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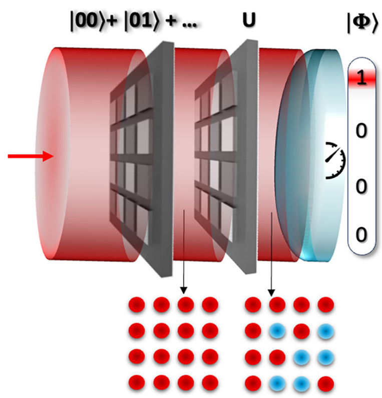
Well-established optical computing methods can be used to execute vector-matrix algebra for quantum computing.



Quantum computing has the potential to transform industries by making previously unsolvable problems solvable, but common optical computational methods in the field require complex operations and hardware. Koni et al. developed a technique that simplified these computations by using structured light as a resource.

The authors found they could exploit the high-dimensional states of laser beams, which, unlike traditional quantum information bits or "qubits," encode more than two states of information at a time. They adapted well-established optical vector-matrix computation methods to perform parallel processing, making use of superposition and interference and replicated the well-known Deutsch-Jozsa algorithm in quantum computing.

"The scheme is easy to implement, adaptable, and dynamic," author Isaac Nape said. "One simply encodes the required information using 'pictures' that are encoded as digital holograms and loaded on pixelated digital displays that interact with the laser beams."

The team's primary tools included digitally addressed spatial light modulators, which are reprogrammable devices that can be used to encode the optical analogue of quantum states, the "quantum gates" that act on them, and a cylindrical lens that performs Fourier transforms to deliver an interpretable pattern corresponding to the results of the team's calculations.

"We anticipate that numerous other protocols can be demonstrated since the scheme is dynamic," Nape said. "Due to the reconfigurability of spatial light modulators, most quantum gates can be simulated with this scheme."

Next steps include implementing the approach at a single-photon level and including quantum entangled states to enable the computation of more complex algorithms.

Source: "Emulating quantum computing with optical matrix multiplication," by Mwezi Koni, Hadrian Bezuidenhout, and Isaac Nape, *APL Photonics* (2024). The article can be accessed at https://doi.org/10.1063/5.0230335.