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Searching for Noiseless Subsystems via Scalable Experiments

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Abstract

The task of finding a correctable encoding that protects information from some physical quantum noise process is, in general, hard. Two main obstacles are the exponential number of experiments needed to gain complete information about the quantum process, and the fact that known algorithmic methods for finding correctable encodings involve operations on exponentially large matrices. In this talk we show that in some cases it is possible to find encodings with only partial information about the quantum process, avoiding the first obstacle. Such useful partial information can be systematically extracted by averaging over information obtained from the Ramsey interferometry of the individual qubits – this is a special case of what is known as twirling. The resulting symmetries of the twirled quantum process allow for a direct investigation of which observables are unaffected by the noise. This allows us demonstrate a post-processing scheme for finding protective encodings for quantum information which avoids the second obstacle of manipulating exponentially large matrices. Most importantly, these schemes are robust against experimental uncertainties, and can also be used to find encodings which only correct errors approximately.