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The power of $O(1)$ qubits: perfect state discrimination with tiny quantum computers

In this paper, we show that quantum information processors (QIPs) with $O(1)$ qubits can substantially reduce measurement complexity – i.e., the number of samples required to learn something about an unknown quantum state. We present tiny-QIP algorithms that:

1. use a $\log_2 K$-qubit QIP to discriminate optimally between K N-copy pure states $|\psi_k\rangle^{\otimes N}$, which is *not* known to be achievable with local measurements.

2. use a $\log_2(KD)$-qubit QIP to discriminate optimally between K N-site matrix product states with bond dimension D, achieving an $O(N)$ improvement over local tomography.

These protocols demonstrate useful applications for the 2-14 qubit QIPs that exist today. Such QIPs are computationally trivial (their dynamics can be easily simulated on classical computers), but our results suggest nontrivial applications in sensing, detection, metrology, and characterization of larger prototype QIPs.

Joint work with Robin Blume-Kohout and Michael Zwolak.