Protection of entangled states of N qubits with dynamical decoupling

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Decoherence of a qubit can be suppressed by subjecting it to a sequence of dynamical decoupling pulses - π rotations effectively interchanging the amplitudes of qubit being in state "0" and "1". For a single spin qubits (quantum dot based [1,2], NV centers [3], phosphorous donors in silicon [4]) dynamical decoupling has led to a substantial (orders of magnitude) increase in coherence times. Furthermore, the dephasing of the qubit due to interaction with its environment was shown to be often well-described under assumption that the environment is a source of classical noise.

Recently, the dynamical decoupling of two qubits from two partially correlated noises was considered theoretically [5]. We extend this theory to the case of N entangled qubits driven by various sequences of pulses. We consider initial states including so-called W, GHZ, and cluster states [6], and noise spectra typically encountered for solid-state based qubits, e.g. Ornstein-Uhlenbeck noise and $1/f^{\alpha}$ noise with $\alpha \in [0.5, 3]$. The relative efficiency of entanglement protection offered by various pulse sequences will be analyzed. We will also investigate which N qubit entangled states can be used for sensing of presence of cross-correlations of noises affecting distinct qubits, thus paving the way for multi-qubit generalization of two-qubit noise correlation sensing protocol described in [5].

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[1] J. Medford, Ł. Cywiński, C. Barthel, C. M. Marcus, M. P. Hanson, and A. C. Gossard, *Phys. Rev. Lett.* **108**, 086802 (2012).
[2] F. K. Malinowski, F. Martins, P. D. Nissen, E. Barnes, M. S. Rudner, S. Fallahi, G. C. Gardner, M. J. Manfra, C. M. Marcus, and F. Kuemmeth, *arXiv:1601.06677* (2015).
[3] Y. Romach et al., *Phys. Rev. Lett.* **114**, 017601 (2015).
[4] J. T. Muhonen et al., *Nature Nanotechnology* **9**, 986 (2014).
[5] P. Szańkowski, M. Trippenbach, and Ł. Cywiński, *arXiv:1507.03897* (2015).
[6] L. Aolita, F. de Melo, and L. Davidovich, *Rep. Prog. Phys.* **78**, 042001 (2015).