REER REVIEW
for the competition for the academic position "Professor"
in the Professional Field 4.5 Mathematics (Algebra, Coding Theory and Applications),
for the needs of the Sofia University "St. Kliment Ohridski"
Faculty of Mathematics and Informatics (FMI of SU),
announced in Newspaper of State, No. 63 of July 30, 2021
and at the Internet pages of FMI and SU

The peer review is written by **Prof. D.Sci. Vesselin Stoyanov Drensky, Full Member of the Bulgarian Academy of Sciences**, working at the Institute of Mathematics and Informatics of the Bulgarian Academy of Sciences, Professional Field 4.5 Mathematics, as a member of the Scientific Jury for the competition by Order No. РД-38-475/28.09.2021 of the Rector of the Sofia University.

The only applicant who has applied for the position is

Assoc. Prof. Ph.D. Maya Miteva Stoyanova from the Department of Algebra at the Faculty of Mathematics and Informatics of the Sofia University "St. Kliment Ohridski".

I. Description of the presented documents

1. Information about the documentation

The documentation presented by the applicant is in accordance with the requirements of the law and the accompanying rules of the Sofia University.

The applicant for the position Assoc. Prof. Ph.D. Maya Miteva Stoyanova participates in the competition with 13 publications in Bulgarian and foreign scientific issues. She has also added 16 other documents which concern: the announcement for the competition; the statement that she wants to apply for the position; CV, diplomas for M.Sci., Ph.D., and Assoc. Professorship; documents confirming her position at the University; documents confirming the supervision of Master and Ph.D. students and her participation in program and organizing committees of conferences; proofs that she covers the minimal scientific requirements of the law for the position; data for the scientific activity of the applicant which we shall comment below.

2. Information for the applicant

The applicant Assoc. Prof. Stoyanova started her scientific career as a Master student in geometry at the FMI of SU and defended her Master thesis under the supervision of Prof. D.Sci. Grozio Stanilov. In the same time she received the qualification of a high school teacher in mathematics. Then she worked as a teacher in mathematics in Technical High School (now Professional High School) in Electrical Engineering and Automation "Kirov" and at the same time was a part-time Assistant Professor in geometry at the FMI of Sofia University. At that time she started her first research in the field of geometry, published in two papers in the Proceedings of the Spring Conference of the Union of Bulgarian Mathematicians. Later she became successively Assistant Professor, Senior Assistant Professor and Chief Assistant Professor in algebra at the Department of Algebra at the FMI of Sofia University. She radically changed her scientific interests and defended her Ph.D. thesis under the supervision of Prof. D.Sci. Peter Boyvalenkov. Later she became an Associate Professor in the professional field 4.5. Mathematics (Algebra and Applications) in the Department of Algebra, where she still works today. She was the head of the department, and is currently the Deputy Dean of FMI responsible for the "Academic Staff" department.

3. General characteristic of the scientific work and achievements of the applicant

After becoming an Assistant Professor in the Department of Algebra at FMI, the main scientific interests of Assoc. Prof. Stoyanova are in the field of spherical codes and in particular

of spherical designs. This is a classical but still actively developed topic - the study of various spherical codes in finite dimensional Euclidean spaces. There are established traditions in this field in Bulgaria, and Assoc. Prof. Stoyanova is a member of the team of Bulgarian mathematicians actively working in the field. Spherical codes are finite sets of points on a unit sphere in the n-dimensional Euclidean space. One of the main problems of the theory is to find (or at least to estimate) the maximal power of a code with a given minimal distance (or, equivalently, with a given maximal scalar product) between the pairwise different vertices. The problem under consideration originates from the well-known classical problem of finding Newton's kissing numbers, i.e. the maximal number of non-intersecting spheres of radius 1 touching simultaneously the unit sphere in the n-dimensional Euclidean space. Spherical τ-designs were introduced by Delsarte, Goethals, and Seidel in 1977. These are spherical codes for which the integral over the sphere of an arbitrary polynomial of degree $\leq \tau$ is equal to the arithmetic mean of the values of the polynomial at the points of the code. One of the main problems for spherical designs is, with a fixed dimension n and strength τ, to find a lower bound for the power (the number of points) of the spherical design. Another main problem is for a given power to establish the existence (or non-existence) of a spherical design with given parameters n and τ. Problems of this type are studied both for specific parameters and asymptotically, when the dimension n tends to infinity. Apart from purely theoretical interest, spherical codes and designs are also studied because they have numerous applications. It is encoded in the very definition of spherical designs the possibility of using them to integrate polynomials of a certain degree. In addition, they find applications in coding theory, for example in the study of the reliability function for a Gaussian channel with limited signal strength. After her habilitation, Assoc. Prof. Stoyanova expanded her scientific interests and began to work actively in two new areas – codes in Hamming spaces and spectra of orthogonal arrays, where she continues to apply successfully the developed methods of the theory of spherical codes. She is the author of 47 scientific publications, of which 24 are in journals, 22 in proceedings of national and international conferences, and one paper is submitted for publication, 3 of these papers have the status of studies. Of the papers, 1 is without coauthors, 1 is with the supervisor of her Master thesis Prof. D.Sci. Grozio Stanilov, and the other joint papers are in the field of the competition. We shall especially mention the long-term cooperation of Assoc. Prof. Stoyanova with her scientific supervisor Prof. D.Sci. Peter Boyvalenkov, which continues today. He is not a coauthor of only 7 of the 47 publications of Assoc. Prof. Stoyanova. A special place in this cooperation has the participation of Assoc. Prof. Stoyanova in the group consisting of Peter Boyvalenkov, Peter Dragnev, Douglas Hardin and Ed Saff (a foreign member of BAS), with whom she has 16 joint publications. The coauthors of the other 13 joint papers with Peter Boyvalenkov are Hristina Kulina (in 6 of the papers), Silvia Boumova (in 5 of the papers), Tanya Marinova (in 4 papers), Danyo Danev, Alexander Barg and Mila Sukalinska (with one paper each). The other 5 papers are coauthored by Silvia Boumova, Tanya Marinova (in 4 of the cases) and Tedis Ramaj (in 3 articles). According to the number of coauthors, the distribution of the articles is as follows: with 1 coauthor – 13, with 2 coauthors – 11, with 3 coauthors – 6 and with 4 coauthors – 16. I believe that in this case the joint papers are a positive fact because the investigations are in the meeting point of several areas of mathematics and computer science. Such collaboration increases the efficiency of research, allows to use methods from different fields and shows the ability to work in a team. Personally, I appreciate the ability of successful teamwork and research at the meeting point of several areas. But I would recommend Assoc. Prof. Stoyanova to start writing also papers without coauthors, which would not only improve her image in the mathematical community in Bulgaria and abroad, but would also show a higher degree of scientific maturity. Of the papers published in journals 17 have an impact factor (3 in quartile Q1, 6 in quartile Q2 and 4 in quartiles Q3 and Q4), and 21 have impact rank (SJR): 6 in Q1, 10 in Q2, 4 in Q3, and 1 paper in conference proceedings has an impact rank.

Assoc. Prof. Stoyanova has presented a list of 47 talks at conferences and seminars at home and abroad (in Austria, Bulgaria, China, Cuba, Greece, Russia, Spain, Sweden, Turkey, USA, etc.). She has participated in numerous research projects funded by Bulgarian and foreign institutions, and in several of them she has been the leader or the coordinator of one of the tasks. She has been a member of program and organizing committees of 8 conferences, at one of them she is the chairperson of the program committee, and one of the conferences is in Russia. Assoc. Prof. Stoyanova has been a referee of papers submitted to national and respectable foreign journals, as well as has written reviews for mathematical databases.

It can be concluded from the applied documentation that:

a) The scientific publications satisfy the minimal requirements of the law and the accompanying rules of the Sofia University for the academic position "Professor" in the scientific field of the competition. With a minimal requirement of 550 points, the applicant has submitted evidence of 781 points, which exceeds by 46% the requirements for the groups of indicators C, D, E and F;

b) The scientific publications submitted for the completion have not been used in previous applications;

c) No plagiarism has been established in the presented for the competition works.

4. **Characteristics and evaluation of the teaching activity of the applicant**

It can be seen from the documentation for the competition that Assoc. Prof. Stoyanova has a very successful teaching work. At the beginning of her career she had seminars in geometric disciplines, and after joining the Department of Algebra she had seminars and lectures in all major algebraic disciplines at the FMI. She has also read courses in Master's programs in mathematics and computer science, as well as lectures in English. For many of the master's courses she has made lecture notes, which are periodically updated on the department's website. I would recommend Assoc. Prof. Stoyanova to publish some of the notes of her courses not only in electronic media, but also as textbooks, for example in the Publishing House of Sofia University. Assoc. Prof. Stoyanova was an advisor of one Master and two Ph.D. students (one of them from Albania) who defended successfully their theses. I do not have direct observations of her teaching activities, but I have attended her talks several times (including the predefense of her Ph.D. thesis). Her talks have always been very well prepared and presented at a good scientific level.

5. Analysis of the scientific and scientific-applied achievements of the applicant contained in the documents and publications presented for the competition

Assoc. Prof. Stoyanova has presented for the competition 13 papers: 6 have an impact factor (1 in Q1, 2 in Q2, 1 in Q3 and 2 in Q4) and 8 have an impact rank (1 in Q1, 4 in Q2, 2 in Q3 and one paper in proceedings with SJR). Of the papers 5 are joint with Boyvalenkov, Dragnev, Hardin and Saff, 2 are with Boyvalenkov and Kulina, 2 with Boumova and Ramaj, 1 with Boyvalenkov and Danev, 1 with Boyvalenkov and Marinova, 1 with Marinova and 1 with Boumova, Marinova and Ramaj. For all papers there are declarations of the coauthors that they were written with equal participation of all coauthors. The results are in two directions: codes in Hamming spaces and spectra of orthogonal arrays.

Codes in Hamming Spaces. This group consists of the papers with numbers 1, 2, 4, 7, 10 and 11 from the list of publications submitted for participation in the competition. They were published in the period 2017-2021. One of the papers is joint with Boyvalenkov and Danev, and the others are with Boyvalenkov, Dragnev, Hardin and Saff. The Hamming distance takes into account the difference between the words of fixed length above a finite alphabet. This allows the introduction of a scalar product that transforms the Hamming space into a polynomial metric space. One of the most important problems in coding theory is to find the maximal power of the code with a fixed length of the words and fixed minimal distance between them

and the minimal power of the design in an n-dimensional Hamming space over an alphabet with q elements. With a given potential (a function h: $[-1,1] \to (0, \infty)$) the potential energy of a configuration in space can be defined. The main contributions of the applicant are obtaining new and improving known bounds for the power of codes and designs with given properties, as well as obtaining universal bounds for the potential energy of the configuration. The main tool in the papers is the Levenshtein approach based on methods of linear programming which is not only used but also improved. In [2] improvements of the Levenshtein bounds are obtained. New bounds are obtained in the first considered cases and the speed of the calculations is compared with the speed in the existing methods. The parameters of hypothetically existing codes that reach the found bounds are given in a tabular form. Levenshtein-type upper bounds for the power of codes with a given minimal and maximal distance and universal lower limits of potential energy are obtained in [1]. The spectra of the codes that reach the bounds are studied. In [4] a unified approach has been developed for the study and obtaining of universal energy bounds, which are valid for a large class of potential functions. In [7] and [11] a general approach for obtaining bounds for the potential energy in polynomial metric spaces is presented. Again, methods of linear programming are used. The obtained universal bounds can be applied to a large class of cases – to Euclidean spheres, in infinite projective spaces, in Hamming spaces and others. It is shown that there are many meeting points with the results of Levenshtein. Finally, a new technique is developed in [10] to test the conjecture of the authors about the optimality of the Levenshtein bounds for spherical codes and it is established that the conjecture is true under some natural restrictions. Experiments are performed for lengths not exceeding 36 and for alphabets with not more than 4 elements and all cases are found in which the conditions obtained in the paper are satisfied.

Spectra of orthogonal arrays. This group consists of papers with numbers 5, 6, 8, 9, 12 and 13. They were published in the period 2013-2021: 2 are joint with Boyvalenkov and Kulina; 2 with Boumova and Ramaj, 1 with Boyvalenkov and Marinova, 1 with Marinova, 1 with Boumova, Marinova and Ramaj. Orthogonal arrays are matrices with entries in a finite alphabet with the following property. If we choose randomly a fixed number of columns and consider the rows of the obtained smaller matrix as words, then all words of this length appear the same number of times. Orthogonal arrays are important combinatorial objects that find numerous applications – in the planning of experiments in statistics, in cryptography, in computer science and others. To prove the existence and for the classification of orthogonal arrays with given parameters it is important to know their spectra. Methods are known for generating all possible spectra of orthogonal arrays with given parameters. The presented papers combine combinatorial methods typical for the study of orthogonal arrays with polynomial techniques from design theory and find connections between the spectra of a given orthogonal array and other related with it orthogonal arrays. The application of these techniques essentially reduces the possibilities for the spectra of the considered arrays. As a consequence, the non-existence of arrays with given parameters or strong restrictions of the properties of the arrays are established. In [13], [8] and [3] the non-existence of binary arrays with given parameters is proved, including the first ones for which this was not known. The results of [8] allow to reduce drastically the number of possible spectra, which can be useful in classifying arrays with given parameters. In [12] binary arrays are considered, which were assumed to exist by other authors. Again restrictions on their properties and their structure are obtained. Ternary arrays are studied in [6] and [5]. Again, restrictions on their spectra are obtained. As an application the conjecture is confirmed that one of these arrays does not exist. The non-existence of another array is also established. As a consequence of the results, lower bounds on the so-called minimum possible index are given. Using analytical methods in the last publication [9] of this group upper bounds for the covering radius of orthogonal arrays are found and an algorithm for reducing the number of possible spectra is proposed. Under some mild restrictions this reduces

the bounds for the covering radius. The results are illustrated with examples of arrays with a covering radius close to the obtained bounds.

I would characterize the contributions of the applicant as enriching of the existing knowledge, but there are also moments in which conjectures are stated and new research methods are developed. The results are theoretical in their nature, but the objects studied have direct applications. For this reason, it can be expected that the obtained results will find practical applications.

The Hirsch index of Assoc. Prof. Stoyanova in the databases of Web of Science and Scopus is 5. She presented a list of 64 citations of her works, 30 of which are in articles published in journals with impact factor or impact rank. Most of these citations are in publications of prominent foreign mathematicians, and the rest are by Bulgarian authors. I think that the number of citations and the h-index are modest, but after I read the papers submitted for participation in the competition and the titles in the list of all publications, I expect that in the nearest future the papers of the applicant will increase their impact on the area of research and will have new citations.

It makes a very pleasant impression to see the excellent preparation of the documentation for the competition. It is immediately clear which contributions were used in previous procedures and to meet the minimum requirements. In addition, the documentation contains detailed information for the achievements of the applicant in the common databases. The only inaccuracies I found are that the SJR has the paper [2.20] and not [2.22] as stated in the documentation. In addition, the data in IEEE Xplore are for papers [2.16], [2.20], [2.21] and [2.22], and not for [2.18], [2.22], [2.23] and [2.24], as in the documentation.

6. Critical remarks and recommendations

The main critical remarks and recommendations I have (to start publishing also papers without coauthors and to publish some of the lecture notes of the courses she read as textbooks) were made above. In my review for the associate professorship of Assoc. Prof. Stoyanova in 2013, I made the recommendation: “I would recommend the applicant to expand her scientific interests. She has the knowledge and potential to do this. In addition, the ideas and methods at her disposal would find natural application in related fields." Now I can say that the applicant has really expanded the field of her research and successfully applies both the methods mastered and developed then, and a new arsenal of methods.

7. **Personal impressions for the applicant**

I know Assoc. Prof. Stoyanova since she started working in the Department of Algebra at the FMI. My personal impressions are excellent. I would like to emphasize many positive things in her character, such as extreme modesty, integrity, responsiveness, always ready to take responsibility and responsibility in the performance of commitments.

8. Conclusion for the application

After my careful and critical reading of the documentation and the publications presented for the competition and my analysis of their significance and the scientific and scientific-applications contributions **I confirm** that the scientific contributions are sufficient as required by the law and the additional requirements of the Sofia University for the position “Professor” in the scientific field of the competition. In particular, the applicant satisfies the minimal national requirements for the scientific field and there is not a plagiarism in the presented publications for the competition.

I give my **positive** evaluation for the application.

II. CONCLUSION

I r**ecommend** the Scientific Jury to suggest that the Council responsible for the election of the Faculty of Mathematics and Informatics of the Sofia University "St. Kliment Ohridski" to elect Assoc. Prof. Ph.D. Maya Miteva Stoyanova for the academic position "Professor" in the professional field 4.5 Mathematics (Algebra, Coding Theory and Applications).

November 19, 2021 Referee:
(Prof. D.Sci. Vesselin Drensky, Full member of the BAS)