Entanglement and decoherence within neutron interferometry

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Abstract

Fundamental quantum properties like quantum coherence and entanglement are amoung the most interesting features of quantum mechanics which are studied nowadays. They form the basis for the new, fast developing fields of quantum information and computation.

The physical system of interest is the (massive) neutron subjected to interferometric and polarimetric measurements. Neutrons are proper objects for a study of quantum mechanical behavior: they allow for rather easy experimental control and the neutron spin is the simplest two-level system which can be manipulated by magnetic fields. In combination with interferometric measurements the system has enough intrinsical richness to show interesting quantum features such as entanglement.

The coupling of the neutron to an external magnetic field allows for selective manipulations of the spinor quantum states. This can be used, on the one hand, to create entangled states where the entanglement occurs between different degrees of freedom (e.g., spin and path) and, on the other hand, one can introduce dephasing and decoherence by varying magnetic fields.

Decoherence arises in quantum systems which can not be perfectly isolated from the surrounding environment. We are faced with a modification of the state of the system described by an effective master equation. In choosing different Linblad generators for the master equation it is possible to study different decoherence modes for a two qubit system.

We investigate different kinds of entanglement for the neutron system and mechanisms for decoherence and dephasing. Especially we propose an experimental realization of several decoherence modes within neutron interferometry where the sources of decoherence are fluctuating magnetic fields [1]. In particular we study the effects of decoherence for maximally entangled states and Schrödinger cat states [2].

The time dependent solutions for different decoherence modes are depicted in the so-called spin geometry picture which allows to illustrate the evolution of the (nonlocal) correlations stored in a certain state [3].

Keywords: neutron interferometry, entanglement, decoherence

References

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