The Peres conjecture is false: One of the most famous problems in quantum information physics solved

November 5 2014

Since 1999, the conjecture by Asher Peres, who invented quantum teleportation, has piqued the interest of many scientists in the field. According to his hypothesis, the weakest form of quantum entanglement can never result in the strongest manifestation of the phenomenon. Today, a team of researchers from the University of Geneva (UNIGE), Switzerland, and the Hungarian Academy of Sciences have proven this conjecture to be false, thus solving one of the most famous problems in quantum information physics. This news was published in *Nature Communications* review.

The physicist Asher Peres was very interested in the phenomenon of quantum entanglement and its different manifestations. When two objects (take photons, for example) are entangled, they remain correlated regardless of the distance that separates them physically: whether they are separated by a millimetre or by several kilometres, any action done to one of them will immediately affect the other. To check whether a system is entangled, scientists test for Bell's inequality. If the experimental measurements violate Bell's inequality, this means that the two objects are entangled, and that they correspond to two manifestations, in different locations, of the same single object. This is called nonlocality.

A Problematic Conjecture

In 1999, Asher Peres conjectured that the weakest form of an entanglement will never result in the strongest manifestation of the phenomenon. Explanations.

The violation of Bell's inequality represents the strongest form of entanglement. Two objects must indeed be strongly entangled in order for the system's experimental measurements to violate Bell's inequality. On the other hand, there also exist states with very weak entanglement. Asher Peres wondered if it would be possible to distil several weakly entangled states in order to make a strongly entangled one, as one would distil alcohol. The theory showed that this was possible, but not in every case. Certain states are in fact too weakly entangled to be distilled; this is the case of bound entanglement, which is considered the weakest form of the phenomenon. Peres therefore concluded that the weakest form of entanglement could never result in the strongest manifestation of the phenomenon, namely nonlocality.

Later, a number of scientists tried to prove his conjecture. Some succeeded in a few particular cases, but none were able to demonstrate the claim in general. Peres's conjecture was therefore considered to be one of the most famous unresolved problems in the field of quantum information physics... until now. In fact, Nicolas Brunner, a physics Professor at UNIGE's Faculty of science, and Tamas Vertesi, a researcher at the Hungarian Academy of Sciences, were able to disprove Peres's conjecture. "To do so, we just had to find a counter-example," explains Professor Brunner. "Using numerical algorithms, we showed that a bound entanglement can violate Bell's inequality, without needing to be distilled."

Provided by University of Geneva

Citation: The Peres conjecture is false: One of the most famous problems in quantum

information physics solved (2014, November 5) retrieved 19 April 2024 from
https://phys.org/news/2014-11-peres-conjecture-false-famous-problems.html

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