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All-versus-nothing (AVN) proofs [1–6] show the conflict between Einstein, Podolsky, and Rosen’s (EPR) elements of reality [7] and the perfect correlations of some quantum states. The name of “all-versus-nothing” [8] reflects a particular feature of these proofs: If one considers a set of perfect correlations and assumes EPR elements of reality, then a subset of these correlations leads to a conclusion that is opposite of the one obtained from the complementary subset of correlations.

The perfect correlations among single qubit measurements required for AVN proofs are given by the $2^n$ stabilizer operators of an $n$-qubit graph state. The possibility of experimentally preparing new classes of graph states [9–11] naturally leads to the following problem: Does a distribution of an $n$-qubit graph state between $m$ parties allow an AVN proof? This problem has been solved for $m = 2$ [12]. Here we describe a method to decide whether a given $n$-qubit $m$-particle graph state allows an $m$-partite AVN proof specific for this state (i.e., which cannot be obtained using a graph state with fewer qubits) [13]. This method requires that two observables of each qubit are EPR elements of reality. This forces a series of constraints that are only satisfied by a reduced group of the graph state’s stabilizer operators. We detail these requirements and apply them to decide whether some $n$-qubit $m$-particle graph states recently prepared in the laboratory [9–11] allow $m$-partite AVN proofs.

We also address the following problem: Given an $n$-qubit graph state, what is the minimum number $m$ of parties that allows a specific $m$-partite AVN proof? The solution of this problem enables us to obtain all inequivalent distributions allowing AVN proofs with $n < 9$ qubits and an arbitrary number $m$ of parties [13].

These results provide the tools to help experimentalists to design tests of new AVN proofs and new Bell inequalities based on these proofs [14].

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