STATEMENT REPORT

on the procedure for defense of a dissertation thesis entitled:

"Algorithms for characterization of orthogonal arrays"

for obtaining the scientific degree "Doctor" (educational and scientific)

by Tanya Todorova Marinova

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

Professional field: **4.5. Mathematics,**

Ph. D. program **"Algebra, topology and applications",** Department of Algebra,

Faculty of Mathematics and Informatics IFMI),

Sofia University "St. Kliment Ohridski" (SU),

The statement report has been prepared by: Associate Professor **Maya Miteva Stoyanova**, Ph. D., in my capacity as a member of the scientific jury for the defence of this dissertation according to Order № 38-121/24.02.2021 of the Rector of the Sofia University.

1. General characteristics of the dissertation thesis and the presented materials

The dissertation thesis investigates the structure of some classes of orthogonal arrays in Hamming space considered as a polynomial metric space. Using polynomial technics and combinatorial properties, various general characteristics about those combinatorial configurations have been shown. The various uses of orthogonal arrays, especially in modern statistics, makes them an important object in mathematics that has been investigated by numerous mathematicians and physicists.

The Ph. D. thesis contains 115 pages consisting of an introduction, four chapters and a bibliography containing 59 titles. Tanya Todorova Marinova 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 Act on Development of the Academic Staff in the Republic of Bulgaria as well as the Regulations for the conditions and rules for acquiring Ph.D. degree of the Sofia University "St. Kliment Ohridski".

2. Short CV and personal impressions of the candidate

I have known Tanya Marinova since 2007, when she was studying Informatics in FMI, Sofia University. In 2011 I started working with T. Marinova, who by this point had earned a master's degree in Discrete and Algebraic Structures, as a supervisor of her thesis, which was the beginning of our joint work on orthogonal arrays. In 2014 she was enrolled as a part-time doctoral student in the Ph. D. program "Algebra, Topology and applications". As her supervisor, up to this day we have an excellent joint scientific work, as evidenced by 6 scientific publications presented in the materials on this procedure.

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 results in the thesis are done in the Hamming space H(n, q), when viewed as a polynomial metric space. The distance distributions of some classes of orthogonal arrays have been studied and some restrictions about the structures of the studied arrays have been proven. The personal motivation about why the author decided to work in this field and what are the general problems she has decided to do research on are outlined in the introduction.

The first chapter outlines all the needed definitions and notations that are later used in the thesis. Furthermore, this chapter includes a summary showing the known relevant results in the field. References are cited accordingly.

In the second chapter two constructions which are used to study binary orthogonal arrays are presented. The first construction takes an orthogonal array with fixed parameters $(n, M, 2, \tau)$ and removes an arbitrary column of the said array. Then we study the relations between the distance distributions of the original orthogonal array C and the distance distributions of those obtained as detailed above. The second construction is similar but removes two columns instead of one. This leads to various new restriction on the distance distributions of the original array C as well as the distance distributions of the arrays obtained by the construction. This led to the development of algorithms and with them new results about the nonexistence of arrays with some specific parameters. More specifically, the minimal value of the possible index for a given binary orthogonal array with the following parameters has been established: $\lambda(9, 4, 2) = \lambda(10, 4, 2) = \lambda(11, 4, 2) = \lambda(12, 4, 2) = 8$ and $\lambda(10, 5, 2) = \lambda(11, 5, 2) = \lambda(12, 5, 2) = \lambda(13, 5, 2) = 8$. It's important to note that a database which shows all the possibilities for the distance distributions of all binary orthogonal arrays for dimension $n \leq 20$ and strength $\tau \leq 10$ has been established.

The third chapters looks into the ternary orthogonal arrays in the Hamming space. A similar construction to the first outlined in the previous chapter has been used to analyze the possibilities of the corresponding distance distributions. An appropriate algorithm has been developed to reduce the possibilities of the distance distributions of the studied ternary orthogonal arrays. As a result, the thesis proves that a ternary orthogonal array with parameters (17, 108, 3, 3) does not exist. Again a database with which shows all the possibilities for the distance distributions of all ternary orthogonal arrays with dimension $n \leq 25$, strength $\tau \leq 10$ and index $\lambda \leq 7$ has been established.

The fourth chapter introduces the notion of energy of an orthogonal array in the Hamming space. Upper and lower bounds for the value of the energy of the orthogonal array have been proven. An algorithm that calculates those values for an array with a fixed potential has been developed and shown in the thesis.

All algorithms are written in Maple.

The work outlined in the thesis is clearly presented, easy to follow and cited promptly. In the end of the introduction the candidate has showcased correctly and in detail the main scientific contributions of the Ph. D. thesis.

4. **Approbation of the results**

The results which are outlined in this Ph. D. thesis have been published in 6 articles. The results from two of them have been announced at the International Workshops. Two of the articles have Impact factor, one has SJR, and two are refereed in the scientific data bases - ZbMath and MathSciNet. The publications have been cited a total of 12 times, of which 10 are in Web of Science or Scopus.

I am a co-author of all scientific publications of Tanya Marinova. For some of the publications co-authors are Prof. Peter Boyvalenkov, Doctor of Sciences; Assoc. Prof. Silvia Bumova, Ph. D.; Assoc. Prof. Hristina Kulina, Ph. D.; Ph. D. student Tedis Ramaj and Mila Sukalinska. It is evident from the submitted declarations for co-authorship that we all declare the equal contribution of Tanya Marinova in our joint work.

The presented reference shows that the scientific works categorically meet and repeatedly exceed the minimum national requirements (under Art. 2b, para. 2 and 3 of the according to the Act on Development of the Academic Staff in the Republic of Bulgaria as well as the Regulations for the conditions and rules for acquiring Ph.D. degree of the Sofia University "St. Kliment Ohridski" for acquiring the educational and scientific degree "Doctor" in Professional field 4.5. Mathematics.

The obtained results are original and there is no proven plagiarism, as it was confirmed on the basis of the received report for similarity of the text of the presented dissertation in the system for prevention against plagiarism of the Sofia University.

5.   Qualities of the abstract

The abstract is 20 pages long, written both in Bulgarian and English. The abstract is prepared according to all requirements and correctly reflects the content of the dissertation and the scientific contributions of the doctoral student.

6. Critical notes and recommendations

I have no critical remarks. I hope that Tanya Marinova and I will continue our joint scientific work on the characterization of different classes of orthogonal arrays, as well as in other areas of Mathematics.

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 confirm** that the dissertation 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 as well as the Regulations for the conditions and rules for acquiring Ph.D. degree of the Sofia University "St. Kliment Ohridski" for acquisition by the candidate of the scientific degree "Doctor" in the Scientific area "Algebra, Topology and applications" and, in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.5. Mathematics. In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the scientific papers submitted for the competition.

Based on the above, **I strongly recommend** the scientific jury to award **Tanya Todorova Marinova** the scientific degree „Doctor" (educational and scientific) in the Scientific field 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.5. Mathematics, Scientific area: Algebra, Topology and applications.

Date: April 16, 2021   Signature: ....
                                               Assoc. Prof. Maya Stoyanova, Ph. D.