

# REPORT

by **Prof. Dr. Sci. Tsonka Stefanova Baicheva**

Institute of Mathematics and Informatics, BAS

of the Dissertation Thesis

by **Asia Ruseva-Landjeva**

entitled

**„Finite geometries and codes“**

submitted for obtaining the scientific degree “Doctor of Science”

in the area of higher education 4. Natural Sciences, Mathematics and Informatics,

professional field 4.5 Mathematics, doctoral program “Geometry”

## 1. Ground

This opinion was presented on the basis of order № RD 38-186 of 14. 05. 2020 of the Rector of Sofia University “St. Kliment Ohridski” and the first meeting of the scientific jury on 19.05.2020. The opinion was prepared in accordance with the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for its implementation and the Regulations for holding academic positions at Sofia University “St. Kliment Ohridski”. Asya Ruseva-Landzheva has submitted all required documents according to Chapter 2 of ZRASRB, has acquired educational and scientific degree "Doctor" with diploma № 30097 from 27.12.2005 issued by the Higher Attestation Commission and meets the minimum national requirements of ZRASRB for obtaining the scientific degree "Doctor of Science" in the professional field 4.5 Mathematics.

## 2. Topic and relevance of the dissertation

The dissertation is dedicated to the application of techniques for the study of geometric structures related to noisy coding structures. The obtained results represent contributions both in the theory of finite geometries and in the theory of linear codes. These two scientific fields are relatively new and the tasks solved in the present dissertation represent theoretical progress in 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.

## 3. Content and results of the dissertation

The dissertation is 182 pages long and contains an introduction and five chapters.

The introduction gives a brief overview of the origin and development of coding theory and the theory of finite geometries, noting the main results achieved by scientists working in these two areas, presents the structure of the dissertation and describes the publications reflecting the results obtained in it.

Chapter two contains basic definitions and statements about sets of points in finite geometries and linear codes in finite fields. Special constructions of arcs and blocking sets are presented, important multisets of points are described, and a classification of some arcs in small projective planes is given, which are used repeatedly in the dissertation. The basic concepts and results related to linear over finite fields are also introduced, as well as the correspondence between some concepts from coding theory and finite geometries.

The results obtained in the dissertation are presented in the next three chapters.

In the third chapter, codes that lie on the Griesmer bound are considered and a geometric characterization of these codes is made, as the main scientific results obtained in it are the following:

- an inequality has been proved for the maximum deviation of the length of the optimal  $q$ -ary code from the value set by the Griesmer bound  $t_q(k)$  for each even dimension, which depends only on  $q$ , and the inequality is refined for dimension 4;
- the result for  $t_q(3)$  is refined, when  $q$  is an even number and when  $q$  is an even degree of an odd prime number;

- non-existence of hypothetical grismer arcs (grismer 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 four examines the conditions for extensibility of arcs, which are equivalent to the conditions for extensibility of the associated linear codes. The following scientific results have been obtained:

- a new geometric object is introduced - arcs with subdivision  $((t \bmod q)$ -arcs), their structure is studied and a condition for their extensibility related to the structure of a special dual  $(t \bmod q)$ -arc is proved;
- it has been proved 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  $PG(3,5)$  is made;
- the nonexistence of  $(104,22)$  -arcs in  $PG(3,5)$  (of  $[104,4,82]_5$  linear codes) has been proved, thus solving one of the four open cases for determining the exact value of  $n_5(4, d)$ .

In the fifth chapter are proposed:

- 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 S. Ball are constructed.

The layout of the dissertation text is precise and I especially want to note the drawings that illustrate the structures of the considered geometric objects, which contribute to a clearer and more correct perception of the proposed structures and the results obtained.

#### **4. Review of the cited literature**

The paper cites 57 titles, 7 of which are works by the author of the dissertation. Both classic developments from the middle of the last century and the latest results obtained in recent decades by Bulgarian and foreign scientists are included. The addresses of electronic tables with bounds for the parameters of optimal linear codes or arcs in projective spaces are included. These tables summarize all the results obtained so far, and the data in them are constantly updated.

#### **5. Publications and citations of publications on the dissertation**

The dissertation is written on the basis of seven papers. Five of them are included in the reference for compliance with the minimum national requirements under Art. 26 of ZRASRB for professional field 4.5 Mathematics in the procedure for obtaining the scientific degree "Doctor of Science" and carry 177 points out of the required 100.

There are 13 citations of works by Asia Ruseva-Landjeva in refereed publications, which carry 100 points out of the required 100.

#### **6. Authorship of the obtained results**

In two of the seven publications on the dissertation Asia Ruseva-Landjeva is the only author, and the others are with one co-author. I accept as equal the participation of the candidate in the works in which he is a co-author.

#### **7. Abstract and reference for the contributions**

They are written in sufficient detail and give a clear and adequate idea of the content and main results of the dissertation.

#### **8. Conclusion**

I believe that the presented dissertation **fully meets** the requirements of ZRASRB, the Regulations for the application of ZRASRB and the Regulations on the terms and conditions for obtaining scientific degrees and holding academic positions at Sofia University "St. Kliment Ohridski". The dissertation publications do not repeat those of previous procedures for acquiring a scientific degree and holding an academic position. There is no legally proven plagiarism in these publications.

All the above gives me reason to give a **positive assessment** of the dissertation "Final Geometries and Codes" and convincingly recommend to the esteemed Scientific Jury to award Asia Ruseva-Landjeva the degree of "Doctor of Science" in higher education field 4. Natural Sciences, Mathematics and Informatics, professional field 4.5 Mathematics.

08.07.2020 г.

**Signature:**

/Prof. Dr. Sci. Ts. Baicheva /