

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Aleksey Lunkin

**PhD Program:** Physics

**Title of Thesis:** Sachdev-Ye-Kitaev model in the presence of the quadratic perturbation

**Supervisor:** Assistant Professor Konstantin Tikhonov

**Name of the Reviewer:** Igor Gornyi

I confirm the absence of any conflict of interest

**Date:** 10-06-2022

*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 addresses stability of the Sachdev-Ye-Kitaev (SYK) model to quadratic perturbations, following the consideration in the two works by the candidate published in a high-impact scientific journal (Physical Review Letters). The main result of the thesis is the “phase diagram” of the model, Figure 4-1, which shows that a finite region in the parameter space exists, where the perturbation does not break down the non-Fermi-liquid state of the pure SYK model. This should be contrasted with a popular believe in the community, based on the neglect of the interplay between the perturbation and fluctuations, that quadratic perturbations necessarily restore a Fermi-liquid behavior. Moreover, it has been found in the present work that the perturbation can even stabilize some non-Fermi-liquid features of the SYK model. The overall structure of the thesis is fully adequate to its content. The background chapter presents a comprehensive review of the SYK model. The two main chapters of are devoted to the analysis of the effect of the perturbation at zero and finite temperatures, where different analytical techniques are employed. The scientific level of the thesis is high and the results are solid. The methodology comprises modern sophisticated approaches of theoretical physics and the calculations are mathematically involved. The topic of the dissertation is highly relevant to the ongoing research in the field of strongly correlated systems, and the content of the thesis fully displays its relevance. The significance of the results presented in the dissertation is beyond any doubt: the results are at the forefront of the current research and represent the state-of-the-art international level. The potential impact of the results is mainly academic: the work will definitely stimulate further theoretical activities in the rapidly developing field of the SYK-related models (as already confirmed by numerous citations of the original papers).

The following issues should be addressed before the defense. Unfortunately, the quality of presentation in the thesis is affected by numerous typos (like “wawe” or “law temperatures”). Overall, the language in the dissertation should be improved. In addition, in many equations, commas separating the equations are missing, like in Eq. (2.10) and (2.13), which may lead to a confusion. After many equations, the full stop should be inserted. I do not put here the full list of such issues; the candidate should carefully read his thesis once again and improve the formatting and language. I would also recommend to add some more figure; for example, plots of functions  $f_i(x)$  and  $f_z(x)$  from Eq. (3.9) would add clarity to the main text, given these functions are presented only in the appendix. It would also be interesting to see the plots of the eigenfunctions of Hamiltonian (4.7). A minor issue: Eq. (2.28) does not involve  $q$ , but  $q$  appears in Eq. (2.30), which is a certain limit of Eq. (2.28).

#### 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*