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Experimental design of a loophole-free Bell test with spin qubits in diamond BAS HENSEN, HANNES BERNIEN, ANAÏS DRÉAU, ANDREAS REISERER, JUST RUITENBERG, MACHIEL BLOK, STEPHANIE WEHNER, Kavli Institute of Nanoscience Delft, Delft University of Technology, Post Office Box 5046, 2600 GA Delft, Netherlands, M. MARKHAM, D. TWITCHEN, Element Six, Ltd., Kings Ride Park, Ascot, Berkshire SL5 8BP, UK, RONALD HANSON, Kavli Institute of Nanoscience Delft, Delft University of Technology, Post Office Box 5046, 2600 GA Delft, Netherlands — 50 years ago, John Bell formulated his famous theorem [1]. The outcomes of independent measurements on entangled objects can reveal strong correlations that violate Bell's inequality. Until now, all experimental implementations of Bell's test required additional assumptions, that open the door for so-called loopholes. These loopholes are particularly important in a cryptography setting where Bell violations enable fully device-independent protocols for quantum key distribution and certified generation of randomness. Here we will present the experimental design of a Bell test, aimed at closing the detection loophole and addressing the locality and free-will loopholes in a single experiment. We use two qubits associated with the electronic spin of the nitrogen-vacancy (NV) center in diamond, separated far enough to allow space-like separation between the two qubits during their measurement. The heralded nature of our remote entanglement protocol [2] and efficient qubit readout [3] allow us to use all entangled pairs, avoiding the fair-sampling assumption. Finally, the free-will loophole is addressed by the use of fast random number generators.

[1] J.S. Bell, Physics 1, 195-200 (1964)
[2] H. Bernien et al., Nature 497, 86-90 (2013)
[3] L. Robledo et al.,Nature 574, 477 (2011)

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