

Optimizing qubit phase estimation

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R sum  en anglais

The theory of quantum state estimation is exploited here to investigate the most efficient strategies for this task, especially targeting a complete picture identifying optimal conditions in terms of Fisher information, quantum measurement, and associated estimator. The approach is specified to estimation of the phase of a qubit in a rotation around an arbitrary given axis, equivalent to estimating the phase of an arbitrary single-qubit quantum gate, both in noise-free and then in noisy conditions. In noise-free conditions, we establish the possibility of defining an optimal quantum probe, optimal quantum measurement, and optimal estimator together capable of achieving the ultimate best performance uniformly for any unknown phase. With arbitrary quantum noise, we show that in general the optimal solutions are phase dependent and require adaptive techniques for practical implementation. However, for the important case of the depolarizing noise, we again establish the possibility of a quantum probe, quantum measurement, and estimator uniformly optimal for any unknown phase. In this way, for qubit phase estimation, without and then with quantum noise, we characterize the phase-independent optimal solutions when they generally exist, and also identify the complementary conditions where the optimal solutions are phase dependent and only adaptively implementable.

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