

## **STATEMENT REPORT**

**under the procedure for obtaining the scientific degree “Doctor of Science”**

**by Assoc. Prof. Assia Petrova Rousseva-Landjeva, Ph.D.,**

**of the Dissertation Thesis entitled: “Finite Geometries and Codes”,**

In the Scientific field: 4. Natural sciences, mathematics and informatics,

Professional field: 4.5 Mathematics,

Doctoral program “Geometry”, Department of Geometry,

Faculty of Mathematics and Informatics (FMI),

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

The statement report has been prepared by: **Assoc. Prof. Dr. Maya Miteva Stoyanova**, Deputy Dean of the Faculty of Mathematics and Informatics, academic staff, Department of Algebra, FMI, Sofia University “St. Kliment Ohridski”, in the capacity as a member of the scientific Jury for the defense of this dissertation according to Order № RD 38-186 / 14.05.2020 of the Rector of the Sofia University. At the first meeting of the scientific jury on 19.05.2020 I was elected chairman of the scientific jury.

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

The dissertation thesis contains 180 pages and consists of an introduction, four chapters and a bibliography with 201 references. It contains research on several important problems in the field of finite geometries, as well as their connections with the noise coding structures. The results obtained and scientific contributions of Assoc. Prof. Assia Rousseva-Landjeva, Ph.D., presented in the dissertation, show that she knows, in depth, the field of finite geometries, her research is on current issues, and the dissertation thesis is theoretical in nature and meets the generally accepted requirements for the defense this dissertation and scientific degree “Doctor of Sciences” can be awarded.

The results obtained represent contributions both in the theory of finite geometries and that of linear codes. These two scientific fields are relatively new and the dissertation makes strides in progressing them. On the other hand, optimal linear codes can find specific practical applications in important areas of modern communications such as noisy coding and cryptography.

From the dissertation thesis and other documents and papers presented by Assoc. Prof. Assia Petrova Rousseva-Landjeva, I made sure that they meet all the requirements of the Act on Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its application, and the Rules for the conditions and regulations for acquiring scientific degrees and occupying academic positions in the Sofia University “St. Kliment Ohridski”. I attended the pre-defense of the dissertation thesis presented under this procedure, which was held on 22.04.2020 and ended with a positive assessment of readiness for defense. From the report presented by Assoc. Prof. Assia Rousseva it is evident that the minimum national requirements for obtaining the scientific degree “Doctor of Science” in the professional field 4.5. Mathematics in accordance with the Regulations for the Application of the Act on Development of the Academic Staff in the Republic of Bulgaria are fulfilled.

### **2. Short CV and personal impressions of the candidate**

Assia Petrova Rousseva-Landjeva graduated in Mathematics at the Faculty of Mathematics and Informatics at Sofia University "St. Kliment Ohridski" in 1988. Since 1993 she has been giving lectures and exercises at FMI-SU both in basic courses and in specialized elective disciplines in the field of geometry and its applications. Assoc. Prof. Assia Rousseva-Landjeva has obtained the educational and scientific degree "Doctor" with a Diploma № 30097, issued on 27.12.2005 by the Higher Attestation Commission, and from 24.10.2009 until now she holds the academic position of associate professor in the Department of Geometry, FMI, Sofia University.

I have known Assoc. Prof. Assia Petrova Rousseva-Landjeva for more than 20 years, I have attended many of her presentations at national and international scientific forums and I have excellent impressions of the systematic nature of her research, originality and quality of the scientific achievements received by her, as well as their excellent performance before the scientific college.

### **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**

In the presented dissertation thesis, problems of finite geometries, arising from problems in coding theory, are investigated. The obtained original results are described in three of the chapters of the dissertation (chapters 3-5) and represent contributions both in the theory of finite geometries and in that of linear codes. With the help of geometric techniques and constructions, a number of bounds and classification results were obtained on the studied arcs and blocking sets. These are topical problems in the two scientific fields mentioned above, and the obtained results lead both to theoretical progress in the theory of finite geometries and to practical applications in the theory of coding and cryptography.

The introduction provides a synthesized overview of the origin and development of the recent classical geometry results related closely to coding theory. A historically consistent report of the results achieved so far by the scientists working in these two areas and the motives of Assoc. Prof. Assia Rousseva-Landjeva, Ph.D., to direct her research work in these areas is given. The structure of the dissertation, a list of publications reflecting the results obtained in it and a brief reference to the main scientific forums, where the described results were presented by the candidate.

The second chapter presents the basic definitions, notations and known results, necessary and used in the following statement.

The results in Chapter 3 are based on a study of the achievement of the Griesmer bound and a geometric characterization of the codes meeting this bound. The main scientific results obtained in Chapter 3 are the following:

- the problem to determine the behavior of the function  $t_q(k)$  defined as the maximal deviation of the optimal length of a code of dimension  $k$  from the value given by the Griesmer bound, which is equivalent to the rate of increase of the function  $t_q(k)$ , is investigated; An inequality has been proved for the maximum deviation of the length of the optimal  $q$ -ary of Griesmer  $t_q(k)$  for each even dimension, which depends only on  $q$ ;

- the above inequality is specified for dimension 4; the result for  $t_q(3)$  is refined when  $q$  is an even number and when  $q$  is an even power of an odd prime number;

- one of the main results is Theorem 3.10, which can be considered as a generalization of the construction of Belov, Logachev and Sandimirov for non-Griesmer codes;
- another important result is a proof of Ball's conservative estimate for the possible deviation of the best 3-dimensional linear codes from the Griesmer bound.
- non-existence of hypothetical Griesmer arcs (Griesmer codes) for  $q = 4$ ,  $k = 5$  has been proved. Thus closing 10 open cases for determining the exact values of the function  $n_4(5, d)$ .

Chapter 4 is devoted to the study of the extensibility conditions of arcs, which are equivalent to the extensibility conditions of the associated linear codes. The main scientific contributions here are:

- a new geometric approach to the extensibility problem is proposed; a new object was introduced - arcs with subdivision  $(t \bmod q)$ -arcs; their structure has been studied and a condition for their extensibility to the structure of a special dual  $(t \bmod q)$ -arc has been proved;
- it has been shown that for certain values of  $t$  and  $q$ ,  $(t \bmod q)$ -arcs can be obtained as a sum of arcs of smaller dimensions;
- a partial characterization of  $(3 \bmod 5)$ -arcs in  $PG(2,5)$  and  $PG(3,5)$  was made;
- the nonexistence of  $(104,22)$ -arcs in  $PG(3,5)$  has been proved thus solving one of the four open cases for codes with  $k = 4$  and  $q = 5$ .

Chapter 5 presents a general construction for affine blocking sets. A new infinite class of  $t$ -blocking sets with  $t = q - n + 2$  lying on the Bruen bound is constructed. The first five examples of blocking sets lying on the bound of Ball are constructed.

The structuring and layout of the text in the presented dissertation thesis is clear and precise. The considered geometric objects are illustrated in detailed drawings, which contributes to a clearer and more correct perception of the proposed structures and the results obtained.

The bibliography of 201 references shows in-depth knowledge in the relevant fields. Both the classically known results from the middle of the last century and the most recent achievements obtained in recent decades by a number of foreign and Bulgarian scientists are included.

The addresses of tables with bounds for the parameters of optimal linear codes or arcs in projection spaces are impressively indicated. These tables summarize all the results obtained so far, and the data in them is constantly updated.

#### **4. Approbation of the results**

The dissertation thesis is written on the basis of seven scientific publications. Five of those are included in the references for compliance with the minimum national requirements under Art. 26 of ADAS in the Republic of Bulgaria for professional field 4.5 Mathematics in the current procedure for obtaining the scientific degree "Doctor of Science" and carry 177 points (the required is 100). Also presented are 13 citations of scientific papers of Assoc. Prof. Assia Rousseva-Landjeva, Ph.D., in refereed editions which carry the required 100 points under this procedure.

Five of the scientific publications are in scientific journals with impact factor, and the other two are in the Annual of Sofia University "St. Kliment Ohridski", FMI, which are

traditionally referred to in the scientific databases MathSciNet and / or Zentralblatt. One of these two publications was accepted for publication when the pre-defense documents were submitted, and as of now is published and available.

Two of the seven publications on the dissertation are independent, and the other five are co-authored. I accept that Assoc. Prof. Assia Rousseva-Landjeva, Ph.D., and her co-author have equal contribution to the joint papers.

The results are presented at a number of national and international scientific forums.

All the facts described above give me reason to believe that:

a) the presented dissertation thesis and the related scientific papers meet the minimum national requirements (under Art. 2b, para. 2 and 3 of ADASRB) and the requirements of Sofia University “St. Kliment Ohridski” respectively.

b) the results presented by the candidate in the dissertation thesis and related scientific works do not repeat those from previous procedures for acquiring a scientific title and academic position;

c) there is no legally proven plagiarism in the submitted dissertation thesis and scientific papers on this procedure.

## 5. Qualities of the abstract

The abstracts prepared in both Bulgarian and English, contain 28 pages and show in detail the relevance of the investigated problems and the motives of the candidate for work on the selected topic. The content of the dissertation by chapters and the main scientific results and contributions in it is clear and presented in detail.

## 6. 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 in them, **I confirm** that the dissertation presented and the related scientific publications, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the ADAS in the Republic of Bulgaria, the Rules for its Implementation and the corresponding Rules at the Sofia University “St. Kliment Ohridski” (FMI-SU) for acquisition by the candidate of the scientific degree “Doctor of Science” 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 Assoc. Prof. Assia Petrova Rousseva-Landjeva, Ph.D., the scientific degree „Doctor of Science” in the Scientific field 4. Natural Sciences, Mathematics and Informatics, Professional field 4.5. Mathematics (Geometry).

13.07.2020

Signature:.....

/Assoc. Dr. Maya Stoyanova /