Summer School 2026: Solvable quantum circuits: correlations, chaos, and information scrambling.

Target: The course aims to help students understand universal features of Quantum dynamics through the eyes of solvable Quantum Circuits.

References for parts of the course

- **Primary Text:** Bertini, B. (2026). *Exact Dynamics in Solvable Quantum Circuits*. arXiv:2601.22375.
- **Dual Unitary Review:** Bertini, B., Kos, P., & Prosen, T. (2019). *Exact Correlation Functions for Dual-Unitary Lattice Models in Arbitrary Dimensions*. arXiv:1904.02140.
- **Random Circuits Review:** Fisher, M. P. A., et al. (2023). *Random Quantum Circuits*. arXiv:2207.14280.

Background & Prerequisites

- **Quantum Mechanics Foundation:** Tensor product many-body space, partial trace, and entanglement entropy.
    - *Suggested Ref:* Nielsen & Chuang, *Quantum Computation and Quantum Information*.
- **Tensor Networks:** Basics of tensor networks and graphical notation.
    - *Reference:* M-Carmen Bañuls, GGI Lecture Notes.
    - Reference: Luca's lectures from the first week.

Lecture Schedule

Lx: lecture x, Tx: tutorial x

L1: Quantum Dynamics & Quantum Circuits

- **What & Why:** Introduction to Quantum Quenches and the motivation for discrete-time modeling.
- Connecting Hamiltonian evolution and Quantum Circuits.
- Recent experiments
- Brickwork circuits, graphical notation, and calculating local correlations.

L2: Examples of Solvable Quantum Circuits (QC)

- Dual Unitary Circuits
- Random Unitary Circuits

T1: Numerical Simulation

- Simulating quantum quenches of dynamics given by quantum circuits on a classical computer.

L3: Entanglement and Information Spreading

- Linear growth of entanglement entropy and the "entanglement velocity".
- Scrambling: Information spreading and Out-of-Time-Ordered Commutators (OTOCs).

L4: Quantum Chaos

- **Spectral Chaos:** The Spectral Form Factor (SFF) and Random Matrix Theory (RMT) predictions.
- **Dynamical Chaos:** Operator spreading and local operator entanglement growth.

T2: TBA

(Still need to decide exactly what. Some ideas: Spectral Statistics, Implementation on a Q. computer (e.g., IBM,) Finding new soluble models by brute force search, Proving chaotic spectral form factor)

L5: Other interesting circuit models

- Generalizations of solvable circuits: random permutation circuits, generalizations of dual unitary circuits
- Kinetically constrained model: Floquet Quantum East model

(Probably too ambitious, will need to trim it down a bit)