STATEMENT

of the dissertation entitled

"Stochastic Numerical Methods for Eigenvalue Estimation"

for the acquisition of PhD degree

by Silvi-Maria Todorova Gurova

in the higher education area of: 4. *Natural Sciences, Mathematics and Informatics,*
professional field: 4.5. *Mathematics,*
doctoral program: *Mathematical Modeling and Application of Mathematics*
at the Institute of Information and Communication Technologies (IICT-BAS)

The statement was prepared by Prof. Nadia Zlateva, DSci, member of the scientific jury for the procedure, pursuant to Order No. 101/04.05.2026 of the Director of IICT-BAS.

1. General description of the dissertation

The **dissertation** presented by Silvi-Maria Gurova has a total volume of 118 pages, includes 15 figures and 16 tables, and is written in Bulgarian. It begins with an introduction, followed by 3 chapters, a conclusion (which includes a declaration of originality of the results), an appendix, and a bibliography of 121 sources.

The dissertation contains scientific results that represent an original contribution to stochastic numerical analysis, with the potential to be extended in further research. References to already known results are comprehensive and correct. The presentation is clear and in some places even overly detailed. A unified approach to the topic is demonstrated, showing a good mastery and ability to combine various methods and techniques in obtaining the main results.

2. Data and personal impressions of the candidate

Silvi-Maria Gurova is a graduate of the Sofia High School of Mathematics, after which she completed at the Faculty of Mathematics and Informatics (FMI) of Sofia University St. Kliment Ohridski her Bachelor's degree in *Applied Mathematics* in 2017 and her Master's degree in *Computational Mathematics and Mathematical Modeling* in 2019. From 2020 to 2022, she was a full-time PhD student in the doctoral program *Mathematical Modeling and Application of Mathematics* at IICT-BAS under the supervision of Prof. Aneta Karaivanova.

I know Silvi-Maria Gurova as a student (and as my teaching assistant in Linear Programming), and I have very good impressions of her as a colleague with inexhaustible enthusiasm and sincere curiosity for Mathematics. As a student, she was a part-time

teaching assistant for various major disciplines at FMI, such as *Calculus* 1 and 2, *Numerical Methods of Analysis*, *Probability and Statistics*, and since her graduation, she continue to assist in the discipline *Stochastic Numerical Methods and Simulations.*

3. Substantive analysis of the presented dissertation

The dissertation is devoted to the development, investigation, and practical application of effective stochastic numerical methods for estimating extreme eigenvalues of large-scale square symmetric matrices. The research focuses on the optimization of Monte Carlo and randomized Quasi-Monte Carlo type algorithms based on finite Markov chains. One of the main goals is to achieve a controlled computational balance between the arising stochastic and systematic errors.

New algorithmic modifications of the stochastic Power method and the Resolvent power method have been developed and studied for estimating both extreme eigenvalues ($\lambda_{\max}$ and $\lambda_{\min}$) of large-scale symmetric matrices.

A transition from standard pseudorandom generators to deterministic low-discrepancy sequences (of Sobol and Halton) has been implemented within finite Markov chains using almost optimal transition densities.

A comprehensive numerical analysis of the convergence and accuracy of the proposed algorithms for large matrix dimensions has been conducted. The influence of the number of random variables realizations, the length of the Markov chains, and the sequence modification operators (skip and leap) on the balance between stochastic and systematic errors was investigated.

The practical applicability of the developed stochastic algorithms has been demonstrated in Financial Mathematics models for market risk assessment through the efficient approximation of the maximum eigenvalue of real correlation matrices of financial assets.

The bibliography of the dissertation is comprehensive and shows knowledge of the subject area. The titles in it are arranged alphabetically by the surname of the first author.

As minor drawbacks of the presentation, the following can be noted: the presence of formulas with identical content but different numbering; the repetition of a passage of 10 lines on page 71; $q > 1$ and $q < 1$ in formula (2.48) instead of $q > 0$ and $q < 0$, respectively, etc. However, they do not affect the overall good impression of the dissertation.

4. Approbations of the results

In the conclusion part of the dissertation, on pages 104-106, the main contributions are stated, and on page 102, four papers containing the results are listed:

- Gurova, S.-M., Karaivanova, A., Quasi-Monte Carlo Algorithms for Eigenvalue Problems, 4th International Conference Numerical Methods for Scientific Computations and Advanced Applications, NMSCAA'24, 18-22, (2024) (short communication)
- Gurova, S.-M., Atanassov, E., Karaivanova, A., A Resolvent Quasi-Monte Carlo Method for Estimating the Minimum Eigenvalues Using the Error Balancing, In: Lirkov, I., Margenov, S. (eds), Large-Scale Scientific Computing, LSSC'23, LNCS, vol. 13952, 394–403, (2024), doi.org/10.1007/978-3-031-56208-2_40

- Gurova, S.-M., Gurov, T., Karaivanova, A., On the Stochastic Power Algorithms for Estimating the Maximum Eigenvalue of Symmetric Matrices, Contemp. Math., 6(5):7223–7249 (2025), doi.org/10.37256/cm.6520257781
- Gurova, S.-M., Gurov, T., Karaivanova, A., Eigenvalue Estimation in Portfolio Risk: The Role of Skipping and Leaping in Sobol and Halton Sequences, In: Lirkov, I., Margenov, S. (eds), Large-Scale Scientific Computing, LSSC'25, LNCS, vol. 16061, accepted for publication

The scientific supervisor is a co-author of the PhD student in all four publications, in two of them T. Gurov is a co-author, and in one – E. Atanassov. I find that the contributions of S.-M. Gurova in them are equivalent. Paper [3] is published in a journal in Q1 Mathematics of WoS for 2024, and papers [2] and [4] – in the LNCS series, which has an SJR, providing at least 135 points against the required 30 for the minimum national requirements for acquisition of PhD degree. The presented dissertation and the related publications contain original results, and I find no plagiarism in them. S.-M. Gurova has personally gave 5 talks at international conferences, one of which was in Linz, Austria, and has been a member of the teams of one international and four national scientific and infrastructure projects.

5. Qualities of the extended abstract

The **extended abstract** has a volume of 50 pages and a bibliography of 94 sources. It follows the structure of the dissertation and comprehensively and correctly reflects the results described in it. On pages 42-43, the contributions of the dissertation are explicitly stated. Unfortunately, the numbering of the formulas in the extended abstract does not match their numbering in the dissertation, which makes it difficult to trace the correspondences.

6. Conclusion

The presented by S.-M. Gurova dissertation is an original study in the field of Stochastic Numerical Methods. The obtained results are interesting and have potential for further development.

Based on the analysis made above, I **confirm** that the presented dissertation and the scientific publications related to it, as well as the quality and originality of the results presented therein, meet the Bulgarian legal regulations for the candidate's acquisition of the PhD degree in Mathematics. In particular, the candidate satisfies the minimal national requirements and no plagiarism was found in the scientific works submitted by her within the procedure.

Based on the above, **I recommend the scientific jury to award Silvi-Maria Todorova Gurova PhD degree in Mathematics (Mathematical Modeling and Application of Mathematics).**

На основание
ЗЗЛД

Sofia, June 1, 2026