

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Kirill Pavlenko

PhD Program: Mathematics and Mechanics

Title of Thesis: Quantum KdV charges, 2d conformal theories and eigenstate thermalization hypothesis

Supervisor: Associate Professor Anatoly Dymarsky

Name of the Reviewer: Alexander Maloney

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	21-08-2022 Date: DD-MM-YYYY
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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

This is an interesting thesis which describes several novel approaches to the integrability structure of two dimensional CFTs, all related to the so-called “Quantum KdV Charges.” Important results in the thesis include: a careful derivation of the spectrum of QKdV generators, a computation of the Generalized Gibbs Ensemble partition function including chemical potentials conjugate to these charges, and a careful discussion of the implications of this for the eigenstate thermalization hypothesis. The overall quality of the thesis is high, and the structure is appropriate. The methods used are quite interesting and include various sophisticated CFT techniques related to the study of exactly solvable systems. These methods are relevant, and their application to eigenstate thermalization is novel. This work is certainly on an international level and combines in an interesting way many state-of-the art techniques at the intersection of integrable systems and quantum chaos. The overall scientific significance is high.

Overall recommendation: This is a strong thesis which presents interesting, important, and timely results of scientific significance. This thesis is ready to proceed to a formal thesis defense.

Potential Questions to be discussed during the defense:

- I would like to understand better the origin of equation 3.29 and its relation to QKdV eigenvalues.
- I am a little confused by the discussion of equilibration in integrable theories on p.54. In what sense do integrable theories equilibrate? I thought the discussion of GGE would be relevant for theories with many (or an infinite number of) conserved charges, but which are still not integrable. This is partly a semantic issue related to the different ways of defining the word “integrable” for systems with an infinite number of degrees of freedom but is probably worth clarifying at least a bit.
- Can Quantum KdV be understood in terms of $SL(2, \mathbb{R})$ Chern-Simons? How is this related to 3d gravity?
- QKdV charges allow one to “disentangle” the soft hair of a 3d black hole. Could this be useful to understand (or disprove) various recent attempts to describe BH entropy in terms of soft hair?
- You have computed various QKdV quantities in a perturbation series in powers of $1/c$. Do you expect this perturbative series to be convergent or asymptotic? What are the implications of your answer?

I noticed a few trivial typos which should be corrected:

- p.8 “one-cute” -> “one-cut”
- p.17 “receipt” -> “recipe” (twice)
- p.18 “approxiamtion”-> “approximation”
- p.25 two +’s in 4.36, and missing period in the following sentence.
- p.52 “petrubative” -> “perturbative”

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