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k-vertex-minor-universal graphs and small k-pairable quantum states

Nathan Claudet, Inria Mocqua, LORIA, CNRS, Université de Lorraine, F-54000 Nancy, France, nathan.claudet@inria.fr

Mehdi Mhalla, Université Grenoble Alpes, CNRS, Grenoble INP, LIG, F-38000 Grenoble, France mehdi.mhalla@univ-grenoble-alpes.fr

Simon Perdrix, Inria Mocqua, LORIA, CNRS, Université de Lorraine, F-54000 Nancy, France, simon.perdrix@loria.fr

A k-pairable n-qubit quantum state is a resource state that allows Local Operations and Classical Communication (LOCC) protocols to generate EPR-pairs among any k-disjoint pairs of the n qubits. Bravyi et al. introduced a family of k-pairable n-qubit states, where n grows exponentially with k [1]. Our primary contribution is to establish the existence of 'small' pairable quantum states, by highlighting a sufficient condition on a graph for the corresponding graph state to be k-pairable. Specifically, we present a family of k-pairable n-qubit graph states, where n is polynomial in k, namely $n = O(k^3 \ln^3 k)$. Our construction relies on probabilistic methods.

Furthermore, we prove that the pairability of a graph state is at most half of the minimum degree up to local complementation of the underlying graph, i.e., $k(|G\rangle) \leq \lceil \delta_{loc}(G)/2 \rceil$.

We also investigate the related combinatorial problem of k-vertex-minor-universality : a graph G is k-vertex-minor-universal if any graph on any k of its vertices is a vertex-minor of G. When a graph is $2k$-vertex-minor-universal, the corresponding graph state is k-pairable. More precisely, one can create not only EPR-pairs but also any graph state on any $2k$ qubits through local operations and classical communication. We establish the existence of k-vertex-minor-universal graphs of order $O(k^4 \ln k)$.

This talk is based on [2].

Références

[1] S. Bravyi, Y. Sharma, M. Szegedy, and R. De Wolf, *Generating k EPR-pairs from an n-party resource state*, QIP2023, arXiv :2211.06497 (2022)

[2] N. Claudet, M. Mhalla and S. Perdrix, *Small k-pairable states*, arXiv (2023)