Quantum information scrambling and hybrid machine learning with trapped ions


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Trapped ions are a promising candidate to realize a scalable quantum computer. We present a system comprised of a chain of $^{171}$Yb$^+$ ions with individual Raman beam addressing and individual readout (see Fig. 1). This fully connected processor can be configured to run any sequence of single- and two-qubit gates, making it an arbitrarily programmable quantum computer [1, 2].

We use this versatile system to perform a teleportation-based protocol to verify quantum information scrambling (see Fig. 2). This phenomenon describes the dispersal of local information into many-body entangled systems, and has recently been conjectured to shed light on the black-hole information paradox [3].

Quantum-classical hybrid systems offer a path towards the application of near-term quantum computers to different optimization tasks. We present several demonstrations relating to machine learning in such a hybrid approach. They include finding the ground state binding energy of the deuteron nucleus, the training of shallow circuits (see Fig. 3), and the preparation of quantum critical states using a quantum approximate optimization algorithm (QAOA) scheme. We also mention concepts for scaling up this architecture locally, and for networking it with entangled photons.