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Improved data analysis for verifying quantum nonlocality and entanglement YANBAO ZHANG, University of Colorado at Boulder and National Institute of Standards and Technology, SCOTT GLANCY, EMANUEL KNILL, National Institute of Standards and Technology — Given a finite number of experimental results originating from local measurements on two separated quantum systems in an unknown state, are these systems nonlocally correlated or entangled with each other? These properties can be verified by violating a Bell inequality or satisfying an entanglement witness. However, violation or satisfaction could be due to statistical fluctuations in finite measurements. Rigorous upper bounds, on the maximum probability (i.e., the p-value) according to local realistic or separable states of a violation or satisfaction as high as the observed, are required. Here, we propose a rigorous upper bound that improves the known bound from large deviation theory [R. Gill, arXiv:quant-ph/0110137]. The proposed bound is robust against experimental instability and the memory loophole [J. Barrett et al., Phys. Rev. A 66, 042111 (2002)]. Compared with our previous method [Phys. Rev. A 84, 062118 (2011)], the proposed method takes advantage of the particular Bell inequality or entanglement witness tested in an experiment, so the computation complexity is reduced. Also, this method can be easily extended to test a set of independent Bell inequalities or entanglement witnesses simultaneously.

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