

Advanced Seminar (2025)

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Abstract

Topics for talks

- **Open quantum systems (May 5, Zemin):** Kraus maps, Lindblad equation (derivation from symmetry/Kraus maps, derivation based on Born-Markov)

References:

- A short introduction to the Lindblad master equation, AIP Advances 10, 025106 (2020);
- Lecture notes on the theory of open quantum systems, arXiv:1902.00967;
- Universality in driven open quantum matter, arXiv:2312.03073.
- Quantum Computing in the NISQ era and beyond, Quantum 2, 79 (2018).
- Beyond NISQ: The Megaquop Machine, ACM Trans. Quantum Comput. March 2025.

- **Unraveling of Lindblad eq., quantum trajectories / jumps, application (May 12, Bo):**

References:

- Quantum trajectories and open many-body quantum systems, Adv. Phys. 63, 77 (2014);
- To catch and reverse a quantum jump mid-flight, Nature volume 570, pages 200–204 (2019).

- **Theory of quantum measurement (May 19, Yoshito):** relation to Lindblad, measurement-induced phase transitions (possibly: projective/weak measurements)

References:

- A straightforward introduction to continuous quantum measurement, Contemporary Physics 47, 279 (2006) ;
- Quantum Zeno effect and the many-body entanglement transition, Phys. Rev. B 98, 205136 (2018);

• **Quantum computing with open quantum systems (May 26, Zemin):**

References:

- Quantum computation and quantum information (Cambridge University Press, New York, 2011);
- Symmetry-Protected Phases for Measurement-Based Quantum Computation, Phys. Rev. Lett. 108, 240505 (2012);
- A One-Way Quantum Computer, Phys. Rev. Lett. 86, 5188 (2001);
- Measurement-based quantum computation, Reports on Mathematical Physics 57, 147 (2006).

• **LRE from measuring SPTs (June 2, Bo):** long-range vs. short-range entanglement (LRE/SRE), gauging symmetry-protected topological (SPT) order, gauging by single-qubit measurement

References:

- Long-Range Entanglement from Measuring Symmetry-Protected Topological Phases, Phys. Rev. X 14, 021040 (2024).
- The Physics of (good) LDPC Codes I. Gauging and dualities, arXiv:2310.16032
- Symmetry protected topological phases under decoherence, Quantum 9, 1607 (2025).
- Classifying One-Dimensional Quantum States Prepared by a Single Round of Measurements, PRX Quantum 6, 010329 (2025).

• **Toric code and error correction (June 16, Yoshito):**

References:

- Introduction to quantum error correction and fault tolerance, SciPost Phys. Lect. Notes 70 (2023);
- Fault-tolerant quantum computation by anyons, Annals Phys. 303 (2003) 2-30 (see also, Chapter 10, in "condensed matter field theory", 3rd edition);
- Topological quantum memory, J. Math. Phys. 43, 4452-4505 (2002);
- Diagnostics of mixed-state topological order and breakdown of quantum memory, PRX Quantum 5, 020343 (2024).
- Exact Calculations of Coherent Information for Toric Codes under Decoherence: Identifying the Fundamental Error Threshold, arXiv:2402.16937.
- Realizing topologically ordered states on a quantum processor, Science 374, 1237-1241 (2021).

- Quantum error correction below the surface code threshold, Nature volume 638, pages 920–926 (2025)

- **Topology of mixed quantum states and quantum information (June 23, Zemin):**

References:

- Many-body open quantum systems, arXiv:2409.10300;
- Unconventional topological mixed-state transition and critical phase induced by self-dual coherent errors, Phys. Rev. B 110, 125152 (2024).
- Topology by dissipation, New J. Phys. 15 085001 (2013).

- **Emergent non-unitary CFTs in monitored dynamics (June 30, Bo): stat mech mappings**

References:

- Review papers.
- Quantum Zeno effect and the many-body entanglement transition, Phys. Rev. B 98, 205136 (2018).
- Conformal invariance and quantum nonlocality in critical hybrid circuits, Phys. Rev. B 104, 104305 (2021).
- Statistical mechanics of quantum error correcting codes, Phys. Rev. B 103, 104306 (2021).
- Decodable hybrid dynamics of open quantum systems with $\mathbb{Z}_2$ symmetry, Phys. Rev. B 108, 214302 (2023).
- Statistical mechanics model for Clifford random tensor networks and monitored quantum circuits, Phys. Rev. B 109, 174307 (2024).