REVIEW

in a competition for an academic position
"Professor"
in a professional field 4.5. Mathematics (Algebra, Coding Theory and Applications),
for the needs of Sofia University "St. Kliment Ohridski ",
Faculty of Mathematics and Informatics,
announced in SG no. 63 of 30.07.2021 and on the websites of FMI and Sofia University

The review was prepared by Prof. Dr. Sci. Tsonka Stefanova Baicheva, Institute of Mathematics and Informatics, BAS, in my capacity as a member of the scientific jury for the competition in the professional field 4.5. Mathematics (Algebra, Coding Theory and Applications) according to Order № РД 38-475 / 28.09.2021 of the Rector of Sofia University.

One candidate has submitted documents for participation in the announced competition: Assoc. Prof. Dr. Maya Miteva Stoyanova, Sofia University "St. Kliment Ohridski ", FMI, Department "Algebra".

I. General description of the submitted materials

1. Details of the application

For participation in the competition, the candidate Maya Miteva Stoyanova presented a list of a total of 13 titles of publications in Bulgarian and foreign scientific journals and scientific forums. Other documents supporting the candidate's achievements are also included: references for fulfilled minimum requirements under Art. 26 of ZRASRB, for the scientometric indicators of the publications, for the citations, for participation in and management of national and international projects, as well as documents reflecting the teaching experience and the management of doctoral students.

The documents submitted for the competition by the candidate comply with the requirements of ZRASRB, PPZRASRB and the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University „St. Kliment Ohridski" (PURPNSZADSU).

I have no notes or comments on the documents.

2. Details for the applicant

Maya Stoyanova received bachelor's and master's degrees in Mathematics with a specialization in Geometry and a second specialty teacher of mathematics at Sofia University „St. Kliment Ohridski" in the period 1987 - 1992. From 2003 to 2006 she was a doctoral student in the department Mathematical Foundations of Informatics at the Institute of Mathematics and Informatics of the Bulgarian Academy of Sciences under the supervision of Prof. Petar Boyvalenkov. In 2009 she defended a dissertation on the topic "On the structure of some spherical codes and designs" and obtained the educational and scientific degree "Doctor" in the scientific field 01.01.02 Algebra and number theory.

Maya Stoyanova's entire professional career is connected with Sofia University "St. Kliment Ohridski" where, immediately after completing his master's degree in 1992, she worked as a part-time assistant until 1999. Since 1999 she has been in a permanent position at Sofia University „St. Kliment Ohridski" and is successively assistant, senior assistant and chief assistant. In 2014 she held the position of associate professor. From 2016 to 2020 she was the head of the Department of Algebra. Since 2017 she has been Deputy Dean of the Faculty of Mathematics and Informatics at Sofia University „St. Kliment Ohridski" and is responsible for research, projects and international activities and doctoral students, and after that for the academic staff.

Assoc. Prof. Stoyanova has 24 published and 1 submitted scientific publications in journals and 22 publications in proceedings of scientific forums. She has given talks at 47 national and international scientific sessions, seminars, conferences, symposia. She has participated in 9 national and international scientific and educational projects and has been a member of the program and/or organizing committees of 8 international and national conferences, scientific sessions and seminars. She has been the scientific supervisor of two successfully defended doctoral students.

3. General characteristics of the scientific works and achievements of the candidate

The original scientific contributions in the works of Maya Stoyanova presented for participation in the competition are in two main directions: codes in Hamming spaces and spectra of orthogonal arrays.

In the first direction, studies have been made regarding the obtaining bounds for the maximum cardinality of codes in polynomial metric spaces and of bounds for energies of codes and designs. Improvements of the derived by Levenstein universal bounds of linear programming for code cardinality are proposed. They lead to obtaining more precise bounds in most of the cases considered in the study. Levenstein's type upper bounds for the cardinality of codes with a fixed maximum and minimum distance and universal lower bounds for the potential energy for codes with a given maximum distance and fixed cardinality are derived. Universal bounds for the potential energy of codes and designs in Hamming spaces have been obtained. A general approach for obtaining bounds for the potential energy of codes in polynomial metric spaces is proposed and upper bounds for the energy of designs in such spaces are introduced.

In the second direction, algorithms have been developed for studying the possible spectra of binary orthogonal arrays with respect to a point in the binary Hamming space, and with their help the non-existence of such arrays with certain parameters has been proved. A method for obtaining the spectra of ternary orthogonal arrays is proposed, which is used to prove the non-existence of such arrays with fixed parameters. Analytical upper bounds for the coveraging radius of orthogonal arrays are derived based on the study of the set of possible spectra of the orthogonal array.

Maya Stoyanova has presented 13 publications for participation in the competition. Six of the publications are in journals with impact factor, 2 are in journals with impact rank, and the remaining publications are referenced in world-renowned databases of scientific information. From the reference for the implementation of the minimum national requirements under art. 2b of the ZRASRB, it is evident that the candidate has excellent achievements, which significantly exceed the required minimum. Therefore, the submitted scientific papers meet the minimum national requirements (under Art. 2b, par. 2 and 3 of ZRASRB) and respectively the additional requirements of Sofia University „St. Kliment Ohridski" for holding the academic position "professor " in scientific field 4. Natural sciences, Mathematics and Informatics, professional field 4.5. Mathematics.

None of the publications with which the candidate participates in the competition has been used in previous procedures for obtaining a scientific degree or for holding an academic position.

There is no legally proven plagiarism in the scientific papers submitted at the competition.

4. Characteristics and evaluation of the teaching activity of the candidate

Maya Stoyanova has extensive teaching experience and has led exercises in all disciplines offered by the Department of Algebra. Later, she was or currently is a lecturer of the courses in Linear Algebra and Analytical Geometry, Linear Algebra, Higher Algebra, Algebra and the elective course Selected Chapters in Algebra. She has also prepared an elective course Codes and Designs in Polynomial Metric Spaces, directly related to her research interests. Lecture notes for students have been prepared and are constantly updated for the courses. Assoc. Prof. Stoyanova is able to clearly and accurately present the study material and to motivate her students for independent and in-depth work. Simultaneously with her work as a teacher, Maya Stoyanova advises and supports the professional development of her assistants.

5. Content analysis of the scientific and scientific-applied achievements of the candidate contained in the materials for participation in the competition

The works submitted for participation in the competition have significant scientific contributions related to the expansion and enrichment of existing knowledge in the two main areas in which Maya Stoyanova has worked. New bounds have been derived and existing bounds for the cardinality of codes and designs with certain properties have been improved, and universal bounds for the potential energy of codes and designs have been obtained. New approaches have been proposed and algorithms for studying orthogonal arrays have been developed. Specific results have been obtained for some of the main characteristics of orthogonal arrays or the non-existence of those with fixed parameters has been proved.

The results obtained in the first direction, in which Maya Stoyanova worked - codes in Hamming spaces, are published in the works with numbers **1, 2, 4, 7, 10** and **11** from the list of publications for participation in the competition.

Linear programming bounds for the cardinality of a code were first introduced by Delsart. Later, Levenstein derived universal linear programming bounds for this code parameter. McEllis also has obtained results for the linear programming bounds in the binary case. In **2**, improvements of the Levenstein's bounds in q-ary Hamming spaces are described. The improved bounds have the advantages of being easily deduced and allowing analytical investigation to a certain extent. Generalizations and q-ary analogs of the McEllis bound are derived. The approach used has been shown to be as good as full linear programming, but offers faster calculations. In a table are systematized the parameters of the codes, which, if they existed, would reach the obtained new limits.

In **10**, universal upper bounds for the maximum cardinality of a spherical code and the related lower bounds for their minimum potential energies are studied. A hypothesis about the optimality of the Levenstein's bounds for spherical codes is presented and it is shown that it is true under certain initial constraints. Necessary conditions for the validity of Levenstein-type bounds for q-ary codes with fixed minimum and maximum distances are considered. The paper describes all cases for codes up to lengths 36 and alphabet size q = 2, 3, 4, for which these conditions are met. It is stated that results for codes with longer lengths and size of the alphabet are also available and they can be obtained from the authors upon request.

In **4**, universal lower bounds which are optimal for a large class of potential functions for the potential energy of codes and designs in Hamming spaces are proved. Three ways to improve these bounds are described - by using the discrete structure of the scalar product, higher degree polynomials, or information about the structure of the considered codes and designs. Specific examples of upper bounds for codes and designs in the binary Hamming space are given.

The connection between the problem of finding upper bounds for the maximum cardinality of codes and lower bounds for the minimum cardinality of τ designs is expanded by one of its characteristics - finding universal lower bounds for code energies in polynomial metric spaces in **7**. Tests are presented on whether these universal lower bounds can be improved in larger spaces. For the case of Euclidean spheres and binary Hamming space, asymptotic results are obtained for the universal lower bounds in the case when the cardinality and dimension of the space increase in a certain ratio.

Upper bounds for the energy of designs in polynomial metric spaces and the energy of codes with a given minimum distance are also introduced.

In **1**, linear programming techniques are used to derive upper bounds for the cardinality of codes with a given minimum and maximum distance and for universal lower bounds for the potential energy of codes with fixed maximum distance and cardinality, and in **11** such bounds are derived for the case of absolutely monotonous potentials. In **1** necessary and sufficient conditions for the optimality of the derived limits are also presented and codes that would reach these limits are described.

Spectra of orthogonal arrays is the second direction, in which are the results of the works of Maya Stoyanova, and they are published in the works with numbers **3, 5, 6, 8, 9, 12** and **13** from the list of publications for participation in the competition.

Orthogonal arrays were introduced in 1946 by Rao. Due to their various practical applications, their rich combinatorial structure and their connection with the finite fields, geometry and error control codes, they are the subject of numerous scientific studies using techniques from different fields of mathematics. However, there still are many open questions related to the existence, classification and calculation of basic parameters of these arrays. The works from the second group used the approach proposed by Delsart for calculating the weight distributions of orthogonal arrays by solving a system of linear equations of a certain type. In order to reduce the number of possible weight distributions, it is further checked whether certain relations between the weight distributions of the studied orthogonal array and some of its derivatives are fulfilled.

This method is applied in **13** to prove the non-existence of (8, 12, 1536) orthogonal array and as a consequence of all orthogonal arrays with parameters (n, $n + 4$, 6.2^{n+4}) for any integer $n \geq 8$. Using a similar approach, in **12** constraints that reduce the possibilities for the spectra of (4, 9, 96) orthogonal arrays with minimum distance 1 are obtained.

In **8**, combinatorial algorithms are proposed for determination of possible spectra of binary orthogonal arrays with respect to an internal or external point for an array using (similar to those from works **12** and **13**) connections with arrays derived from the orthogonal array under consideration. The developed algorithms prove the non-existence of binary orthogonal arrays with parameters (4, 9, 96), (5, 10, 192), (4, 10, 112), (5, 11, 224), (4, 11, 112) and (5, 12, 234). The approach proposed in **8** is extended in **3** by considering a larger collection of derivatives of a particular orthogonal array to obtain constraints on the spectrum of its possible distances and thus proving the nonexistance of binary orthogonal arrays (4, 9, 112) and (5, 10, 224).

Polynomial and combinatorial techniques for determining the distribution of possible distances in a ternary orthogonal array with fixed parameters are applied in **5** and **6**. An algorithm for determining possible distances based on a result obtained in a recent work of Nikolai Manev has been developed. The non-existence of the ternary orthogonal arrays (3, 16, 108) and (3, 17, 108) has been proved. Results have been obtained for the structure of ternary orthogonal arrays (3, 15, 108) and (3, 16, 1458), which may be useful in the construction of orthogonal arrays with these parameters.

In **9**, two analytical upper bounds for the covering radius of an orthogonal array, depending on its basic parameters, are derived. It is also shown that when the basic parameters of the orthogonal array satisfy certain conditions, the upper bound for the covering radius is reduced by one.

All publications submitted by Maya Stoyanova for participation in the competition are co-authored. According to the attached declarations, the contribution of the candidate is completely equal to that of the other co-authors. There are 13 citations, which carry 104 points for the required 100.

6. Critical remarks and recommendations

I have no critical remarks or recommendations.

7. Personal impressions of the candidate

I have known Maya Stoyanova since the time she started attending the National Seminar on Coding Theory "Professor Stefan Dodunekov". I had the opportunity to follow her successful growth as a scientist, thanks to her perseverance, erudition and strong motivation to work. She is a responsive, correct and well-meaning colleague, with whom it is easy and pleasant to communicate. In recent years she has gained significant managerial and administrative experience, which makes her a complete professional in the field of science and education.

8. Conclusion on the application

After getting acquainted with the materials and scientific works presented in the competition and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I **confirm** that the scientific achievements of Maya Stoyanova meet the requirements of ZRASRB, the Regulations for its application and the relevant Regulations of Sofia University "St. Kliment Ohridski” for holding the academic position “professor ” in the scientific field and professional direction of the competition. In particular, the applicant meets the minimum national requirements in the professional field 4.5. Mathematics and no plagiarism has been established in the scientific papers submitted at the competition.

I give my **positive** assessment of the candidacy.

II. GENERAL CONCLUSION

Based on the above, I **recommend** to the esteemed scientific jury to propose to the competent for the selection authority of the Faculty of Mathematics and Informatics at Sofia University „St.

Kliment Ohridski" to choose Maya Stoyanova to take the academic position "professor" in the professional field 4.5. Mathematics (Algebra, Coding Theory and Applications).

11.11. 2021 Reviewer: ....

(Prof. Dr. Sci. Tsonka Baicheva)