Quantum state tomography in noisy environments

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Quantum state tomography, which aims to find the best description of a quantum state—the density matrix, is an essential building block in quantum computation and communication. Standard techniques for state tomography are incapable of tracking changing states and often perform poorly in the presence of environmental noise. In this talk, I will give a brief introduction to quantum state tomography and then present our approach, matrix-exponentiated gradient (MEG) tomography. Our method allows for state tracking, updates the estimated density matrix dynamically from the very first measurements, is computationally efficient, and converges to a good estimate quickly even with very noisy data. The algorithm is controlled via a single parameter, its learning rate, which determines the performance and can be tailored in simulations to the individual experiment. We present an experimental implementation of MEG tomography on a qutrit system encoded in the transverse spatial mode of photons. We investigate the performance of our method on stationary and evolving states, as well as significant environmental noise, and find fidelities of around 95% in all cases.

References:
1. Rambach M, Youssry A, Tomamichel M, Romero J, Efficient quantum state tracking in noisy environments, Quantum Sci. Technol. **8**, 015010 (2023)