SCHRÖDINGER'S CAT KICKED BY ARNOLD'S CAT

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Real quantum systems are never isolated, interactions with its environment induce quantum decoherence, i.e. transitions from quantum state superpositions into incoherent classical mixtures of eigenstates. Ensembles of spins can be viewed as assemblies of qubits, which must be controlled to perform quantum calculations. However the decoherence processes can drastically decrease the efficiency of the control. Some studies concerning decoherence of qubit (spin) ensemble focused on decoherence induced by spin-spin interactions inner the ensemble. We study decoherence processes induced by disturbances of the control caused by a classical environment. Since it is a simple but efficient control method [3,4,5] , we focus on a control by a train of ultrashort pulses (kicks) in an adiabatic approach (which is developped in [2]). However, before reaching the qubit, each pulse is disturbed by a classical environment so that each spin ``views" a different train. This last environment is modeled by classical dynamical systems which can be regular, random, stochastic or chaotic. In order to enlighten the role of classical control disturbances in decoherence processes and to avoid other decoherence causes, we consider a spin bath without any spin-spin interaction.

We have shown in ref. [1] that the decoherence process of the qubit ensemble exhibits signatures of the dynamical process disturbing the control. Initially we have considered a qubit ensemble in which all qubits are in the state

$$|\psi_0 >= \alpha|0> +\beta|1> \qquad (1)$$

$(0 < \alpha, \beta < 1)$, i.e. a Schrodinger's cat. After, the disturbed kick train affects it. The case of a chaotic disturbance is modelled by continuous automorphisms of the torus like the famous Arnold's cat map. The results show that the spin ensemble is subject to different dynamical effects: decoherence, relaxation, population oscillations, population jumps. These different phenomena can be controlled to a certain extent by adjusting the system parameters. The different dynamical effects could also permit distinguishing the different classical baths by studying the coherence and the populations of the quantum bath.

The chaotic disturbances induce decoherence and relaxation processes very differently from a stochastic or a random disturbance. Indeed qubit ensemble submitted to a chaotically disturbed control presents a horizon of coherence, a duration where the ensemble remains completly coherent. After this horizon, the coherence of the ensemble falls dramatically with a speed similar to the case of a random disturbance (but in this last case, the coherence fall occurs immediately). Moreover, we have shown that this horizon of coherence is larger than the horizon which is due to the sensitivity to initial conditions, the horizon of predictability of the chaotic dynamical system modelling the disturbance. This result can permit the hope of achieving a coherent control disturbed by chaotic processes during a relatively long duration before the decoherence occurs.

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