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Compressed Sensing Quantum State Tomography: An Alternate Approach

The matrix generalizations of Compressed Sensing (CS) were adapted to Quantum State Tomography (QST) previously by Gross et al. [Phys. Rev. Lett. 105, 150401 (2010)], where they consider the tomography of n spin-1/2 systems. For the density matrix of dimension d = 2^n and rank r with r « 2^n, it was shown that randomly chosen Pauli measurements of the order O[dr log(d)^2] are enough to fully reconstruct the density matrix by running a specific convex optimization algorithm. The result utilized the low operator-norm of the Pauli operator basis, which makes it "incoherent" to low-rank matrices. For quantum systems of dimension d not a power of two, Pauli measurements are not available, and one may consider using SU(d) measurements. Here, we point out that the SU(d) operators, owing to their high operator norm, do not provide a significant savings in the number of measurement settings required for successful recovery of all rank-r states. In this work [Phys. Rev. A 101, 062328], we propose an alternative strategy, in which the quantum information is swapped into the subspace of a power-two system using only poly[log(d)^2] gates at most, with QST being implemented subsequently by performing O[dr log(d)^2] Pauli measurements. We show that, despite the increased dimensionality, this method is more efficient than the one using SU(d) measurements.

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