of triple points*
- 29.07.2022 International Conference on Complexity and Topology in Quantum Matter CT.QMAT 22, Würzburg, Germany, talk
Title: *From a hyperbolic drum towards hyperbolic topological insulators*
- 16.03.2022 APS March Meeting, Chicago, USA, talk
Title: *Simulating hyperbolic space on a circuit board*
- 11.03.2021 TopCor 22 Workshop on Topological Materials: From Weak to Strong Correlations, Dresden, Germany, poster
Title: *Classification and higher-order topology of triple points*
- 29.09.2021 Condensed Matter Theory Symposium ETH Zürich, Zurich, Switzerland, poster
Title: *Classification and higher-order topology of triple points*
- 02.09.2021 SPS Annual Meeting, Innsbruck, Austria, talk
Title: *Classification and higher-order topology of triple points*
- 15.03.2021 APS March Meeting, online, talk
Title: *Classification and higher-order topology of triple points*
- 25.01.2021 Waiting for the conference on Highly Frustrated Magnetism, online, poster
Title: *From triple points to multi-band nodal links with monopole charges and higher-order topology*