Kazan Federal University

Zavoiskii Physical-Technical Institute, FRC Kazan Scientific Center of RAS

International Conference "Magnetic Resonance - Current State and Future Perspectives" and satellite XXI International Youth Scientific School "Actual problems of magnetic resonance and its application"

devoted to the 75-th anniversary of the discovery of Electron Paramagnetic Resonance by E.K. Zavoiskii

Book of
ABSTRACTS

September 23-27, 2019 Kazan, Russia

Multiple-Quantum NMR Spectroscopy and Quantum Information Delocalization in Solids in the Presence of Magnetic Fields Inhomogeneities

A.A. Lundin[1], V.E. Zobov[2]

[1]N.N. Semenov Institute of Chemical Physics, RAS, 117977, Moscow, Russia
[2]Kirensky Institute of Physics, Federal Research Center KSC SB RAS, Krasnoyarsk, Russia

e-mail: rsa@iph.krasn.ru

The process of the delocalization initially localized quantum information covering all particles of the system is accompanied by redistribution of this information and the appearance of various, generally speaking, not local correlations. In particular, by means of above correlations the quantum register of the computer can be created. This redistribution process of information to various correlations (scrambling) may be accompanied by irreversible violations in the transferring one. These violations can be caused by a variety of reasons. The mentioned disorders refer as loss of coherence (decoherence) as a rule. In particular, decoherence can be caused by imperfection of measuring equipment.

For the study of scrambling, determining its speed, etc., four-particle time correlation functions (TCF) with the English abbreviation OTOC (out-of-time-ordered correlator) are used [1 - 3]. These TCF's, associated with information entropy, contain specific information about the most intimate processes occurring in the system. For example, many-particle entanglement, many-body localization, the development of chaos, and so on. In multiple-quantum spectroscopy, TCF's OTOC's is realized as the second moment of the multiple-quantum NMR spectrum [3].

Usually, the theoretical studies of these TCF's exploit numerical calculations for small spin clusters. However, we have shown analytically that for spin systems with a secular dipole-dipole (DDI) interaction or with the effective two-quantum interaction obtained from one, the second moment of the multiple-quantum spectrum (OTOC) is growing up exponentially with time [4]. The latter means that all the nuclear spins of the sample would be quickly correlated, if there are no processes of decoherence. It has been shown [5] that at the presence of, for example, randomly distributed across the crystal inhomogeneities of magnetic fields exceeding the inter-nuclear DDI, the exponential growth of the TCF is replaced by a power one, i.e., the increase in the number of correlated spins slows down with time, and the excitation is largely localized. This "phase transition", previously discussed for other systems [1], probably associates with the termination of the "entanglement" of the wave functions of spins. Due to the dispersion of local fields, these functions become separable. The effect can be clarified for a pair of 1/2 spins. For DDI, the singlet and triplet combinations will be eigenfunctions, while in the presence of an inhomogeneous field, the products of the functions in the "S_z" representation will become eigenfunctions.

[1] R.-Q. He and Z.-Y. Lu, Phys. Rev. B **95**, 054201 (2017).
[2] K.X. Wei, C. Ramanathan, and P. Cappellaro, Phys. Rev. Lett. **120**, 070501 (2018).
[3] K.X. Wei, P. Peng, O. Shtanko, I. Marvian, S. Lloyd, C. Ramanathan, and P. Cappellaro, arXiv:1812.04776.
[4] V.E. Zobov and A.A. Lundin, J. Exp. Theor. Phys. **103,** 904 (2006).
[5] V.E. Zobov and A.A. Lundin, JETP Letters **105**, 514 (2017).