1 Abstract

The Dissertation *Quantumness of Gaussian and non-Gaussian states in the optical domain* collects my personal both theoretical and experimental contributions, in the context of the Quantum Information theory in continuous variables (cv). In this context, the research focused on the analysis of the quantum properties of bipartite states of electromagnetic radiation.

The Dissertation contains, first, the study of the main possible quantum correlations between two modes of the electromagnetic field. Particular attention has been devoted to the analysis of the different forms of non-locality present in quantum mechanics. Second, it shows the analysis of how the presence of quantum properties in bipartite states affects the performance of these states, when they are used as resources in quantum protocols. In particular, the cv teleportation protocol was used as a reference to test the *goodness* of results.

The quantum resources can be divided in two main classes: Gaussian resources and non-Gaussian ones. My research activity has been strucured in which way to be able to proceed, in parallel, to the analysis of both classes.

Gaussian resoures.To assess the presence of entanglement in a quantum system it is possible to refer to the many criteria proposed in the literature. In the Dissertation it is reported the study of some main criteria generally used for Gaussian bipartite mixed states. This study has allowed us to establish a hierarchy very useful for the evaluation of the entanglement. Then we have discussed and experimentally analyzed the effects of the transmission over a lossy channel on the quantumness of bipartite Gaussian states, focusing our analysis on the states generated by a type-II optical parametric oscillator (OPO). Eventually it is reported the study of the Bell's inequality in terms of purity and entanglement for a bipartite Gaussian state, desribed by a symmetric covariance matrix..It allows to investigate how the "quantumness" owned by a state, established by the violation of Bell's inequality, is related to the purity of the state and to the entanglement.

Non-Gaussian resources. The study of non-Gaussian resources is mainly related to a particular class of states: the *squeezed Bell states*. All the analysis carried out to date show that these states are one of the best possible resources for efficient BKV quantum teleportation protocol. This is confirmed by two additional theoretical tests presented in the Dissertation. In fact, *squeezed Bell states* maximize the violation of Bell's inequality with respect to all other (Gaussian and non-Gaussian) states obtained from the same class. So they represent the most *non-local* resource among all those considered (for example, the *squeezed photon number states*, the *photon subtracted squeezed states*, the *photon added states*, the s*queezed vacuum states*). Moreover, as demonstrated in the course of the Dissertation, *squeezed Bell states* are the best resource for teleportation of a coherent state, even after having undergone a process of entanglement swapping. The result is compared with that provided by the other main quantum swapped resources of the same class. As a consequence of the positive results obtained from the tests, it was designed a scheme that allows the experimental production of *squeezed Bell states*. It is then evaluated its

experimental feasibility both in ideal and realistic conditions obtaining very encouraging results. Finally, it is dealt the study (it is at a very preliminary stage) of a non-Gaussian state produced by a sub-threshold *OPO*, when there are fluctuations of some parameters of the optical device (amplitude and phase of the pump, etc..) at the aim to find a new strategy for the generation of non-Gaussian resources.