Abstract

Quantum systems can necessarily be viewed as open systems. As in classical physics, any realistic description of a system must take into account the coupling to an environment that strongly influences the system itself. Since perfect isolation of a quantum system is not feasible and the complete description of the degrees of freedom of the environment is not possible, it is required a description that accounts for these aspects. Furthermore, not all the degrees of freedom are of interest in order to effectively describe the system. Hence a probabilistic approach to a quantum evolution is most appropriate: the idea is to consider only the degrees of freedom that are useful, thus reducing to a small set the number of variables needed to describe the evolution of the system.

In last years the remarkable progress of quantum technologies opened up new perspective in the investigation of the dynamics of open systems; in this sense, particularly relevant are the techniques which allow to control the degrees of freedom of the environment that influence the system of interest. Till now the attention was focused on the methods to reduce the detrimental effect on the quantum properties of the system-environment interaction; namely, on the methods allowing to make the system the more isolated as possible. On the other hand, it has been experimentally checked that in situations requiring effective quantum transfer a system-environment coupling can become a resource: an example is provided by efficient quantum-information processing , in which the present thesis is specifically framed. The question is that a set of approximations usually exploited in describing quantum evolution (collectively known as Markovian approximation) are too strong to carefully manage some quantum phenomena.

The aim of this thesis is twofold. On the one hand, the characterization and quantification of non-Markovian content for continuous-variable quantum systems; on the other hand, its possible usefulness as a resource in the framework of Quantum Information. The attention is focused mainly on the class of Gaussian states and Gaussian channels; this choice is motivated by their experimental relevance, and by the advantage to pass from the infinite-dimensional Hilbert space to a finite-dimensional Hilbert space because, in this case, we can exploit the finite-dimensional matrix analysis. However, we consider also some non-Gaussian resources, which are anyway needful for implementing universal quantum computation, an potentially more powerful for all the quantum protocols.