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Large-scale quantum hybrid solution for linear systems of equations

The state-of-the-art noisy intermediate-scale quantum devices, although imperfect, enable computational tasks that are manifestly beyond the capabilities of modern classical supercomputers. However, present quantum computations are restricted to exploring specific simplified protocols, whereas the implementation of full-scale quantum algorithms aimed at solving concrete large-scale problems arising in data analysis and numerical modeling remains a challenge.

Here we realize a hybrid quantum/classical algorithm for solving one of the emergent pressing problems, linear systems of equations, that utilizes quantum phase estimation, one of the exemplary core protocols for quantum computing. We introduce theoretically classes of linear systems that are suitable for current generation hybrid quantum machines and solve experimentally a 130,000-dimensional problem on superconducting IBMQ devices, which is a record in a linear system solution on real quantum computers.

The considered large-scale algorithm shows superiority over conventional solutions and demonstrates the advantages of hybrid quantum data processing.