Researchers develop new method for putting quantum correlations to the test

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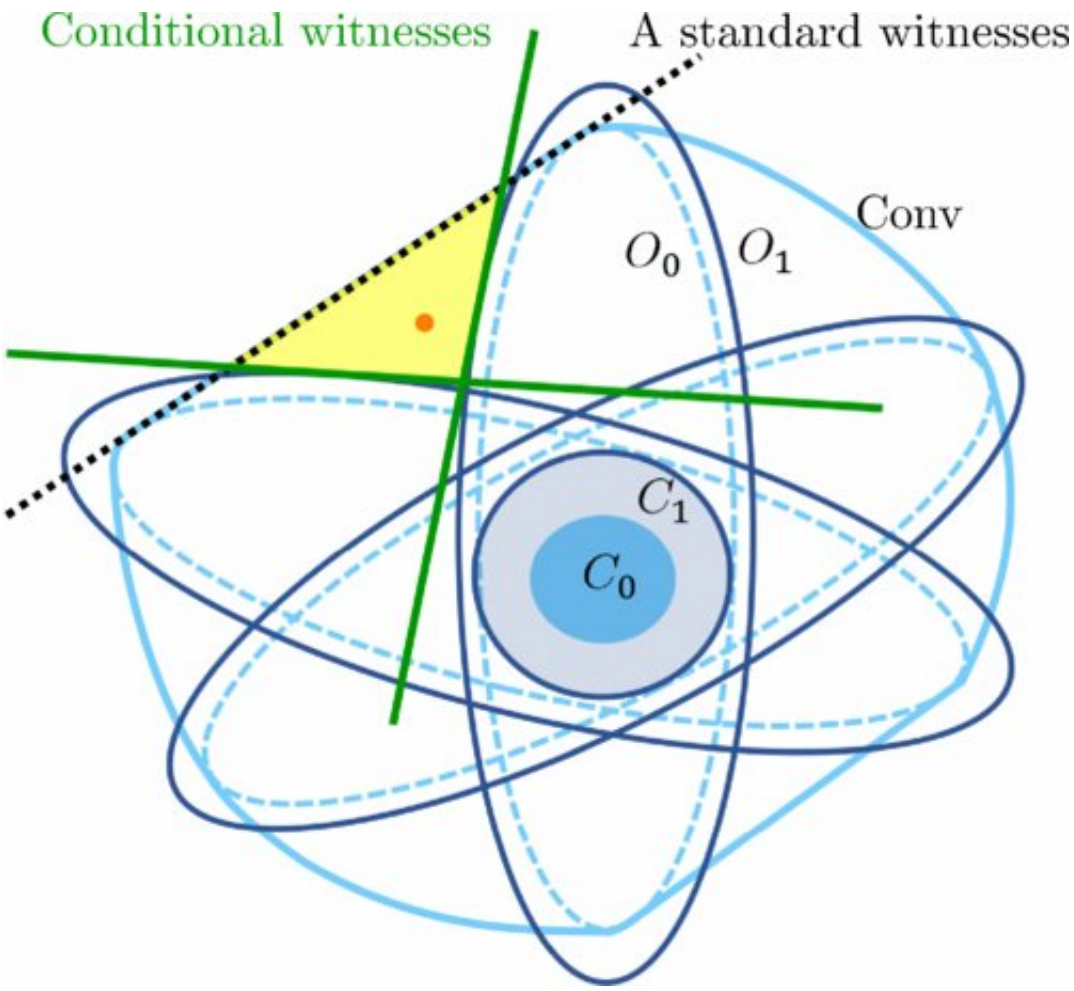

Heuristic comparison between standard GME witnessing and conditional GME witnessing technique. Credit: *PRX Quantum* (2021). DOI: 10.1103/PRXQuantum.2.020304

Physicists from Swansea University are part of an international research collaboration which has identified a new technique for testing the quality of quantum correlations.

Quantum computers run their algorithms on large quantum systems of many parts, called qubits, by creating quantum correlations across all of them. It is important to verify that the actual computation procedures lead to quantum correlations of desired quality.

However, carrying out these checks is resource-intensive as the number of tests required grows exponentially with the number of qubits involved.

Researchers from the College of Science, working with colleagues from Spain and Germany, have now proposed a new technique that helps to overcome this problem by significantly reducing the number of measurements while increasing the resilience against noise.

Their method offers a solution to the problem of certifying correlations in large systems and is explained in a new paper which has just been published in PRX Quantum, a prestigious journal from American Physical Society.

Research fellow Dr. Farid Shahandeh, the lead scientist of this research, said: "To achieve this we combine two processes. Firstly, consider a juicer—it extracts the essence of the fruit by squeezing it into a small space. Similarly, in many cases quantum correlations in large systems can also be concentrated in smaller parts of the system. The 'squeezing' is done by measurements on the rest of the system called the localization process.

"Suppose the juicer directly converts the fruit into juice boxes without any labels. We don't know what is inside—it could be apple juice,

orange juice, or just water. One way to tell would be to open the box and taste it. The quantum comparison of this is to measure a suitable quantity that tells us whether quantum correlations exist within a system or not.

"This process is called witnessing and we call the combination of the two approaches conditional witnessing."

In their research the physicists prove their method is efficient and generically tolerates higher levels of noise in experiments. They have also compared their approach with previous techniques in a class of quantum processors that use ions to demonstrate its efficiency.

Dr. Shahandeh, the recipient of a Royal Commission for the Exhibition of 1851 research fellowship, added: "This is of crucial importance in current technology where the addition of each qubit unavoidably amplifies the complexity of quantum states and experimental imperfections."

More information: Andrea Rodriguez-Blanco et al. Efficient and Robust Certification of Genuine Multipartite Entanglement in Noisy Quantum Error Correction Circuits, *PRX Quantum* (2021). DOI: 10.1103/PRXQuantum.2.020304

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