PURDUE INNOVATES | Office of Technology Commercialization

# Deterministic Optical Quantum Logic with Multiple High-dimensional Degrees of Freedom in a Single Photon

**Scalable, deterministic single- and two-qudit optical quantum gates exploit the full information capacity of single photons to implement quantum computing algorithms in large Hilbert spaces.**

Quantum computation promises to enable the simulation of complex quantum mechanical systems which are impossible to realize with our current computing infrastructure. Quantum computation using optical states consists of making photons interact with one another, which leads to a probabilistic process, hence not scalable. Currently, deterministic quantum gates use different degrees of freedom in a single photon, utilizing two-dimensional encoding per each degree of freedom, thus failing to exploit the full information capacity of single photons while having very limited Hilbert space dimensions.

Researchers at Purdue University have developed deterministic single- and two-qudit optical quantum gates in a single photon. By proposing a scalable scheme to execute quantum gates, this technology can implement quantum computing algorithms in large Hilbert spaces. This technology can help producers of optical quantum processors who want to demonstrate quantum computing algorithms in the optical domain.

**Advantages**:

-Scalable scheme

-Implementations in large Hilbert spaces

-Exploits full information capacity of single photons

Potential Applications:

-Near-term quantum computing

-Optical quantum processors

**Technology ID**

2018-WEIN-68315

**Category**

Computing/Quantum Technologies

Computing/Photonic & Optical Computing Technologies

**Authors**

Poolad Imany

Jose Jaramillo-Villegas

Andrew M Weiner

**Further information**

Parag Vasekar

psvasekar@prf.org

**View online**

**TRL:** 2

**Intellectual Property:**

Provisional-Patent, 2019-05-10, United States | Utility Patent, 2020-05-08, United States | DIV-Gov. Funding, 2023-05-08, United States

**Keywords:** Quantum computation, optical quantum gates, single photon, two-qudit, scalable scheme, quantum computing algorithms, large Hilbert spaces, optical quantum processors, deterministic quantum gates, full information capacity