Geometric phase in open systems

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Geometric phases have attracted a great deal of interest since Berry showed that a state acquires a purely geometric feature (called the Berry phase) in addition to the usual dynamical phase when it evolves slowly and cyclically. The Berry phase has been extensively studied, generalized in various directions and has very interesting applications, such as implementation of quantum computation by geometrical means.
In a strict sense, however, the Berry phase has only been studied in a context of closed systems, in which a state (pure or mixed) evolves under a general unitary evolution. However, any realistic description of a physical system must take into account the influence of environment as a source of decoherence.
We address the problem of the determination of geometric phase in the context of open systems. By using a quantum jump approach, we calculate the geometric phase associated to the evolution of a system subjected to a Markovian master equation. The method is general and can be applied to many different physical systems. As examples,two main source of decoherence are considered: dephasing and spontaneous decay. We show that the geometric phase is completely insensitive to the former, i.e. it is independent of the number of jumps determined by the dephasing. This is no longer the case when other sources of decoherence are taken into account. The reason for this is analysed, and an intuitive geometrical interpretation of the effect of decoherence on the geometric phases is presented.