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Title: Quantum advantage using a hybrid algorithm for linear systems of equations

Abstract:

A wealth of quantum algorithms developed during the past decades brought about the concept of quantum supremacy. The state-of-the-art noisy intermediate-scale quantum devices (NISQ), 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 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 algorithm for solving one of the emergent pressing problems, linear systems of equations, with exponential speedup that utilizes quantum phase estimation, one of the exemplary core protocols for quantum computing. We experimentally solve a 2^{17} dimensional problem on superconducting IBMQ devices, which is a record in a linear system solution on quantum computers. The developed large-scale algorithm shows supremacy over classical computers, demonstrates advantages of quantum data processing via phase estimation, and holds high promise for meeting practically relevant challenges.