

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Igor Ermakov

PhD Program: Physics

Title of Thesis: Dynamics of exceptional states in many-body systems

Supervisor: Professor Boris V. Fine

Co-supervisor: Dr. Oleg Lychkovskiy.

Name of the Reviewer: Prof V Antonov

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	Date: 16-09-2022
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The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The thesis concerns a theoretical study of thermalization dynamics in classical and quantum many-body systems. The work considers specific initial nonequilibrium states which have thermalization patterns different from that of the typical states. It is a subject of periodic and chaotic trajectories in classical and quantum cases. In classical limit it was demonstrated stable periodic trajectories in relatively large systems, quasi-periodic time dynamics so-called the time crystal. In the quantum case, there are remnants of the classical periodic trajectories, which are the “Finite-size quantum scars”, which have dynamic of the relaxation of the initial conditions much slower compared to the other eigenstates. One introduces also the “quantum separatrix” between the topologically different regimes of motion.

Another interesting phenomenon discussed in the thesis is reviving of the initial state in the part of the system. Thus an initial fully polarized state of a 1D lattice of spins $\frac{1}{2}$ exhibits an almost complete recovery of the initial polarization. This happens at a predetermined moment. The procedure is outlined to design a system with the Almost Complete Reviving State (ACRS). The phenomenon can be used for delayed disclosure of secret messages.

Finally, the quantum coherence of the heavy particle in the bath of colliding light particles is modeled. It is shown that there are eigenstates in the spectrum where the heavy particles would have a very non-classical state with low decoherence.

The work was done systematically using standard methods of theoretical physics and chaos analysis with Lyapunov exponents. The thesis is based on a respectful number of numerical calculations. I appreciate the wide range of calculation methods used in the thesis. The formulation of the problems is clear, and self-consistency checks are made where needed. The important parameters of modeling are described.

The thesis is coherently written with good English grammar. The pictures are clear and of good quality. All borrowed materials are properly referenced. A good introduction and background are given at the beginning of the thesis. All findings and conclusions are summarized, and directions for future research are discussed. The material of the thesis is published in 2 refereed journals with a high impact factor and disseminated at several conferences. I believe the thesis is a standard for Doctor of Philosophy work.

Particular questions and corrections:

P54 Caption to figure Fig. 2-15: Horizontal lines -> Vertical lines?

P72 Line 3 from the top: “.. Fig ?? (a) “

P74 Line 5 from the bottom: “Figure ??”

P89 EDH: Conclusion

I would suggest slightly expand conclusions with some examples of the real system.

Provisional Recommendation

I recommend that the candidate should defend the thesis by means of a formal thesis defense

I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report

The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense