Project Title: Quantum photonic neural networks

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Short description of the project: In recent years, artificial intelligence (AI) and quantum computing have emerged as two of the leading candidates for the future of computing. However, training AI systems is slow and inefficient using standard computers while the demonstration of quantum advantage on a useful task on a quantum computing platform remains elusive and the quest for algorithms that can be run efficiently on a quantum platform is open.

Prof. Rotenberg and Prof. Shastri's are developing *hybrid quantum-classical photonic neural network* architectures, that interface neuromorphic processors with quantum circuits. Such a hybrid architecture could potentially enable (1) quantum networks to accelerate the training of classical neural networks, and (2) conversely, the neural networks could make the noisy intermediate-scale quantum (NISQ) processors more effective and practical. The key to this architecture is that quantum gates and neurons can both be implemented by the *same* nanophotonic device called a microring resonator (MRR), and thus the hybrid architecture could be fabricated on a single integrated chip enabled by advances in silicon photonics. Shastri Lab has already demonstrated MRR based silicon photonic neural networks that are fast and efficient.

The objective of this project will be to design a hybrid quantum-classical neural interface, focusing on integrating both quantum photonic circuits and sources with classical photonic neural networks. The proposed project has the potential to create a link between two of the most cutting-edge computing techniques in the world today, AI and quantum computing. The synergy of these techniques could enable significant improvements of current applications in each of their domains separately, as well as create a new domain of interfacing hybrid quantum-classical hardware.

Unique opportunities provided to student

- Work with multi-disciplinary team: The student will have the opportunity to work intimately with team of postdoctoral researchers and graduate students from physics and engineering at Niels Bohr Institute and Princeton University.
- Acquire a unique skillset: The student will receive training in quantum computing nanophotonics, photonic integrated circuits, and machine learning. As one of the fastest developing areas, the knowledge and skillset acquired in this field, will strategically position the student to either pursue graduate studies or industry prospects (IBM, Xanadu, Apple, HP Labs).

What sort of aptitudes and interests should the student have?

1) Be strongly self-motivated and ability to demonstrated ability to work collaboratively.
2) Desired (but not necessarily required) background in quantum mechanics, optics, photonics, or neural networks.