

STATEMENT REPORT

on the procedure for defence of a Ph.D. thesis entitled:
“DESCRETE TRANSFORMS AND THEIR APPLICATION
IN CODING THEORY AND COMBINATORICS”
for obtaining the educational and scientific degree “Doctor”
by PASKAL NIKOLAEV PIPERKOV

In the Scientific field: **4. Natural Sciences, Mathematics, and Informatics**,
Professional field: **4.6. Informatics and Computer Sciences**,
Ph.D. program “**Algebra and Number Theory**”,
Section: **Mathematical Foundations of Informatics**,
Institute of Mathematics and Informatics (IMI),
Bulgaria Academy of Sciences (BAS),

The statement report has been prepared by: Professor **Maya Miteva Stoyanova**, Ph.D., Deputy Dean (Academic staff) of Faculty of Mathematics and Informatics, Sofia University “St. Kliment Ohridski”, in my capacity as a member of the Scientific jury for the defence of this Ph.D. thesis according to Order № 159/27.06.2022 of the Director of the IMI, BAS.

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

The presented Ph.D. thesis contains 97 pages and consists of an introduction, three chapters and a bibliography of 71 titles, it also contains all the necessary references for the scientific contributions and the approval of the results obtained by the candidate. Pascal Nikolaev Piperkov 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

Pascal Nikolaev Piperkov obtained Master's degree at the Faculty of Mathematics and Informatics of Sofia University "St. Kliment Ohridski" in 1997, Master's program "Mathematical logic and algorithms". He worked successively as an assistant, senior assistant and chief assistant at "St. Cyril and St. Methodius" University of Veliko Tarnovo from 2003 to 2016. From 2016 onwards, he has been working in the Section: Mathematical Foundations of Informatics, IMI, BAS. On 01.01.2018, he was enrolled as a part-time Ph.D. student in the doctoral program "Algebra and Number Theory" of IMI, BAS, as of 01.01.2022, he was dismissed with the right of defence (Order

No. 5/07.01.2022). Doctoral student Pascal Piperkov has 16 publications, 4 of which are on the subject of the presented Ph.D. thesis.

I know Pascal Piperkov from his reports at the seminar of the MOI section, as well as at the National Seminar on Coding Theory "Prof. Stefan Dodunekov" and I have good impressions of his 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 deals with classic problems in coding theory, namely finding the distribution of distances and the coverage radius of linear codes. One of the important directions in these studies is the development and research of efficient algorithms for solving these two problems for different classes of parameters. The research in the presented Ph.D. thesis is focused on the use of fast discrete transformations proposed by Mark Karpovsky in his publications in 1979 and 1981, applying Walsh-Hadamard transform (in the binary case), Vilenkin-Krestensen (for finite simple fields) and trace transform (for finite composite fields).

In the first chapter, all the definitions and known results necessary for the further exposition related to finite fields, traces, linear codes with their parameters and characteristics, the discrete Walsh-Hadamard and Vilenkin-Crestensen transforms and their basic properties, Kronecker multiplication of matrices and its relation to fast transforms, trace transform are introduced.

In Chapter 2, a basic algorithm is developed for computing the weight distribution of a linear code over a simple field using an eigenvector (of a linear code relative to its generating matrix). A characteristic distribution and a truncated characteristic distribution are introduced, the finding of which is central to the approach. The complexity of the proposed algorithms (main and auxiliary) is analyzed and results of the numerical experiments are presented, including those for codes with large lengths.

Chapter 3 discusses methods for finding the distance distribution of linear codes over composite fields. A general algorithm for finding the weight distribution along a given extended characteristic vector has been developed. It uses a trace transform and a self-dual basis, through which the considered transform is reduced to a Walsh-Hadamard transform (for a field with characteristic 2) or a transform of Vilenkin-Crestensen. This leads to a q -fold improvement in the complexity of the algorithms.

Chapter 4 is devoted to the use of the Vilenkin-Crestensen transform applied to the characteristic function of a check matrix of the corresponding linear code to find its coverage radius. A similar idea was proposed by Karpovski for the binary case, and the dissertation's work on this task can be seen as an interesting continuation. In the cases of a simple and a compound field, results have been obtained allowing the reduction of the problem of finding the radius of coverage to the use of the algorithms developed in Chapters 2 and 3.

The obtained results are presented clearly and in detail, with the necessary distinction being made between the known results and the new results obtained in the Ph.D. thesis. The originality of the obtained results is beyond doubt and they have served as the basis of the four published articles.

4. Approbation of the results

The publications on the basis of which the presented Ph.D. thesis is formed are four - one is in *Cryptography and Communications*, a scientific journal with an impact factor of 1.376 and second quartile (Q2) for 2021, one in the collections *Recent Topics in Differential Geometry and its Related Fields* and *World Scientific's New Horizons in Differential Geometry and its Related Fields*, published in 2019 and 2022 respectively. The fourth publication is in the *Proceedings of the International Workshop on Optimal Codes and Related Topics, 2017*. Co-authors are the scientific supervisor Prof. Ilija Buyukliev, Prof. Stefka Buyuklieva (in three of the works) and Prof. T. Maruta (in one of the works). From my personal conversations with Prof. Ilija Buyukliev (scientific supervisor of Pascal Piperkov), I have reason to believe that the contributions of all authors are equal. The Ph.D. thesis describes 3 citations of Piperkov's works, but one of them is a self-citation of a co-author. The results of the Ph.D. thesis have been presented at several seminars on coding theory and at the *Eight International Workshop on Optimal Codes and Related Topics*.

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, 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 32 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 31 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 and the aforementioned self-citation of a co-author, but this does not change my good impression of the quality of the Ph.D. thesis and the scientific contributions of Pascal Nikolaev Piperkov.

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, 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: 4.5. Mathematics (Algebra and Number Theory).

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 **Paskal Nikolaev Piperkov** the educational and scientific degree „Doctor” in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.5. Mathematics (Algebra and Number Theory).

Date: August 18, 2022,

Signature:

Prof. Maya Stoyanova, Ph.D.