Experimental investigation of environment-induced entanglement using an all-optical setup

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In this work we present an experimental investigation based on the environment-induced entanglement between the polarization and the transverse mode of a paraxial beam following the proposal of Environment-induced entanglement with a single photon. A sequence of conditional operations are performed on polarization and transverse mode, controlled by the path degree of freedom that realizes the decoherence effects of the environment. An entanglement witness and the concurrence are readily evaluated from intensity measurements performed on different output ports of the conditional operations. The experimental results show very good agreement with the theoretical predictions. The experiment is performed with an intense laser beam, which can be described either as a macroscopic number of photons in a coherent state or simply as a classical electromagnetic field. It captures, nevertheless, the essential features of the phenomenon under investigation here, and is therefore a useful simulation of a single-photon experiment. This kind of simulation provides a test bed for subtle quantum properties, with simple experimental setups, as has been widely discussed in the literature. We have good results in this experimentally investigated the induction of entanglement by a common environment acting on a two-qubit system, using the structural non-separability between the transverse modes and the polarization of a classical laser beam. The optical setup allows the investigation of the sole effect of the environment, since there is no direct interaction between the qubits. Furthermore, an optimal entanglement witness has allowed the quantification of entanglement over the entire evolution of the system, exhibiting in a clear way the monotonous increase of entanglement to its final value.