Density matrix and Quantum State Tomography

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Abstract

So far in the lecture, we have formulated the states of quantum mechanical systems in terms of state vectors residing in a complex Hilbert space, the state space. In this presentation, we present an alternative way to formulate the rules of quantum mechanics, in terms of a statistical operator called the density matrix. In the first part of the talk, we introduce in detail the density matrix formalism, including some important concepts as pure/mixed states, measurements and the reduced density matrix, as well as the equivalence with the state vectors formalism. In the second part of the talk, we define the basic notion of quantum state tomography, by introducing Stokes parameter, including the several most common approaches to quantum tomography, such as linear inversion using Born's Rule, Maximum likelihood estimation and Bayesian mean estimation. Advantage and downside of each method is briefly mentioned and compared. Application such as quantum process tomography and verifying fidelity of states will be demonstrated.

References

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