Curriculum Vitae Norbert Schuch

(Date: May 11, 2025)

Summary

Professional data

Univ.-Prof. Dr. Norbert Schuch
Full Professor of Quantum Algorithms
Faculty of Physics and Faculty of Mathematics
University of Vienna, Austria

https://schuch.univie.ac.at/nschuch
norbert.schuch@univie.ac.at
https://scholar.google.com/citations?user=ZHmDt48AAAAJ

Track record

106 publications in peer-reviewed journals, **8 preprints**, 7 further publications
9720 citations, h-index 49 (Google Scholar); **5720 citations, h-index 39** (Scopus)

117 invited talks at international conferences, 20 contributed talks at peer-reviewed international conferences (including one invited lecture and 7 accepted talks held at QIP, the leading conference in Quantum Information and Quantum Computing)
64 invited seminar talks

Awards and funding

Total own ongoing funding **3.2 Million EUR**; total own funding acquired **6.1 Million EUR** (excluding joint funding e.g. through clusters)

Selected grants:

- **ERC Consolidator Grant 2019** (10/2020–03/2026, 1.95 Million EUR)
- **ERC Starting Grant 2014** (03/2015–06/2020, 1.34 Million EUR)
- PI on the Austrian SFB *beyondC – Quantum Information Systems beyond classical capabilities*, and on the Austrian Cluster of Excellence *quantA – Quantum Science Austria*

Supervision and mentoring

Mentoring of 14 PhD students (6 ongoing), 19 Postdocs (8 ongoing), and 9 long-term visiting scholars

Community Service

- organization of **3-4 international conferences per year**
- organizer of a **yearly international school on Tensor Networks** since 2016
- regular reviewer for over 20 international journals from physics, computer science, and mathematics
- regular program committee member (6 times since 2012) for the QIP conference, the most important conference in Quantum Information and Quantum Computing

1. Personal Information and CV

Personal Information

Family name, first name:	Schuch, Norbert
Date and place of birth:	7. April 1978, Timişoara/Romania
Nationality:	German
Homepage:	https://schuch.univie.ac.at/nschuch
Contact:	norbert.schuch@univie.ac.at +43 1 4277 51270
Researcher unique identifiers:	http://www.arxiv.org/a/schuch_n_1.html https://orcid.org/0000-0001-6494-8616 https://www.scopus.com/authid/detail.uri?authorId=57206230380 https://scholar.google.com/citations?user=ZHmDt48AAAAJ
Mailing address:	Quantenoptik, Quantennanophysik, Quanteninformation Fakultät für Physik, Universität Wien Boltzmanngasse 5 1090 Wien Austria

Professional Career

since 10/2020	Full Professor of Quantum Algorithms, Faculty of Physics and Faculty of Mathematics, University of Vienna (Austria)
06/2016 – 09/2020	Lecturer (*Privatdozent*) at the Technical University Munich (Germany)
11/2015 – 09/2020	Group Leader (W2/tenured) at the Max-Planck-Institute for Quantum Optics (MPQ) in Garching (Germany)
03/2012 – 10/2015	Junior Professor (tenure track) at the Institute for Quantum Information at RWTH Aachen University in Aachen (Germany). Mid-term evaluation (equivalent to habilitation) successfully passed in 02/2015.
11/2009 – 02/2012	Postdoctoral Scholar at the Institute for Quantum Information, led by Prof. J. Preskill, at the California Institute of Technology, Pasadena (USA).
11/2007 – 10/2009	Postdoctoral Researcher at the Max-Planck-Institute for Quantum Optics in Garching (Germany) in the group of Prof. I. Cirac.

Education

02/2003 – 10/2007	PhD at the Max-Planck-Institute for Quantum Optics and the TU Munich in Garching (Germany) in the group of Prof. I. Cirac; Thesis: *Quantum Entanglement: Theory and Applications.* Grade: 1.0, *summa cum laude* – with distinction.
11/1997 – 12/2002	Studies of Physics at the University of Regensburg. Diploma grade: 1.0 – "with distinction" Thesis: *Implementation of quantum algorithms with Josephson charge qubits*, supervised by Prof. K. Richter and Dr. J. Siewert.
11/1997 – 10/1999	Studies of Mathematics at the University of Regensburg, Exams (Vordiplom) with grade 1.0.

2. Awards and funding

Awards

- **ERC Consolidator Grant 2019**
- **ERC Starting Grant 2014**
- Visiting Professor at University of Toulouse Paul Sabatier, 2014
- Member of the Elite Network of Bavaria PhD programme "Quantum Computing, Control and Communication" (QCCC), 2005–2007
- VDE-Price 2003 for Diploma Thesis
- Prize of the Alumni of the University of Regensburg, 1998
- Students' prize of the German Physical Society (DPG) in 1997 and 1998
- Scholar of the "Studienstiftung des Deutschen Volkes" (German National Merit Foundation), 1996–2002
- 27th International Physics Olympiad 1997, Sudbury (Canada): Gold Medal, Special Price for the best Theoretical Exam
- 26th International Physics Olympiad 1996, Oslo (Norway): Bronze Medal

Funding and grants

Total **ongoing funding: 3.2 Million EUR**; total **funding acquired: 6.1 Million EUR**
(excluding joint funding e.g. through clusters)

Ongoing funding and grants

- ERC Consolidator Grant *Symmetries and Entanglement in Quantum Matter (SEQUAM)*
  (own awarded funding: 1.95 Million EUR, 10/2020–03/2026)
- PI on the Austrian Special Research Programme (SFB) *BeyondC: Quantum information systems beyond classical capabilities* (total funding volume in funding period: 6.5 Million EUR)
  (own awarded funding: 419 kEUR, 03/2023–02/2027)
- PI on the Austrian Cluster of Excellence *quantA – Quantum Science Austria*
  (total funding volume: 21 Million EUR 10/23–9/28)

  Within the Cluster of Excellence, I have acquired the following grants ("core projects") which were awarded through competitive calls (with a cap of 3 core projects per PI)
  - *Rigorous estimates for quantum many-body systems*, with M. Navascues and R. Küng
    (own awarded funding: 145 kEUR)
  - *Entanglement in fermionic quantum matter*, with S. Paschen, J. Leonard, H. Pichler, and P. Zoller
    (own awarded funding: 145 kEUR)
  - *Variational approach to quantum dynamics and entangled state preparation*, with M. Serbyn and H. Pichler
    (own awarded funding: 145 kEUR)
- FWF Standalone project *Entanglement Order Parameters*
  (own awarded funding: 422kEUR, 04/2023–03/2026)
- regular computing time grants on the Vienna Scientific Cluster (VSC)

Past funding and grants

- Startup funding at RWTH Aachen University through D. DiVincenzo's Humboldt grant
  (own funding: 550 kEUR, 03/2012–01/2016)

- PI on EU FET STREP *Quantum Algorithmics (QALGO)*
  (own awarded funding: 250 kEUR, 05/2013–04/2016; jointly with B. Terhal and D. DiVincenzo)
- PI on DFG Gradiertenkolleg (Research Training Group) 1995 *Quantum many-body methods in condensed matter systems* (total funding volume: 3.6 Million EUR)
  (own awarded funding: 200 kEUR, 10/2014 – 03/2019)
- ERC Starting Grant *Wavefunctions for strongly correlated systems (WASCOSYS)*
  (own awarded funding: 1.34 Million EUR, 03/2015 – 06/2020)
- Grant for a HPC cluster from the Max-Planck-Society, 74kEUR (07/2016)
- PI in the International Max Planck Research School *Quantum Science and Technology*
  (09/2016–09/2020, included 150kEUR funding for 1 PhD position,
- PI on the German Excellence Cluster *Munich Center for Quantum Science and Technology (MCQST)*
  (01/19–03/21, granted funding for 1 PhD position from 01/19–12/21 in an internal call, 150kEUR)
- Grant for a HPC cluster from the Max-Planck-Society, 185kEUR (03/2020; declined)
- regular computing time grants on the JARA-HPC Cluster (Aachen/Jülich)

Hosted grants

- Andras Molnar, quantA Discovery Grant (150 kEUR for 2 years, 2025-2027)
- Refik Mansuroglu, quantA Fellowship Grant (2 years postdoc position, 2025–2027)
- Jose Garre Rubio, FWF Schrödinger Fellowship (3 years postdoc position: 2 years abroad + 1 year return phase, 2024–2027)
- Anna Francuz, FWF ESPRIT Grant (3 years postdoc position, 2023-2026)
- Antoine Sterdyniak, Humboldt Fellowship (2 years postdoc position, 2017-2019, at MPQ)

3. Community service

Organization of Conferences, Schools, and Seminars

- Organization of the **yearly *European Tensor Network School*** since 2016, with ∼80 participants:
  Nov. 2016, Dresden (Germany); **Nov. 2017**, Gent (Belgium);
  Nov. 2018, Dresden (Germany); **Nov. 2019**, San Sebastian (Spain);
  Oct. 2020, Bad Honnef (Germany); **Sept. 2021**, Barcelona (Spain);
  Sept. 2022, Vienna (Austria); **Sept. 2023**, Oxford (UK);
  May 2024, Padova (Italy); **Nov. 2025**, Göttingen (Germany) *(forthcoming)*;
  Oct. 2026, Cambridge (UK) *(forthcoming)*.
- Organization of the **yearly 2-week workshop *Entanglement in Strongly Correlated Systems*** in Benasque (Spain), since 2018, with ∼80 participants:
  Feb. 2018; **Feb. 2019**; **Feb. 2020**; **Feb. 2021** *(online)*; **Feb./Mar. 2022**;
  Aug. 2023; **Feb./Mar. 2025**.
- Other workshops, conferences, and schools organized:
  - Focus Week *Tensor Networks and entanglement*,
    Galileo Galilei Institute, Florence (Italy), June 2018
  - Workshop *Analysis and design of tensor algorithms*,
    IPAM, UCLA, Los Angeles (USA), May 2021 *(changed to online)*;
  - Workshop ***Quantum Complexity: Theory and Application*****,**
    Schloss Dagstuhl (Germany), June 2021
  - Workshop *Physics and Information Capabilities of Highly Entangled Quantum Matter*,
    Aspen Center for Physics, Aspen (USA), July 2022.
  - **8-week Thematic Programme *Tensor Networks: Mathematical Structure and Novel Algorithms***,
    Erwin Schrödinger Institute for Mathematics and Physics, Vienna, Aug.–Oct. 2022
    including two workshops: *Computational aspects of Tensor Networks* Sept. 2022, and
    Mathematical structure of Tensor Networks", Oct. 2022.
  - International Quantum Tensor Network Workshop *Chiral Tensor Networks*, Oxford (UK), Dec. 2023.
  - Advanced School *Topological order: anyons and fractons*,
    Les Houches (France), April 2024.
  - **5-week Thematic Programme *Entanglement in Many-body Quantum Matter: Dynamics, Dissipation, Equilibration***, **Erwin Schrödinger Institute** for Mathematics and Physics,
    Vienna, May/June 2025 *(forthcoming)*.
- Organizer of the **Online Seminar & Colloquium Series** of the ***European Tensor Network***, 2021–2023.
- Founding Partner of the **EPSRC Network *IQTN – International Quantum Tensor Network***, organizing regular international meetings on tensor networks: London (UK), June 2023; New York (USA), March 2023; Raitenhaslach (Germany), July 2023; Glasgow (UK), Jan. 2024.

Committees, Editorships, and Reviewing

- Member of the **Editorial College** at the platinum open access journal *SciPost*.
- Member of the **Scientific Governing Board** of the International Erwin Schrödinger Institute for Mathematics and Physics in Vienna (Austria).
- **Grant reviewer** for the European Research Council (ERC), the European Union, and more than 15 national science foundations in Europe, Asia, and Australia.

- **Regular referee for more than 25 journals**, including Nature, Nature Physics, Nature Communications, Physical Review Letters, Physical Review X, Physical Review A and B, Quantum, SciPost, JHEP, Communications in Mathematical Physics, Journal of Mathematical Physics, SIAM Journal on Computing, and Theory of Computing.
- Member of the **Program Committee for the QIP Conference** (the leading international conference in Quantum Information and Quantum Computing) for QIP 2012 (Montreal), QIP 2014 (Barcelona), QIP 2018 (Delft), QIP 2019 (Boulder), QIP 2022 (Pasadena), and QIP 2023 (Gent), and the Program Committee for the **TQC conference** (Theory of Quantum Computation, Communication, and Cryptography) for TQC 2016 (Berlin), TQC 2022 (Urbana-Champaign), and TQC 2025 (Bengaluru).
- Member of the Judging Panel for the **XPrize Quantum Applications**, a 5 M$, 3-year (2024–2027) global competition to generate quantum algorithms to solve real-world challenges.
- Member of the Steering Committee of the International Max Planck Research School on Quantum Science and Technology, 2017-2019.
- Co-Coordinator of the Elite Network of Bavaria PhD programme "Quantum Computing, Control and Communication" at the Technical University of Munich and the MPI of Quantum Optics, 2008-2009.

4. Teaching and supervision

Teaching

Courses taught at university

SS 2025	Lecture *Entanglement in quantum many-body systems* (jointly with B. Vanhecke) Lecture *Entanglement in quantum many-body systems: Mathematical results* (jointly with A. Molnar) Seminar *Quantum Information and Quantum Many-Body Physics – Part II* Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, A. Molnar, H.P. Stimming, T. Flöss)
WS 2024/25	Lecture *Quantum Information, Quantum Computing, and Quantum Algorithms* (jointly with A. Molnar) Seminar *Quantum Information and Quantum Many-Body Physics* Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, A. Molnar, H.P. Stimming)
SS 2024	Lecture *Entanglement in quantum many-body systems* (jointly with B. Vanhecke) Lecture *Entanglement in quantum many-body systems: Mathematical results* (jointly with A. Molnar and J. Garre-Rubio) Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, J. Garre-Rubio, A. Molnar, H.P. Stimming)
WS 2023/24	Lecture *Quantum Information, Quantum Computing, and Quantum Algorithms* (jointly with A. Molnar) Lecture *Lineare Algebra für PhysikerInnen* (jointly with S. Fredenhagen) Seminar *Quantum Information and Quantum Many-Body Physics* Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, J. Garre-Rubio, A. Molnar, C. Rampf, H.P. Stimming)
SS 2023	Lecture *Tensor network methods in many-body physics* (jointly with B. Vanhecke) Lecture *Mathematical aspects of tensor networks in many-body physics* (jointly with A. Molnar and J. Garre-Rubio) Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, J. Garre-Rubio, A. Molnar, C. Rampf, H.P. Stimming)
WS 2022/23	Lecture *Quantum Information, Quantum Computing, and Quantum Algorithms* Seminar *Entanglement in Complex Quantum Systems* Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, J. Garre-Rubio, A. Molnar, C. Rampf, H.P. Stimming, I. Mazets)
SS 2022	Seminar *Quantum Information and Quantum Many-Body Physics* Seminar *Mathematical/Computational Astro/Quantum Physics* (jointly with N. Mauser, O. Hahn, J. Garre-Rubio, A. Molnar, C. Rampf, H.P. Stimming, I. Mazets)
WS 2021/22	Lecture *Quantum Information, Quantum Computing, and Quantum Algorithms* Proseminar *Quantum Information, Quantum Computing, and Quantum Algorithms*
SS 2021	Lecture *Entanglement in Quantum Many-Body Systems* Seminar *Quantum Information and Quantum Many-Body Physics*
WS 2020/21	Lecture *Quantum Information, Quantum Computing, and Quantum Algorithms* Proseminar *Quantum Information, Quantum Computing, and Quantum Algorithms*
WS 2019/20	Lecture *Quantum Information*

WS 2018/19	Lecture *Quantum Information*
SS 2018	Lecture *Quantum Information Methods in Many-Body Physics* (jointly with I. Cirac and M.C. Banuls)
WS 2017/18	Lecture *Quantum Information*
WS 2016/17	Lecture *Quantum Information*
SS 2015	Lecture *Quantum Information*
WS 2014/15	Lecture *Entanglement and Locality in Quantum Many-body Systems*
SS 2014	Lecture *Mathematische Methoden der Physik (Mathematical Methods of Physics)*
WS 2013/14	Lecture *Quantum Optics*
SS 2013	Lecture *Condensed matter applications of entanglement theory* at the IFF Spring School "Quantum Information" at Forschungszentrum Jülich
WS 2012/13	Lecture *Analytical and numerical methods in many-body physics from a quantum* information perspective

Lectures at international schools

- 2022 Summer School for Physics and Tensor-Network Methods in correlated systems, NCTS, Taipei (Taiwan), Aug. 2022 (online): Lecture *Projected Entangled Pair States, topological order, and topological spin liquids.*
- International School "Tensor Network based approaches to Quantum Many-Body Systems", Bad Honnef (Germany), Oct. 2020: Lecture *Topological order and spin liquids in tensor networks*.
- Croucher Summer School "Quantum entanglement and topological order", Hongkong, July 2019: Lecture *Tensor network states and quantum entanglement*.
- VDS Winter School on Mathematics, Dienten (Austria), March 2019: Lecture *Introduction to Quantum Error Correction*.
- 41st Heidelberg Graduate Days, Heidelberg (Germany), Oct. 2018: Lecture course *Entanglement in quantum many-body systems*.
- 9th International School on Mathematical Physics "Topological order and beyond", Bogota (Colombia), May 2018: Lecture course *Topological order: a simple perspective from stabilizer codes and tensor networks*.
- Advanced School on Quantum Science and Quantum Technologies, ICTP, Trieste (Italy), Sept. 2017: Lecture course on *Tensor Networks*.
- Workshop "Entanglement in Strongly Correlated Systems", Benasque (Spain), Feb. 2017: Lecture course on *Tensor Network States*.
- QIP Workshop, Seattle (USA), Jan. 2017: Lecture *Matrix Product States and Tensor Network States*.
- International School "Tensor product state simulations of strongly correlated systems", Dresden (Germany), Nov. 2016, Lecture course *Analytical study of many-body systems with Tensor Network States*.
- International Workshop on Tensor Networks and Quantum Many-Body Problems, Kashiwa (Japan), July 2016, Lecture course *Topological Order in Projected Entangled Pair States*.
- IDEA League School, Zurich (Switzerland), Sept. 2015, Lecture course *Entanglement and Many-Body Systems*.
- Tensor Network Summer School, University of Gent (Belgium), June 2015, Lecture course *Projected Entangled Pair States – Theory and Mathematical Foundations*.
- QUROPE Summer School, Smolenice (Slovakia), Aug. 2014, Lecture course *Quantum information and many-body systems*.
- Autumn School "Correlated Electrons: From Models to Materials", Jülich (Germany), Sept. 2012, Lecture course *Entanglement in correlated quantum systems: A quantum information perspective*.

- 11th Canadian Summer School on Quantum Information, Sherbrooke (Canada), June 2011, Lecture course *Quantum Information and Quantum Many-Body Physics*.

Supervision of Students and Postdoctoral Scholars

PhD theses

2017	Manuel Rispler, *Symmetry breaking and long-range order in quantum many-body systems*
2018	Mohsin Iqbal, *Topological order and phase transitions in quantum spin systems*
2020	Henrik Dreyer, *Symmetries and Tensor Networks in Two-Dimensional Quantum Physics* (jointly with I. Cirac)
2021	Anna Hackenbroich, *Entanglement in Chiral Topological Systems*
2021	David Stephen, *Entanglement and locality in complex quantum systems*
2022	Caroline de Groot, *Topological Phases, Symmetries and Open Systems*
2023	Ilya Kull, *Quantum Information techniques for many-body problems* (jointly with C. Brukner)
2024	Ivana Kurecic
(ongoing)	David Blanik
(ongoing)	Kevin Tam
(ongoing)	Paul Brehmer
(ongoing)	Lilith Zschetzsche
(ongoing)	Christian Reinmoser
(ongoing)	Milan Rozman

Two further PhD students co-supervised as a postdoctoral researcher.

Postdocs

2013–2015	Lauri Lehman
2013–2017	Kasper Duivenvoorden *(jointly with B. Terhal)*
2015-2017	Andrew Goldsborough
2018	Katharina Schwaiger
2016–2019	Antoine Sterdyniak
2018–2020	Mohsin Iqbal
2019–2021	Ji-Yao Chen
2018–2021	Clement Delcamp
2020–2022	Wen-Tao Xu
2021–2023	Mingru Yang
2021–2024	Jose Garre-Rubio
2021–	Bram Vanhecke
2021–	Andras Molnar
2022–	Anna Francuz
2023–	Ilya Kull
2024–	Refik Mansuroglu
2024–	Shuhei Oyama
2024–	Adrian Franco Rubio
2024–	Andreas Klingler

Master and diploma theses

2013	Stefan Haßler, *Entanglement spectra and boundary theories for Gaussian fermionic PEPS*
2013	Mohsin Iqbal, *Semionic Resonating Valence Bond states on the kagome lattice*
2014	Gregor Bransky, *The Hubbard model in the light of computational complexity*
2016	Andreas Bauer, *Symmetries and excitations in the quantum double models – a tensor network approach*
2022	Manuel Mekonnen, *Analysis of variational quantum optimization algorithms for non-interacting fermions*
2024	Daniel Fan, *Optimizing constraints for ground state optimization*
2024	Milan Rozman, *Bounding spectral gaps in the Matrix Product State formalism*
(ongoing)	Georg Hübner
(ongoing)	Johannes Wladika
(ongoing)	Maybrit Schröder
(ongoing)	Clemens Prinz

Bachelor theses

2012	Peter Schmitz, *The AKLT model and its excitations*
2014	Madita Nocon, *The role of boundaries in one-dimensional gapped phases*
2017	Vu Phan Thanh, *The classification of one-dimensional gapped phases*
2017	Julian Sieber, *Area laws and Matrix Product States*
2019	Sven Jandura, *Topological Order in Quantum N-mer Models*

Three further Bachelor students co-supervised as a postdoctoral researcher.

Long-term visiting students and scholars

02/2013 – 04/2013	Carlos Fernandez-Gonzalez, UNED (Madrid)
10/2013 – 12/2013	Jutho Haegeman, University of Gent (Belgium)
06/2017 – 07/2017	Helena Casademunt, Princeton University (USA)
06/2018 – 07/2018	Frankie Lam, Princeton University (USA)
10/2018 – 03/2019	Giuliano Giudici, SISSA, Trieste (Italy)
06/2019 – 07/2019	Henry Ando, Princeton University (USA)
02/2022 – 04/2022	Bryan Renard, Université de Namur (Belgium)
02/2022 – 05/2022	Alberto Ruiz de Alarcón, Universidad Complutense & ICMAT, Madrid (Spain)
03/2023 – 03/2023	Elena Petrova, Institute for Science and Technology Austria, Klosterneuburg (Austria)

5. Publications

Publications in peer-reviewed journals

1. A. Francuz, N. Schuch, and B. Vanhecke,
Stable and efficient differentiation of tensor network algorithms.
Phys. Rev. Research **7**, 013237 (2025); arXiv:2311.11894.
2. J. Jiang, J. Chen, N. Schuch, and D. Hangleiter,
Positive bias makes tensor-network contraction tractable.
Proceedings of the 57th Annual ACM Symposium on Theory of Computing (STOC) (*to appear*), (2025); arXiv:2410.05414.
3. J. Garre Rubio and N. Schuch,
Fractional domain wall statistics in spin chains with anomalous symmetries.
SciPost Phys. **18**, 043 (2025); arXiv:2405.00439.
4. J. Chen, J. Jiang, D. Hangleiter, and N. Schuch,
Sign problem in tensor network contraction.
PRX Quantum **6**, 010312 (2025); arXiv:2404.19023.
5. M. Ljubotina, E. Petrova, N. Schuch, and M. Serbyn,
Tangent space generators of matrix product states and exact Floquet quantum scars.
PRX Quantum **5**, 040311 (2024); arXiv:2403.12325.
6. W.-L. Tu, L. Vanderstraeten, N. Schuch, H.-Y. Lee, N. Kawashima, and J.-Y. Chen,
Generating function for projected entangled-pair states.
PRX Quantum 5, 010335 (2024); arXiv:2307.08083.
7. H. Dreyer, L. Vanderstraeten, J.-Y. Chen, R. Verresen, and N. Schuch,
Robustness of critical U(1) spin liquids and emergent symmetries in tensor networks.
Phys. Rev. B **109**, 195161 (2024); arXiv:2008.04833.
8. I. Kull, N. Schuch, B. Dive, and M. Navascués,
Lower Bounding Ground-State Energies of Local Hamiltonians Through the Renormalization Group.
Phys. Rev. X **14**, 021008 (2024); arXiv:2212.03014.
9. M. Arildsen, J.-Y. Chen, N. Schuch, and A. Ludwig,
Entanglement Spectrum as a diagnostic of chirality of Topological Spin Liquids: Analysis of an SU(3) *PEPS.*
Phys. Rev. B **110**, 235147 (2024); arXiv:2305.13240.
10. M. Yang, B. Vanhecke, and N. Schuch,
Detecting emergent continuous symmetries at quantum criticality.
Phys. Rev. Lett. **131**, 036505 (2023); arXiv:2210.17539.
11. M. Arildsen, N. Schuch, and A. Ludwig,
Entanglement spectra of non-chiral topological (2+1)-dimensional phases with strong time-reversal breaking, Li-Haldane state counting, and PEPS.
Phys. Rev. B **108**, 245150 (2023); arXiv:2207.03246.
12. Q. Mortier, N. Schuch, F. Verstraete, and J. Haegeman,
Tensor networks can resolve Fermi surfaces.
Phys. Rev. Lett. **129**, 206401 (2022); arXiv:2008.11176.
13. C. de Groot, A. Turzillo, and N. Schuch,
Symmetry Protected Topological Order in Open Quantum Systems.
Quantum **6**, 856 (2022); arXiv:2112.04483.

14. W.-T. Xu, J. Garre-Rubio, and N. Schuch,
Complete characterization of non-Abelian topological phase transitions and detection of anyon splitting with projected entangled pair states.
Phys. Rev. B **106**, 205139 (2022); arXiv:2208.13200.
Selected as *Editors' suggestion* at Phys. Rev. B.

15. G. Giudici, J.I. Cirac, and N. Schuch,
Locality optimization for parent Hamiltonians of Tensor Networks.
Phys. Rev. B **106**, 035109 (2022); arXiv:2203.07443.

16. E. Cruz, F. Baccari, J. Tura, N. Schuch, and J.I. Cirac,
Preparation and verification of tensor network states.
Phys. Rev. Research **4**, 023161 (2022); arXiv:2105.06866.

17. L. Lootens, B. Vancraeynest-De Cuiper, N. Schuch, and F. Verstraete,
Mapping between Morita-equivalent string-net states with a constant depth quantum circuit.
Phys. Rev. B **105**, 085130 (2022); arXiv:2112.12757.

18. D.J. Williamson, C. Delcamp, F. Verstraete, and N. Schuch,
On the stability of topological order in tensor network states.
Phys. Rev. B **104**, 235151 (2021); arXiv:2012.15346.

19. J.I. Cirac, D. Perez-Garcia, N. Schuch, and F. Verstraete,
Matrix product states and projected entangled pair states: Concepts, symmetries, theorems.
Rev. Mod. Phys. **93**, 045003 (2021); arXiv:2011.12127.

20. C. Delcamp and N. Schuch,
On tensor network representations of the (3+1)d toric code.
Quantum **5**, 604 (2021); arXiv:2012.15631.

21. M. Iqbal and N. Schuch,
Entanglement Order Parameters and Critical Behavior for Topological Phase Transitions and Beyond.
Phys. Rev. X **11**, 041014 (2021); arXiv:2011.06611.

22. W.-T. Xu and N. Schuch,
Characterization of topological phase transitions from a non-Abelian topological state and its Galois conjugate through condensation and confinement order parameters.
Phys. Rev. B **104**, 155119 (2021); arXiv:2107.04549.

23. W.-L. Tu, H.-K. Wu, N. Schuch, N. Kawashima, and J.-Y. Chen.
Generating function for tensor network diagrammatic summation.
Phys. Rev. B **103**, 205155 (2021); arXiv:2101.03935.

24. A. Hackenbroich, A. Hudomal, N. Schuch, B. A. Bernevig, and N. Regnault,
Fractional chiral hinge insulator.
Phys. Rev. B **103**, 161110 (2021); arXiv:2010.09728.
Selected as *Editors' suggestion* at Phys. Rev. B.

25. M. Şahinoğlu, D. Williamson, N. Bultinck, M. Mariën, J. Haegeman, N. Schuch, and F. Verstraete,
Characterizing Topological Order with Matrix Product Operators.
Ann. Henri Poincare **22**, 563 (2021); arXiv:1409.2150.

26. S. Jandura, M. Iqbal, and N. Schuch,
Quantum trimer models and topological SU(3) spin liquids on the kagome lattice.
Phys. Rev. Research **2**, 033382 (2020); arXiv:2006.08646.

27. J. Guth Jarkovsky, A. Molnar, N. Schuch, and J.I. Cirac,
Efficient description of many-body systems with Matrix Product Density Operators.
PRX Quantum **1**, 010304 (2020); arXiv:2003.12418.

28. C. de Groot, D.T. Stephen, A. Molnar, and N. Schuch,
Inaccessible entanglement in symmetry protected topological phases.
J. Phys. A: Math. Theor. **53**, 335302 (2020); arXiv:2003.06830.

29. G. Scarpa, A. Molnar, Y. Ge, J.J. Garcia-Ripoll, N. Schuch, D. Perez-Garcia, and S. Iblisdir,
Projected Entangled Pair States: Fundamental analytical and numerical limitations.
Phys. Rev. Lett. **125**, 210504 (2020); arXiv:1802.08214.

30. Z. Gong, C. Sünderhauf, N. Schuch, and J. I. Cirac,
Classification of Matrix-Product Unitaries with Symmetries.
Phys. Rev. Lett. **124**, 100402 (2020); arXiv:1812.09183.

31. M. Iqbal, H. Casademunt, and N. Schuch,
Topological Spin Liquids: Robustness under perturbations.
Phys. Rev. B **101**, 115101 (2020); arXiv:1910.06355.

32. A. Hackenbroich, B.A. Bernevig, N. Schuch, and N. Regnault,
Fermionic tensor networks for higher order topological insulators from charge pumping.
Phys. Rev. B **101**, 115134 (2020); arXiv:1912.08219.

33. M. Iqbal, D. Poilblanc, and N. Schuch,
Gapped Z2 spin liquid in the breathing kagome Heisenberg antiferromagnet.
Phys. Rev. B **101**, 155141 (2020); arXiv:1912.08284.

34. J.-Y. Chen, S. Capponi, A. Wietek, M. Mambrini, N. Schuch, and D. Poilblanc,
$\mathrm{SU}(3)_1$ *Chiral Spin Liquid on the Square Lattice: a View from Symmetric PEPS.*
Phys. Rev. Lett. **125**, 017201 (2020); arXiv:1912.13393.

35. N. Schuch and B. Bauer,
Matrix product state algorithms for Gaussian fermionic states.
Phys. Rev. B **100**, 245121 (2019); arXiv:1906.10144.

36. C. Sünderhauf, L. Piroli, X.-L. Qi, N. Schuch, and J.I. Cirac,
Quantum chaos in the Brownian SYK model with large finite N: OTOCs and tripartite information.
JHEP **2019**, 38 (2019); arXiv:1908.00775.

37. D.T. Stephen, H. Dreyer, M. Iqbal, and N. Schuch,
Detecting subsystem symmetry protected topological order via entanglement entropy.
Phys. Rev. B **100**, 115112 (2019); arXiv:1904.09450.

38. I. Kurecic, L. Vanderstraeten, and N. Schuch,
A gapped $\mathrm{SU}(3)$ *spin liquid with* $\mathbb{Z}_3$ *topological order.*
Phys. Rev. B **99**, 045116 (2019); arXiv:1805.11628.

39. G. De las Cuevas, N. Schuch, D. Perez-Garcia, and J.I. Cirac,
Continuum limits of Matrix Product States.
Phys. Rev. B **98**, 174303 (2018); arXiv:1708.00880.

40. A. Molnar, J. Garre-Rubio, D. Pérez-García, N. Schuch, and J.I. Cirac,
Normal projected entangled pair states generating the same state.
New J. Phys. **20**, 113017 (2018); arXiv:1804.04964.

41. C. Sünderhauf, D. Perez-Garcia, D.A. Huse, N. Schuch, and J.I. Cirac,
Localization with random time-periodic quantum circuits.
Phys. Rev. B **98**, 134204 (2018); arXiv:1805.08487.

42. H. Dreyer, J.I. Cirac, and N. Schuch,
Projected Entangled Pair States with continuous virtual symmetries.
Phys. Rev. B **98**, 115120 (2018); arXiv:1805.03659.

43. A. Hackenbroich, A. Sterdyniak, and N. Schuch,
Interplay of SU(2)*, point group and translation symmetry for PEPS: application to a chiral spin liquid.*
Phys. Rev. B **98**, 085151 (2018); arXiv:1805.04531.

44. M. Iqbal, K. Duivenvoorden, and N. Schuch,
Study of anyon condensation and topological phase transitions from a $\mathbb{Z}_4$ topological phase using Projected Entangled Pair States.
Phys. Rev. B **97**, 195124 (2018); arXiv:1712.04021.

45. A. Molnar, Y. Ge, N. Schuch, and J.I. Cirac,
A generalization of the injectivity condition for Projected Entangled Pair States.
J. Math. Phys. **59**, 021902 (2018); arXiv:1706.07329.

46. G. De las Cuevas, J.I. Cirac, N. Schuch, and D. Perez-Garcia,
Irreducible forms of Matrix Product States: Theory and Applications.
J. Math. Phys. **58**, 121901 (2017); arXiv:1708.00029.

47. J.I. Cirac, D. Perez-Garcia, N. Schuch, and F. Verstraete,
Matrix Product Unitaries: Structure, Symmetries, and Topological Invariants.
J. Stat. Mech. 083105 (2017); arXiv:1703.09188.

48. M Rispler, K. Duivenvoorden, and N. Schuch,
$\mathbb{Z}_N$ symmetry breaking in Projected Entangled Pair State models.
J. Phys. A: Math. Theor. **50**, 365001 (2017); arXiv:1703.04137.

49. L. Vanderstraeten, M. Mariën, J. Haegeman, N. Schuch, J. Vidal, and F. Verstraete,
Bridging Perturbative Expansions with Tensor Networks.
Phys. Rev. Lett. **119**, 070401 (2017); arXiv:1703.04112.

50. K. Duivenvoorden, M. Iqbal, J. Haegeman, F. Verstraete, and N. Schuch,
Entanglement phases as holographic duals of anyon condensates.
Phys. Rev. B **95**, 235119 (2017); arXiv:1702.08469.
Selected as *Editors' Suggestion* at Phys. Rev. B.

51. J.I. Cirac, D. Perez-Garcia, N. Schuch, and F. Verstraete,
Matrix Product Density Operators: Renormalization Fixed Points and Boundary Theories.
Annals of Physics **378**, 100 (2017); arXiv:1606.00608.

52. C. Fernandez-Gonzalez, R.S.K. Mong, O. Landon-Cardinal, D. Perez-Garcia, and N. Schuch,
Constructing topological models by symmetrization: A PEPS study.
Phys. Rev. B **94**, 155106 (2016); arXiv:1608.00594.

53. D. Poilblanc, N. Schuch, and I. Affleck,
$SU(2)_1$ *chiral edge modes of a critical spin liquid.*
Phys. Rev. B **93**, 174414 (2016); arXiv:1602.05969.

54. T. Morimae, D. Nagaj, and N. Schuch,
Quantum proofs can be verified using only single qubit measurements.
Phys. Rev. A **93**, 022326 (2016); arXiv:1510.06789.

55. M. Rispler, K. Duivenvoorden, and N. Schuch,
Long range order and symmetry breaking in Projected Entangled Pair State models.
Phys. Rev. B **92**, 155133 (2015); arXiv:1505.04217.

56. D. Poilblanc, J.I. Cirac, and N. Schuch,
Chiral topological spin liquids with projected entangled pair states.
Phys. Rev. B **91**, 224431 (2015); arXiv:1504.05236.

57. J. Haegeman, V. Zauner, N. Schuch, and F. Verstraete,
Shadows of anyons and the entanglement structure of topological phases.
Nature Comm. **6**, 8284 (2015); arXiv:1410.5443.

58. J. Haegeman, K. Van Acoleyen, N. Schuch, J.I. Cirac, and F. Verstraete,
Gauging quantum states: from global to local symmetries in many-body systems.
Phys. Rev. X **5**, 011024 (2015); arXiv:1407.1025.

59. S. Yang, T.B. Wahl, H.-H. Tu, N. Schuch, and J.I. Cirac,
Chiral projected entangled-pair state with topological order.
Phys. Rev. Lett. **114**, 106803 (2015); arXiv:1411.6618.

60. V. Zauner, D. Draxler, L. Vanderstraeten, M. Degroote, J. Haegeman, M.M. Rams, V. Stojevic, N. Schuch, and F. Verstraete,
Transfer Matrices and Excitations with Matrix Product States.
New J. Phys. **17**, 053002 (2015); arXiv:1408.5140.

61. A. Molnár, N. Schuch, F. Verstraete, and J.I. Cirac,
Approximating Gibbs states of local Hamiltonians efficiently with PEPS.
Phys. Rev. B **91**, 045138 (2015); arXiv:1406.2973.

62. C. Fernández-González, N. Schuch, M.M. Wolf, J.I. Cirac, and D. Pérez-García,
Frustration free gapless Hamiltonians for Matrix Product States.
Commun. Math. Phys. **333**, 299 (2015); arXiv:1210.6613.

63. T.B. Wahl, S.T. Haßler, H.-H. Tu, J.I. Cirac, and N. Schuch,
Boundary theories for chiral Projected Entangled Pair States.
Phys. Rev. B **90**, 115133 (2014); arXiv:1405.0447.

64. M. Iqbal, D. Poilblanc, and N. Schuch,
Semionic resonating valence bond states.
Phys. Rev. B **90**, 115129 (2014); arXiv:1407.7773.

65. D. Poilblanc, P. Corboz, N. Schuch, and J.I. Cirac,
Resonating valence bond superconductors with fermionic projected entangled pair states.
Phys. Rev. B **89**, 241106 (2014); arXiv:1404.5268.

66. S. Yang, L. Lehman, D. Poilblanc, K. Van Acoleyen, F. Verstraete, J.I. Cirac, and N. Schuch,
Edge theories in Projected Entangled Pair State models.
Phys. Rev. Lett. **112**, 036402 (2014); arXiv:1309.4596.

67. T.B. Wahl, H.-H. Tu, N. Schuch, and J.I. Cirac,
Projected entangled-pair states can describe chiral topological states.
Phys. Rev. Lett. **111**, 236805 (2013); arXiv:1308.0316.

68. G. De las Cuevas, N. Schuch, D. Pérez-García, and J.I. Cirac,
Purifications of multipartite states: limitations and constructive methods.
New J. Phys. **15**, 123021 (2013); arXiv:1308.1914.

69. D. Poilblanc, N. Schuch, and J.I. Cirac,
Field-induced superfluids and Bose liquids in Projected Entangled Pair States.
Phys. Rev. B **88**, 144414 (2013); arXiv:1308.3463.

70. N. Schuch, D. Poilblanc, J.I. Cirac, and D. Perez-Garcia,
Topological order in PEPS: Transfer operator and boundary Hamiltonians.
Phys. Rev. Lett. **111**, 090501 (2013); arXiv:1210.5601.

71. J.I. Cirac, S. Michalakis, D. Perez-Garcia, N. Schuch,
Robustness in Projected Entangled Pair States.
Phys. Rev. B **88**, 115108 (2013); arXiv:1306.4003.

72. J. Haegeman, S. Michalakis, B. Nachtergaele, T.J. Osborne, N. Schuch, and F. Verstraete,
Elementary excitations in gapped quantum spin systems.
Phys. Rev. Lett. **111**, 080401 (2013); arXiv:1305.2176.

73. D. Poilblanc and N. Schuch,
Simplex Z2 spin liquids on the Kagome lattice with Entangled Pair States: spinon and vison coherence lengths, topological entropy and gapless edge modes.
Phys. Rev. B **87**, 140407 (2013); arXiv:1302.0306.

74. C. Fernández-González, N. Schuch, M.M. Wolf, J.I. Cirac, and D. Pérez-García,
Gapless Hamiltonians for the toric code using the PEPS formalism.
Phys. Rev. Lett. **109**, 260401 (2012); arXiv:1111.5817.

75. N. Schuch, D. Poilblanc, J.I. Cirac, and D. Pérez-García,
Resonating valence bond states in the PEPS formalism.
Phys. Rev. B **86**, 115108 (2012); arXiv:1203.4816 (2012).
Selected as *Editors' Suggestion* at Phys. Rev. B.

76. J. Haegeman, D. Pérez-García, J.I. Cirac, and N. Schuch,
An order parameter for symmetry-protected phases in one dimension.
Phys. Rev. Lett. **109**, 050402 (2012); arXiv:1201.4174.

77. D. Poilblanc, N. Schuch, D. Pérez-García, and J.I. Cirac,
Topological and Entanglement Properties of Resonating Valence Bond wavefunctions.
Phys. Rev. B **86**, 014404 (2012); arXiv:1202.0947 (2012).

78. M. Christandl, N. Schuch, and A. Winter,
Entanglement of the Antisymmetric State.
Commun. Math. Phys. **311**, 397 (2012); arXiv:0910.4151.

79. N. Schuch, D. Perez-Garcia, and J.I. Cirac,
Classifying quantum phases using MPS and PEPS.
Phys. Rev. B **84**, 165139 (2011) ; arXiv:1010.3732.

80. N. Schuch, S.K. Harrison, T.J. Osborne, and J. Eisert,
Information propagation for interacting particle systems.
Phys. Rev. A **84**, 032309 (2011); arXiv:1010.4576.

81. N. Schuch,
Complexity of commuting Hamiltonians on a square lattice of qubits.
Quantum Inf. Comput. **11**, 901 (2011); arXiv:1105.2843.

82. B. Brown, S.T. Flammia, and N. Schuch,
Computational difficulty of computing the Density of States.
Phys. Rev. Lett. **107**, 040501 (2011); arXiv:1010.3060.

83. I. Cirac, D. Poilblanc, N. Schuch, and F. Verstraete,
Entanglement spectrum and boundary theories with projected entangled-pair states.
Phys. Rev. B **83**, 245134 (2011); arXiv:1103.3427.

84. N. Schuch, J.I. Cirac, and D. Perez-Garcia,
PEPS as ground states: degeneracy and topology.
Annals of Physics **325**, 2153 (2010); arXiv:1001.3807.

85. N. Schuch and J.I. Cirac,
Matrix Product State and mean field solutions for one-dimensional systems can be found efficiently.
Phys. Rev. A **82**, 012314 (2010); arXiv:0910.4264.

86. A. Sfondrini, J. Cerrillo, N. Schuch, and J.I. Cirac,
Simulating two- and three-dimensional frustrated quantum systems with string-bond states.
Phys. Rev. B **81**, 214426 (2010); arXiv:0908.4036.

87. M. Christandl, N. Schuch, and A. Winter,
Highly Entangled States With Almost No Secrecy.
Phys. Rev. Lett. **104**, 240405 (2010); arXiv:1101.4522.

88. C.V. Kraus, N. Schuch, F. Verstraete, and J.I. Cirac,
Fermionic Projected Entangled Pair States.
Phys. Rev. A **81**, 052338 (2010); arXiv:0904.4667.

89. F. Pastawski, A. Kay, N. Schuch, and J.I. Cirac,
Limitations of Passive Protection of Quantum Information.
Quant. Inf. Comput. **10**, 580 (2010); arXiv:0911.3843.

90. N. Schuch and F. Verstraete,
Computational complexity of interacting electrons and fundamental limitations of density functional theory.
Nature Physics **5**, 732 (2009); arXiv:0712.0483.

91. F. Mezzacapo, N. Schuch, M. Boninsegni, and J.I. Cirac,
Ground-State Properties of Quantum Many-Body Systems: Entangled-Plaquette States and Variational Monte Carlo.
New J. Phys. **11**, 083026 (2009); arXiv:0905.3898.

92. F. Pastawski, A. Kay, N. Schuch, and J.I. Cirac,
How long can a quantum memory withstand depolarizing noise?
Phys. Rev. Lett. **103**, 080501 (2009); arXiv:0904.4861.

93. S. Perseguers, L. Jiang, N. Schuch, F. Verstraete, M.D. Lukin, J.I. Cirac, and K.G.H. Vollbrecht,
One-shot entanglement generation over long distances in noisy quantum networks.
Phys. Rev. A **78**, 062324 (2008); arXiv:0807.0208.

94. N. Schuch, J.I. Cirac, and F. Verstraete,
The computational difficulty of finding matrix product ground states.
Phys. Rev. Lett. **100**, 250501 (2008); arXiv:0802.3351.

95. N. Schuch, M.M. Wolf, K.G.H. Vollbrecht, and J.I. Cirac,
On entropy growth and the hardness of simulating time evolution.
New J. Phys. **10**, 033032 (2008); arXiv:0801.2078.

96. N. Schuch, M.M. Wolf, F. Verstraete, and J.I. Cirac,
Simulation of Quantum Many-Body Systems with Strings of Operators and Monte Carlo Tensor Contractions.
Phys. Rev. Lett. **100**, 040501 (2008); arXiv:0708.1567.

97. D. Gross, J. Eisert, N. Schuch, and D. Perez-Garcia,
Measurement-based quantum computation beyond the one-way model.
Phys. Rev. A **76**, 052315 (2007); arXiv:0706.3401.

98. N. Schuch, M.M. Wolf, F. Verstraete, and J.I. Cirac,
Entropy scaling and simulability by Matrix Product States.
Phys. Rev. Lett. **100**, 030504 (2008); arXiv:0705.0292.

99. N. Schuch, M.M. Wolf, F. Verstraete, and J.I. Cirac,
The computational complexity of PEPS.
Phys. Rev. Lett. **98**, 140506 (2007); quant-ph/0611050.

100. N. Schuch, J.I. Cirac, and M.M. Wolf,
Quantum states on Harmonic lattices.
Commun. Math. Phys. **267**, 65 (2006); quant-ph/0509166.

101. N. Schuch, M.M. Wolf, and J.I. Cirac,
Optimal squeezing and entanglement from noisy Gaussian operations.
Phys. Rev. Lett. **96**, 023004 (2006); quant-ph/0505145.

102. N. Schuch, F. Verstraete, and J.I. Cirac,
Quantum entanglement theory in the presence of superselection rules.
Phys. Rev. A **70**, 042310 (2004); quant-ph/0404079.

103. N. Schuch, F. Verstraete, and J.I. Cirac,
Nonlocal resources in the presence of Superselection Rules.
Phys. Rev. Lett. **92**, 087904 (2004); quant-ph/0310124.

104. N. Schuch and J. Siewert,
Programmable networks for quantum algorithms.
Phys. Rev. Lett. **91**, 027902 (2003); quant-ph/0303063.

105. N. Schuch and J. Siewert,
Natural two-qubit gate for quantum computation using the XY interaction.
Phys. Rev. A **67**, 032301 (2003); quant-ph/0209035.

106. N. Schuch and J. Siewert,
Implementation of the Four-Bit Deutsch-Jozsa Algorithm with Josephson Charge Qubits.
phys. stat. sol. (b) **233**, 482 (2002).

Preprints

107. N. Schuch and F. Verstraete,
Matrix product state approximations for infinite systems.
arXiv:1711.06559 (2017).

108. A. Molnar, A. Ruiz de Alarcón, J. Garre-Rubio, N. Schuch, J.I. Cirac, and D. Pérez-García,
Matrix product operator algebras I: representations of weak Hopf algebras and projected entangled pair states.
arXiv:2204.05940 (2022).

109. M. Florido-Llinàs, A. Alhambra, R. Trivedi, N. Schuch, D. Pérez-García, and J.I. Cirac,
The product structure of MPS-under-permutations.
arXiv:2410.19541 (2024).

110. H. Buhrman, S. Gharibian, Z. Landau, F. Le Gall, N. Schuch, and S. Tamaki,
Beating the natural Grover bound for low-energy estimation and state preparation.
arXiv:2407.03073 (2024).

111. K. S. Rai, I. Kull, P. Emonts, J. Tura, N. Schuch, and F. Baccari,
A Hierarchy of Spectral Gap Certificates for Frustration-Free Spin Systems.
arXiv:2411.03680 (2024).

112. N. Schuch, A. Molnar, and D. Perez-Garcia,
Simple Hamiltonians for Matrix Product State models.
arXiv:2503.10767 (2025).

113. D. Blanik, J. Garre-Rubio, and N. Schuch,
Gauging Quantum Phases: A Matrix Product State Approach.
arXiv:2504.14380 (2025).

114. R. Mansuroglu and N. Schuch,
Preparation Circuits for Matrix Product States by Classical Variational Disentanglement.
arXiv:2504.21298 (2025).

Papers in Proceedings

115. N. Schuch, M.M. Wolf, and J.I. Cirac,
Gaussian Matrix Product States.
Quantum Information and Many Body Quantum Systems proceedings (2008); arXiv:1201.3945.

116. N. Schuch, M.M. Wolf, and J.I. Cirac,
Squeezing and entanglement from noisy Gaussian operations (Invited paper).
Proc. SPIE 5842, 37 (2005).

117. F. Verstraete, N. Schuch, and J.I. Cirac,
Nonlocality in the presence of superselection rules (Invited paper).
Proc. SPIE 5468, 93 (2004).

Book Chapters

118. N. Schuch,
Entanglement in correlated quantum systems: A quantum information perspective.
In: E. Pavarini, E. Koch, F. Anders, and M. Jarrell (eds.): Correlated Electrons: From Models to Materials, Modeling and Simulation, Vol. 2 (Verlag des Forschungszentrum Jülich, 2012).

119. N. Schuch,
Condensed Matter Applications of Entanglement Theory.
In: D. DiVincenzo (ed.): Quantum Information Processing. Lecture Notes of the 44th IFF Spring School 2013 (Verlag des Forschungszentrums Jülich, 2013). arXiv:1306.5551.

120. J.D. Whitfield, N. Schuch, and F. Verstraete,
The computational complexity of density functional theory.
In: V. Bach and L. Delle Site (eds.): Many-Electron Approaches in Physics, Chemistry and Mathematics. (Springer, 2014). arXiv:1306.1259.

Popular Articles

121. M.C. Banuls, J.I. Cirac, and N. Schuch,
Verschränkung und Information. (in German)
Physik Journal 09/2018, pg. 48 (2018).

6. Talks

Invited talks at international conferences and schools

1. Workshop on "Tensor network methods and entanglement in quantum many-body systems", Vienna (Austria), Jan. 2008: *The complexity of finding MPS ground states.*
2. ISCQI '08 Conference, Bhubaneswar (India), Mar. 2008: *Simulating quantum many-body systems using string-bond states.*
3. Workshop on Quantum Information, Sant Benet (Spain), Dec. 2008: *Simulating quantum many-body systems: Algorithms and limitations (tutorial talk).*
4. Conference "Numerical Approaches to Quantum Many-Body Systems", University of California Los Angeles (USA), Jan. 2009: *Quantum simulations using string-bond states: Joining PEPS and Monte Carlo.*
5. Workshop on Tensor Networks, Garching (Germany), Jan. 2010: *Understanding PEPS as topological ground states from symmetries.*
6. Workshop on Complex Quantum Systems, IMS, Singapore (Singapore), Mar. 2010: *How symmetries determine the properties of quantum many-body systems.*
7. CECAM Workshop on Tensor Network Methods for Quantum Chemistry, Zurich (Switzerland), Mar. 2010: *Quantum Simulations combining Tensor Networks and Monte Carlo.*
8. 10th Symposium on Topological Quantum Information, Leeds (UK), Apr. 2010: *Understanding topological properties from symmetries in tensor networks.*
9. 3rd International Workshop on the Density Matrix Renormalization Group method, Beijing (China), Aug. 2010: *Classifying quantum phases using tensor network states.*
10. Workshop on Hamiltonians and Gaps, Cambridge (UK), Sept. 2010: *Classifying quantum phases using Matrix Product States and PEPS.*
11. Workshop on Collective Quantum Operations for Information Technologies, Hannover (Germany), Nov. 2010: *Classifying quantum phases using Matrix Product States and PEPS.*
12. Sydney Workshop on Quantum Information and Condensed Matter, Sydney (Australia), Jan. 2011: *Classifying quantum phases using Matrix Product States and PEPS.*
13. FRG workshop on "Quantum spin systems and quantum computing", Harvard University, Cambridge (USA), May 2011: *Classifying gapped quantum phases using Matrix Product states.*
14. 11th Canadian Summer School on Quantum Information, Sherbrooke (Canada), June 2011: Lecture course on *Quantum Information and Quantum Many-Body Physics.*
15. QCCC Workshop, Bernried (Germany), Oct. 2011: *Symmetry protected phases in one dimension.*
16. CIFAR Workshop on Quantum Information Processing, Calgary (Canada), Nov. 2011: *Studying the entanglement structure of twodimensional systems at their boundary.*
17. Sydney Quantum Information Theory Workshop, Sydney (Australia), Jan. 2012: *An order parameter for symmetry-protected topological order.*
18. 14th Annual SQuInT workshop, Albuquerque NM (USA), Feb. 2012: *Matrix Product States, Projected Entangled Pair States, and the entanglement spectrum of two-dimensional quantum systems.*
19. Workshop "Networking tensor networks: many-body systems and simulations", Benasque (Spain), May 2012: *Entanglement spectrum and boundary theories with Projected Entangled Pair States.*
20. Quantum Information Workshop, Seefeld (Austria), July 2012: *An order parameter for symmetry-protected topological order.*
21. Autumn School on Correlated Electrons: From Models to Materials, Jülich (Germany), Sept. 2012: Lecture course on *Entanglement in correlated quantum systems: A quantum information perspective.*

22. Sydney Quantum Information Theory Workshop, Sydney (Australia), Jan. 2013: *Bulk-boundary correspondence and entanglement Hamiltonians in the PEPS formalism.*
23. Symposium on Topological Quantum Information, Benasque (Spain), Feb. 2013: *Topological phases and tensor networks: The role of symmetries.*
24. 44th IFF Spring School "Quantum Information Processing", Jülich (Germany), Feb./Mar. 2013: *Lecture course on Condensed Matter Applications of Entanglement Theory.*
25. Conference "Emergence and Entanglement II", Perimeter Institute, Waterloo (Canada), May 2013: *Characterizing topological spin liquids using Projected Entangled Pair States.*
26. CECAM Workshop "Tensor network algorithms in computational physics and numerical analysis", Zurich (Switzerland), May 2013: *Characterizing topological spin liquids using PEPS.*
27. Symposium KCIK 2013, Gdansk (Poland), May 2013: *Characterizing topological spin liquids using PEPS.*
28. CECAM Workshop "Topological phases in Condensed Matter and Cold Atom Systems: towards quantum computations", Cargese (France), June 2013: *Characterizing topological order in Projected Entangled Pair States.*
29. Workshop "Statistical Physics of Quantum Matter", Taipei (Taiwan), July 2013: *Characterizing topological order in Projected Entangled Pair States.*
30. QCCC Symposium, IAS, TU Munich (Germany), Oct. 2013: *Boundaries of strongly correlated systems: A Quantum Information perspective.*
31. Workshop on Quantum Hamiltonian Complexity, Simons Institute, UC Berkeley (USA), Mar. 2014: *Bulk-boundary correspondence in Projected Entangled Pair States.*
32. Workshop "Tensor Networks and Simulations", Simons Institute, UC Berkeley (USA), Apr. 2014: *Topological order in Projected Entangled Pair States.*
33. Workshop "Quantum Matter", Benasque (Spain), June 2014: *Topological order and Projected Entangled Pair States.*
34. Workshop "Quantum Information", Seefeld (Austria), July 2014: *Characterization of topological spin liquids with Projected Entangled Pair States.*
35. ESI Programme "Topological Phases of Quantum Matter, Wien (Austria), Aug. 2014: *Topological order and chirality in Projected Entangled Pair States.*
36. QUTE-Europe Summer School, Smolenice (Slovakia), Aug. 2014: Lecture on *Quantum information and many-body systems.*
37. Workshop "Numerical and analytical methods for strongly correlated systems", Benasque (Spain), Sept. 2014: *Symmetries and topological order in Projected Entangled Pair States.*
38. CMSI International Workshop 2014: "Tensor Network Algorithms in Materials Science", Kobe (Japan), Oct. 2014: *Identifying quantum order from the transfer operator.*
39. Workshop "Entangle This: Space, Time, and Matter", Madrid (Spain), Feb. 2015: *Topological phase transitions: a holographic perspective.*
40. APS March Meeting, San Antonio (USA), Mar. 2015: *The computational complexity of many-electron problems and Density Functional Theory.*
41. Tensor Network Summer School, University of Gent (Belgium), June 2015: *Projected Entangled Pair States – Theory and Mathematical Foundations.*
42. Topological Phases in Condensed Matter and Cold Atom Systems, Cargese (France), Sept. 2015: *Topological order in Projected Entangled Pair States.*
43. IDEA League School, Zurich (Switzerland), Sept. 2015: *Lecture on Entanglement and Many-Body Systems.*

44. Workshop on the Frontiers of Quantum Information and Computer Science, University of Maryland (USA), Oct. 2015: *Topological phase transitions in Tensor Networks: A holographic perspective.*
45. Sydney Quantum Information Theory Workshop, Sydney (Australia), Feb. 2016: *Topological phases in Tensor Networks: A holographic perspective.*
46. Workshop "Entanglement in Strongly Correlated Systems", Benasque (Spain), Feb. 2016: *Introduction to Tensor Networks.* (tutorial talk)
47. NORDITA Workshop "From Quantum Field Theories to Numerical Methods", Stockholm (Sweden), May 2016: *Topological phase transitions and anyon condensation in tensor networks: A holographic perspective.*
48. Workshop "Exploring Quantum Matter", Übersee (Germany), June 2016: *Assessing topological spin liquids with projected entangled pair states.*
49. Workshop "Entanglement Matters", Aspen (USA), June 2016: *Topological order and tensor networks.*
50. International Workshop on Tensor Networks and Quantum Many-Body Problems, Kashiwa (Japan), July 2016: *Lecture on Topological Order in Projected Entangled Pair States.*
51. International Workshop on Tensor Networks and Quantum Many-Body Problems, Kashiwa (Japan), July 2016: *Constructing topological models by symmetrization: a PEPS study.*
52. Gordon Research Conference "Quantum Science", Boston (USA), Aug. 2016: *Topological Order and Tensor Networks: A Holographic Perspective.*
53. KITP Conference "Topological Quantum Matter", Santa Barbara (USA), Oct. 2016: *Tensor Network States for the Study of Strongly Correlated Quantum Systems.*
54. International School "Tensor product state simulations of strongly correlated systems", Max Planck Institute for the Physics of Complex Systems, Dresden, Nov. 2016: *Analytical study of many-body systems with Tensor Network States.*
55. Symposium "Frontiers in Physical Sciencies", Buenos Aires (Argentina), Nov. 2016: *Entanglement and topological order: A quantum information perspective.*
56. Workshop "Many-body entanglement and topological quantum phenomena", Sanya (China), Dec. 2016: *Studying topological quantum phenomena using Tensor Networks.*
57. Meeting "Materials on the Exascale", Trieste (Italy), Jan. 2017: *Quantum Information and Technology, and possible overlaps with high-performance electronic structure calculations.*
58. QIP Workshop, Seattle (USA), Jan. 2017: *Matrix Product States and Tensor Network States* (tutorial talk).
59. Workshop "Entanglement in Strongly Correlated Systems", Benasque (Spain), Feb. 2017: *Introduction to Matrix Product States and Projected Entangled Pair States.*
60. Invited talk at Spring Meeting of the German Physical Society (DPG), Bremen (Germany), March 2017: *Entanglement in topologically ordered systems: A quantum information perspective.*
61. Workshop "Entangle This: Tensor Networks and Gravity", Madrid (Spain), May 2017: *Many-body systems: Entanglement spectra and symmetries at the boundary.*
62. Advanced School on Quantum Science and Quantum Technologies, ICTP, Trieste (Italy), Sept. 2017: *Lecture course on Tensor Networks.*
63. Workshop on Quantum Science and Quantum Technologies, ICTP, Trieste (Italy), Sept. 2017: *Entanglement and topological order: A quantum information perspective.*
64. Arnold Sommerfeld School, Munich (Germany), Sept. 2017: *Lecture on Tensor Networks.*
65. Programme "Quantum Physics of Information", KITP, Santa Barbara (USA), Oct. 2017: *Introduction to tensor networks.*

66. European Tensor Network School, Gent (Belgium), Nov. 2017: *Tensor Networks in two dimensions: Basics, entanglement spectra and edge physics, topological order.*
67. Pre-Workhop Lectures "Tensor-Network Methods: Structure, Applications and Holography", Simons Center for Geometry and Physics, Stony Brook (USA), Dec. 2017: *Lecture course on Tensor Network Theory – Symmetries, Entanglement, and Topological Order.*
68. Workshop "Tensor-Network Methods: Structure, Applications and Holography", Simons Center for Geometry and Physics, Stony Brook (USA), Dec. 2017: *Anyon condensation and topological phase transitions in tensor networks.*
69. Conference "Quantum Information Theory", Institut Henri Poincare, Paris (France), Dec. 2017: *Entanglement in complex quantum systems.*
70. Sydney Quantum Information Theory Workshop, Sydney (Australia), Jan. 2018: *Studying topological spin liquids with PEPS.*
71. Invited Tutorial at Spring Meeting of the German Physical Society (DPG), Erlangen (Germany), March 2018: *An Introduction to Quantum Computers.*
72. 9th International School on Mathematical Physics "Topological order and beyond", Bogota (Colombia), May 2018: Lecture course *Topological order: a simple perspective from stabilizer codes and tensor networks.*
73. International Workshop "Optimising, Renormalising, Evolving and Quantising Tensor Networks", Dresden (Germany), June 2018: *Constructing and analyzing topological spin liquids using Projected Entanged Pair States.*
74. SIGN'18 – International Workshop on the sign problem in QCD and Beyond, Bielefeld (Germany), Sept. 2018: *Symmetries and topological order in strongly correlated quantum systems – a Tensor Network perspective.*
75. Bad Honnef Physics School "Gauge theory and topological quantum matter", Bad Honnef (Germany), Sept. 2018: *Tensor networks for chiral topological states.*
76. International School and Workshop "Topological Phases in Condensed Matter and Cold Atom Systems", Cargese (Corsica), Oct. 2018: *SU(3) topological spin liquids and trimer models.*
77. 41st Heidelberg Graduate Days, Heidelberg (Germany), Oct. 2018: Lecture course *Entanglement in quantum many-body systems.*
78. Workshop "Quantum Information and Statistical Mechanics", CRM, Montreal (Canada), Oct. 2018: *Constructing topological models by symmetrization: A PEPS study.*
79. Workshop Anyons in Quantum Many-Body Systems, Dresden (Germany), Jan. 2019: *Entanglement spectroscopy of anyons with tensor networks.*
80. Aspen Winter Conference "New Approaches to Strongly Correlated Quantum Systems", Aspen (USA), Feb. 2019: *Study of topological spin liquids with projected entangled pair states.*
81. VDS Winter School on Mathematics, Dienten (Austria), March 2019: Lecture *Introduction to Quantum Error Correction.*
82. Workshop on Low-D Quantum Condensed Matter, Amsterdam (Netherlands), July 2019: *Order parameters for topological phases from tensor networks.*
83. Croucher Summer School "Quantum entanglement and topological order", Hongkong, July 2019: Lecture *Tensor network states and quantum entanglement.*
84. KITP program "Topological Quantum Matter: Concepts and Realizations", KITP, Santa Barbara (USA), Sept. 2019: *Order parameters for topological phases from tensor networks.*
85. Focus Week "Tensor Networks", ICMAT, Madrid (Spain), Sept. 2019: *Construction and analysis of SU(3) spin liquids and resonating trimer models using Projected Entangled Pair States.*

86. Workshop “Symmetry, Phases of Matter, and Resources in Quantum Computing”, Perimeter Institute, Waterloo (Canada), Nov. 2019: *Detecting subsystem symmetry protected topological order using entanglement entropy and tensor networks.*
87. Sydney Quantum Information Theory Workshop, Sydney (Australia), Feb. 2020: *Order parameters for topological phases from tensor networks.*
88. Munich Conference on Quantum Science and Technology 2020, Munich (Germany), July 2020 (online): *An entanglement-based view on quantum many-body systems.*
89. International School “Tensor Network based approaches to Quantum Many-Body Systems”, Bad Honnef (Germany), Oct. 2020: Lecture *Topological order and spin liquids in tensor networks.*
90. Online Conference “Quantum Matter in the Age of Entanglement”, Princeton (USA), Dec. 2020 (online): *Entanglement order parameters for Quantum Matter.*
91. BeyondC Winter Workshop, Vienna (Austria), Feb. 2021 (online): *Quantum many-body systems: An entanglement-based perspective.*
92. Physics Road Trip: Quantum Optics and Quantum Information, jDPG Siegen, Apr. 2021 (online): *From Quantum Information to Quantum Many-Body Physics – A Physics Road Trip.*
93. Workshop “Tensor Network States and Applications”, IPAM, UCLA, Los Angeles (USA), Apr. 2021 (online): *Matrix product state algorithms for Gaussian fermionic states.*
94. Institute of Nuclear Theory Workshop “Tensor Networks in Many Body and Quantum Field Theory”, Seattle (USA), May 2021 (online): *Entanglement order parameters from Tensor Networks.*
95. Workshop “The Quantum Wave in Computing”, Simons Institute for the Theory of Computing, UC Berkeley, Berkeley CA (USA), July 2021 (online): *Preparation and Verification of Tensor Network States.*
96. Summer Cluster Quantum Computation, Simons Institute for the Theory of Computing, UC Berkeley, Berkeley CA (USA), Aug. 2021: *Complexity of the free energy problem.*
97. Invited talk at Autumn Meeting of the German Physical Society (DPG), University of Kaiserslautern (Germany), Sept. 2021 (online): *An entanglement-based perspective on quantum many-body systems.*
98. Symposium “Mathematical analysis of complex quantum systems”, DMV-ÖMG Meeting 2021, Passau (Germany), Sept. 2021: *Study of complex quantum systems using Tensor Network States.*
99. Workshop “Topology, Disorder, and Hydrodynamics in Non-equilibrium Quantum Matter”, Erwin Schrödinger International Institute for Mathematics and Physics (ESI), Vienna (Austria), Dec. 2021: *Matrix product state algorithms for free fermions in and out of equilibrium.*
100. Workshop “Random Tensors at CIRM”, Centre International de Rencontres Mathematiques (CIRM), Marseille (France), March 2022: *Representation Theory of Tensor Network States.*
101. Conference “Quantum Information 2022”, Seefeld (Austria), June 2022: *Entanglement and topological order in many-body systems*
102. 2022 Summer School for Physics and Tensor-Network Methods in correlated systems, NCTS, Taipei (Taiwan), Aug. 2022 (online): *Projected Entangled Pair States, topological order, and topological spin liquids.*
103. Workshop “Tensors: Quantum Information, Complexity and Combinatorics”, Centre de Recherches Mathématiques (CRM), Montreal (Canada), Nov. 2022 (online): *Fundamental theorems of tensor networks and what to use them for.*
104. Workshop “Entanglement Scaling and Criticality with Tensor Networks”, CECAM, Lausanne (Switzerland), Nov. 2022: *Lower bounds on ground state energies from tensor networks.*
105. QIP Satellite Workshop, London (UK), Feb. 2023: *Lower bounding ground state energies using tensor networks.*

106. First Symposium on Correlated Quantum Materials and Solid State Quantum Systems, TU Vienna, Vienna (Austria), Feb. 2023: *Entanglement and topological order in many-body systems.*
107. Second Plenary Meeting of the International Quantum Tensor Network, Center for Computational Quantum Physics (CCQ), Flatiron Institute, New York (USA), March 2023: *Identification and characterization of topological order using tensor networks.*
108. Research Term "Quantum Information Theory 2023", Focus Week "Tensor Networks", Instituto de Ciencias Matemáticas (ICMAT), Madrid (Spain), March 2023: *Relaxing with tensor networks: Lower bounding ground state energies using renormalization.*
109. Workshop "Tensor Networks in Many Body and Quantum Field Theory", Institute for Nuclear Theory, University of Washington, Seattle (USA), April 2023: *Identification and characterization of topological order with tensor networks.*
110. JSF Workshop on the Fermion Sign Problem, Peyresq (France), July 2023: *The negative sign problem in tensor networks.*
111. Workshop "Many-body Quantum Systems via Classical and Quantum Computation", IPAM, UCLA, Los Angeles (USA), Nov. 2023: *Lower bounding ground state energies through renormalization and tensor networks.*
112. Workshop "Tensor Networks", IPAM, UCLA, Los Angeles (USA), Feb. 2024: *Tensor networks and the negative sign problem.*
113. Workshop "Recent progress on tensor network methods", Institute for Advanced Study, TU Munich, Munich (Germany), April 2024: *Tensor networks and the negative sign problem.*
114. Workshop "Bridging the Gap between Classical and Quantum Simulation", Lorentz Center, Leiden (The Netherlands), May 2024: *Classical Complexity of Tensor Network Simulations.*
115. Workshop on Quantum Information and Physics, Institute for Advanced Study (IAS), Princeton (USA), Aug. 2024: *Quantum Information Theory* (tutorial talk).
116. Conference "Random Tensors", Institut Henri Poincare (IHP), Paris (France), Oct. 2024: *The role of positivity in tensor network contraction.*
117. Workshop "Tensor Network States: Algorithms and Applications", The Chinese University of Hong Kong (Hong Kong), Dec. 2024: *Hardness of contracting tensor networks and the negative sign problem.*

Invited seminar talks

1. Institute for Mathematical Sciences, Imperial College, London (UK), Oct. 2006: *The computational complexity of Projected Entangled Pair States.*
2. University of Vienna (Austria), Sept. 2007: *Simulating many-body systems with string-bond states.*
3. Universidad Complutense, Madrid (Spain), Dec. 2007: *The complexity of understanding quantum systems.*
4. Technical University Munich, Dept. of Computer Science, Munich (Germany), Feb. 2008: *Tensor Network methods for simulating quantum systems.*
5. Perimeter Institute, Waterloo (Canada), Nov. 2008: *Computational difficulty of simulation methods: Density Functional Theory, DMRG, and beyond.*
6. University of Heidelberg, Dept. of Theoretical Physics, Heidelberg (Germany), Nov. 2008: *Nonlocality and entanglement in the presence of Superselection Rules.*
7. IQI Seminar, Caltech, Pasadena (CA, USA), April 2009: *Simulating quantum systems using Tensor Networks and Monte Carlo.*
8. Niels Bohr Institute, Copenhagen (Denmark), May 2009: *Fermionic Projected Entangled Pair States.*

9. CSIC, Madrid (Spain), April 2010: *How symmetries determine the properties of quantum many-body systems.*
10. University of Potsdam, Potsdam (Germany), June 2010: *Symmetries in tensor networks and topological order.*
11. ETH Zurich, Zurich (Switzerland), March 2011: *Classifying quantum phases using Matrix Product States and PEPS.*
12. IQC, University of Waterloo, Waterloo (Canada), April 2011: *Classifying quantum phases using Matrix Product States and PEPS.*
13. University of Southern California, Los Angeles (USA), May 2011: *Classifiying quantum phases using Matrix Product States and PEPS.*
14. Harvard University, Cambridge MA (USA), May 2011: *Entanglement spectrum and boundary theories with projected entangled-pair states.*
15. Centre for Quantum Technologies, Singapore (Singapore), Aug. 2011: *The matrix product state formalism and symmetry protected phases in one dimension.*
16. Forschungszentrum Jülich, Jülich (Germany), Sept. 2011: *Matrix Product States and PEPS: A local perspective on correlated quantum many-body systems.*
17. AMO seminar, UC Berkeley (USA), Dec. 2011: *Matrix Product States: A local perspective on correlated quantum many-body systems.*
18. Condensed Matter seminar, UC Berkeley (USA), Dec. 2011: *Matrix Product States, Projected Entangled Pair States, and the entanglement spectrum of two-dimensional quantum systems.*
19. Computer Science Quantum Meeting, UC Berkeley (USA), Dec. 2011: *Simulating quantum systems using Matrix Product States and PEPS: Numerical application and rigorous results.*
20. Quantum Information Seminar, University of Washington, Seattle WA (USA), Sept. 2012: *Characterizing topological spin liquids using Projected Entangled Pair States.*
21. Quantum Information Seminar, University of British Columbia, Vancouver (Canada), Sept. 2012: *Characterizing topological spin liquids using Projected Entangled Pair States.*
22. Theoretical Physics Colloquium, University of Cologne (Germany), Dec. 2012: *Projected Entangled Pair States: An entanglement-based framework for characterizing correlated quantum systems.*
23. Mathematical Physics Seminar, University of Hannover, Hannover (Germany), April 2013: *Characterizing topological spin liquids using PEPS.*
24. Condensed Matter Seminar, Universite Paul Sabatier, Toulouse (France), Feb. 2014: *Symmetries in Tensor Network States.*
25. Royal Holloway University of London, London (UK), Nov. 2014: *Bulk-boundary correspondence with Projected Entangled Pair States.*
26. University of the Basque Country, Bilbao (Spain), Nov. 2014: *Bulk-boundary correspondence with Projected Entanged Pair States.*
27. California Institute of Technology, Pasadena (USA), March 2015: *Topological phase transitions and symmetry breaking with Tensor Network States.*
28. University of Oxford, Oxford (UK), May 2015: *Topological phases and phase transitions with Projected Entangled Pair States.*
29. ExQM Seminar, TU Munich, Munich (Germany), Jan. 2016: *Tensor network models for the study of correlated quantum systems.*
30. Quantum Information Seminar, Universidad Complutense, Madrid (Spain), April 2016: *Topological phase transitions in tensor networks: A holographic perspective.*

31. CoQuS Colloquium, TU Vienna, Vienna (Austria), April 2016: *Entanglement structure of Complex Quantum Systems.*
32. Theoretical Physics Seminar, University of Göttingen, Göttingen (Germany), May 2016: *Tensor Network States: A framework for the local description of complex entangled quantum systems.*
33. Condensed Matter Theory Seminar, LMU Munich, Munich (Germany), June 2016: *Topological phases and anyon condensation in tensor network models.*
34. Chinese University of Hong Kong, Hong Kong (China), Dec. 2016: *Entanglement structure of complex quantum systems.*
35. IQI Seminar, California Institute of Technology, Pasadena (USA), Jan. 2017: *Constructing topological models by symmetrization: A Projected Entangled Pair State study.*
36. Mathematical Physics Seminar, Technical University Munich, Munich (Germany), March 2017: *Entanglement structure of complex quantum systems.*
37. Condensed Matter Theory Seminar, Technical University Munich, Munich (Germany), July 2017: *Constructing topological models by symmetrization: A Projected Entangled Pair State study.*
38. Innsbruck University, Innsbruck (Germany), Nov. 2017: *Lecture course on Tensor Networks.*
39. Theoretical Physics Colloquium, Innsbruck University, Innsbruck (Germany), Nov. 2017: *Topological order and tensor networks: A local perspective on global entanglement.*
40. ENS, Paris (France), Nov. 2017: *Topological order and tensor networks: A local perspective on global entanglement.*
41. Condensed Matter Seminar, ICTP, Trieste (Italy), Jan. 2018: *Topological order and tensor networks: A local perspective on global entanglement.*
42. Summer School of the Research Training Group SFB 1277 at the University of Regensburg, Bamberg (Germany), Sept. 2018: *An introduction to Quantum Computing.*
43. Weekend Seminar on Quantum Technologies of the jDPG, Munich (Germany), Oct. 2018: *Quantencomputing – eine Einführung* (in German).
44. Evangelische Akademie Villigst, Villigst (Germany), Feb. 2019: *Quantentechnologien* (in German).
45. IQI Seminar, California Institute of Technology, Pasadena (CA, USA), Sept. 2019: *Construction and analysis of SU(3) spin liquids and resonating trimer models using Projected Entangled Pair States.*
46. Universite Toulouse Paul Sabatier, Toulouse (France), Sept. 2019: *Construction and analysis of SU(3) spin liquids and resonating trimer models using Projected Entangled Pair States.*
47. Quantum Seminar, University of Gent, Gent (Belgium), Nov. 2019: *Matrix product state algorithms for Gaussian fermionic states.*
48. Condensed Matter Seminar, Hebrew University, Jerusalem (Israel), Jan. 2020: *Characterizing topological phases and phase transitions using tensor networks.*
49. HEP-TN Online Seminar (heptnseminar.org), Jan. 2021: *Entanglement order parameters from symmetric tensor networks.*
50. Seminar of the Atominstitut, TU Wien, Vienna (Austria), May 2021 (online): *An entanglement perspective on quantum many-body systems.*
51. Quantum Glue Seminar, Bilbao (Spain), June 2021 (online): *Entanglement order parameters from Tensor Networks.*
52. Analysis and Quantum Seminars, University of Copenhagen (Denmark), Sept. 2021: *Tensor Networks and the entanglement structure of quantum many-body systems.*
53. Seminar of the Quantum Group, University of Gent (Belgium), Sept. 2021: *Disorder Operators from Tensor Networks.*

54. IST Physical Sciences Seminar Series, IST Austria, Klosterneuburg (Austria), Oct. 2021: *Entanglement order parameters from symmetric tensor networks.*
55. VCQ Colloquium, Vienna (Austria), Dec. 2021: *Quantum Information and Quantum Many-Body Systems.*
56. Sommerfeld Colloquium, LMU Munich, Munich (Germany), Dec. 2021: *Entanglement in complex quantum systems: From quantum information to many-body systems and back.*
57. Quantum Group Seminar, University of Gent, Gent (Belgium), June 2022: *On the adiabatic theorem.*
58. Laboratoire de Physique Théorique, Université Paul Sabatier & CNRS, Toulouse (France), March 2023: *Probing topological order with and without tensor networks.*
59. Caltech/AWS Lunch seminar, California Institute of Technology and AWS Quantum, Pasadena (USA), April 2023: *Lower bounding ground state energies with tensor networks.*
60. Condensed Matter Theory Seminar, University of Amsterdam, Amsterdam (Netherlands), Nov. 2023: *Identification and characterization of topological order with and without tensor networks.*
61. IQIM/AWS Seminar, California Institute of Technology, Pasadena (USA), Nov. 2023: *Identification and characterization of topological order without and with tensor networks.*
62. Condensed Matter Seminar, UC Berkeley, Berkeley (USA), March 2024: *Tensor networks and the negative sign problem.*
63. Theoretical Nanophysics seminar, LMU Munich (Germany), Oct. 2024: *Tensor networks and the negative sign problem.*
64. Quantum Information and Computation Initiative seminar, University of Hong Kong (Hong Kong), Dec. 2024: *How to find lower bounds to ground state energies.*

Contributed talks at peer-reviewed conferences

1. Conference "Hardware concepts in Quantum Computing", Bad Honnef (Germany), May 2002: *Implementation of quantum algorithms with Josephson charge qubits.*
2. Workshop "Quantum Computing: mesoscopic implementations, perspectives and open problems", Torino (Italy), June 2002: *Implementation of quantum algorithms with Josephson charge qubits.*
3. YEP Meeting, Budmerice (Slovakia), Dec. 2004: *Optimal generation of squeezing and entanglement with noisy Gaussian operations.*
4. YEP Meeting, Budmerice (Slovakia), Dec. 2005: *Harmonic oscillators on a lattice.*
5. 6th Joint Conference on Mathematics and Computer Science, Pécs (Hungary), July 2006: *Quantum states on Harmonic lattices.*
6. QIP Workshop, Brisbane (Australia), Jan. 2007: *The computational complexity of PEPS.*
7. QAP meeting, Bristol (UK), April 2007: *The computational complexity of PEPS.*
8. MATHQCI workshop, Madrid (Spain), May 2008: *Interacting Electrons, Density Functional Theory, and Quantum Merlin Arthur.*
9. QIP Workshop, Santa Fe (NM, USA), Jan. 2009: *Interacting electrons, Density Functional Theory, and Quantum Merlin Arthur.*
10. QIP Workshop, Santa Fe (NM, USA), Jan. 2009: *The computational difficulty of finding MPS ground states.*
11. IMA Conference on Quantum Computing and Complexity of Quantum Simulation, London (UK), March 2009: *Interacting electrons, Density Functional Theory, and Quantum Merlin Arthur.*
12. IMA Conference on Quantum Computing and Complexity of Quantum Simulation, London (UK), March 2009: *The computational difficulty of finding MPS ground states.*

13. QIP Workshop, Zurich (Switzerland), Jan. 2010: *An efficient algorithm for finding Matrix Product ground states.*
14. SQUINT conference, Santa Fe (NM, USA), Feb. 2010: *An efficient algorithm for finding Matrix Product ground states.*
15. QIP Workshop, Singapore (Singapore), Jan. 2011: *Information propagation for interacting particle systems.*
16. Workshop on Quantum Information and Quantum Many-Body Systems, Montreal (Canada), October 2011: *The complexity of commuting Hamiltonians for qubits on a square lattice.*
17. QIP Workshop, Montreal (Canada), Dec. 2011: *Complexity of commuting Hamiltonians on a square lattice of qubits.*
18. QIP Workshop, Beijing (China), Jan. 2013: *Resonating valence bond states in the PEPS formalism.*
19. Workshop "Perspectives on Quantum Many-Body Entanglement", Mainz (Germany), Sept. 2013: *Edge physics and topological protection in Projected Entangled Pair State models.*
20. Online Workshop "Tensor product methods for strongly correlated molecular systems", Max-Planck-Institute for the Physics of Complex Systems, Dresden (Germany), March 2021: *Matrix product state algorithms for Gaussian fermionic states.*

Contributed talks at other conferences

1. DPG Meeting, Regensburg (Germany), Mar. 2002: *Implementation of quantum algorithms with Josephson charge qubits.*
2. DPG Meeting, Dresden (Germany), Mar. 2003: *Implementation of quantum algorithms with an arbitrary number of Josephson charge qubits.*
3. DPG Meeting, Munich (Germany), Mar. 2004: *Nonlocal resources in the presence of Superselection Rules.*
4. DPG Meeting, Berlin (Germany), Mar. 2005: *Optimal generation of squeezing with Gaussian operations.*
5. DPG Meeting, Frankfurt (Germany), Mar. 2006: *Quantum states on Harmonic lattices.*
6. DPG conference, Hamburg (Germany), Mar. 2009: *Interacting electrons, Density Functional Theory, and Quantum Merlin Arthur.*
7. DPG Meeting, Stuttgart (Germany), Mar. 2012: *Entanglement spectrum and boundary theories with projected entangled-pair states.*