SYSTEM AND METHOD FOR QUANTIFICATION OF ALL-OPTICAL QUANTUM GATES VIA QUANTUM STATE TOMOGRAPHY

IITM Technology Available for Licensing

Problem Statement

- **Effective quantification of all-optical quantum gates** via tomography enhances precision in quantum computing.
- **Conventional** optical quantum gate technologies **lack robust systems for efficient and accurate state quantification.**
- Further, conventional quantification technologies have **poor reliability** due to high error rates, inefficiencies, and limited scalability in analyzing and implementing quantum gates.
- There is a need for **a scalable, accurate, and efficient method for quantum state tomography**, improving reliability and practicality in quantum computing.

Intellectual Property

- IITM IDF Ref 2955
- **IN 202441049687 Patent Application**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category- Quantum Technology
Industry Classification:
Quantum computing systems or methods; Optical systems or apparatus; Semiconductor and Related Device Manufacturing
Applications:
Precise quantification and implementation of all-optical quantum gates; robust quantum state tomography, improving the reliability of quantum information processing; efficient and accurate optical systems for quantum gate operation.

Market report:
The global quantum computing market was valued at USD 1.3 Billion in 2024 and projected to grow to USD 5.3 Billion by 2029 with a CAGR of 32.7%

Research Lab

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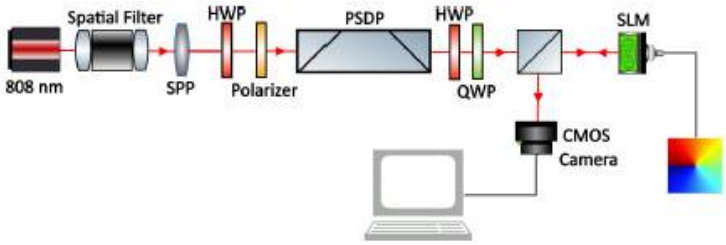

Figure: An illustration of a schematic of an experimental setup to perform quantum state tomography to obtain the gate fidelity of the Polarization Selective Dove Prism (PSDP).

Generating a beam of light

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Altering the OAM of the beam for creating the desired OAM mode.

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Altering the polarization of the beam to obtain a desired input state and control the polarization state.

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Using at least one PSDP for coupling the OAM and polarization of the beam.

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Performing projective measurements on the polarization basis and controlling the polarization of the beam.

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Managing the beam path for subsequent measurements.

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Performing projective measurements on the OAM basis and generating a beam with 36 states.

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Capturing the intensity of the resultant measurements from the projective measurements.

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Performing quantum state tomography to reconstruct the output state of the PSDP and comparing the reconstructed output state with the known input state to determine the fidelity of the CNOT gate.

Figure: Illustrates a method for quantification of all-optical quantum gates via quantum state tomography.

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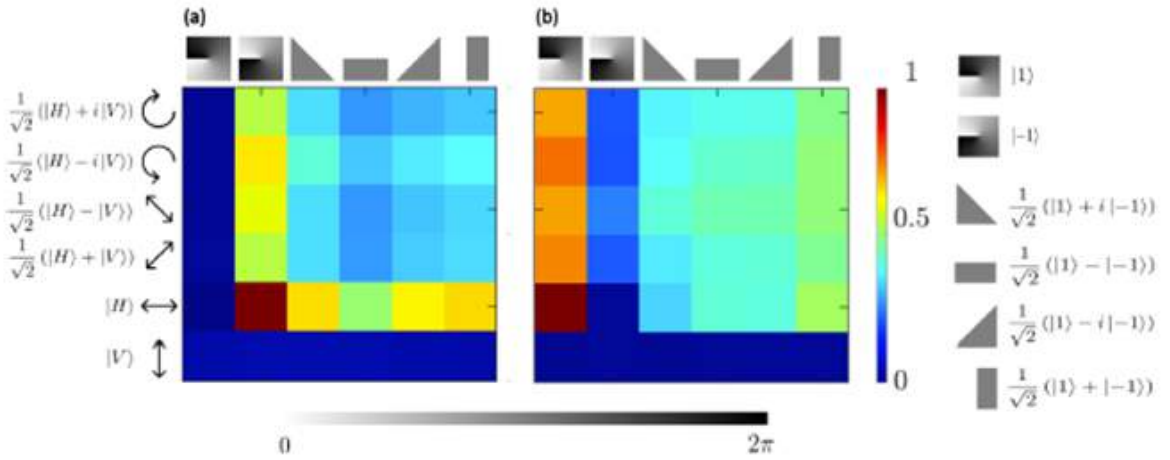

Figure: Illustrates a graphical representation of normalized intensity maps for the 36 projective measurements comprising of various polarization and orbital angular momentum (OAM) superposition. Figs. **(a)** and **(b)** show the averaged normalized intensities captured over a radius of 15 pixels using a CMOS camera. The row and column headers represent the polarization states and the SLM holograms respectively that were used to make the projective measurement.

Technology

- The invention quantifies all-optical quantum gates using quantum state tomography, enabling accurate measurement of gate fidelity essential for advanced quantum computing applications.
- **Utilizes Polarization State Dependent Polarizer (PSDP) to couple orbital angular momentum (OAM) and polarization, facilitating precise projective measurements and state reconstruction.**
- Features an optical system generating 36 OAM and polarization states, with projective measurements on each, ensuring robust quantum state tomography and fidelity assessment.
- Demonstrates superior fidelity measurement accuracy for quantum gates like CNOT, leveraging efficient beam path management and state quantification methodologies.
- Critical for quantum computing, optical quantum systems, and research involving precise state quantification and optimization of quantum gate performance metrics.

Key Features / Value Proposition

- The invention employs quantum state tomography for precise fidelity assessment of optical quantum gates, surpassing traditional methods with higher accuracy in state reconstruction.
- Utilizes PSDP to couple orbital angular momentum (OAM) and polarization, a novel feature improving the scope of projective measurements in quantum systems.
- Generates and measures 36 OAM and polarization states, significantly expanding the parameter space for accurate gate performance analysis.
- Offers a systematic and reproducible methodology, making it adaptable for future advancements in scalable quantum computing technologies.
- Outperforms existing technologies by ensuring lower error rates and providing robust tools for gate fidelity comparison and optimization

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