Typical thermalization

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Proving thermalization from the unitary evolution of a closed quantum system is one of the oldest questions that is still nowadays only partially resolved [1]. Several efforts have led to various formulations of what is called the eigenstate thermalization hypothesis, which leads to thermalization under certain conditions on the initial states. These conditions, however, are sensitive to the precise formulation of the hypothesis.

In the core part of this talk [2], we focus on the important case of low entanglement initial states, which are operationally accessible in many natural physical settings, including experimental schemes for testing thermalization and for quantum simulation. We prove thermalization of these states under precise conditions that have operational significance. More specifically, motivated by arguments of unavoidable finite resolution, we define a random energy smoothing on local Hamiltonians that leads to local thermalization when the initial state has low entanglement. Finally we show that such a transformation affects neither the Gibbs state locally nor, under generic smoothness conditions on the spectrum, the short-time dynamics.

In an outlook of the talk, we will look at new classical simulation methods for long time quantum evolution [3], quantum simulations of non-equilibrium quantum field systems with cold atoms [4] including curved background simulations [5], contributions to a generalised linear response theory [6], and ways of measuring out quasi-local integrals of motion from entanglement [7].

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[3] Unraveling long-time quantum dynamics using flow equations, S. J. Thomson, J. Eisert, arXiv:2308.13005, Nature Physics, in press (2024).

[4] Experimental observation of curved light-cones in a quantum field simulator, M. Tajik et al., PNAS 120, e2301287120 (2023).

[5] Decay and recurrence of non-Gaussian correlations in a quantum many-body system, T. Schweigler et al., Nature Physics 17, 559 (2021).

[6] Generalised linear response theory for the full quantum work statistics, G. Guarnieri, J. Eisert, H. J. D. Miller, arXiv:2307.01885, Phys. Rev. Lett., in press (2024).

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