Referee's report
on the Ph. D. thesis of Maria Kuznetsova
entitled "Nuclear spin effects in self-assembled quantum dots"
submitted for the degree of Doctor of Philosophy in Physics
at the St. Petersburg State University

The dissertation of M.S. Kuznetsova is devoted to experimental investigation of the nuclear spin dynamics in semiconductor quantum dots (QD). The main goal of this work is the investigation of main characteristics of optically created dynamical nuclear polarization in nanostructures with InGaAs Qds.

QD's widely used in biology, as solar cells and potential replacements for Light-emitting diods (LEDs) and so on. In the near future, quantum dots could be used in quantum computing.
The spin dynamics in semiconductor structures has been extensively investigated in the second half of the last century, but a special development these researches is received in recent decades, when one began to discuss the prospects of using the carriers spin states for the realization of quantum computing. It was found that the characteristic time of spin relaxation of carriers are strongly dependent on their interaction with the nuclear spin reservoir. This is especially evident in the interaction of spatially confined structures such as quantum dots, in which the electron density is distributed in a relatively small number of nuclei and the energy of the electron - nuclear spin interaction takes maximum values. Thus, the PhD thesis of M.S.Kuznetsova is in line with modern trends of physical research and the results obtained in these work are clearly useful.

The thesis consists of 2 chapters, covers 78 pages , including introduction and four original papers and 19 figures. The first part, the introduction, shortly reviews dominant mechanisms of the dynamic nuclear polarization, different experimental methods for study photoluminescence spectra of QD's and electron polarization created by optical pumping in an external magnetic field. This section also contains the main goals, the short description of the method of investigation and main results of this work.

The second chapter presents the main content of the dissertation. This chapter gives the overview of the author's original contribution including samples and experimental techniques, dynamics of nuclear polarization in a transverse magnetic field, description of nuclear spin fluctuations and resonant nuclear spin pumping.

Considering this work as a hole, I would like to note that M.S. Kuznetsova uses the modern methods of optical orientation to study the nuclear spins dynamics. These methods of optical orientation consist in that the polarization of the nuclear system in quantum dots arising under optical pumping of the electronic states by a circularly polarized laser beam is registered by the change of the polarization degree of the recombination luminescence. Investigation of the degree of polarization in the magnetic field which is perpendicular to the optical axis (the Hanle effect), with different protocols of optical pumping modulation; give opportunity to receive a lot of experimental data. The result of the theoretical analysis of these data gives new information about the rise and decay times of the nuclear polarization in the systems under study.

To study the influence of effective field of electron spin (Knight field) to the nuclear spin system were measured a series of experimental Hanle curves in the presence of magnetic field component parallel to the optical axis. The analysis of the experimental data produced using the original theoretical model describing the spin cooling model including the nuclear spin fluctuations, gave important information about the value of the effective nuclear fields, realized

in such experiments. At the final part of the PhD thesis M.S. Kuznetsova represent a detailed classification of the transitions between the spin sublevels of all isotopes of nuclei included in the quantum dots under study. It became possible using the recently discovered method of resonant optical pumping of nuclear polarization.

I have two questions for a discussion:

1) The results obtained in the thesis are presented in the four papers published in highly reputed physical journals. However, these papers have a large number of co-authors. Is it possible to estimate the contribution of the author to this work, for example, in percentage.

2) It is not clear for me how many adjustable parameters were used in the standard and in the extend cooling models. What is the physical meaning of these parameters? Is the number of parameters in the extended model is more than the standard one? If yes, could this fact to be the reason of the better agreement between the theoretical and the experimental data in the extended cooling model?

In conclusion, I would like to note, that the results of the thesis are completely original and have scientific value. Interpretation of results, based on a detailed analysis of the literature in the field and implemented using proven theoretical models is quite authentic. The thesis is well illustrated, characterized of sequential logic of presentation the materials and written literate language. The main results of the work were reported at many international conferences and I believe that the PhD thesis of Maria S. Kuznetsova is a completed scientific work. *I highly recommend Mrs Kuznetsova for the title of PhD SPbSU degree in Physics.*

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