TOPIC OF A COMPETITION PROMOTING STUDENT ENGAGEMENT IN SCIENTIFIC ACTIVITIES

Topic: Photonic Quantum Technologies for Secure Communication

Goal: To explore the role of single-photon sources and detectors in quantum key distribution (QKD).

Short description (max. 2000 characters):

Quantum key distribution (QKD) ensures secure communication using quantum mechanics. Students will review integrated photonics QKD demonstrations. Using Python (QuTiP/Qiskit), they will simulate quantum states through a channel and study how loss, noise, and timing jitter affect key rates. The will then model key rate vs. distance and analyze how parameters such as detector efficiency or photon source quality influence performance. The project ends with recommendations for integrated photonic components to enable scalable QKD.

Tools and Materials: Python (QuTiP/Qiskit), Octave, QKD literature.

Desired Background: Quantum Optics, Probability & Statistics, Photonics/Optical Communication.

Suitable for a third or fourth -year Bachelor or Master student.

References:

- Yu, H., et al. (2025). Quantum key distribution implemented with d-level time-bin entangled photons. Nature Communications. doi:10.1038/s41467-024-55345-0
- Finco, G., et al. (2024). Time-bin entangled Bell state generation and tomography on a lithium-niobate photonic chip. npj Quantum Information. doi:10.1038/s41534-024-00925-7

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