Review of the official opponent on the thesis

"Nuclear Spin Effects in Self-assembled Quantum Dots"

presented by Maria S. Kuznetsova and submitted for

the Degree of Doctor of Philosophy at Saint-Petersburg State University

The problems studied by M.S. Kuznetsova in PhD thesis lie in the important and promising field of the solid state physics – spintronics of semiconductor quantum objects which deals with the phenomena depended on the electron and nuclear spins. The problem treated in this work is dynamical nuclear polarization. In quantum dot ensemble via an electron spin polarization created by optical pumping. This thesis provides a comprehensive investigation of Hanle curves under various experimental conditions and geometries and their analysis by the use of original models. Some details of electron spin dynamics have been revealed by means of magneto-optical Kerr effect on the photo-induced electron spin alignment in the special system of quantum dots.

The data obtained from the experimental study of the Hanle contours under the unusual geometry in the presence of a weak magnetic field parallel to the excitation light beam have been analyzed by means of the model based on the nuclear spin cooling. This investigation contributes significantly to the sophisticated problem of nuclear spin dynamics in semiconductor quantum dots. In particular, this study makes possible to estimate the maximum values of optically created nuclear field and also to determine Knight field for the system with high degree of electron spin polarization.

The author has observed for the first time the resonant stimulation of the precessing transverse component of the nuclear spin polarization by the way of the appropriate protocol of optical excitation. The scrupulous experiments permit to detect Nuclear Magnetic Resonance for all isotopes presented in the quantum dots under study. The fine analysis of the obtained data was possible due to the calculation of the quadrupole spin state splitting in the strain induced gradient electric field. Thus, one of the evident achievements of M. S. Kuznetsova is the modeling of transverse and longitudinal nuclear spin polarization in quantum dots taking into account the strong splitting of the spin states.

In my opinion there are minor shortcomings in thesis:

1. The author did not characterize in details the quantum dot ensemble: the dot sizes and size dispersion, the degree of electron wave function penetration in barrier, eventual dot coupling after annealing etc.

2. It is not clear if the nuclear field fluctuation depends on the size of quantum dots under study.

This work reveals the potentialities of the applied experimental methods and models to elucidate the details of electron-nuclear spin interaction as well as the nuclear field peculiarities specific for the quantum dot ensemble.

M. S. Kuznetsova shows a good knowledge of the up to date situation in the field under study, i. e. in spintronics of the semiconductor quantum systems. The original results are well reported through the papers in reviewed journals and conference publications. The thesis is well-structured and carefully written.

In conclusion, I estimate highly the thesis “Nuclear Spin Effects in Self-assembled Quantum Dots“ which contains new important and well proved results on the actual problems concerning the nuclear spin dynamics in quantum dots. This field is promising both for the academic studies and optoelectronic applications in the near future.

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