Universally robust sequences for dynamical decoupling

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Quantum technologies are increasingly important nowadays for a multitude of applications in sensing, processing, and communication of information. Nevertheless, protection of quantum systems from unwanted interactions with the environment remains a major challenge. Pulsed dynamical decoupling (DD) is a widely used approach that aims to achieve this goal by applying sequences of pulses. Most DD schemes focus on dephasing processes due to their high contribution to data loss. Then, pulse imperfections remain the main challenge. Robust DD sequences have also been designed but most compensate errors in one or two parameters only or for a specific initial state. Ultra-high fidelity can potentially by achieved by nesting of sequences, but this requires a very fast growth in the number of pulses for higher order error compensation.

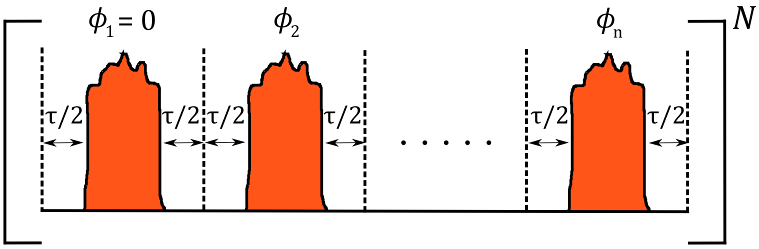

FIG. 1: Schematic description of a DD sequence with n equally separated phased pulses. A single cycle free evolution-pulse-free evolution lies within the dashed lines. The proper choice of the relative phases of the pulses compensates both pulse errors and dephasing due to the environment. The DD sequence is repeated N times during the storage time; the pulse shape can be arbitrary.

We introduce universally robust sequences for dynamical decoupling, which simultaneously compensate pulse imperfections and the detrimental effect of a dephasing environment to an arbitrary order, work with any pulse shape, and improve performance for any initial condition [1]. Moreover, the number of pulses in a sequence grows only linearly with the order of error compensation. Our sequences outperform the state-of-the-art robust DD sequences. Beyond the theoretical proposal, we also present convincing experimental data for dynamical decoupling of atomic coherences in a solid-state optical memory.

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