STATEMENT REPORT

on the procedure for defence of a Ph.D. thesis entitled:

"OPTIMIZATION AND PARALIZATION OF ALGORITHMS RELATED TO CODING THEORY"
for obtaining the Educational and scientific degree "Doctor"

by MARIA RUMENOVA PASHINSKA-GADZHEVA

In the Scientific field: 4. Natural Sciences, Mathematics, and Informatics,

Professional field: 4.6. Informatics and Computer Science,

Ph.D. program "Informatics",

Section: Mathematical Foundations of Informatics (MFI),

Institute of Mathematics and Informatics (IMI),

Bulgaria Academy of Sciences (BAS),

The statement report has been prepared by: Professor **Maya Miteva Stoyanova**, Ph.D., Dean of the Faculty of mathematics and informatics, Sofia University "St. Kliment Ohridski", Department of Algebra, Professional field 4.5. Mathematics, in my capacity as a member of the Scientific jury for the defence of this Ph.D. thesis according to Order № 456 / 03.12.2024 of the Director of the Institute of mathematics and informatics, BAS.

1. General characteristics of the Ph.D. thesis and the presented materials

The presented Ph.D. thesis contains 102 pages and consists of an introduction, five chapters and a bibliography of 83 titles. It also contains all the necessary references for the scientific contributions and the approval of the results obtained by the candidate. Maria Rumenova Pashinska-Gadzheva has presented all required documents and materials that concern the procedure. The documents show that the applicant fully meets the minimal national requirements according to the Art. 2b, para. 2 and 3 of the Act on Development of the Academic Staff in the Republic of Bulgaria (ADASRB), The Rules for Implementation of the ADAS in the Republic of Bulgaria as well as the Rules on the Terms and Requirements for Acquisition of Scientific Degrees and Occupation of Academic Positions of the Institute of Mathematics and Informatics and Bulgaria Academy of Sciences.

2. Short CV and personal impressions of the candidate

Maria Pashinska-Gadzheva obtained a Bachelor's degree in Computer Science from the University of Veliko Tarnovo "St. St. Cyril and Methodius" in 2019, as well as a Master's degree in Mathematical Structures in Information Security in 2020. In the period 2021 - 2024, she was a full-time Ph.D. student at the "Mathematical Foundations of Informatics" section, IMI, BAS, doctoral program "Informatics". As of 02.01.2024, she has been discharged with the

right to defend (Order No. 7/02.01.2024). From 2019 to March 2024, Maria Pashinska-Gadzheva worked as a mathematician in the "Mathematical Foundations of Informatics" section, IMI, BAS, and from March 2024 to the present, she has been an assistant in the same section. Ph.D. student Maria Pashinska-Gadzheva has 6 publications.

I know Maria Pashinska-Gadzheva from the reports she gave at the seminar of the Mathematical Foundations of Informatics section, as well as at the National Seminar on Coding Theory “Prof. Stefan Dodunekov” and I have excellent impressions of her scientific work.

3. Content analysis of the scientific and scientific-applied achievements of the candidate, contained in the presented dissertation thesis and the publications to it, included in the procedure

The Ph.D. thesis examines classical problems in coding theory related to the parallelization of algorithms, with an emphasis on the main method used by doctoral student Pashinska-Gadzheva, namely the method of parallelization by vectorization.

The first chapter introduces all the concepts and known results necessary for the further presentation.

The second chapter presents the main algorithms for finding the weight spectrum of a linear code, with Maria Pashinska-Gadzheva grouping them into two main groups. The first group includes the algorithms (called high-level algorithms in the Ph.D. thesis), which are based on an approach for emulating nested cycles and present the approach for generating a new code-word and finding its weight. The second group, called low-level algorithms in the Ph.D. thesis, are the algorithms that perform the basic calculations. The implementation of the second group is the subject of scientific research by M. Pashinska-Gadzheva, describing the implementation of such algorithms, optimizations depending on the field and the representation of its elements, as well as analyzing the effectiveness of the presented algorithms depending on the compiler and instructions used in the implementation.

In the third chapter, optimization methods for the collection of vectors using unsigned data types, as well as saturation operations, are considered. The use of such data in combination with the use of specialized instructions AVX512 for x86 and NEON for ARM allows for efficient implementation for simple fields with up to 128 elements.

The fourth chapter is devoted to the applications of the methods described in the previous chapters to coding theory, aimed at studying the class of binary self-complementary codes reaching the Gray-Rankin limit. Six families of codes with two and three weights reaching the Gray-Rankin limit are considered. The connections between them are determined and it is shown that codes with such parameters exist. A partial classification of the considered codes in dimensions eight and nine is also presented.

Chapter 5 presents the LinCodeWeightInv software library developed by doctoral student Maria Pashinska-Gadzheva and her supervisor Prof. Buyukliev. The main functionalities of the presented library, the interface functions, as well as the testing and verification module are described.

The obtained results are presented clearly and in detail, with the necessary distinction made between the known results and the new results obtained in the dissertation. The originality of the scientific results and contributions obtained by Maria Pashinska-Gadzheva is beyond doubt, and there is no doubt whatsoever about plagiarism in the Ph.D. thesis.

4. Approbation of the results

The publications on the basis of which the presented Ph.D. thesis is formed are six (according to the candidate's numbering) – two in the Science Series-Innovative STEM Education [P1, P2]; one in the 2022 International Conference Automatics and Informatics (ICAI) [P3]; one in Mathematics [P4], which is with IF and in the first quartile Q_1; one in the International Conference on Large-Scale Scientific Computations. LSSC 2023. Lecture Notes in Computer Science [P5], which is with SJR, and one in the ACM Transactions on Mathematical Software [P6]. Five of these articles [P1-P5] have been published, and the sixth [P6] is in the process of being reviewed. Two of the articles, namely [P2] and [P3], are independent, and the rest are co-authored with the scientific supervisor. The Ph.D. thesis describes 2 citations of the candidate's works, as such are generally not required. The results of the Ph.D. thesis have been reported at nine national and international scientific forums.

The published works meet the minimum national requirements (according to the Art. 2b, para. 2 and 3 of the Act on Development of the Academic Staff in the Republic of Bulgaria), and, accordingly, the additional requirements of IMI, and of BAS for the acquisition of the Educational and scientific degree "Doctor" in the scientific field and professional direction of the procedure. The results presented by the candidate in the Ph.D. thesis and related scientific works do not repeat those from previous procedures for acquiring a scientific degrees and academic positions. From the submitted documents it can be seen that there is no proven plagiarism in the submitted Ph.D. thesis and the accompanying publications.

5. Qualities of the abstract

The abstract in Bulgarian is 30 pages long and meets the requirements for its preparation. The results of the dissertation work and its content are correctly presented. The abstract in English has a volume of 29 pages and also accurately presents the scientific contributions of the candidate.

6. Critical notes and recommendations

I have no substantial criticisms. There are some minor technical errors, but this does not change my good impression of the quality of the Ph.D. thesis and the scientific contributions of Maria Pashinska-Gadzheva.

7. Conclusion

Having become acquainted with the dissertation thesis presented in the procedure and the accompanying scientific papers and on the basis of the analysis of their importance and the scientific and applied contributions contained therein, **I give my positive opinion** and **I confirm** that the Ph.D. thesis presented and the scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the Act on Development of the Academic Staff in the Republic of Bulgaria, the Rules for its Implementation and the corresponding Rules at the IMI, and at the BAS, for the acquisition by the candidate of the educational and scientific degree "Doctor" in the Scientific field: 4. Natural

Sciences, Mathematics, and Informatics, Professional field: 4.6. Informatics and Computer Science (Informatics).
In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the Ph.D. thesis, and in the scientific papers submitted for this procedure.

Based on the above, **I recommend** the scientific jury to award Maria Rumenova Pashinska-Gadzheva the Educational and scientific degree „Doctor" in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.6. Informatics and Computer Science (Informatics).

Date: January 23, 2025

Signature:

Prof. Maya Stoyanova, Ph.D.