Title: **Quantum speed limits to operator flows and operator growth**

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Quantum speed limits (QSLs) identify fundamental timescales of physical processes by providing lower bounds on the rate of change of a quantum state or the expectation value of an observable. We generalize QSLs to operator flows, which are ubiquitous in physics and relevant for applications in both the quantum and classical domains. We derive both a MT and a ML-type of operator QSLs (OQSLs) and assess the existence of a crossover between them, which we illustrate with a qubit and a random matrix Hamiltonian. We further apply our results to the time evolution of autocorrelation functions, obtaining computable constraints on the linear dynamical response of quantum systems out of equilibrium and the quantum Fisher information governing the precision in quantum parameter estimation.

Crucially, the growth undergone by the observables of a quantum system accounts for the build-up of quantum complexity. This time evolution, also known as operator growth, can be efficiently represented in Krylov space. In this representation, an initial operator becomes increasingly complex with the passing of time, a feature that can be quantified by the Krylov complexity. We introduce a universal limit to the growth of the Krylov complexity by formulating a Robertson uncertainty relation involving the Krylov complexity operator and the Liouvillian. We show the conditions for this bound to be saturated and illustrate its validity in paradigmatic models of quantum chaos. Remarkably, we find that the maximal speed limit can be reached even in the absence of chaos, e.g. by a qubit.

Finally, using a geometric approach, we introduce an additional OQSL that is shown to be tight for geodesic evolution. This result holds for operator flows induced by arbitrary unitaries, i.e., with time- or parameter-dependent generators. The geometric OQSL is applied to the Wegner flow equations in Hamiltonian renormalization group theory and to the operator growth quantified by the Krylov complexity. We show the equivalence between the saturation of the dispersion bound and the one of the geometric OQSL. In other words, complexity grows at the maximal rate when it follows a geodesic trajectory.