Entanglement and Distinguishability of Quantum States

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Abstract

Entanglement is an algebraic property of quantum states. Its physical interpretation is typically related to non-locality. In our talk we will show that entanglement is physically related also with the concept of distinguishability of quantum states. Lets consider two systems differing by a unitary transformation. Can we decide if the two corresponding states are different with a finite number of measurements? This would be possible only if the difference between the state probabilities is smaller than the fluctuations of the results of the measurements [1]. It is therefore possible to define a statistical distance which is the number of distinguishable states along a certain path in the Hilbert space.

We demonstrate that quantum mechanics put an upper bound on the minimal statistical distance among two classically correlated states of N q-bits. However, if the q-bits are entangled, the statistical distance can be reduced up to a factor $\sqrt{N}$. In other words, entangled states can evolve faster under unitary transformations than classical states. This has important implications in the theory of quantum Zeno dynamics [2] as well as in interferometry and, quite generally, in the theory of a parameter estimation [3]. In particular, we will show that entanglement is a necessary resource to overcome the shot noise limit and saturate the Heisenberg limit, the highest sensitivity allowed by quantum mechanics.

Keywords: Entanglement, quantum interferometry, quantum Zeno dynamics

References

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