

OPINION

on a dissertation titled:

Stochastic Numerical Methods for Eigenvalue Estimation

for the award of the educational and scientific degree of “Doctor” to

the candidate: **Silvi-Maria Todorova Gyurova**

Field of higher education: **4. Natural Sciences, Mathematics and Informatics.**

Professional field: **4.5. Mathematics**

Doctoral program: Mathematical Modeling and Applications of Mathematics, Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences

This opinion was prepared by Prof. Dr. Ivan Georgiev Georgiev, Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences, in my capacity as a member of the scientific jury, pursuant to Order No. 101/04.05.2026 of the Director of the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences.

1. General Characteristics of the Dissertation and the Submitted Materials

The materials submitted by the candidate and used for this opinion are: a curriculum vitae; the dissertation in Bulgarian and an abstract in English and Bulgarian; the author’s summary of contributions in the dissertation; a self-assessment report on compliance with the minimum national requirements; a report on the completion of the educational and research program of the doctoral program “Mathematical Modeling and Applications of Mathematics.”

The dissertation consists of 118 pages, with the content organized into an introduction, three chapters, a conclusion, an appendix, and a list of references (121 titles, including articles, monographs, manuals, and other sources). The dissertation includes 15 figures and 16 tables, which are necessary to illustrate the results.

The first chapter focuses on the development of efficient stochastic power algorithms for estimating the maximum eigenvalue of dense symmetric matrices. The stochastic Power Method in two variants are considered: the Power Monte Carlo method and Power Quasi-Monte Carlo method. The construction of the random variable using a Markov chain is described. Pseudocode for the developed near-optimal algorithms is presented, and the conditions for balancing stochastic and systematic error are determined. The second chapter is devoted to the problem of estimating the minimum eigenvalue of symmetric square matrices using their resolvent matrix. The role of the parameters affecting the convergence of the infinite series representing the resolvent matrix is investigated. Almost optimal algorithms are constructed, and the balance between stochastic and systematic error is analyzed. Results from the numerical experiments

related to estimating the minimum eigenvalue of test symmetric matrices are presented. Chapter 3 addresses a problem in the field of financial mathematics. To estimate the market risk of an investment portfolio, the maximum eigenvalue of the portfolio's correlation matrix is used. Numerical experiments were conducted using real financial data, demonstrating the applicability and effectiveness of the proposed algorithms.

2. Background and personal impressions of the candidate

Silvi-Maria Gyurova graduated from the Sofia Mathematical High School "Paisii Hilendarski." In 2019, she obtained a Master's degree in applied mathematics from the Faculty of Mathematics and Informatics at Sofia University St. Kliment Ohridski, Master Program on Computational Mathematics and Mathematical Modeling. She began work on her dissertation in 2020 at the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences, Doctoral Program of Mathematical Modeling and Applications of Mathematics, as a full-time student under the supervision of Prof. Aneta Karaivanova.

I know the dissertation candidate personally as a colleague at the institute and have a very favorable impression of her scientific research, her work on projects at the institute, and her presentations at scientific conferences.

3. Analysis of the scientific and scientific-applied contributions of the candidate

The scientific and applied research contributions are fully consistent with the objectives and tasks set out in the dissertation. They reflect the justification, development, and experimental investigation of a Power Monte Carlo algorithms and Resolvent Quasi Monte Carlo algorithms for estimating extreme eigenvalues of symmetric matrices. The contributions have been validated in a real-world problem from financial mathematics by estimating the market risk of a portfolio of global assets.

I firmly believe that the candidate has conscientiously and fully met the requirements for the "educational" component of the doctoral degree. The results presented in the dissertation are original and have both scientific and practical applications. I accept the formulated contributions as corresponding to the obtained results.

4. Dissemination of the results. Fulfillment of the minimum requirements

The results in the dissertation have been validated in a total of 4 scientific publications. The publications are collective; I acknowledge the candidate's substantial contribution. The results presented in the dissertation have been reported at 5 scientific conferences.

I find no evidence of plagiarism in the dissertation submitted to me, as established by law.

5. Characteristics of the Abstract

The abstract meets the requirements for its preparation—it contains all sections of the dissertation: It includes an introduction justifying the scientific significance of the dissertation topic, while the subsequent chapters outline the research objectives and methods, briefly present the main results, and discuss the possibilities and limitations of the proposed solutions. The content corresponds to that in the dissertation. The contributions, as stated by the candidate, are listed separately. There is a list of the candidate's publications on the dissertation topic, acknowledgments are expressed to the academic advisor, and finally, the candidate has declared the originality of the dissertation.

6. Critical Remarks and Recommendations

I have no significant comments regarding the accuracy of the results obtained by the candidate or the approaches used in the dissertation.

7. Conclusion

Having reviewed the dissertation and the accompanying scientific papers submitted as part of this procedure, and based on an analysis of their significance and the scientific and applied scientific contributions they contain, I confirm that the submitted dissertation and the scientific publications associated with it, as well as the quality and originality of the results and achievements presented therein, meet the requirements of the Law on the Academic Degrees and Academic Titles in the Republic of Bulgaria (ZRASRB), the Regulations for its implementation, and the relevant regulations of the Bulgarian Academy of Sciences and the Institute of Information and Communication Technologies at Bulgarian Academy of Sciences for the award of the educational and scientific degree of "Doctor" in scientific field 4. Natural Sciences, Mathematics, and Informatics and professional field 4.5. Mathematics. In particular, the candidate meets the minimum national requirements in the professional field, and no plagiarism has been found in the dissertation and scientific publications submitted under the procedure.

Based on the foregoing, I recommend that the academic jury award Silvi-Maria Todorova Gyurova the educational and scientific degree of "Doctor" in scientific field 4. Natural Sciences, Mathematics, and Informatics, professional field 4.5. Mathematics.

June 01, 2026

Prepared

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