

Jury Member Report - Doctor of Philosophy thesis.

Name of Candidate: Alexandra Tambova

PhD Program: Computational and Data Science and Engineering

Title of Thesis: THE NUMERICAL MODELING OF NANOPHOTONIC STRUCTURES WITH UNBOUNDED CHANNELS BY MEANS OF FAST CURRENT-BASED VOLUME INTEGRAL EQUATION METHOD

Jury Member: Prof Ivan Oseledets

Name of the Reviewer:

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	Signature:  Date: 25-10-2019
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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 presented thesis has 153 pages, introduction, 4 chapters, discussion, conclusion and appendix. It is devoted to modeling of nano-photonics structures in unbounded channels using volume integral equation methods. The main challenge is that in such channels special absorbing layers are needed in order to reduce the equation to a final domain. Such problems are not very common in VIE methods, since they typically reduce a system of partial differential equations (PDEs) in unbounded domains to the bounded domains. Unbounded (in practice, very long) channels arise in nano-photonics applications, and even VIE method require special treatment of in the unbounded domain.

This thesis in fact introduces a new concept: adiabatic absorber for VIE, and they also leave untouched the nice convolutional structure of the operator.

A second contribution of the thesis is a technical, but very important contribution for evaluation of singular integrals over quadrilateral elements. This advances the field of numerical methods for VIE. The original DIRECTFN used triangular patches.

Overall, the topic is of high practical importance, and the problems solved are of high complexity. The approach developed is simple and novel, and outline in several high-profile publications.

Comments:

1. Page 104, Figure 4-9: It quotes «theoretical convergence rates», which, as I can see, are empirical estimates, which are not strictly speaking theory in mathematical sense (i.e. there are no theorems).
2. A close question: some comments about theoretical justification of the proposed methods are needed.
3. The algorithms proposed are not summarized as formal algorithms, see, for example, 2.9
4. Section 2.10 (Fig 2-12, 2-14)./ The mesh refinement is presented as convergence when mesh size goes to zero. This is good, but estimate of the order of convergence is needed, which is achieved by plotting the error of the approximation, between, say, linear interpolates of these quantities. Also, typically, the mesh is refined like $\lambda m/2$, $\lambda m/4$, ... and then the order of the convergence is recovered.

This comments do not change the overall evaluation of the high-quality and high-standard work by Alexandra. I recommend the thesis for defense.

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