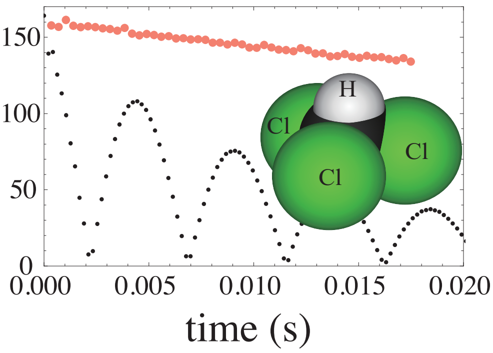
Suppression of Decoherence by Using Quantum Zeno Effect

Y. Kondo, Y. Matsuzaki,[A] K. Matsushima and J. G. Filgueiras[B,C]

Dept. of Phys, Kinki Univ., [A]NTT BRL, [B]Techn. Univ. Dortmund and [C]Universidade de São Paulo
email: ykondo@kindai.ac.jp

Projective measurements are an essential element of quantum mechanics. In most cases, they cause an irreversible change of the quantum system on which they act. However, measurements can also be used to stabilize quantum states from decay processes, which is known as the Quantum Zeno Effect (QZE) [1]. Here, we demonstrate this effect for the case of superposition states of nuclear spin qubits, using an ancilla to perform the measurement [2]. As a result, the quantum state of the qubit is protected against dephasing. To our best knowledge, this is the first demonstration to suppress the dephasing by QZE.

We employ a ^{13}C-labeled chloroform (Cambridge Isotopes) diluted in d_6-acetone with a 303 mM concentration for a proof-of-principle demonstration. See, the inset of the right figure. The experiments are carried out using a JEOL ECA-500 spectrometer at room temperature. Unlike previous NMR experiments demonstrating QZE [3], we do not employ a field gradient to simulate measurements.
The dephasing of the ^{13}C nuclear spin is introduced through the proton by adding a magnetic impurity (47.7 mM of Iron(III) acetylacetonate). This dephasing of the ^{13}C spin is suppressed, as shown in the right figure, by frequent measurements with the proton (entanglement with ^{13}C and decoherence of the proton [4, 5]).



QZE experiments. Big (red) points are the results of QZE. The absolute values of the FID signals (small black points) are also plotted for comparison. The structure of a chloroform molecule is also shown.

This work will soon appear in New Journal of Physics.

[1] See a review paper by P. Facchi and S. Pascazio, J. of Phys. A: Math. and Theor. **41**, 493001 (2008) and references therein.
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