Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Andrey Tarkhov

PhD Program: Physics

Title of Thesis: Ergodization dynamics of the Gross-Pitaevskii equation on a lattice

Supervisor: Associate Professor Boris Fine, Skoltech

Name of the Reviewer: Sergej Flach

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 22-09-2020**

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 is devoted to a timely subject of thermalization and ergodization in interacting many-body systems. It consists of three main chapters, devoted to (a) Loschmidt Echo, (b) extracting ergodization time scales from the Lyapunov process, and (c) thermalization of quenches across second order phase transitions. I enjoyed reading all main chapters. The chapters are logically connected to each other. Chapters (a) and (c) appear to be mostly advanced. Chapter (b) could have benefitted from a detailed discussion and comparison of the proposed ergodization time extractions from Lyapunov processes with a number of other published methods. Still the thesis quality is high, and I see no reason to postpone the defense, assuming the possibility to add minor corrections after the defense. The topic of the thesis is fully related to its actual content. The results from chapters (a) and (c) are highly significant and of interest for further advancement of the field. Chapter (a) addresses possible experimental realizations of the Loschmidt echo measurement with ultracold atoms. Chapter (c) is motivated by and models light-induced charge-density wave melting in LaTe3. The thesis results are therefore highly relevant to applications. The publications are of high quality and published in respectable journals. To summarize, I recommend to accept this thesis. A number of questions and comments are listed below and could be hopefully used to add minor revisions accordingly, which can be executed after the actual defense act.

Detailed comments

1. P.22: Section 1.4. discusses microcanonical thermodynamics and the way to microcanonically measure temperature. Since the GP system also conserves the norm, the chemical potential is another relevant parameter. How can that quantity be measured? How are the relations (1.9) and (1.10) taking the existence of the chemical potential into account?
2. P.26 2nd paragraph: 'above beta=0' is not a clear. Since beta is a real number, above zero would mean positive temperatures. But that is not what the author probably had in mind.
3. P.26 2nd paragraph: 'astronomically large … times' is not a scientifically sound statement.
4. P.32 below (2.1): what defines the transient regime time length?
5. P.34: 'fixed such that epsilon=1 …' – epsilon seems not to be defined. What is that? The energy density? And what is then the corresponding inverse temperature beta? I guessed it is infinite, implying the simulations are done on the borderline between Gibbs and nonGibbs dynamics?
6. P.35 section 2.3: why did the author choose RK? Why not some symplectic algorithm? At least a few words on the reasons for that choice of the integrator would be appropriate.
7. P.36 section 2.3.1: Am I correct in assuming that the slightly perturbed trajectory was integrated using the full nonlinear GP generated differential equations? If so, why did the author not implement the usual method of tangent dynamics and variational equations?
8. Chapter 3: there are plenty of other ergodization time scales defined in the literature. I am missing a discussion and comparison with the one used in this thesis.
9. P.45: 'sufficiently long' is not clear.
10. P.45: 'dynamically localized' is not clear.
11. P.77 section 4.7: Nice result! But why does the largest LE does not indicate the slowing down at the phase transition? And isn't that result precisely a case where the LE based ergodization time fails to predict the true ergodization times? If so, then when does do the right work?

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*