Magnetic interactions and spin dynamics of the ^{53}Cr in the orthosilicate host crystals

R. Likerov,[1] K. Konov,[1] A. Sukhanov,[1] I. Yatsyk,[1] and V. Tarasov[1]

[1] *Zavoisky Physical-Technical Institute, FRC Kazan Scientific Center of RAS, Sibirsky tract, 10/7 420029 Kazan, Russia*

Recently, much attention has been paid to finding ways of practical implementation of various algorithms of quantum informatics. An active search is carried out of quantum systems for practical implementation of quantum computers. To transfer quantum information over long distances and create a universal quantum computer, quantum memory devices capable to remember and to reproduce quantum information are needed. Rare-earth impurity ions with a nonzero nuclear spin in oxide crystals (in particular, the yttrium orthosilicate Y_2SiO_5 (YSO)) are widely studied [1-5] as a possible material basis for practical implementation of quantum memory in optic range. In the field of quantum computing, significant progress has been associated with the creation of systems of coupled quantum bits (Q-bits) based on superconductor devices. The characteristic operating frequencies of superconducting qubits lie in the microwave range. Therefore, a quantum memory for the quantum computers should also operate in the microwave range.

In this work, we measured the orientation dependencies of the EPR spectra of ^{5}3Cr impurity monoisotopic ions in YSO and determined principal values and orientations of the principal axes of the D-tensor that determines anisotropy of the electron levels of trivalent chromium in YSO single crystal. Values of isotropic g-factor and the energy of the hyperfine interaction between electron and nuclear spins were also determined. Temperature dependencies of spin-lattice relaxation time and memory phase time were measured and estimated.

References:

[1] M. Rancic, M. P. Hedges, R. L. Ahlefeldt, M. J. Sellars, Coherence time of over a second in a telecom-compatible quantum memory storage material, Nature Physics 14 (2018) 50-55

[2] P. Jobez, C. Laplane, N. Timoney, N. Gisin, A. Ferrier, Ph. Goldner, M. Afzelius, Coherent Spin Control at the Quantum Level in an Ensemble-Based Optical Memory, Phys. Rev. Lett. 114 (2015) 230502

[3] M. Zhong, M. P. Hedges, R. L. Ahlefeldt, J. G. Bartholomew, S. E. Beavan, S. M. Wittig, J. J. Longdell, M. J. Sellars, Optically addressable nuclear spins in a solid with a six-hour coherence time, Nature 517 (2015) 177-181

[4] A. L. Alexander, J. J. Longdell, M. J. Sellars, Measurement of the ground-state hyperfine coherence time of $^{151}Eu^{3+}$:Y_2SiO_5, J. Opt. Soc. Am. B 2 (2007) 79-24

[5] S. P. Horvath, J. V. Rakonjac, Y.-H. Chen, J. J. Longdell, P. Goldner, J.-P. R. Wells, M. F. Reid, Extending Phenomenological Crystal-Field Methods to C1 Point-Group Symmetry: Characterization of the Optically Excited Hyperfine Structure of $^{167}Er^{3+}$: Y_2SiO_5, Phys. Rev. Lett. 123 (2019) 057401

The authors are grateful to V. A. Shustov for the X-ray study of the samples. This research was supported by the Russian Science Foundation, project No. 16-12-00041