James Cockburn
Reference - Direct generation of photon triplets using cascaded photon-pair sources, Hübel, Hamel, Fedrizzi, Ramelow, Resch and Jennewein, Nature, 466, 601-603 (29 July 2010)

Summary

The problem laid out was to produce an entangled photon triplet. The most widely used technique for creating these photon pairs is by spontaneous parametric down-conversion of laser light. Using the same theory as is used in the production of photon pairs such a problem could be theoretically solved, yet the approaches that were proposed were not viable. In this experiment, each of the produced triplets is generated from the same pumped photon and should thus quantum correlations should be common to all three of them. This work could lead to applications in quantum computing, three party quantum communication, since two of the photons created are optimal for optical transmission, and further work on the generation of photon triplets.

The method works by having down-conversion sources be pumped by a laser in order to produce a photon pair. This primary source was periodically poled potassium titanyl phosphate, or PPKTP. This produced photons of 775nm and 848nm from the laser photon at 405nm. From this created photon pair, the 775nm one is subjected to another down-conversion at a secondary source, this time of periodically poled lithium niobate (PPLN)., producing two photons at 1510nm and 1590nm. The photon triplets, then, were measured using three different photon counters, D1, D2 and D3. D1 detected the 848nm photon, at a frequency of about 1MHz, and this detection opened a 20ns gate at D2, which detects one of the photons made at the second source, and this opened the gate at D3 for 1.5ns. It then follows that, since D3 can only be opened if D1 and D2 have both detected, an event at D3 would mean a photon triplet was detected.

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The results of the experiment showed that, indeed, photon triplets were observed. It shows that most of the photons were detected in the period between events at D3 and D1 at 1.2ns. This width of time interval is dominated by detector jitter. Other peaks were observed as well, but are caused by a read detection at D1 and a dark detection at D3. A dark detection is caused by background noise and so is discountable. From the results, it can be showed that there is a raw triplet production rate of 124 +/- 11 events in 20 hours. Using conversion efficiencies, the theoretical model predicts the triplet rate to be 5.6 +/- 1.1 counts per hour, which then agrees very well with the measured value.

In future experiments, it should be possible to increase the photon triplet rate by at least one order of magnitude by utilizing an improved tome acquisition system, a dichroic beam splitter at the secondary source and by equating the down-conversion bandwidth of the initial photon pair to the PPLN crystal.

Conclusions that can be drawn from this experiment include being able to create hyper-entangled photons without elaborate and probabilistic post-selection schemes. The results also confirmed that down-conversion efficiency is independent of the pump power down to the single-photon level, which would allow for new tests of nonlinear optics in the quantum system.