Demonstrating quantum speed-ups in reinforcement learning using an integrated photonic processor

The field of artificial intelligence (AI) has experienced major developments over the last decade. Within AI, of particular interest is the paradigm of reinforcement learning (RL), where autonomous agents learn to accomplish a given task via feedback exchange with the world they are placed in, called an environment. Thanks to impressive advances in quantum technologies, the idea of using quantum physics to boost the performance of RL agents has been recently drawing the attention of many scientists. In my talk I will focus on the bridge between RL and quantum mechanics, and show how RL has proven amenable to quantum enhancements. In particular, I will show that a reduction in learning time can be achieved and quantified only if the agent and the environment can also interact quantum-mechanically, that is, if they can communicate via a quantum channel [1]. This idea has been implemented on an integrated processor that makes use of single photons as information carriers. Such device is a silicon-on-insulator (SOI) type and consists of many small components accommodated on small areas. This is possible thanks to the high contrast in refractive index between the silicon and the insulator, which enables the fabrication of waveguides with very small bend radii.
The achieved speed-up in the agent's learning time, compared to the fully classical picture, confirms the potential of quantum technologies for future RL applications.

[1] Saggio, V. et al. Nature 591, 229–233 (2021).