Opinion

On: Finite geometries and codes
Dissertation for the scientific degree "Doctor of Sciences" in
Area of higher education: 4. „Natural Sciences, mathematics and informatics"
Professional area: 4.5 „Mathematics" (Geometry)
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This opinion is prepared and presented on the basis of order № 38-186 from 14.05.2020 of the Rector of Sofia University for appointment of Scientific Jury and the minutes of the first meeting of the Jury conducted on 19.05.2020.

1. **Presentation of the candidate.** Assia Rousseva has completed her secondary school education in 1983 with 35 GRE, Sofia, and higher education (MS) in 1988 with FMI of Sofis University, specialization Geometry. She has defended PhD dissertation in professional area 4.5 (Mathematics) in scientific specialty 01.01.02 Algebra and Number Theory entitled "Arcs in finite projective geometries and applications in coding theory" with SSC in 2005 as a result of PhD procedure in IMI-BAS. She is working in FMI-SU consecutively as assistant, senior assistant, professor assistant and associate professor at present.

2. **Materials presented and preliminary defense.** All required for preliminary defense admission and defense admission materials are presented in FMI in time and correspondingly to the requirements of the Regulations of FMI. The preliminary defense is conducted on 22.04.2020, followed by a positive evaluation for the defense preparadness.

3. **Theme and actuality of the dissertation.** The dissertation is devoted to important problems from the theory of finite geometries which are naturally related to coding theory. The problems under consideration are in two major directions – arcs and blocking sets, as constructions and bound (nonexistence results) are obtained for arcs and constructions are presented for blocking sets. These themes are actual and this is proved by the works from other authors in the same area and from the citations. The list of references includes 201 titles of other authors, classical and recent, which means that the candidate is well educated in the area.

4. **Methodology of the investigation.** The author uses both classical and ad hoc developed (with coauthors, when applicable) algebraic, geometric and combinatorial approaches. The constructions are based on skillful dealing with existing objects and their structure, as a good example is the proposed new geometric approach for extensions of arcs. The proofs show the difficulties surmounted. The exposition in Chapter 2 is suitable for university and PhD students to be introduced in the thematic.

5. **Contents and results of the dissertation.** The dissertation has 182 standard pages and consists of introduction, four chapters and list of references. In Chapter 2 the main definitions and notations, along with results, are presented as much as they are necessary for the further exposition. The main results are subject to the next three chapters.
   In Chapter 3 the problem for attaining the Griesmer bound along with the description of attaining codes is considered. This problem and its related is investigated in coding theory since its establishment as separate area. Nontrivial upper bounds for the function $t_q(k)$ – the maximal deviation of an optimal code from the Griesmer bound are obtained, as one

of the main results is a general bound which leads to a particular answer (Theorem 3.18) of a question of Ball. Concrete problems from the „periphery" of the open cases are investigated resulting in finding several exact values of the optimal length of a linear code with fixed dimension and minimum distance. In Chapter 4 a new (geometric) approach for the problem of extension of arcs and its relation to codes extension is proposed and investigated and (t mod q) arcs are introduced. The main results are Theorem 4.3, describing sufficient conditions for extendability, the structural Theorems 4.12 and 4.15, and the characterizing Theorem 4.19. The relation with codes is subject of investigation in the last two sections of the chapter, as in section 4.4 general results are obtained and in section applications are considered. In Chapter a general construction (Theorem 5.6) of affine blocking sets by relation with arcs in projective geometries is proposed and investigated. Special cases of this construction give blocking sets which attain the Bruen bound as well as sets which are not attaining but still optimal. Concrete applications are considered to give new record results.

6. **Contributions of the dissertation.** The "autoreferat" presents a reference to the scientific contributions in the dissertation. I accept this reference and completely agree with its claims. The results obtained and their number meet, in my opinion, the high standards of FMI-SU for a DrSci dissertation.

7. **Publications and approbation related to the dissertation.** The dissertation is based on 7 papers, published as follows:
   - 5 papers in impact factor journals;
   - 2 papers in Annual of Sofia University (indexed in ZBL and MR).
   The impact factor journals are prestigious and highly valued in the field of coding theory. The minimal national requirements are satisfied.
   The work of Assia Rousseva is also approbated many times by talks at national and international level. I had been present at such talks this way formed my impression that assoc. prof. Rousseva is able to present well new results and motivation.

8. **Authorship of the results.** The authorship of the publications is as follows: 2 are single-authored and 5 have one-coauthor. I think that the contribution of Rousseva in the joint publications is equal to the contribution of the corresponding co-authors. I have not detected signs of plagiarism.

9. **Conclusion.** The dissertation presented complies with the minimal national requirements, the requirements of the Law for development of academic personnel Republic of Bulgaria and Regulations of BAS and IMI-BAS for applying the Law. The results obtained allow me to propose to the scientific Jury to award the scientific degree „Doctor of sciences", in area of higher education 4. „Natural sciences, mathematics and informatics", professional area 4.5 „Mathematics" (Geometry) to assoc. prof. Assia Rousseva.

Sofia, 09.07.2020   Signature:

Prof. Dr.Sci Peter Boyvalenkov