Event-ready loophole free Bell tests and beyond

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An experimental test of Bell's inequality allows to test the validity of local-realistic descriptions of nature by measuring correlations between distant systems. While such tests are conceptually simple, there are strict requirements concerning the detection efficiency of the involved measurements, as well as the enforcement of space-like separation between the measurement events. Only recently both loopholes could be closed simultaneously.

Here we present our approach based on combining heralded entanglement of atoms separated by 398 m with fast and efficient measurements of the atomic spin states. We obtain a violation $S=2.22 \pm 0.033 > 2$, which allows us to refute the hypothesis of local-realism with very high significance [1]. With entanglement swapping employed for entangling remote quantum memories, this experiment represents a quantum relay, the basic element of quantum repeater networks, yet, a lot remains to be done, still.

The ability to test for local hidden variables can now be employed to design quantum communication protocols evaluating possible information about the communication. We discuss the benefits and requirements for an experiment implementing such so-called device-independent communication schemes.

References

[1] W. Rosenfeld, Phys.Rev.Lett. **119**, 010402 (2017)