Experimental comparison of several tomographic protocols

Antonín Černoch,[1,*] Karol Bartkiewicz,[2] Karel Lemr,[3] and Adam Miranowicz[2,4]

[1]*Institute of Physics of Academy of Science of the Czech Republic, Joint Laboratory of Optics of PU and IP AS CR, 17. listopadu 50A, 77207 Olomouc, Czech Republic*
[2]*Faculty of Physics, Adam Mickiewicz University, PL-61-614 Poznań, Poland*
[3]*RCPTM, Joint Laboratory of Optics of Palacký University and Institute of Physics of Academy of Sciences of the Czech Republic*
[4]*CEMS, RIKEN, 351-0198 Wako-shi, Japan*

Quantum state tomography is a tool for determining an unknown quantum state (e.g. density matrix). It uses series of measurements on multiple copies of the input state. Tomographic measurements are necessary for the verification of functionality of the quantum devices used in quantum state engineering, quantum communication and quantum information processing.

Many tomographic protocols have been proposed up to these days. We focused on five of them (see Tab. I), which are used mainly for two photon polarisation states analysis. We perform series of local and non-local measurements needed for these protocols. Than we analysed the results with respect to number of measurements needed and error of the state estimation.

Protocol	Meas.	local/global
optimal generalized Pauli operators [1]	16	local & global
Pauli operators	16	local
James et al. basis [2]	16	local
standard separable basis [3]	36	local
mutually unbiased bases [4]	20	local & global

TABLE I. List of tested tomographic protocols.

Entangled photon pairs were generated in the process of SPDC using two optically contacted BBO crystals (so-called Kwiat source). Subsequently, we engineered diverse two-photon states subjecting these pairs to polarisation rotations using wave plates. To implement quantum state tomography on these states we constructed experimental setup as depicted in Fig. 1. Our setup is capable of performing polarisation projections onto a broad class of two-photon states – entangled or separable. For each of the prepared states we acquired coincidence counts for all polarisation projections needed for the above mentioned tomography protocols. Resulting density matrices obtained by various tomographic protocols were compared.

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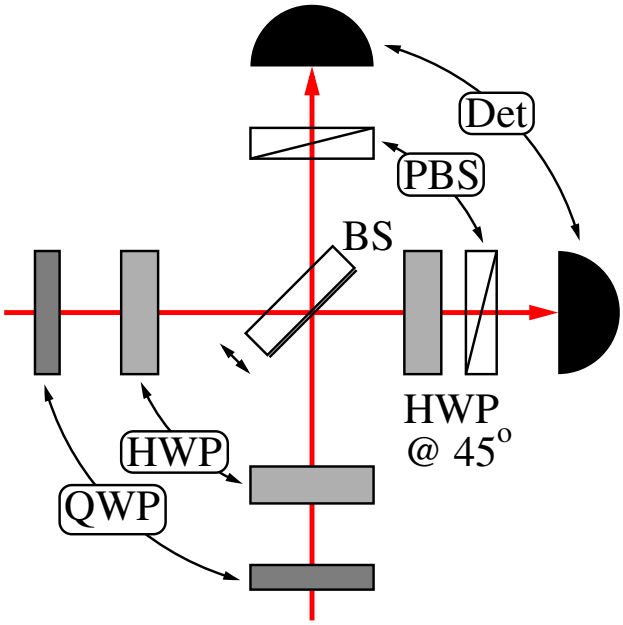

FIG. 1. Experimental setup for tomographical measurements. HWP – half-wave plate, QWP – quarter-wave plate, BS – non-polarizing beam splitter, PBS – polariser, Det – detector. For local measurements the BS is shifted out and the rotation of HWP behind is set to zero.

* acernoch@fzu.cz

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