**Verification of pairwise non-locality trade-off in pure symmetric 3-qubit states using the IBM open access quantum computer ibmq\_lima**

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Violation of Bell inequality reveals inherent non-locality in quantum entangled systems [1]. In particular, the Clauser-Horne-Shimony-Holt (CHSH) inequality [2] may be used to verify pairwise non-locality of constituent two-qubits of multiqubit systems. Yet another essential feature of entangled multiparty systems is monogamy i.e., restriction placed on the shareability of entanglement [3]. Non-local correlations recorded by the violation of CHSH inequalities obey monogamy trade-off relations. Monogamy trade-off relation in the case of 3-qubit states $ρ\_{ABC}$ is given by [4]:

$$M\_{ABC}≡\left〈CHSH\right〉\_{AB}^{2}+\left〈CHSH\right〉\_{BC}^{2}+\left〈CHSH\right〉\_{AC}^{2}\leq 12$$

where $\left〈CHSH\right〉\_{AB}=\left〈A\_{1}⊗ B\_{1}\right〉+ \left〈A\_{1}⊗ B\_{2}\right〉+\left〈A\_{2}⊗ B\_{1}\right〉-\left〈A\_{2}⊗ B\_{2}\right〉$ ; $\left〈A\_{i}⊗ B\_{j}\right〉=Tr\left[ρ\_{AB}A\_{i}⊗ B\_{j}\right]$ and $A\_{i}=\vec{σ}. \vec{a}\_{i}, B\_{j}= \vec{σ}. \vec{b}\_{j}, i,j=1,2 $are Pauli observables with orientation directions $\vec{a}\_{i}, \vec{b}\_{j} $of qubits $A, B$ respectively. While violation of the CHSH inequality $\left|\left〈CHSH\right〉\_{AB}\right|<2$ reveals non-locality, monogamy constraint imposes the trade-off relation $M\_{ABC}\leq 12$ on 3-qubit states. In the special case of 3-qubit permutation symmetric states for which $\left〈CHSH\right〉\_{AB}=\left〈CHSH\right〉\_{BC}=\left〈CHSH\right〉\_{AC}$, one obtains $M\_{ABC}=3\left〈CHSH\right〉\_{AB}^{2} \leq 12$, in turn indicating that $\left|\left〈CHSH\right〉\_{AB}\right|<2$. Hence one ends up with the monogamy restriction on non-locality: Any arbitrary 2-qubit state extracted from 3-qubit permutation symmetric system cannot violate CHSH inequality, even though the constituent qubits are entangled.

In this work, we verify monogamy relations obeyed by one parameter family of symmetric 3-qubit states[5]: $|\left.Ψ\_{β}\right⟩=\frac{1}{\sqrt{2+\cos(β)}} \left(|\left.0\right⟩⊗|\left.0\right⟩⊗|\left.β\right⟩+ |\left.β\right⟩⊗|\left.0\right⟩⊗|\left.0\right⟩+ |\left.0\right⟩⊗|\left.β\right⟩⊗|\left.0\right⟩\right), \left.|β\right⟩=\cos(\frac{β}{2})\left.|0\right⟩+ \sin(\frac{β}{2}) \left.|1\right⟩, 0<β\leq π$ (known as W-class states) using open access IBM quantum computer ibmq\_belem. A scheme of of the paper is outlined here:

* Building quantum circuit using the IBM open-source software kit Qiskit to prepare the 3-qubit state $|\left.Ψ\_{β}\right⟩$ for $β= ^{π}/\_{6},^{π}/\_{4}, ^{3π}/\_{8}, ^{9π}/\_{16}, π$.
* Preparation the quantum state using ibmq\_belem
* Collecting measurement data (based on 8192 statistical trials) and constructing 2-qubit correlation matrices.
* Verification of monogamy relation $M\_{ABC}\leq 12$

Our results agree with theoretical predictions and establish how shareability places restrictions on CHSH non-locality.

**References:**

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