Entanglement and dynamics on the information lattice — thermalisation and its breakdown via many-body localization

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I will discuss entanglement and quantum information in many-body states and their use to understand many-body dynamics and quantum states of matter. The talks will consist of three main overlapping topics.

1. The information lattice

In order to understand the entanglement structure of many-body states it is useful to be able to organize the entanglement, or equivalently information, into scales. I will explain our recently introduced information lattice, which is a way to define information on a given scale. I will give examples of simple states as to give an intuition for what the information lattice is.

2. Thermalization in a closed quantum system

Closed quantum systems generically thermalize at long times. The modern understanding for how this happens is given by the eigenstate thermalization hypothesis. Extensive entanglement in the long-time steady state acts as a thermal reservoir for subsystems and therefore local observables. To simulate such system to long time is difficult due to the entanglement. I will explain how to understand this process on the information lattice.

3. Many-body localization

A generic way to break thermalization is obtained by breaking translation invariance that in interacting systems leads to many-body localization. This is accompanied by the emergence of local integrals of motion. The entanglement dynamics in these systems is slow and is accompanied by a ultraslow particle fluctuations. I will explain how this can be obtained in a random circuit model of the local integrals of motion, and I will give a status update on the current understanding of many-body localization.

Refs.

- Time-evolution of local information: thermalization dynamics of local observables, SciPost Phys. **13**, 080 (2022)
- Efficient Large-Scale Many-Body Quantum Dynamics via Local-Information Time Evolution, PRX Quantum **5,** 020352 (2024)
- Ultraslow Growth of Number Entropy in an l-bit Model of Many-Body Localization, arXiv:2312.13420