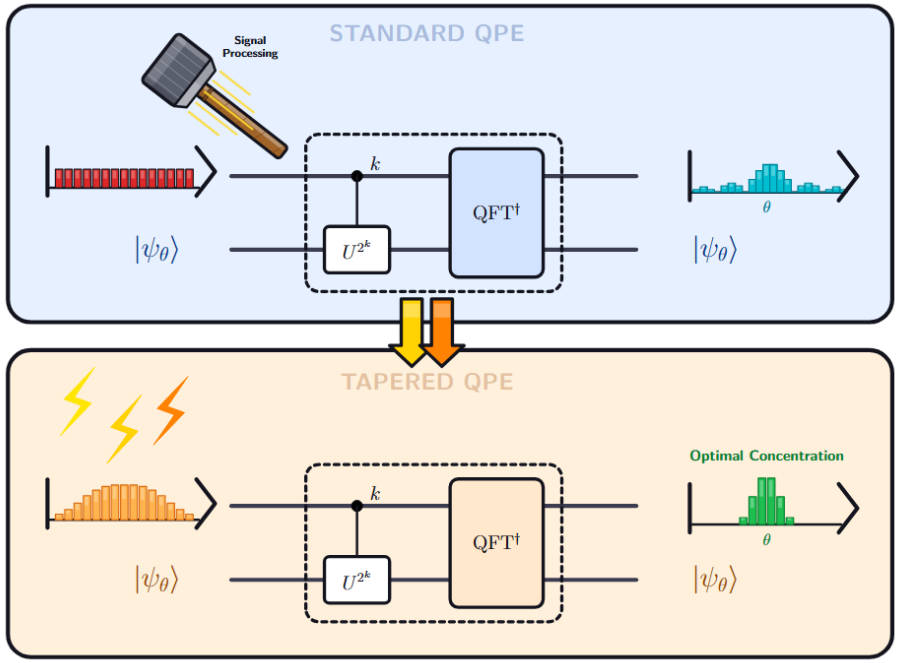
Optimal Coherent Quantum Phase Estimation



Tapered QPE implements high confidence coherent phase estimation using minimal number of qubits and uses of target unitary.

Scientific Achievement

Many applications of quantum phase estimation (QPE) require it to be implemented coherently and with high confidence. We outline an algorithm that achieves both goals using optimal resources.

Significance and Impact

Our approach significantly reduces the hardware overhead required for high-precision, coherent QPE, paving the way for its implementation on near-term quantum devices.

Research Details

- By optimizing the ancilla state of QPE we achieve mathematically optimal success rates using exponentially fewer extra qubits than traditional median-based method.
- We provide efficient quantum circuits for preparing approximations of the optimal ancilla state.

Dhrumil Patel, Shi Jie Samuel Tan, Yiğit Subaşı, and Andrew T. Sornborger "Optimal Coherent Quantum Phase Estimation Via Tapering", PRX Quantum **7**, 020302 (2026) https://doi.org/10.1103/l5y6-6zxv

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- **NQISRC Intellectual Role:** *Lead*
- **NQISRC Funding Role:** *Majority*
  - This project lasted for three years, and a set of funding sources supported different collaborators with the largest fraction being support by the Quantum Science Center. Sornborger and Subasi conceived of the project. Subasi's funding came entirely from the QSC. Sornborger's funding was sequentially, ASC, LDRD, QSC (renewed). The two primary authors were LANL QCSS students (see below). Subasi was the primary mentor of the QCSS students. Sornborger was secondary mentor. For Sornborger, although Algorithms thrust lead in the QSC for the first two years, his scope for research was in quantum sensing. Therefore, he was not funded by the first QSC. However, this work fit under his scope in the renewed QSC and his LDRD funding was ended, hence he was funded from the renewed QSC during final manuscript writing.
- **Explanation of Funding Institution Contributions**
  - LANL Advanced Simulation and Computing (Beyond Moore's Law): Initial project concept (ATS).
  - DOE Office of Science, Quantum Science Center (NQISRC), Quantum Algorithms thrust: Project design, quantum algorithmic research, theorems, proofs (YS).
  - DOE Office of Science, Quantum Science Center (NQISRC, Renewal): Manuscript writing, theorems, proofs (YS, Hybrid Algorithms thrust; ATS, Scientific Applications thrust).
  - Laboratory Directed Research and Development program of Los Alamos National Laboratory (LANL) under Project No. 20230049DR: Collaborative quantum algorithmic research, theorems, proofs, contributions on connections with signal analysis (ATS).
  - LANL Information Science & Technology Institute: Supported D. Patel and S.J.S. Tan via the Los Alamos Quantum Computing Summer School.