

## OPINION

on PhD thesis for acquiring of the educational and scientific degree “doctor” (PhD)

**Topic:** „Codes and designs in polynomial metric spaces “

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**Area of higher education:** 4. Natural sciences, mathematics and informatics

**Professional Field:** 4.6. Informatics and computer sciences

**By:** prof. Nikolay Ivanov Yankov, DSc, Shumen University "Bishop Konstantin of Preslav”

I was appointed by order № 48/26.03.2021 of IMI’s director to be a member of this scientific jury and on the first session I was voted to write this opinion. I confirm that I have received all materials for this procedure according to LDASRB (the Law for the development of the academic staff in the Republic of Bulgaria). I do not have information for violation of the procedure, nor I’m aware of plagiarism in the presented PhD thesis.

### 1. PhD student “curriculum vitae”

Konstantin Delchev has a degree of mathematics from Sofia University issued 2015. From December 2015 he was a full doctoral student in “Informatics and computer sciences” studying at section MFI of IMI. According to PhD candidate’s CV he was a member of the teams in 5 scientific projects, 2 for fundamental research funded by Bulgaria’s National Science Fund, and 3 projects from EU’s program Horizon 2020. Unfortunately, in the dissertation, as well as in the attached CV, I did not find a list of reports and participation in conferences and seminars.

### 2. PhD Data

The doctoral studies started on 01.01.2016 for a 3-year period and concluded with the right to defend thesis according to decision by IMI’s scientific board (Protocol № 2/15.02.2019). The preliminary discussion of the dissertation took place on 25.02.2021 at an extended meeting of the MFI. By order of the Director of IMI, a

scientific jury and the date of the defense have been determined. I believe that the procedure is regular and there are no violations.

### **3. Thesis and abstract data**

The PhD thesis has the following structure: introduction (16 pp.), main text (55 pp.) in 4 chapters divided in sections. There is a list of candidate's contributions, a list of 100 references, a list of candidate's publications. I did not find a list of scientific oral talks at conferences and seminars. The thesis meets the requirements of LDASRB and RALDASRB (Rules on the application of the Law for the development of the academic staff in the Republic of Bulgaria), as well as of Regulations on the terms and conditions for acquiring scientific degrees and for holding academic positions in BAS. The abstract adequately reflects the main ideas and significant final results, which are described in the dissertation.

### **4. Scientific contributions**

Chapter 2 focuses on maximal antipodal codes with few distances and the restriction here is, to meet the linear programming bound for their cardinality, meaning they possess the maximum obtainable cardinality for fixed dimension and maximal scalar product. There is a new and more direct proof of a theorem by Barg and U, setting a linear programming bound for equiangular lines. This is a more general result than previously obtained. Antipodal codes with 4 scalar products are considered, the new one here being the scalar product 0. A result is obtained which is analogous to the relative bound of van Lint and Seidel in equiangular lines. The rationality of the parameter  $s$  for the antipodal  $(n, M, s)$ -spherical code with 4 scalar products 1,  $\pm s$ , and 0 meeting the analogue of the relative bound. In the last section of this chapter, codes with 5 scalar products are considered and an analogue of the relative bound is established. Results from this chapter are published in Electronic notes in discrete mathematics.

Chapter 3 is dedicated to upper bounds for the  $h$ -energy of spherical  $\tau$ -designs and the results are published in Discrete and combinatorial geometry. The main result proven here is that spherical designs are energy efficient, i.e. all relatively low power designs have  $h$ -energy in a narrow range. The obtained upper limits are close

to what is known so far and are valid for all absolutely monotonic potentials. Examples and special cases are given as well as tables with upper limits of Newtonian energy.

The next chapter 4 of the dissertation is devoted to codes with two adjacent distances. Using the boundary of the linear programming and the boundary obtained from the bijection  $\mathbb{F}_q^n \rightarrow \mathcal{S}^{n(q-1)-1}$ , upper limits were found for codes with two adjacent distances. Through the described combinatorial constructions, families of codes and individual codes with small parameters are obtained, and the results are set in a table, from which it can be seen that in some cases the new codes reach upper or lower limits.

Codes with two distances  $d$  and  $d+\delta$  were studied in the ice chapter, for small  $\delta$ . A boundary is shown that coincides with that of Helleset-Klove-Levenstein for codes with a certain maximum and minimum distance. Again, the results are obtained using spherical codes and various combinatorial arguments.

I confirm the scientific and applied contributions indicated in the dissertation.

## **5. Publications and participation in scientific forums**

There are 6 papers in the list of publications. All publications have one or more co-authors, and all articles are in peer-reviewed publications. Of the publications 4 are scientific journals, of which 3 have impact factor: Discrete mathematics (IF 0.824), Discrete and computational geometry (IF 0.621), and Problems of information transmission (IF 0.593). One journal has impact rank: Electronic notes in discrete mathematics (SJR 0.262). Two of the articles are in refereed conference proceedings ACCT16 and ACCT20. I believe that the contributions of Konstantin Delchev in all publications is equal to the other co-authors. The number of articles significantly exceeds the requirements of RALDASRB.

## **Opinion, remarks and recommendations**

- a) As I have already noted, there is not a list of participations in conferences and seminars that can be considered as an approbation of the thesis results.
- b) I recommend publishing as separate programs the implementations of the random walk algorithm for codes with two adjacent distances (Section 4.6) and the modification for codes with two close distances.

## 6. Conclusion

This PhD thesis fully meets the requirements established by the LDASRB, as well as the regulations of BAS and IMI, so I confidently suggest to the esteemed scientific jury to vote for the educational and scientific degree "Doctor" to BE ACQUIRED by Konstantin Vasilev Delchev in **Professional Field:** 4.6. Informatics and computer sciences.

Jury member: .....

/prof. Nikolay Yankov, PhD/

26.04.2021