Measurement induced enhancement of quantum dot coherence

Katarzyna Roszak[1], Radim Filip[2], and Tomáš Novotný[3]

[1] *Institute of Physics, Wrocław University of Technology, Wyb. Wyspianskiego 27, 50-370 Wroclaw, Poland*

[2] *Department of Optics, Palacký University, 17. listopadu 50, 77207 Olomouc, Czech Republic*

[3] *Department of Condensed Matter Physics, Faculty of Mathematics and Physics, Charles University, 12116 Prague, Czech Republic*

Excitonic states in semiconductor self assembled quantum dots (QDs) are one of the solid state candidates for the implementation of quantum computation [1]. Due to the atomic structure of QD energy levels, it is easy to single out a subset of excitonic states to encode the logical qubit values. Being artificial, their properties can be tailored to a very high extent through growth conditions and the choice of materials used. Initialization, manipulation and readout techniques via ultrafast laser spectroscopy are experimentally accessible. The single, but serious drawback on the way to QD based quantum computatopm is the fact that being embedded in bulk semiconductor, excitons in QDs interact with phonon modes of the surrounding crystal. This interaction leads to an unavoidable partial pure dephasing effect on picosecond timescales [2,3].

We address the problem of inhibiting phonon-induced partial pure dephasing of an exciton confined in a QD and show that intermediate measurements on the QD system generically decrease the level of decoherence caused by pure dephasing due to the phonon bath. We explain this counter-intuitive effect by identifying subtle correlations imposed into the reservoir, rather than the qubit itself, by the measurement process and eventually transferred during the non-Markovian dynamics to the asymptotic state of the qubit. It turns out to be advantageous, if the measurements are well separated in time from the initialization of the QD state and from each other. Although the measurements may cause both increase and loss of asymptotic coherence depending on the measurement times and outcomes, we show for the single measurement case that performing a measurement at any time after the initialization of the state is favorable, due to the interplay of given-outcome probabilities and corresponding dephasing values.

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