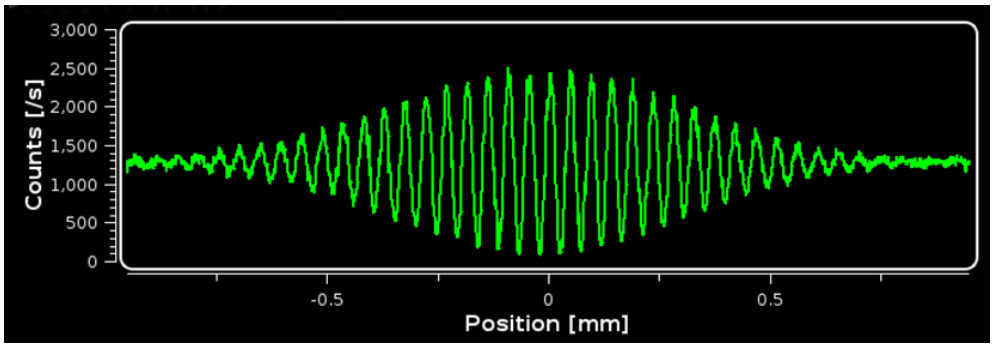
QP-TECH.EDU

Experimental Quantum Technologies

Hong-Ou-Mandel Interference



1. **Experiment:** Hong-Ou-Mandel Interference

Building upon the "wave-particle duality of photons" experiment, we will now examine the destructive interference of a pair of photons. The key feature we shall exploit is the fact that a reflection of a photon incurs a phase shift, or equivalently a factor of $i = \sqrt{-1}$.

When coupling two indistinguishable photon sources to an interferometer which in turn is coupled to two single photon detectors, we expect to obtain the superposition state shown in fig. 1.

$$i|2,0\rangle + |1,1\rangle - |1,1\rangle + i|0,2\rangle$$

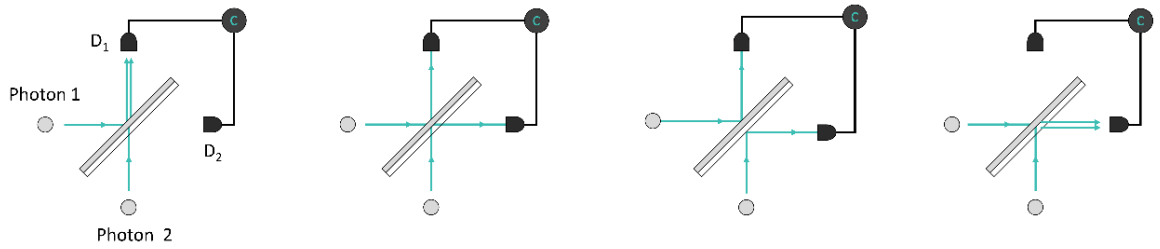


Fig. 1: Superposition of four possible states

Clearly, the two middle terms cancel and we are left with the case of both photons arriving either at detector one or detector two respectively.

However, the above interference will only happen if it is in principle impossible to distinguish between the two middle interference diagrams. One possibility to do so is to shorten or prolong the optical path between the interferometer and one of the detectors. Then the arrival time of the photons will differ and we would expect the destructive interference to vanish. This is precisely what is observed in fig. 2 where the dip corresponds to the case of equal optical paths.

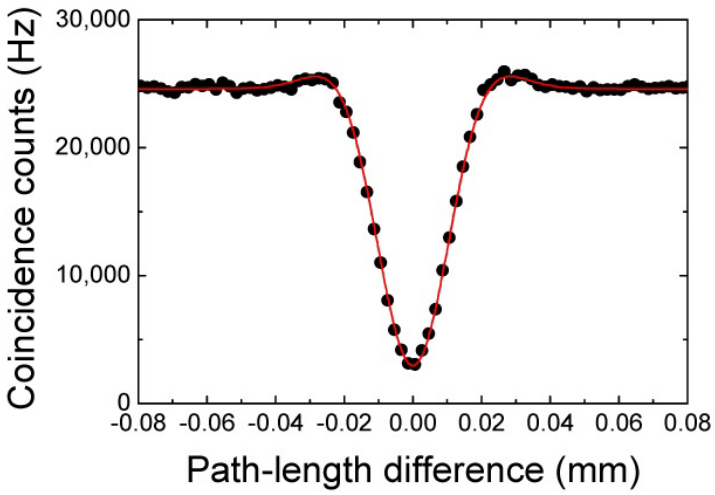


Fig. 2: HOM interference pattern. The dip at zero optical path length difference clearly shows the destructive interference of quantum states [1].

By introducing a path length difference the quality of the destructive interference degrades.