Quantum speed steering

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Abstract

The energy/time uncertainty relation has a very different interpretation than the standard Heisenberg uncertainty principle, which is stated in terms of the variance of observables. In quantum theory, time does not have an associated observable and its relation with the energy variance implies a bound on the rate of change of a quantum state given the fluctuations of its Hamiltonian. This quantum speed limit (QSL) has been theoretically explored in different contexts for several quantum states and dynamics [1].

On the other hand, steering is a non-classical correlation, stronger than entanglement but weaker than non-locality, stated by Schrödinger in response to the EPR paradox [2]. In the standard formulation we have two parties, Alice and Bob, who share a quantum state and are allowed to perform local operations and classical communications. Bob's setting is trusted and they know what their state is and which measurements their device carried out, whereas Alice's operations are untrusted. If the correlations observed in the shared state do not admit a classical description, e.g. a Local Hidden State (LHS), then the uncertainty principle can be violated [3].

In this work we present new steering witnesses, in the form of the violation of a conditional QSL. Furthermore, we provide a new interpretation of quantum correlations, namely the possibility to influence the speed of evolution of an entangled quantum state using local measurements and classical communications. We provide applications of our steering witnesses on different physical scenarios and states (e.g. two modes squeezed state and GHZ state), finding the most suitable QSL bound to be violated according to the degrees of freedom of the system. These new bounds might find applications in different fields of quantum physics, such as quantum computation, quantum thermodynamics and quantum control theory. Moreover, quantum speed limits can be probed on different physical platforms, such as cavity QED and ultracold atomic gases, allowing to experimentally test the violation of the bounds.

References

[1] S. Deffner and S. Campbell, Journal of Physics A: Mathematical and Theoretical, vol. 50, no. 45, p. 453001, 2017.
[2] E. Schrödinger, in Mathematical Proceedings of the Cambridge Philosophical Society vol. 31, pp. 555–563, Cambridge University Press, 1935.
[3] M. Reid, P. Drummond, W. Bowen, E. G. Cavalcanti, P. K. Lam, H. Bachor, U. L. Andersen, and G. Leuchs, Reviews of Modern Physics, vol. 81, no. 4, p. 1727, 2009.

Figures

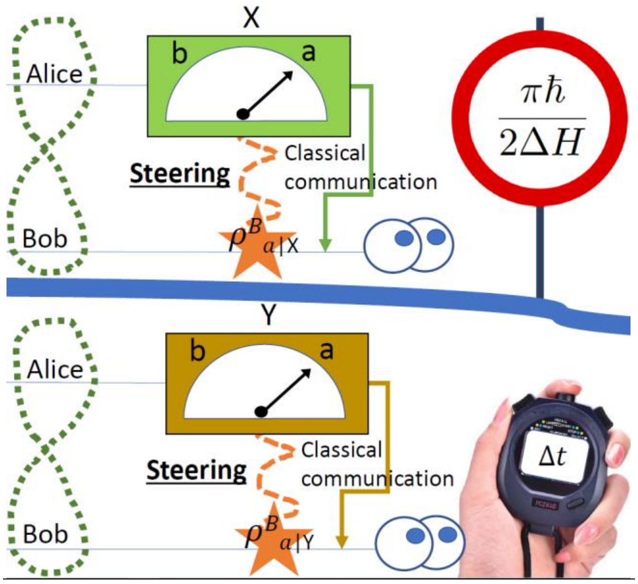

Figure 1: Conditioned on Alice's measurement outcome and setting, Bob decides to either measure the QSL or the effective time of the evolution. The violation of the speed limit is a witness of quantum steering from Alice to Bob.