Using entangled photons to play "quantum Go"

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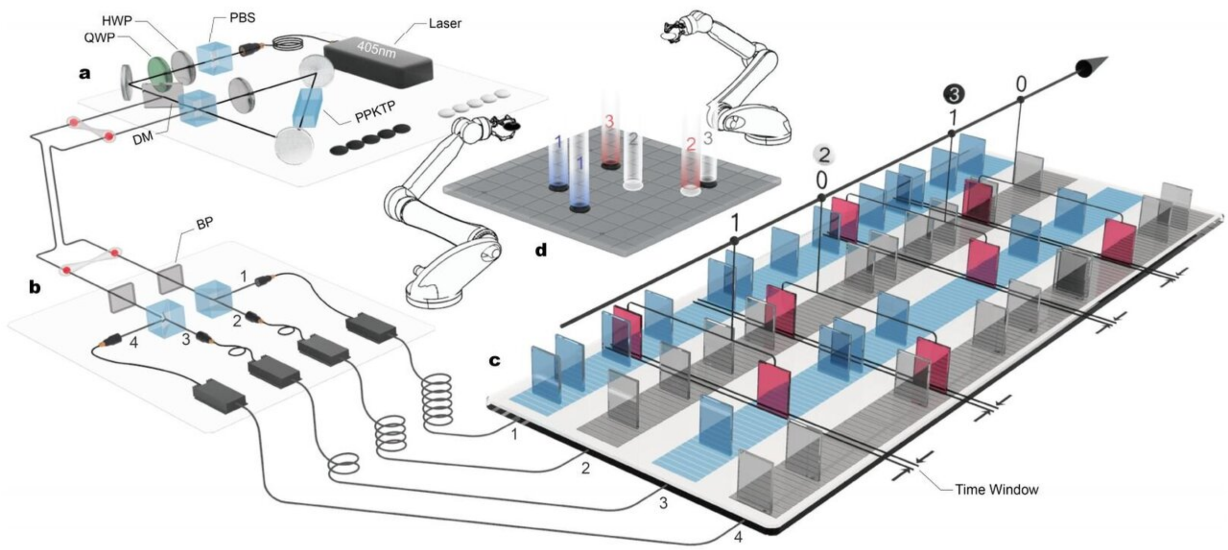

Sketch of quantum Go machine. a, Experimental setup of the quantum stone box. The generated photon pairs can be tuned to maximally entangled states, non-maximally entangled states and product states to behave as difierent quantum stones, see Methods. b, The collapse measurement module. After the photons come into this module, they will be measured by the polarizing beam splitter (PBS) then the quantum state collapses to path 1 and 3 (or path 2 and 4). Four single photon detectors transfer the photon signals to electronic signals. c, The time-of-flight storage module. Four output channels from the collapse measurement module will be guided into this module. The collapse result information of each pair of the entangled photons can be acquired after setting a proper coincidence time window, and recorded as an effective stored state in the time series data. We encode the signals coincidence in Channel 1 and 3 as "1", and Channel 2 and 4 as "0". d, Sketch of playing quantum Go with the quantum stones from the time series data. Two robot arms represent the two agents who help to execute the game of quantum Go together. They pick the quantum stones from the quantum stone box alternately and put every stone onto two intersections of the virtual board. When a quantum stone is put on an intersection that has neighbors, the game will get the collapse results from the time series data with a backdated measurement in the collapse measurement module. Credit: arXiv:2007.12186 [quant-ph]

A team of researchers affiliated with several institutions in China has developed a form of the board game Go using entangled photons. They have posted a paper to the arXiv preprint server describing their game and explaining why they believe their setup could be used as a baseline for creating other quantum-based games.

Go is a board game somewhat resembling checkers—it is played on a square board filled with a grid of boxes, though it involves black and white stones instead of red and black discs. Two players take turns placing stones on the vertices of the squares, rather than within them. The goal for each player is to enclose more of the board than their opponent—rival pieces can be captured by encircling them on all orthogonally adjacent points. At first glance, the game appears simple, but a closer look shows that high levels of play can arise due to complexity. In this new effort, the researchers sought to increase the complexity of Go by adding a quantum element. Instead of using stones, they used entangled photons and instead of each player laying down a single stone, players laid down a pair of entangled photons. In the quantum version of the game, both of the entangled photons remain in play on the virtual board until contact occurs with another photon. At that point, only one of the entangled photons remains in play. Adding entangled photons increases the complexity of the game because adding pairs doubles the number of possible configurations. And that, of course, makes it more difficult for both players to work out their next move. In quantum Go, players can still capture an opponent's stone (photon) by encircling it—with one exception—the stone must not be in an entangled state. Making things even more interesting, the player will not know beforehand if the stone is entangled—if it turns out to be, the encircling is nullified and the stone remains on the board.

The researchers created a version of quantum Go using entangled photons and found that in continuously generating entangled photons as play progressed, they were able to introduce a random element to the game, which, they note, is required to build ever more powerful AI systems able to play sophisticated games with an element of randomness, such as poker.

More information: Quantum Go Machine, arXiv:2007.12186 [quant-ph] arxiv.org/abs/2007.12186