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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: Alex Kamenev

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	01-06-2022 **Date: DD-MM-YYYY**

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 investigations of the perturbed Sachdev-Ye-Kitaev (SYK) model. The latter has been recently suggested as a model of non-Fermi-liquid state which is a holographic dual of the AdS_2 gravity. The subject has received huge attention and has already brought home a few significant lessons, which the community has learned. Lunkin et. al. was the first to address a very important question of the model stability against simplest possible extensions such as quadratic (in fermions) perturbations. The question is highly non-trivial, since within the mean-field treatment such perturbations drive the model towards the Fermi-liquid fixed point. Lunkin et. al. was able to show that quantum fluctuations (described by the so-called re-parametrization modes, which are at the heart of the model's holographic duality) may reverse this predicament and preserve the non-Fermi-liquid character of the ground-state. They predicted the second order transition between the two as a function of the perturbation strength. This is a novel and highly significant result, which leads to numerous practical implications (e.g., it brings the metal-insulator transitions in the anomalous metals, described as array of SYK grains). First, they found indications of the transition using perturbation theory techniques. This tour-de-force approach is presented in Chapter 3 of the thesis. Chapter 4 is devoted to a complimentary approach, which establishes the stability of the Fermi liquid phase using the non-perturbative method, analogues to the one employed in treatment of the polaron phenomenon. This latter highly nontrivial approach is inspired by the gravitation duality.

The subject of the dissertation, the employed methodology and the obtained results are all highly innovative and contribute substantially to the body of knowledge. The results have implications to the physics of strongly correlated compounds as well as discussions of the holographic principle. Most of the results are published in the two quality papers in Phys. Rev. Lett. – one of the premier physics journals. The thesis is well written and provides many important and interesting technical details, which did not find their way into the publications. It will be therefore useful for future researchers.

To conclude, this is a significant, high-quality, and well-presented work. I recommend that the candidate be allowed to defend the thesis.

Provisional Recommendation

X☐ *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*