Decoherence control by quantum decoherence itself.

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Decoherence, which appears as a result of the interaction of a quantum system with an environment, is the most significant obstacle of expanding quantum technology. The most common type of decoherence is dephasing, which reduces a quantum superposition to a classical mixture of states [1]. This means that, if the environment (at least partially) resolves the basis states of the system, their superposition is degraded by the interaction. Frequently, the environment is not directly controllable or measurable, and can be manipulated only by the same interaction which causes the decoherence; this represents a serious limitation.

As a practical example, we consider semiconductor quantum dots (QDs). A vast drawback for many applications of semiconductor QDs is the carrier-phonon interaction which leads to dephasing of electronic superpositions on picosecond timescales [2]. To overcome this difficulty, a number of solutions were proposed, including hybrid spin-charge schemes [3,4] or collective encoding [5]. Although some quite promising results have been shown, a reduction of decoherence is accompanied by either difficulties in qubit control, or in fabrication problems. Contrarily, we propose an inhibition of dephasing by reservoir engineering assisted by the dephasing process via measurements of the qubit state [15].

Since the creation of a QD exciton in a superposition state perturbs the crystal lattice, it leads to a modification of the phonon reservoir state. Thus, applying measurements in the basis corresponding to the initial QD state (which resembles the procedure in the quantum Zeno effect) will not only freeze the QD system for the duration of the measurements, but will also affect the evolution following the measurements and eventually the degree of dephasing. Already in a single measurement scenario the protocol visibly affects the asymptotic value of the dephasing. This value can be higher or lower than in the no-measurement case, depending on the measurement time and outcome, yet the probabilities of both measurement outcomes oscillate synchronously with the asymptotic degree of coherence, so that it is always more likely to measure the state which leads to less decoherence. Additionally, when both probabilities are similar, a measurement induces an increase of coherence regardless of its outcome. This yields an average gain of coherence which is always non-negative, showing that a measurement is always favorable. Note, that although the practical realization of our idea is very similar to that of the quantum Zeno effect, the underlying mechanism is completely different, as it relies on the changes introduced into the state of the phonon sub-system via the measurement.

[1] Y. Imry, Introduction to Mesoscopic Physics (Oxford University Press, 1997).
[2] P. Borri, et al., *Phys. Rev. Lett.* **87**, 157401 (2001).
[3] F. Troiani, E. Molinari, and U. Hohenester, *Phys. Rev. Lett.* **90**, 206802 (2003).
[4] K. Roszak, A. Grodecka, P. Machnikowski, and T. Kuhn, *Phys. Rev. B* **71**, 195333 (2005).
[5] A. Grodecka and P. Machnikowski, *Phys. Rev. B* **73**, 125306 (2006).
[6] K. Roszak, R. Filip, and T. Novotný, arXiv:1401.5016 [cond-mat.mes-hall].