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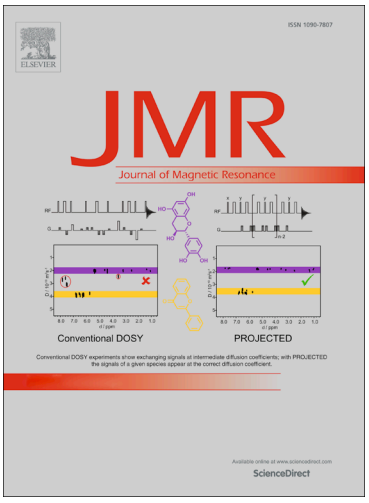

Suppression of electron spin decoherence in Rabi oscillations induced by an inhomogeneous microwave field

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PII: S1090-7807(18)30048-X
DOI: https://doi.org/10.1016/j.jmr.2018.02.003
Reference: YJMRE 6248

To appear in: *Journal of Magnetic Resonance*

Received Date: 7 December 2017
Revised Date: 18 January 2018
Accepted Date: 6 February 2018

Please cite this article as: A.P. Saiko, R. Fedaruk, S.A. Markevich, Suppression of electron spin decoherence in Rabi oscillations induced by an inhomogeneous microwave field, *Journal of Magnetic Resonance* (2018), doi: https://doi.org/10.1016/j.jmr.2018.02.003

Suppression of electron spin decoherence in Rabi oscillations induced by an inhomogeneous microwave field

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Abstract. The decay of Rabi oscillations provides direct information about coherence of electron spins. When observed in EPR experiments, it is often shortened by spatial inhomogeneity of the microwave field amplitude in a bulk sample. In order to suppress this undesired loss of coherence, we propose an additional dressing of spin states by a weak longitudinal continuous radiofrequency field. The Gaussian, cosine and linear distributions of the microwave amplitude is analyzed. Our calculations of the Rabi oscillations between the doubly dressed spin states show that for all these distributions the maximum suppression of the inhomogeneity-induced decoherence is achieved at the so-called Rabi resonance when the radio-field frequency is in resonance with the Rabi frequency of spins in the microwave field. The manifestations of such suppression in the published EPR experiments with the bichromatic driving are discussed. The realization of the Rabi resonance using the radiofrequency field could open new possibilities for separating the contributions of relaxation mechanisms from those due to the inhomogeneous driving in spin decoherence.

Keywords: Pulsed EPR; Rabi oscillations; Spin decoherence; Inhomogeneous microwave field; Longitudinal radiofrequency field; Rabi resonance.

1. Introduction

Coherent manipulation of two-level spin systems (qubits) by electromagnetic fields is attracting interest in pulsed electron paramagnetic resonance (EPR) and in its many applications including quantum information technologies [1,2]. Paramagnetic ions and defects in diamagnetic solid matrixes are among the promising candidates for solid-state qubits [3-5]. Rabi oscillations [6] (or transient nutations [7]) represent the basic phenomenon used for coherent manipulation of spin states. The coupling between the driving electromagnetic field and qubits is characterized by the Rabi frequency. The decay of Rabi oscillations (transient nutations) provides direct information about the coherence time of the coupled field-qubit system. A detailed understanding of processes destroying the quantum coherence is of central importance for quantum computation. In EPR experiments, the decay of Rabi oscillations may results from the intrinsic decoherence in spin systems induced by couplings to the environment as well as from extrinsic decoherence induced by fluctuations and inhomogeneities of external magnetic or microwave fields [3,4]. Spatial inhomogeneities or fluctuations of the driving field can be a source of the so-called driven decoherence of the Rabi oscillations [4]. In particular, the effect of inhomogeneity in the driving amplitude over a spin ensemble increases with increasing this amplitude (the Rabi frequency) and can significantly shorten the decay of the Rabi oscillations. Changing the structure of the