Dynamical Complexity and Chaos in Quantum Many-Body Systems

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The question of characterising the complexity of dynamics of quantum systems with many interacting particles is, at the same time, very attractive and extremely illusive. Although a generalisation of the notion of Kolmogorov's complexity to (non-commutative) quantum dynamical systems has existed for a long time, it does not provide a very useful measure of complexity. For example, it assigns positive complexity even to quasi-free or non-interacting evolutions in the so-called thermodynamic limit.

Within a recent intense burst of studies on dynamical chaos in many-body systems, which were largely motivated by the proposals of Kitaev, Maldacena, Stanford and others on holographic models of black holes, new, more intuitive and more useful, measures of complexity have been proposed. Amongst the most promising one is the concept of the so-called "operator spreading" with a complexity indicator given by "operator entanglement". Most recently, even non-trivial, exactly solvable models of many-body dynamical chaos appeared, where measures of operator spreading can be computed and the transitions from "regularity to chaos" analytically shown. These models are particularly topical, as they provide physical examples that may be used to demonstrate quantum supremacy of the currently emerging quantum computers.