

Unit Name

Theory of Quantum Matter Unit

Collaborations

- Prof. Owen Benton (Queen Mary University), Dr. Pranay Patil (OIST), Z₂ spin liquid in Rydberg atom arrays
- Mr. Snigdha Sabharwal (OIST), Dr. Tokuro Shimokawa (OIST), Prof. Nic Shannon (OIST), Witnessing Disorder in a Frustrated Magnets
- Dr. Matthias Gohlke (OIST), Prof. Jeffrey G. Rau (University of Windsor), Dr. Paul McClarty (LLB, Paris-Saclay), Topological magnons without decay
- Ms. A. K. Dagnino (U Zürich), Dr. Alberto Corticelli (MPIPKS), Dr. Matthias Gohlke (OIST), Dr. Alexander Mook (U Mainz), Prof. Roderich Moessner (MPIPKS), Dr. Paul McClarty (LLB, Paris-Saclay), Symmetry enhancement in tight-binding models
- Mr. Rintaro Eto (Waseda University), Dr. Matthias Gohlke (OIST), Prof. Jairo Sinova (University of Mainz), Prof. Masahito Mochizuki (Waseda University), Prof. Alexander L. Chernyshev (University of California), Dr. Alexander Mook (University of Mainz), Spontaneous Magnon Decay in Altermagnets
- Prof. Rico Pohle (Tohoku University), Prof. Nic Shannon (OIST), Spin-1 magnets on the pyrochlore lattice
- Dr. Ayushi Singhanian (OIST), Dr. Sumiran Pujari (IIT Bombay, India), Single ion anisotropy effect in frustrated Heisenberg model on honeycomb lattice
- Dr. Kimberly Remund (National Yang Ming Chiao Tung University), Dr. Owen Benton (QMUL), Prof. Nic Shannon (OIST), SCGA Approximations for spin-1 magnets
- Dr. Rico Pohle (Keio University), Dr. Matthias Gohlke (OIST), Dr. Ayushi Singhanian (OIST), Quantum spin liquids in S=1 Bilinear-biquadratic-Kitaev model
- Dr. Tokuro Shimokawa (OIST), Dr. Rico Pohle (Tohoku Univ.), Dr. Jonas Sonnenschein (OIST), Prof. Nic Shannon (OIST), Quantum spin liquid state in S=1/2 bilayer breathing kagome magnet
- Dr. Tokuro Shimokawa (OIST), Dr. Masaaki Matsuda (ORNL), Mr. Sho Inoue (Osaka Univ.), Prof. Zentaro Honda (Saitama Univ.), Prof. Masayuki Hagiwara (Osaka Univ.), Quantum paramagnet in a S=1/2 distorted honeycomb Heisenberg antiferromagnet
- Mr. Nicolo Beato (MPIPKS), Dr. Marin Bukos (MPIPKS), Dr. Pranay Patil (OIST), Phase transitions in quantum control landscapes
- Dr. Ankur Dahr (SLAC), Dr. Ludovic Jaubert (CNRS, France), Dr. Cathal Cassidy (OIST), Prof. Tsumoru Shintake (OIST), Prof. Nic Shannon (OIST), Observing magnetic monopoles using electron holography
- Mrs. Ananya Samanta (OIST), Dr. Geet Rakala (OIST), Dr. Han Yan (The University of Tokyo), Prof. Karlo Penc (HUN-REN Wigner Research Centre for Physics), Prof. Nic Shannon (OIST), Negative Thermal Expansion in CdCr₂O₄
- Mr. Jiahui Bao (OIST), Dr. Matthias Gohlke (OIST), Prof. Karlo Penc (HUN-REN Wigner Research Centre for Physics), Prof. Nic Shannon (OIST), Nature of spin nematic state in the square lattice Iridates
- Dr. Yoshitomo Kamiya (OIST), Prof. Yuko Hosokoshi (Osaka Metropolitan University), Prof. Yasu Takano (Florida), Prof. Cristian Batista (Tennessee), Prof. Zhiyuan Xie (China), Multiferroics by design with organic quantum trimer molecular magnets

Mr. Jiahui Bao (OIST), Dr. Matthias Gohlke (OIST), Prof. Jeffrey G. Rau (University of Windsor), Prof. Nic Shannon (OIST), Magnon Spectra of Cuprate Materials beyond Spin Wave Theory

Dr. Yoshitomo Kamiya (OIST), Prof. Yutaka Akagi (Ochanomizu U), Mr. Nanse Esaki (University of Tokyo), Kibble-Zurek mechanism and topological magnons

Dr. Tokuro Shimokawa (OIST), Prof. Owen Benton (QMUL), Dr. Pranay Patil (OIST), Rafael Flores (MPIPKS), Impurity effects in frustrated magnets

Prof. Robert Joynt (UW-Madison, WI, USA), Prof. Nic Shannon (OIST), Hybrid algorithms for quantum computers

Dr. Tokuro Shimokawa (OIST), Mr. Snigdha Sabharwal, (OIST), Prof. Nic Shannon (OIST), Entanglement witness in quantum frustrated magnets

Prof. Anders W. Sandvik (Boston University), Dr. Pranay Patil (OIST), Entanglement Entropy of Transverse Field Ising Glass

Suriyaa Ramanathan (Ohio State University), Dr. Pranay Patil (OIST), Continuous q Potts model investigated using resummed stochastic series expansion quantum Monte Carlo

Mr. Snigdha Sabharwal (OIST), Dr. Han Yan (The University of Tokyo), Analysing Entanglement Witnesses in the Bond Operator Formalism

Mr. Manodip Routh (S.N.B.N.C.B.S), Dr. Ayushi Singhanian (OIST), Dr. Satoshi Nishimoto (IFW Dresden), Prof. Manoranjan Kumar (S.N.B.N.C.B.S), Dzyaloshinskii-Moriya interaction effects in Kitaev Heisenberg model

Students Supervised:

- Mizutani Soshi
- Ananya Samanta
- Jiahui Bao
- Chojnacki Leilee Margaret
- Snigdha Sabharwal

Scholarly Contributions and Creative Productions (by Faculty)

Journal Article

1. Bao, J.; Gohlke, M.; Rau, J. G.; Shannon, N.
Magnon Spectra of Cuprates beyond Spin Wave Theory. *Physical Review Research*.
2. Yan, H.; Thomasen, A.; Shannon, N.; Romhányi, J.
Pinch Points and Half Moons Encode Berry Curvature. *Physical Review B* 2024, 110.
3. Sabharwal, S.; Shimokawa, T.; Shannon, N.
Witnessing Disorder in Quantum Magnets.
4. Pohle, R.; Shannon, N.; Motome, Y.
Eight-Color Chiral Spin Liquid in the $S=1$ Bilinear-Biquadratic Model with Kitaev Interactions. *Physical Review Research* 2024, 6.
5. Chojnacki, L.; Pohle, R.; Yan, H.; Akagi, Y.; Shannon, N.
Gravitational Wave Analogs in Spin Nematics and Cold Atoms. *Physical Review B* 2024, 109.

Presentation at Conference

1. Shannon, N. S.
Simulation of Spin-1 Magnets on Frustrated Lattices. APS March Meeting 2025.

2. Shannon, N. S.
Using Ideas from Quantum Information to Learn about Quantum Magnets. Emergent Quantum Matter with Topology and Correlation 2024.
3. Shannon, N. S.
Fractional Excitations on the Pyrochlore Lattice, from PKS Late 2000, to the Present. Electronic Correlations and Beyond - in Memory of Peter Fuldeto 2024.
4. Shannon, N. S.
Gravitational Wave Analogues in Spin Nematics and Cold Atoms. Quantum Extreme Universe: Matter, Information, and Gravity 2024.
5. Shannon, N. S.
Using Ideas from Quantum Information to Learn about Quantum Magnets. Emergent Quantum Matter with Topology and Correlation.
6. Shannon, N. S.
Gravitational Wave Analogues in Frustrated Magnets and Cold Atoms. Topological Quantum Matter in Magnetic and Synthetic Platforms 2024.
7. Shannon, N. S.
Physics out of Joynt: From Pseudogaps to Quantum Computers. Joynt Fest: From Electron Correlations to Quantum Computing.
8. Shannon, N. S.
Gravitational Wave Analogues in Spin Nematics and Cold Atoms. Ultracold Atoms Japan 2024 2024.

Seminars

1. Shannon, N. S.
AI Meets Theoretical Physics: Machine Learning Assisted Solution of a Difficult Problem in Frustrated Magnetism. 2024.
2. Shannon, N. S.
Using Ideas from Quantum Information to Learn about Quantum Magnets.
3. Shannon, N. S.
AI Meets Theoretical Physics: Machine Learning Assisted Solution of a Difficult Problem in Frustrated Magnetism. 2024.
4. Shannon, N. S.
AI Meets Theoretical Physics: Machine Learning Assisted Solution of a Difficult Problem in Frustrated Magnetism.

Scholarly Contributions (by Unit Members)

Name of Unit Member	Type	Title	Outlet	Publisher	Year Pub
Pranay Patil	Journal Article	Topological phase transitions in a constrained two-qubit quantum control landscape		arXiv	
Pranay Patil	Journal Article	Tunable topological protection in Rydberg lattices via a novel quantum Monte Carlo approach		arXiv	
Matthias Gohlke	Journal Article	Spontaneous Magnon Decays from Nonrelativistic Time-Reversal Symmetry Breaking in Altermagnets		arXiv	

Name of Unit Member	Type	Title	Outlet	Publisher	Year Pub
Jonas Sonneschein	Journal Article	Candidate quantum spin liquids on the maple-leaf lattice		Physical Review B	2024
Matthias Gohlke	Journal Article	Proximate Tomonaga-Luttinger liquid in an anisotropic Kitaev-Gamma model		Physical Review B	2024
Pranay Patil	Journal Article	Towards a theory of phase transitions in quantum control landscapes		arXiv	
Matthias Gohlke	Journal Article	The landscape of symmetry enhancement in tight-binding models		arXiv	
Tokuro Shimokawa	Other Teaching Materials	Computational Physics	Nihon University (90min*15 classes)		
Tokuro Shimokawa	Poster Presentation at Conference	What can we learn about quantum magnets from experimentally accessible entanglement measures?	The 3rd young researchers' workshop of the Extreme Universe Collaboration & The 6th "Extreme Universe" School		
Matthias Gohlke	Poster Presentation at Conference	Proximate Tomonaga-Luttinger Liquid with Spinon Excitations in an Anisotropic Kitaev-Gamma Model	MPI-PKS Topological Quantum Matter in Magnetic and Synthetic Platforms		
Pranay Patil	Poster Presentation at Conference	Tunable topological protection in ryoberg atom arrays	MPI-PKS Topological Quantum Matter in Magnetic and Synthetic Platforms		
Matthias Gohlke	Poster Presentation at Conference	Thermal pure matrix product state in two dimensions: tracking thermal equilibrium from paramagnet down to the Kitaev spin liquid state	MPI-PKS Non-equilibrium Many-body Physics Beyond the Floquet Paradigm		
Ayushi Singhanian	Poster Presentation at Conference	Protecting Hilbert space fragmentation through quantum Zeno dynamics	MPI-PKS Non-equilibrium Many-body Physics Beyond the Floquet Paradigm		
Jiahui Bao	Poster Presentation at Conference	Magnon spectra of Cuprates beyond spin wave theory	The 1st workshop on Quantum Computation meets Quantum Many-Body Computation		
Pranay Patil	Poster Presentation at Conference	Anomalous relaxation of density waves in a ring-exchange system	MPI-PKS Non-equilibrium Many-body Physics Beyond the Floquet Paradigm		
Pranay Patil	Poster Presentation at Conference	Tunable topological protection in Rydberg atom arrays	From Quantum Materials to Quantum Information: Symposium on Trans-Scale Quantum Science and Quantum Materials Synthesis (QMQI2024)		
Snigdha Sabharwal	Poster Presentation at Conference	Witnessing Disorder	From Quantum Materials to Quantum Information: Symposium on Trans-Scale Quantum Science and Quantum Materials Synthesis (QMQI2024)		

Name of Unit Member	Type	Title	Outlet	Publisher	Year Pub
Ayushi Singhanian	Poster Presentation at Conference	Emergence of vortex state in the $S = 1$ Kitaev-Heisenberg model with single-ion anisotropy	From Quantum Materials to Quantum Information: Symposium on Trans-Scale Quantum Science and Quantum Materials Synthesis (QMQI2024)		
Pranay Patil	Poster Presentation at Conference	Topological quantum computing in Rydberg atom arrays	Quantum Extreme Universe: Matter, Information, and Gravity		
Pranay Patil	Poster Presentation at Conference	MPS approach to disordered Heisenberg chain	Current and Future Computational Approaches to Quantum Many-Body Systems 2024 (CompQMB2024)		
Snigdha Sabharwal	Presentation at Conference	Witnessing Disorder in a Spin Liquid	JPS Annual Meeting		
Matthias Gohlke	Presentation at Conference	Thermal pure matrix product state in 2D: tracking thermal equilibrium from paramagnet down to the Kitaev spin liquid state	Current and Future Computational Approaches to Quantum Many-Body Systems 2024 (CompQMB2024)		
Tokuro Shimokawa	Presentation at Conference	What can we learn about quantum magnets from experimentally accessible entanglement measures?	Extreme universe 4th annual meeting		
Jonas Sonneschein	Presentation at Conference	遠の空気(Eternal Air)	the Leading Carbon Removal Business Summit		
Geet Rakala	Presentation at Conference	Are There Divergent Series in the Computational Physics?	XXXV IUPAP Conference on Computational Physics (CCP2024)		
Tokuro Shimokawa	Presentation at Conference	Can experimentally-accessible measures of entanglement distinguish quantum spin liquid and random singlet states?	International conference on Magnetism (ICM) 2024		
Tokuro Shimokawa	Presentation at Conference	Can experimentally-accessible measures of entanglement distinguish quantum spin liquid and random singlet states?	From Quantum Materials to Quantum Information: Symposium on Trans-Scale Quantum Science and Quantum Materials Synthesis (QMQI2024)		
Tokuro Shimokawa	Presentation at Conference	Can experimentally accessible entanglement measures distinguish quantum spin liquid and random singlet states?	APS March Meeting 2025		
Tokuro Shimokawa	Presentation at Conference	Can experimentally accessible entanglement measures distinguish quantum spin liquid and random singlet states?	New Frontiers in Advanced Magnetism 2024		
Tokuro Shimokawa	Presentation at Conference	実験的に測定可能な量子もつれ測度を用いた量子スピノン液体の数値的研究	物性研究所スハコ共同利用・CCMS 合同研究会「計算物質科学の現在と未来」		

Name of Unit Member	Type	Title	Outlet	Publisher	Year Pub
Ayushi Singhania	Presentation at Conference	Emergence of vortex state in the S=1 Kitaev-Heisenberg model with single-ion anisotropy	Quantum Extreme Universe: Matter, Information, and Gravity		
Tokuro Shimokawa	Presentation at Conference	What can we learn about quantum magnets from experimentally-accessible entanglement measures?	第 20 回量子スピソ系研究会		
Jiahui Bao	Presentation at Conference	On the origin of spin nematic order in Sr2IrO4	APS March Meeting 2025		
Ananya Samanta	Presentation at Conference	Exploring Entropy-Driven Thermodynamics in Chromium Spinels	APS March Meeting 2025		
Snigdha Sabharwal	Presentation at Conference	Witnessing Disorder in Quantum Magnets	APS March Meeting 2025		
Jiahui Bao	Presentation at Conference	Magnon Spectra of Cuprates beyond Spin Wave Theory	JPS Annual Meeting		
Matthias Gohlke	Seminars	Quantum Spin Nematics in Spin-1-2 Frustrated Ferromagnets	Max Planck Institute for the Physics of Complex Systems		
Matthias Gohlke	Seminars	Kitaev-like Frustrated Magnets: Minimal Models and their Challenges	The Institute for Theoretical Physics, Leipzig University		
Tokuro Shimokawa	Seminars	Can experimentally accessible entanglement measures distinguish quantum spin liquid and random singlet states	Nomura-Onose Labs joint seminar, Tohoku University		
Ayushi Singhania	Seminars	Emergence of vortex state in the S = 1 Kitaev-Heisenberg model with single-ion anisotropy	Laboratoire de Physique Théorique, CNRS - Université de Toulouse		
Matthias Gohlke	Seminars	Magnetic Excitations through the Lens of Tensor Networks: from Interacting Magnons to Fractional Quasi-Particles	Laboratoire Léon Brillouin, CNRS & CEA		
Snigdha Sabharwal	Seminars	Witnessing Disorder in Spin Chains	Institute of Solid State Physics, The University of Tokyo		
Matthias Gohlke	Seminars	Proximate Tomonaga-Luttinger Liquid with Spinon-like Excitations in an Anisotropic Kitaev-Gamma Model	Institute for Theoretical Physics, University of Cologne		
Pranay Patil	Seminars	Tunable topological protection in a triangular lattice of Rydberg atoms	Laboratoire de Physique Théorique, CNRS		

Honors, Awards & Fellowships

May 2018 - Ongoing August-Wilhelm Scheer Visiting Professorship 2018, 2018, TUM Institute for Advanced Study