Measurement-induced entanglement transitions and Anderson localization

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Generically, quantum mechanical systems exhibit thermalization, where the properties can be easily described by standard statistical mechanics. However, one also loses the access to quantum information, which is smeared-out throughout the system and becomes inaccessible to local measurements. To combat this, many non-equilibrium scenarios have been proposed in the recent decades, such as the recently intensely researched topic of *measurement-induced entanglement transitions* [1], where measurements are used to induce quantum Zeno effect in a quantum circuit in order to stop the growth of entanglement and the ballistic smearing of information. Such non-equilibrium phases have high prospects of usability in quantum computing, as they have tight connections to the topic of quantum error correction.

We review the topic of entanglement transitions and give a brief overview of our current knowledge of the universality class landscape in systems exhibiting this novel behavior. We then focus our discussion on a quantum circuit where the unitary evolution is governed by the Anderson model Hamiltonian. This system exhibits two phases [2]: area-law phase – where the quantum trajectory gets pinned by the measurement and by the disordered field, and the log-law critical phase – where the pinning does not occur (see Figure 1).

We find that the Anderson localization is destroyed for small disorder strengths as one introduces measurements in the circuit. This leads to a sudden emergence of the entanglement phase transition. We explain this behavior by considering nonunitary circuits, which generically favor the critical phase [3]. We also find a non-monotonic shift of the transition point at low disorder, where small random field stabilises the critical phase by coupling to the fermion modes. The universality class of the phase transition (believed to lie within the Berezinskii–Kosterlitz–Thouless class) seems to survive the introduction of a random field term. Our results shed further light on the monitored free-fermion circuits and the stability of the critical phase within these models.

References

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Figures

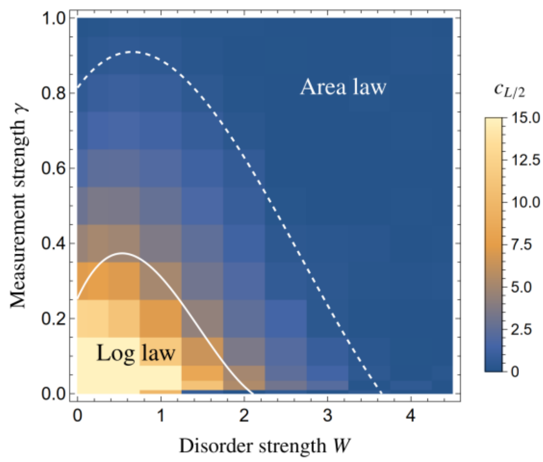

Figure 1: Phase diagram of the monitored circuit with Anderson model unitary evolution. Density map shows the central charge estimate.