SAWtrain Research 7:
"Controllable Photonic Time-Bin Qubits from a Quantum Dot"

Single photons are useful for storing and transmitting information in secure quantum communication and in some implementations of quantum computing. One promising source of single photons is a nanoscale semiconductor particle known as a quantum dot. These dots can produce photons at a very high rate and do not require complicated setups, unlike trapped atoms and ions. Here, we demonstrate an efficient, powerful method for encoding information in a photon generated by a quantum dot.

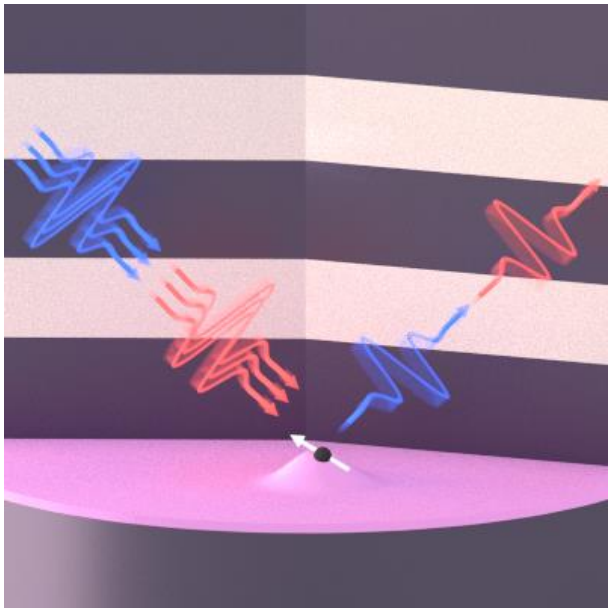

Figure 1: Artist's impression of the experiments. The phase from resonant laser pulses is imprinted onto the single photons scattered from a charge trapped in a quantum dot. Together with wavelength and time-bin encoding, each photon can carry more information.

Time-bin encoding inscribes information in the arrival time of a photon. This encoding scheme is a convenient way to send information over an optical fibre because it does not suffer from decoherence, which degrades the information as it travels.

We borrowed techniques from atomic physics to encode information in the time-bin basis using single photons. Normally, this type of encoding requires the generated photons to be sent through an interferometer and a phase modulator, which results in many of the photons being lost. By moving the location of these components, the photons do not have to be sent through either of them, making it possible to achieve much higher efficiencies. We also adopt a technique used to send multiple signals along a single fibre and apply it to single photons. This allows us to encode more information per photon.

Our technique allows us to, in principle, deterministically produce arbitrary single-photon time-bin-encoded qubits. These results demonstrate the ability to encode large amounts of information in a single photon, which will be critical for practical quantum communication.

Publication:

Lee, J. P. *et al.* Controllable Photonic Time-Bin Qubits from a Quantum Dot. *Phys. Rev. X* **8,** 021078 (2018).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642688.