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Entanglement Signatures of Random Quantum Circuits

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Quantum systems can be chaotic or not, in which case they are called integrable. The difference between these kinds of systems can be seen in the behaviour they exhibit after driven far from equilibrium. We use random quantum circuits to model the dynamics of chaotic and free fermion systems and to compute some signatures of their chaotic (integrable) nature. We focus on the entanglement entropy and the entanglement spectrum. For chaotic systems, the entanglement entropy scales with the Page value while for the free fermions it scales with a value lower than this. The entanglement spectrum also distinguishes between the two: it follows a Wigner-Dyson distribution in the chaotic case, and a Poisson like distribution for the fermionic system. At last, we obtain analytical and numerical results for the OTOC in the free fermion case: the OTOC diffuses in time, a behaviour which contradicts the ballistic behaviour typical of chaotic systems.

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