Compact multifunctional two-photon analyser as an universal QIP setup building block

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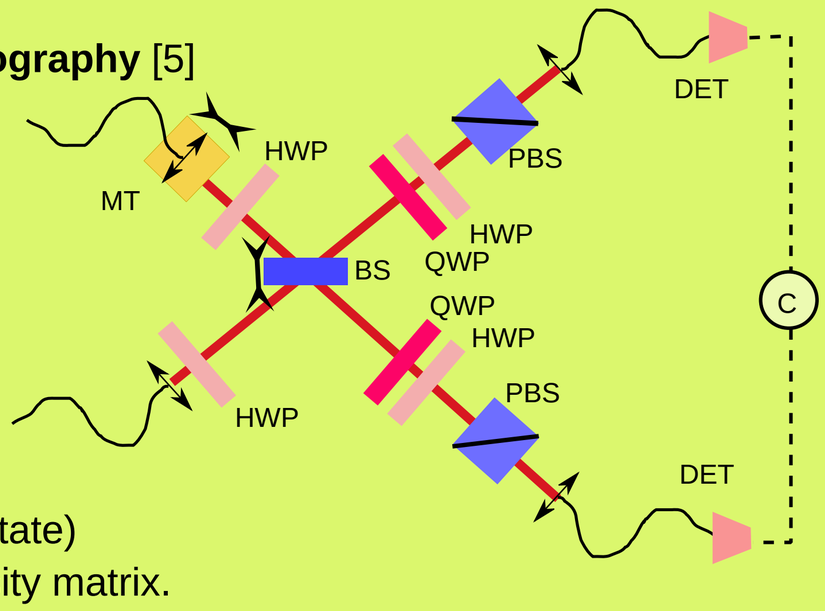
Full characterization of quantum states is very important in many quantum information processing (QIP) experiments. It can be used to study various types of two-photon sources [1, 2, 3, 4]. State analysis is crutial for experimental implementations of QIP schemes (quantum teleportation, computing, cryptography, dense coding). The ultimate goal is a simple all-in-one photon state analyser. Currently we use bulk optics to study and optimise the scheme. Subsequent miniaturization of the setup is planned.

Analyser's functions:

Complete quantum state tomography [5]



Allows to identify:
- purity
- negativity
- fidelity (with respect to target state)

directly from reconstructed density matrix.

Two - photon polarization state analysis

Density matrix is reconstructed for every input state. Photons are detected by avalanche photodiodes (DET) and obtained signal is processed by coincidence logic (C). Tomography is composed by quarter-wave plates (QWP), half-wave plates (HWP) and polarizers (PBS) in each arm to analyze the signal in arbitrary polarization basis.

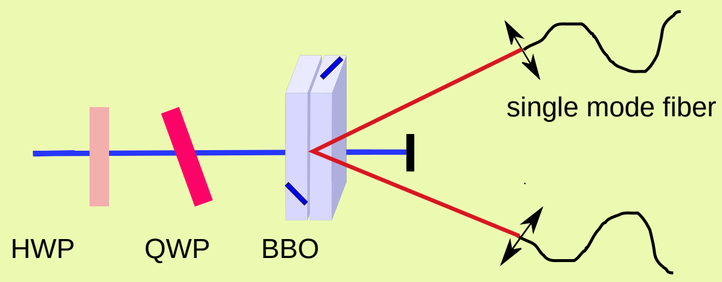
Source of entangled photon pairs:

Photons are produced by the degenerate spontaneous parametric down-conversion process in a pair of nonlinear type I BBO crystals [1]. HWP and QWP are used to control the parameters α, β, φ of the output state

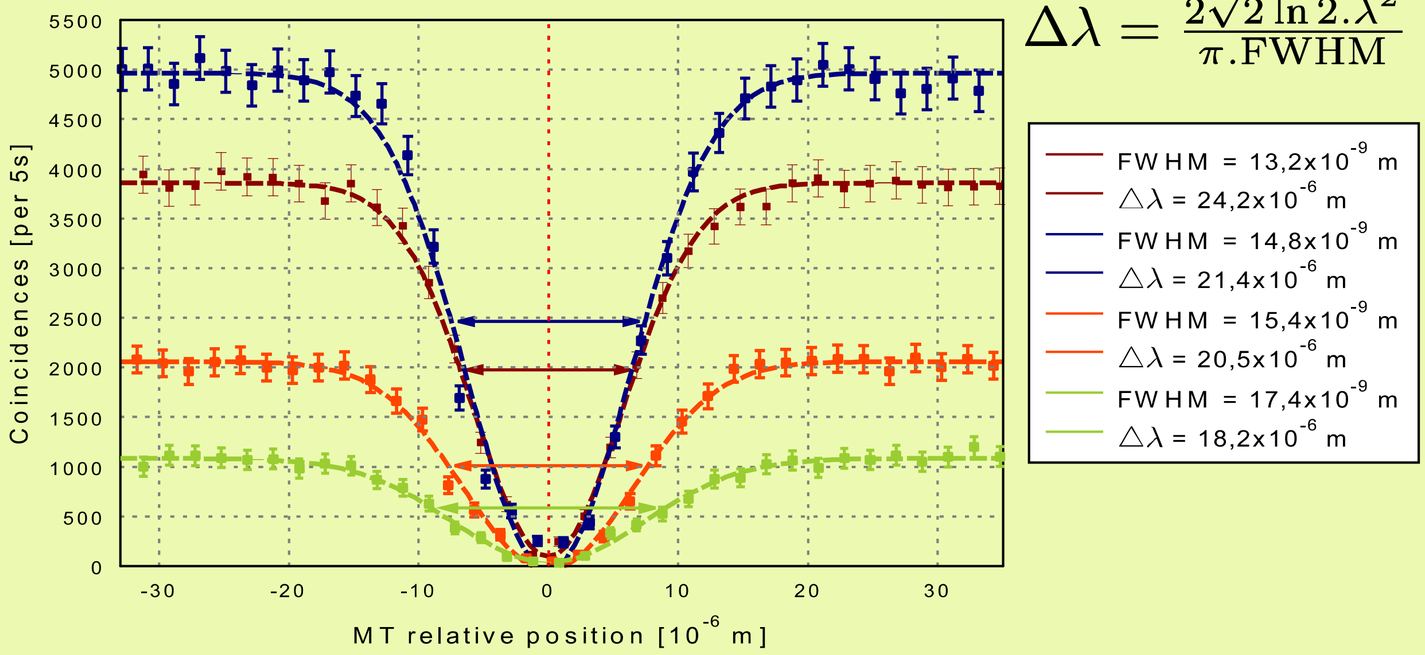
$$\alpha|HH\rangle + \beta e^{i\phi}|VV\rangle$$

Two - photon interference:

It gives information about indistinguishability, spectrum information (FWHM, shape), HOM dip [6] and antidip observation and quick entanglement identification.

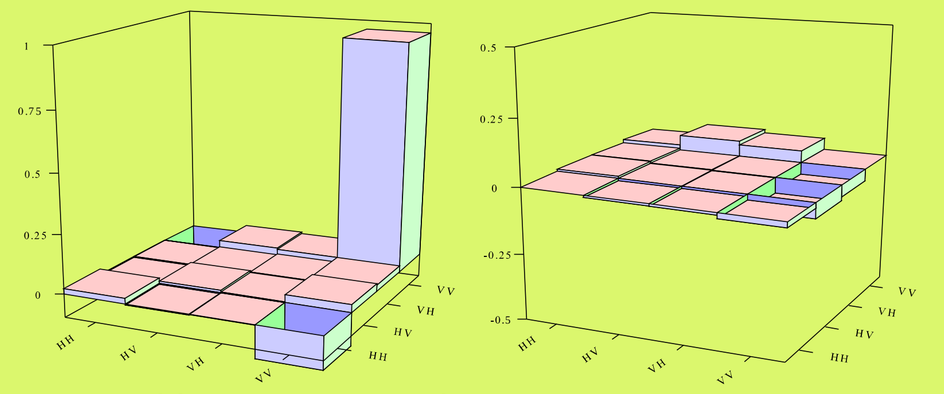


HOM dips for maximally entangled triplet state. Different FWHMs are obtained for various spectral filtering [7].

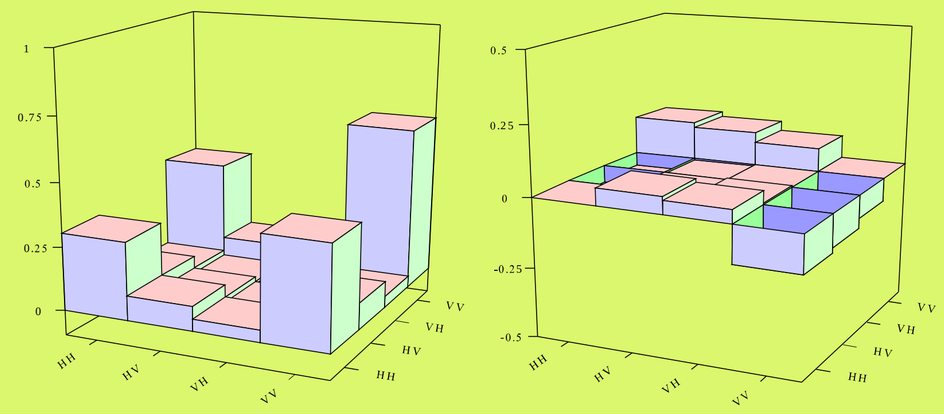


$$\Delta\lambda = \frac{2\sqrt{2}\ln 2.\lambda^2}{\pi.\mathrm{FWHM}}$$

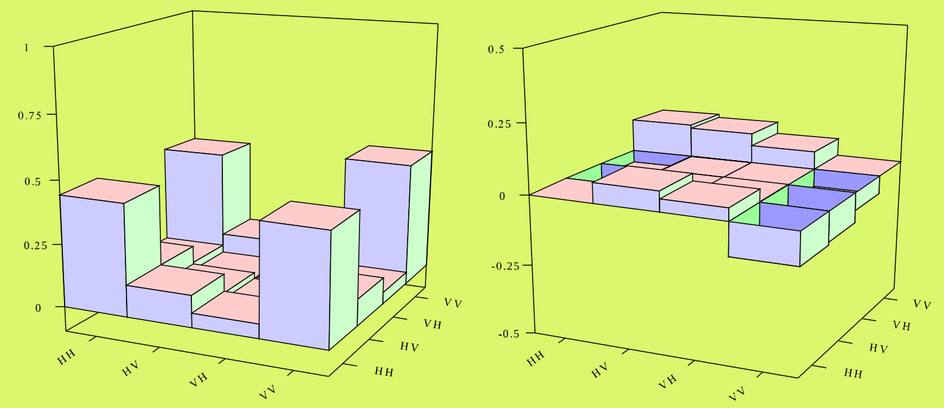
Reconstructed density matrix



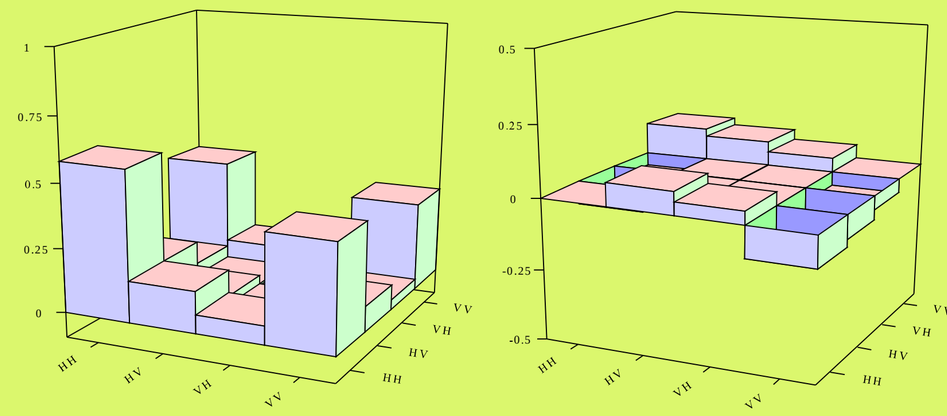
Separable state $|VV\rangle$, purity 97%



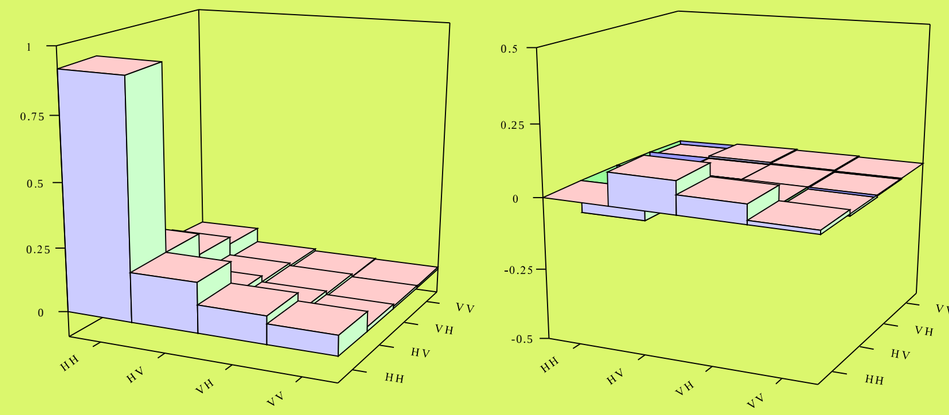
General partially entangled two-photon state, purity 96%



Triplet states, purity 97%, negativity 93%



General partially entangled two-photon state, purity 96%



Separable state |HH>, purity 97%

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