ESONN

Practicals

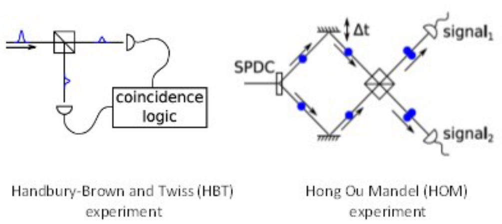
N°06: Single photon source characterization, entangled photon pair generation and Bell's inequality violation.

Teachers: David Ferrand (UGA), location Institut Néel (room D321).

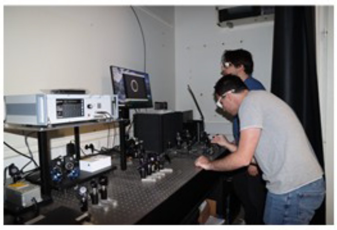
Quantum optics is a highly active and rapidly evolving field of research. Advances in single-photon sources and single-photon detectors have already led to significant progress in quantum cryptography and in the generation of multi-photon entangled states for quantum computing.

In the first part of this laboratory course (4 hours), students will revisit key experiments used to characterize the optical properties of a single-photon source. These include single-photon interference experiments to characterize the coherence, Hanbury Brown and Twiss (HBT) measurements to evaluate single-photon purity, and two-photon Hong–Ou–Mandel (HOM) interference experiments to quantify photon indistinguishability. Students will work with an experimental setup combining a heralded spontaneous parametric down-conversion (SPDC) single-photon source, avalanche photodiode single-photon detectors, and interferometers. Applications to quantum cryptography will be illustrated through an experimental implementation of the BB84 protocol.

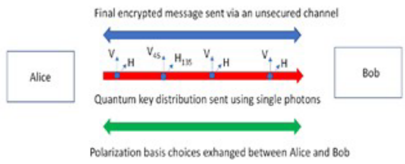
In the second part of the course (4 hours), students will study the generation and polarization properties of entangled photon pairs. They will investigate the spontaneous parametric down-conversion process in nonlinear BBO birefringent crystals, which leads to the emission of polarization-entangled photon pairs. The Einstein–Podolsky–Rosen (EPR) paradox and Bell inequality experiments will be revisited to characterize the degree of entanglement through measurements of the Bell parameter.



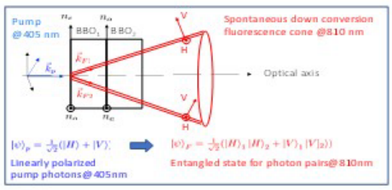
(a) Single photon source characterization



(b) Experimental set-up at Neel Institute



(b) Test of the BB84 quantum cryptography protocol



(d) Bell's inequality violation experiment