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Activation of genuine multipartite entanglement: beyond the single-copy paradigm of entanglement characterisation

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Entanglement shared among multiple parties presents complex challenges for the characterisation of different types of entanglement. One of the most basic insights is the fact that some mixed states can feature entanglement across every possible bipartition of a multipartite system, yet can be biseparable, i.e., can be produced via a mixture of partially separable states. To distinguish biseparable states from those states that genuinely cannot be produced from mixing partially separable states, the term genuine multipartite entanglement was coined. The premise for this distinction is that only a single copy of the state is distributed and locally acted upon. However, advances in quantum technologies prompt the question of how this picture changes when multiple copies of the same state become locally accessible. Here we show that multiple copies unlock genuine multipartite entanglement from partially separable states, even from undistillable ensembles, and we demonstrate that more than two copies can be required to observe this effect.

Our results show that a modern theory of entanglement in multipartite systems, which includes the potential to locally process multiple copies of distributed quantum states, exhibits a rich structure that goes beyond the convex structure of single copies. Indeed, based on our results, we present two conjectures about this structure: (i) the existence of a hierarchy of k-copy activatable states, for which k-1 copies remain biseparable, but k copies are GME, and (ii) the asymptotic collapse of the hierarchy of genuinely k-partite entangled states, i.e., that k copies of any biseparable but not partially separable state become GME as k tends to infinity. In other words, we conjecture separability in multipartite systems to asymptotically collapse to the simple bipartite concept of separability in scenarios with unbounded numbers of copies, and we show that two copies are certainly not sufficient for reaching this simple limit, thus leaving the practical certification a rich problem to be studied.

Reference: [1] Hayata Yamasaki, Simon Morelli, Markus Miethlinger, Jessica Bavaresco, Nicolai Friis, and Marcus Huber, Activation of genuine multipartite entanglement: beyond the single-copy paradigm of entanglement characterisation, arXiv:2106.01372 [quant-ph] (2021)

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