(P10) Amplitude damping channel for orbital angular momentum

A Dudley[a,b], M Nock[a], T Konrad[a] and A Forbes[a,b]

[a] School of Physics, University of KwaZulu-Natal, Durban, South Africa
[b] CSIR National Laser Centre, Pretoria, South Africa

Since the pioneering work on the entanglement of the orbital angular momentum (OAM) states of light [1], much attention has been devoted to the subject, with particular attention into the quantum aspects of information processing using OAM [2]. Furthermore it has recently been shown that the time evolution of the entanglement of a qubit pair caused by a quantum channel acting on one of the qubits can be determined for any initial state by probing only the entanglement evolution of the maximally entangled state [3]. This is most beneficial in experimentally characterizing the entanglement dynamics of unknown channels.
In this paper we outline a simple experiment to test this prediction using the OAM states of light; our approach is an extension of a previously reported OAM sorting device [4]. In Ref. [4] a Mach-Zehnder interferometer with a Dove prism in each arm is used to sort OAM states according to their parity. We extend this concept to implement an amplitude damping channel, and prove its action on the OAM states both theoretically and experimentally.

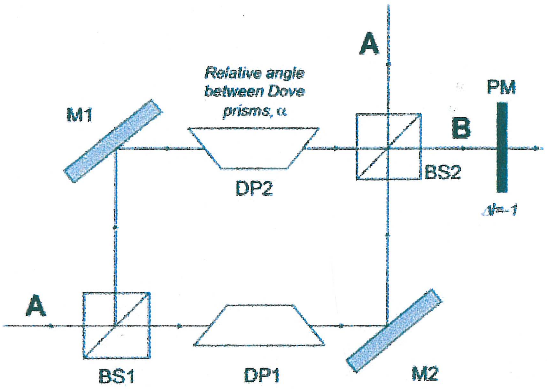

Figure 1. Schematic of the OAM amplitude damping channel.

A photon with $|l=0\rangle$ entering the interferometer (as depicted in figure 1), in port A is not affected by the Dove prisms and exits in port A. A photon with $|l=1\rangle$, however, experiences a relative phase shift $\Delta\phi=\alpha$ due to the alignment of the Dove prisms and therefore exits in a superposition of ports A and B. Subsequently, the value of $|l=1\rangle$ is reduced in port B by a phase mask. We show that the resulting action of the set-up on a general superposition of $|l=0\rangle$ and $|l=1\rangle$ may be expressed as:

$$a|l=0\rangle^A + b|l=1\rangle^A \rightarrow a|l=0\rangle^A + b\left(\sin\frac{\alpha}{2}|l=1\rangle^A + \cos\frac{\alpha}{2}|l=0\rangle^B\right), \quad ...(1)$$

thus mimicking the well-known quantum amplitude channel. We present experimental results on the action of the channel with classical OAM fields, and outline our future plans of introducing it into a two photon entangled OAM system in order to investigate the evolution of the entangled OAM states.

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[2] Molina-terriza G, Torres J P and Torner L 2007 Twisted photons *Nature Phys*. 3 305-10.
[3] Konrad T, De melo F, Tiersch M, Kasztelan C, Arag A and Buchleitner A 2007 Evolution equation for quantum entanglement *Nature Phys*. 4 99-102.
[4] Leach J, Padgett M J, Barnett S M, Frank-arnold S and Courtial J 2002 Measuring the orbital angular momentum of a single photon *Phys. Rev. Lett.* 88, 257901-1-4.