Bounding the amount of entanglement from witness operators

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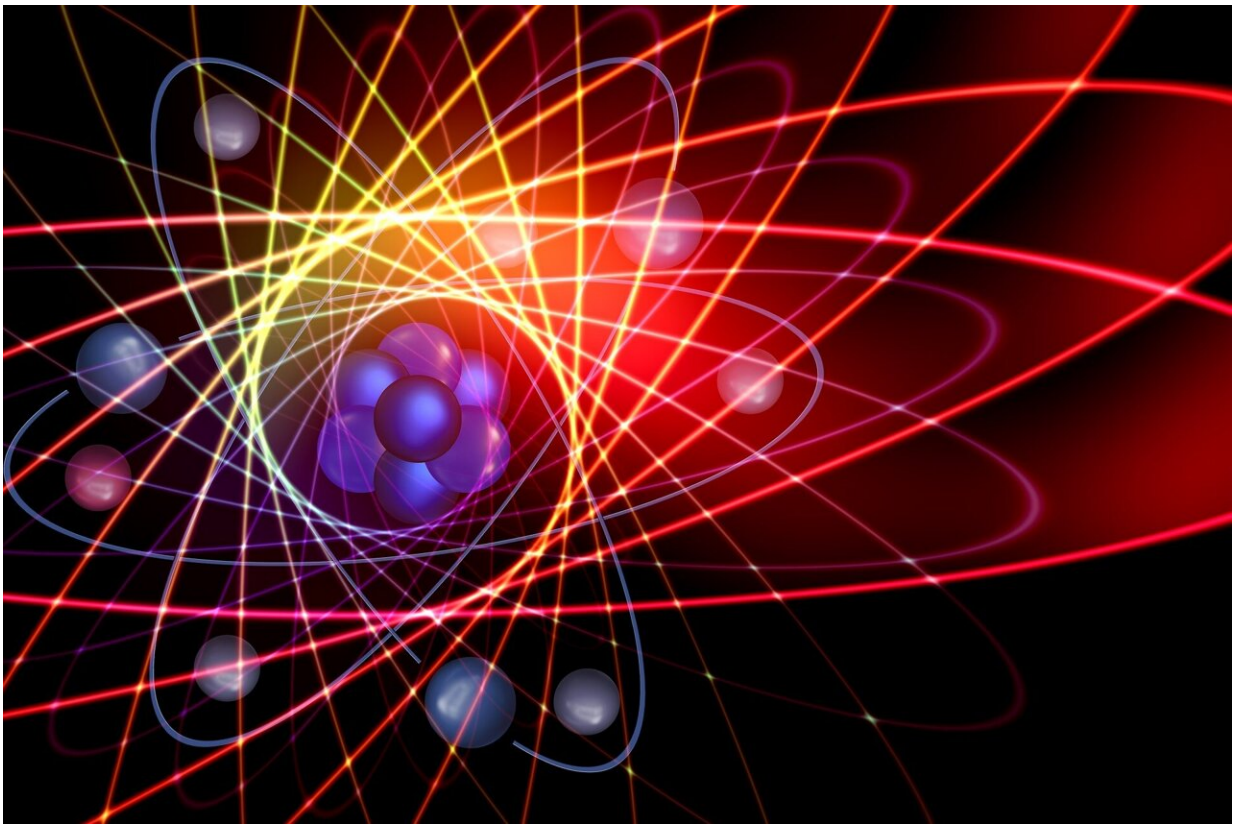

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A team of researchers has proposed an approach to quantify entanglement using the standard entanglement witness procedure under three common experimental scenarios. Their work is published in Physical Review Letters.

Two fundamental tasks in quantum entanglement research are detection and quantification of entanglement. Entanglement witnesses (EWs), which are observable quantities that are negative for entangled states and positive for separable states, are widely used to detect entanglement under various experimental scenarios for its simplicity and strong detection capabilities. Up to now, EWs have only been used to detect the presence of entanglement, remaining silent on estimating the amount of entanglement present in the state.

The team consisting of Prof. Yu Sixia, Associate Researcher Sun Liangliang and Zhou Xiang from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) and others, filled this research gap by discovering that EW can be normalized into a trace distance that characterizes the distinguishability between experimental data generated by a given entangled state and by a separable state under identical measurements.

The distinguishability is the core of entanglement quantifier and can be used to bound a variety of common entanglement measures. In the scenario of trusted devices, the normalized EW characterizes the optimal distinguishability between the given state and separable state.

In the device-independent (DI) scenario, the normalized EW quantifies the optimal distinguishability between the quantum correlations generated by the given state and the local correlations generated by a separable state. Similar normalization of the EW is achieved in the

measurement-device-independent (MDI) scenario.

This entanglement quantifier enables researchers to estimate the lower bounds of various entanglement measures based on the mean value of the EWs, regardless of the experimental scenario. EWs are no longer silent on the quantification of entanglement.

Furthermore, for multipartite systems, the normalized EWs can be leveraged to estimate the entanglement depth, which is the minimum number of entangled particles. When the number of particles approaches infinity, this method provides a rigorous lower bound that asymptotically tends to the exact value of entanglement.

The paper's reviewers praised this work, saying that it "comprehensively addressed an important issue, enabling entanglement experiments to encompass a broader range of entanglement measures."

More information: Liang-Liang Sun et al, Bounding the Amount of Entanglement from Witness Operators, *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.110204. On *arXiv*: DOI: 10.48550/arxiv.2312.04897

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