Certifying asymmetric configuration of three qubit states in the prepare-and-measure scenario

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We consider a prepare-and-measure communication scenario, where Alice prepares a qubit state with an untrusted device chosen from a set of three states and sends it to Bob, who probes the state with an uncharacterized measurement device. We prove that an asymmetric configuration of the Bloch vectors associated with the qubit trine states can be certified in this prepare-and-measure setup. To achieve this, we construct a linear functional *W* on the observed measurement probabilities based on a generalization of the biased 2→1 quantum random access code (b-QRAC). Namely, our witness *W* is defined as the sum of three suitable 2→1b-QRAC functionals. We compute a bound on this witness *W* that holds for any mirror symmetric configuration of the Bloch vectors of the prepared trine states. Besides, the overall maximum of the witness is also given, which is reached by preparing a specific set of states which we call target states. The difference between the above mirror symmetric witness value and the overall maximum witness value defines a so-called witness gap, which can only be zero if the Bloch vectors of the target trine states possess a mirror-symmetric configuration. The latter gap is used as a measure of the degree of asymmetry of the target trine states. By optimizing over the witness gap, we found that the most asymmetric three-qubit configuration defines a scalene right triangle inscribed in the Bloch sphere. In addition to the theoretical analysis, we have implemented our prepare-and-measure scenario on two publicly accessible quantum processors of different quantum technologies, where we found a violation of the mirror symmetric witness bound certifying an asymmetric configuration of trine states on both quantum processors.