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Old and new results in quantum estimation theory

Quantum estimation theory is a powerful tool for the quantum characterization of states and operations and for the search of new physics in different branches of science. In this lecture we review quantum estimation theory emphasizing that a usual assumption in quantum estimation is that the unknown parameters label the possible states of the system, while they influence neither the sample space of outcomes nor the measurement aimed at extracting information on the parameter itself. This assumption is crucial to prove the quantum Cramer-Rao theorem and to introduce the quantum Fisher information as an upper bound to the Fisher information of any possible measurement. However, there are relevant estimation problems where this assumption does not hold and an alternative approach should be developed to find the genuine ultimate bound to precision of quantum measurements. We investigate physical situations where there is an intrinsic dependence of the measurement strategy on the parameter

and find that quantum-enhanced measurements may be more precise than previously thought.