Review

Procedure for receiving educational and scientific degree "Doctor" (PhD)

by

candidate: Konstantin Vasilev Delchev,

dissertation: "Codes and designs in polynomial metric spaces",

Scientific area: 4. Natural Sciences, Mathematics and Informatics,

professional direction: 4.6 Informatics and computer science,

doctor's programme: „Informatics", department Mathematical Foundations of Informatics, Institute of Mathematics and Informatics (IMI), Bulgarian Academy of Sciences (BAS)

This review is prepared by: prof. dr.sci. Peter Gueorguiev Boyvalenkov, Institute of Mathematics and Informatics, BAS, professional direction 4.5 Mathematics, acting as a member of the Scientific Jury according to Order № 48/26.03.2021 г. of the Director of IMI.

1. General characterization of the dissertation and the presented materials

The presented dissertation contains 81 pages as main content, divided into introduction, 4 chapters and list of references with 100 titles, as well as an author's reference, a list of publications related to the work and a list of citations. These parameters correspond to the commonly accepted minimum requirements of a meaningful dissertation A complete set of the remaining necessary documents is also presented.

2. Data and personal impressions for the candidate

Konstantin Delchev has received MSc degree in FMI-SU in 2015. He was enrolled in doctor's programme „Informatics" of IMI-BAS on 01.01.2016. In this programme he worked on investigations of codes and designs with small number of distances on Euclidean sphere and Hamming space using algebraic and combinatorial techniques, including computer use. I am familiar in detail with the field and the work of the candidate. My personal impressions of the work of Delchev are very good.

3. Content analysis of the scientific and applied achievements of the candidate from the dissertation and the related publication in the procedure

The results, presented in the dissertation, concern codes and designs in two classical polynomial metric spaces – the Euclidean sphere and Hamming space. In Chapter 2 the problem for finding the maximal possible cardinality of antipodal spherical codes with few distances is considered together with related classification problems. By using linear programming, proofs

of classical bounds are obtained along with bounds in some specific cases. Results on rationality of the inner products of the optimal codes are proved. Chapter 3 is devoted to obtaining of upper bounds for the energy of spherical designs of relatively small cardnality (i.e., close to the Delsarte-Goethals-Seidel bound). The idea of using Hermite interpolation in the nodes from the graph of the potential which are determined by the zeros of the Delsate-Goethals-Seidel polynomials, turns out successful and leads to bounds which are better that the previously known. An asymptotic form of the new bound is obtained for 2-designs in a process, where the dimension and cardinality tend together to infinity. In Chapters 4 and 5 codes with two distances in Hamming spaces are considered. This problem is classical bu it seems that the nonlinear case was underestimated so far, maybe because of the lack of geometric properties in most cases. Constructions of codes are presented and information for the best codes in a variety of parameters is collected. The first two linear programming bounds are derived and investigated. An application of a classical result of Larman-Rogers-Seidel about spherical codes with two distances is applied in the problem under consideration in order to get good bounds.

The results are well described and the required distinction between known results and these obtained by the author is present. The originality of the obtained results is undoubted and they have deservedly served as a base of already published papers. The work is in classical but still actual field.

4. Approbation of the results

The results from the dissertation are presented at several seminars and international workshops. I was present at a talk by Delchev at the National seminar on Coding Theory and can confirm that he explains the material convincingly and with understanding. The publications which form the base of the dissertation are six – one in Discrete and Computational Geometry (impact factor 0.621 and SJR 0.611 for 2019; Chapter 3 is based on it), one in Problems of Information Transmission (impact factor 0.593 and SJR 0.506 for 2019; Chapter 4 is based on it), one in Discrete Mathematics (impact factor 0.770 and SJR 0.824 for 2019; Chapter 5 is based on it), one in Electronic Notes on Discrete Mathematics (SJR 0.262 for 2017; Chapter 2 is based on it) and one per the proceedings of the international workshops ACCT2018 and ACCT2020 (the second published in IEEE Xplore and indexed in Scopus). There are 4 citations, all in Scopus. Apart from me as supervisor, co-authors are Victor Zinoviev, Dmitrii Zinoviev and Mathieu Jourdain, as the contribution of all authors is equal.

These publications cover the minimum national requirements requirements (art. 2b, par. 2 and 3 of LDAPRB) and, correspondingly, the additional requirements of IMI-BAS for receiving the

educational and scientific degree "doctor" (PhD) in the scientific area and professional direction of the procedure. The results obtained in the dissertation and the related papers do not repeat similar from previous procedures for scientific degrees and academic positions. The documents presented show that not plagiarism is detected in the dissertation and the related papers.

5. Quality of the abstract

The abstract contains 27 pages and fulfills the requirements for preparation of such documents. The results from the dissertation and its content are correctly presented.

6. Critical remarks and recommendations

I do not have critical remarks except for some technical and grammar mistakes. I would recommend the techniques from Chapter 2 to be used for investigation of other classes of spherical codes, for example such with fixed few distances.

7. Conclusion

Having become acquainted with the dissertation 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 Institute of Mathematics and Informatics and Bulgarian Academy of Sciences for acquisition by the candidate of the scientific degree "Doctor" in the Scientific area in the Scientific area "Informatics" and, in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.6. Informatics and Computer Science (Informatics). 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 recommend the Scientific jury to award Konstantin Vasilev Delchev the educational and scientific degree „Doctor" in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.6. Informatics and Computer Science (Informatics).

14.05.2021   Prepared by: ....

(prof. dr.sci. Peter Boyvalenkov)