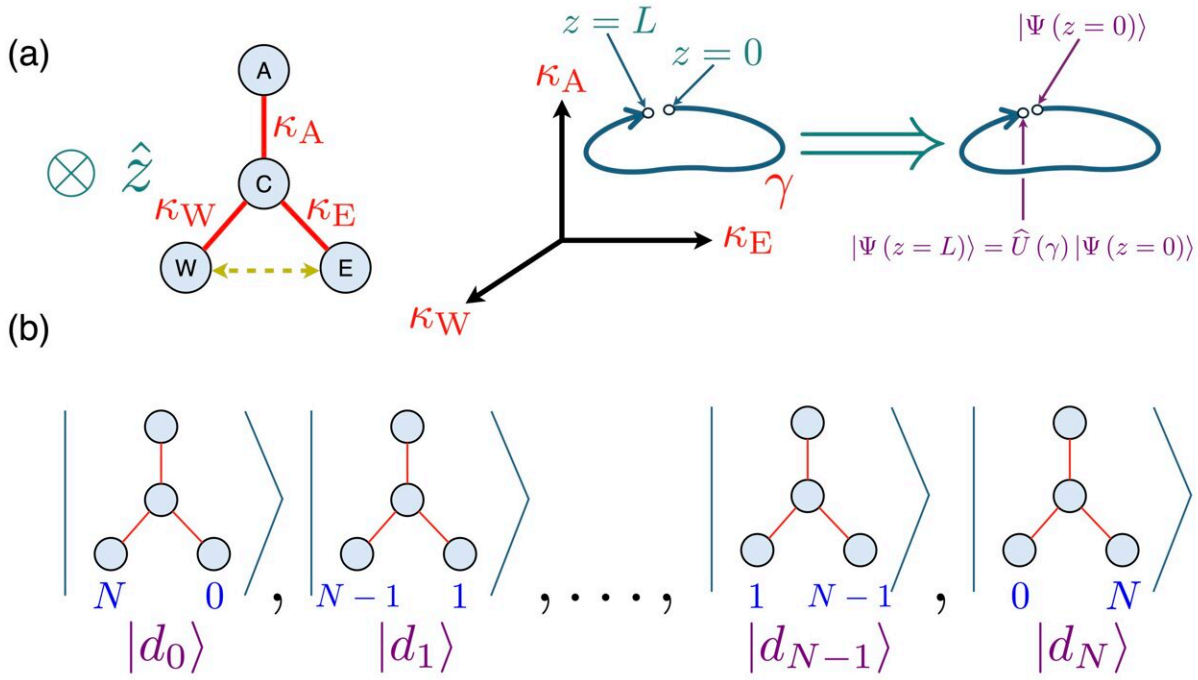
Novel protocol enables photon entanglement without quantum measurement

March 26 2025, by Tess Malone



High-dimensional, deterministic entanglement through holonomy. Credit: *Physical Review Letters* (2025). DOI: 10.1103/PhysRevLett.134.080201

Georgia Tech researchers recently proposed a method for generating quantum entanglement between photons. This method constitutes a breakthrough that has potentially transformative consequences for the future of photonics-based quantum computing.

"Our results point to the possibility of building quantum computers using light by taking advantage of this entanglement," said Chandra Raman, a professor in the School of Physics. The research is published in the journal *Physical Review Letters*.

Quantum computers have the potential to outperform their conventional counterparts, becoming the fastest programmable machines in existence. Entanglement is the key resource for building these quantum computers.

Light has always been seen as ideal for quantum computing, but it presents challenges. Photons don't interact with each other. "If I have two or more photons, it's extremely difficult to make them interact; they fly right by each other," said postdoctoral researcher Aniruddha Bhattacharya. "The key discovery here is we can entangle photons in a useful, controllable, and deterministic way."

The researchers devised a protocol to create entanglement consistently. Their protocol makes use of a mathematical geometric structure known as non-Abelian quantum holonomy, which can entangle photons without requiring quantum measurements. Holonomy can be implemented with on-chip photonic devices, suggesting this protocol could be used to create scalable and integrable photonic quantum computers.

The research's implications are staggering for the future of quantum computing. Photonic quantum computers work well at room temperature, are portable, and are more easily integrated with existing quantum communication systems and links. Quantum computing is the future of not just computing but innovation, and photons could unlock new frontiers.

More information: Aniruddha Bhattacharya et al, Deterministic Photonic Entanglement Arising from Non-Abelian Quantum Holonomy, *Physical Review Letters* (2025). DOI: 10.1103/PhysRevLett.134.080201.