

REVIEW

on competition for the occupation of the **academic position of "Professor"** by professional direction **4.5. Mathematics**, specialty "Computational mathematics", announced for the needs of the Department "Scientific Computations with Laboratory on 3D Digitization and Microstructure Analysis" in SG No. 21/15.03.2022 with a **single candidate Assoc. Prof. Dr. Stanislav Nikolaev Harizanov**

Prepared the review: **Prof. Dr. Nevena Petrova Ilieva-Litova**, Department "Scientific Computations with Laboratory on 3D Digitization and Microstructure Analysis", Institute of Information and Communication Technologies – BAS, appointed as a member of the scientific jury for conducting the competition by order No. 132/13.05.2022, of the Director of IICT-BAS, in implementation of the decision of the SC of IICT-BAS from Protocol No. 4/27.04.2022 for the approval of a scientific jury.

1. **Brief biographical data about the candidate**

Prof. Stanislav Harizanov started his higher education at the Faculty of Mathematics and Informatics of the Sofia University "St. Kliment Ohridski" majoring in mathematics, and after completing his bachelor's degree, he continued his education in the same major at the International University in Bremen (International University Bremen) in Germany to a master's degree. At the same university, he also defended his dissertation for the educational and scientific degree of doctor under the guidance of the well-known specialist in the field of approximation theory and numerical analysis Prof. Peter Oswald. Even as a bachelor student at FMI and a doctoral student in Bremen, the candidate led exercises in analysis, differential and integral calculus, ordinary differential equations, numerical methods, stochastic processes, etc., but the real beginning of his scientific career was connected with the University of Bremen - research assistant to the project on "Nonlinear Subdivision" of the DFG. This was followed by a post-doctorate at the university and at the branch of the Fraunhofer Institute in Kaiserslautern (Germany), focusing on non-convex optimization and image processing. In 2014, after returning to Bulgaria, the candidate started working at the Institute of Information and Communication Technologies – BAS, as an assistant, and in less than four years rose to the academic position of Associate Professor. Along with the main job, Assoc. Prof. Dr. St. Harizanov is also an associate of the Institute of Mathematics and Informatics – BAS, as well as a part-time lecturer at the FMI of SU "St. Kliment Ohridski". The candidate pays great attention to working with young talents in the field of mathematics and

chairman of the National Commission for 2021/2022 for holding the Mathematics Olympiad, ZMS and PMS for pupils from VIII to XII grades at the Ministry of Education and Science. Assoc. Prof. Dr. Harizanov also has significant scientific and organizational experience as the head of two young-scientists projects (at the BAS and FNI), one project on fundamental scientific research (FNI) and one bilateral project with Austria (FNI), co-organizer and member of the program committees of the international conferences LSSC'19, NSFDE&A'20, LSSC'21 and NSFDE&A'22, member of the Scientific Council of ICT-BAS since 2018, vice-chairman of the "Biomathematics and Scientific Computing" section at the Union of Mathematicians in Bulgaria (UMB) since 2021 and member of the Management Board of the UMB since 2021.

2. General description of the presented materials

To participate in the competition, the candidate has submitted in electronic and paper form all the documents required by the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB) and the specific requirements for the relevant procedure according to the Regulations for the Acquisition of Scientific Degrees and the Occupancy of Academic Positions at ICT-BAS, including scientific curriculum vitae, diploma for the educational and scientific degree "doctor", diploma for academic position "Associate Professor", list of scientific publications submitted for participation in the competition, noticed independent citations, participation in and management of scientific projects, as well as author's reference for the contributions in the submitted for the competition publications. In my opinion, the presented materials are in accordance with the normative requirements, as is the conclusion of the special committee at ICT-BAS, which certified the regularity of the applicant's documents.

To participate in the competition, Assoc. Prof. Dr. Stanislav Harizanov submitted 17 publications – 15 articles in scientific journals or series, one chapter of a book indexed in the scientific databases Clarivate Analytics (Web of Science) and Scopus and one educational material in a series of ICT-BAS – distributed as follows (the points are according to the weighting coefficients accepted in the BAS for scientific direction 4.5 Mathematics) - Table 1.

In accordance with the requirements of the LDASRB and the Regulations for its application, four of the presented publications with a total of 120 points replace the habilitation thesis for the relevant procedure. The publications have not been used in previous proceedings.

Table 1

Publication type	Number	Point/un	Points/category (all)
Q1	5	50	250
Q2	-	40	-
Q3	1	30	30
Q4	-	24	-
SJR	9	20	180
Book chapter	1	15	15
Other/not indexed	1	-	-
Total	17		475

3. General characteristics of the candidate's scientific and applied-scientific activity

Publications submitted for participation in the competition cover a relatively wide range of problems in the field of computational mathematics, reflecting the diverse scientific interests and professional expertise of the applicant. They can be divided into three groups.

The first group of publications is devoted to problems with anomalous diffusion, and here two subgroups of research are distinguished: development and analysis of efficient numerical methods for solving this type of problem and research on near-optimal numerical algorithms for solving large problems with anomalous diffusion. These studies focus the candidate's scientific interests and allow a clear trend in his scientific development to be outlined. Quite naturally, the strongest of the works submitted for participation in the competition are concentrated in this group – four articles in journals in the Q1 quartile and four articles in prestigious scientific series with an impact rank. The researches of this group contain new and significant results both in theoretical and methodological aspects, as well as in the field of numerical experiments.

The second group of publications is defined by the candidate as applications of mathematics in the field of biology, but a more correct definition would be applied research in the field of mathematical biology. In fact, here we are talking about two articles dedicated to the current problem of modeling the course of the Covid-19 pandemic and, in particular, the dynamics of the spread of the disease in Bulgaria, using a time-dependent SEIR model. The third paper in the group is related to image analysis and is an interesting contribution to forensics, with the

development of a methodology for reconstructing soft facial tissues geometry from bone structure data. Articles in this group are impact-ranked.

The third group of publications presents results of optimization studies, and optimization should be considered in different contexts – from a new class of preconditioners with optimal computational complexity, through a comparative analysis of the quality of the parallel implementation of restoration algorithms for digital images contaminated with Poisson noise and model for early detection of anomalies in the operation of a distributed information system using microservice architectures and to the modern field of the Internet of Things, where an optimized solution for the architecture of the network infrastructure in a building is proposed from the point of view of improving its energy efficiency. Articles in this group refer to quartiles Q1 and Q3 (one article each) and two articles in impact-ranked series.

The articles submitted for participation in the competition reflect not only the diverse scientific interests of the candidate, but also his skills for working in a team with colleagues with quite different scientific profiles and background from scientific and research institutes from Bulgaria and abroad. Deliberate information is not presented about the contributions of the individual co-authors, who (with only two exceptions) are between three and five, but in nine of the publications the candidate is the first author, which speaks of his leading contribution to the relevant research. I accept that his contribution to the other eight papers is substantial, given the results they contain and the profile of the other co-authors.

4. Main scientific and applied-scientific contributions of the candidate

Publications from all three groups are essential to form the overall assessment of the applicant's scientific qualities and represent a significant contribution to the respective fields, but in my review I will mainly concentrate on the articles from the first group. As I have already noted, they can be separated into two subgroups, each containing four publications, and the ninth publication – article 1 – can be assigned to both subgroups.

(1a) Efficient Numerical Methods for Solving Anomalous Diffusion Problems: Publications 1, 2, 5, 7, and 14.

- New quasi-optimal methods and algorithms have been developed for the numerical solution of problems with a fractional degree of the diffusion operator and homogeneous Dirichlet boundary conditions, based on the best uniform rational approximation (BURA) of the function t^α in the unit interval $[0, 1]$.

- A generalization of the model for a diffusion-reaction type problem and a non-stationary parabolic problem with fractional diffusion is considered: in both cases, an additional linear term $q \geq 0$ is present in the model, having the meaning of reaction, resp. of an inversely proportional to the time step term. A detailed theoretical analysis of the properties of the corresponding BURA element was carried out. An inverse proportionality was found between the magnitude of q and the approximation error.
- Different from classical boundary conditions are considered: inhomogeneous Dirichlet boundary conditions for a model one-dimensional problem and homogeneous Neumann-type boundary conditions. For the latter, the exponential convergence of the proposed method is shown theoretically and through numerical experiments depending on the degree of BURA, and the applicability of BURA methods to problems in a three-dimensional domain with complex geometry is demonstrated.
- An alternative efficient method for solving the classical problem is proposed, in which the BURA element is replaced by a low-rank approximation, allowing a significant reduction of the required computer memory.

(1b) *Near-Optimal Numerical Algorithms for Solving Large Anomalous Diffusion Problems: Publications 1, 3, 4, 11, and 17.*

- Based on a comparative analysis of the effectiveness of different numerical methods for solving large problems with anomalous diffusion, the superiority of the BURA approaches proposed by the candidate and co-authors is shown.
- Possibilities to improve the performance of the algorithm through BURA modifications where the best approximation element is replaced by an uniform rational approximation element (URA) are explored.
- 160 tables containing relevant coefficients, zeros, poles, extreme points of the error function, decomposition into elementary fractions of the BURA- and URA-elements and other practically useful quantities are documented (as an educational aid).
- Through theoretical and experimental analysis, the significantly improved computational efficiency of two modified (truncated) versions of the BURA method, which use a truncated decomposition of the BURA element into a sum or product of elementary fractions, is shown.

- A direct relationship is derived between the order of the poles that can be truncated and the condition number of the stiffness matrix for the classical formulation of the problem: fractional Laplace operator and homogeneous Dirichlet boundary conditions.

I will also briefly touch on the main contributions from the other two groups of publications.

(2) *Applied Research in Mathematical Biology: Publications 9, 10, and 15.*

- Based on a time-dependent inverse SEIR model, a mathematical model of the dynamics of the spread of COVID-19 on the territory of the Republic of Bulgaria has been developed. What is original in the approach is the determination of the model parameters, as well as the consideration of the influence of the mass vaccination process. The two-week forecast is more successful when applying strict restrictive measures.
- A hybrid model was developed for calculating the 'skull-skin' distances, based on semi-infinite cylinders with a fixed radius, and varying the value of this parameter in different regions of the skull allows a balance between the projective and Hausdorff metrics traditionally used in facial reconstruction .

(3) *Optimization Research: Publications 6, 8, 12, and 13.*

- It is shown that replacing the inverse fractional Laplace operator with its BURA counterpart after discretization leads to a new class of preconditioners for the interface blocks in solving high-dimensional coupled problems that have optimal computational complexity $O(N)$ (where N is the number of degrees of freedom).
- An experimental comparative analysis of the quality of the parallel implementation of two algorithms for the restoration of digital images contaminated with Poisson noise was carried out.
- Numerical experiments were carried out to optimize the control sensor network infrastructure, allowing optimization of energy costs (energy efficiency) of buildings.
- The concept of microservice architecture was used to develop a model of early detection of anomalies in the operation of a distributed information system.

5. Scientific indicators

The materials for the competition include a reference of compliance of the presented scientific publications and citations with the requirements of the LDASRB and the Regulations for its application and a candidate's reference of the scientific and applied-scientific contributions. These references do not cover the entire scientific activity of the candidate, but a reference to the scientific databases Clarivate Analytics (Web of Science) and Scopus makes it possible to follow his scientific development, to distinguish clear thematic lines and the gradation of research in them.

The researches of Assoc. Prof. Dr. St. Harizanov are met with great interest by the scientific community, as evidenced by the cited data on independent citations, both of the publications submitted for the competition and of his other scientific works. According to Clarivate Analytics, its h-index is 6 (citations in indexed publications only), and according to Google Scholar, where self-citations are not excluded, but citations in non-indexed in Web of Science and Scopus publications are also counted, it is 10.

The publications and independent citations submitted for this competition have not been used in other procedures and the points corresponding to them according to the above Regulations cover with a large reserve the minimum national requirements for professional direction 4.5. Mathematics. The specific (increased compared to the national) requirements of IICT-BAS for occupying the academic position of "Professor" in this scientific field have also been met (see Table 2).

Table 2

Group of indicators	Requirements/IICT-BAS	Candidate's data
A	50	50
Б	-	-
B	100	120
Г	260	355
Д	70	240
E	20	383

6. Critical remarks

Scientific contributions could be more clearly worded, whereas in their current form they are more of a summary. Article 16 did not find a place in the author's reference for the candidate's scientific and scientific-applied contributions. These remarks, however, in no way affect my overall positive assessment of the candidate.

7. Personal impressions

I have known Prof. Stanislav Harizanov since the beginning of 2015, when I started working at IICT-BAN. He was still only a senior assistant then, but he already stood out as a well-rounded young researcher. From the very beginning, I was impressed by his rich mathematical erudition, his ability to quickly navigate a new issue, identify critical moments in a given discussion, generate solutions and constructive ideas. The many workshops, conference presentations and private discussions over the years allow me to confidently define him as one of the brightest representatives of the young generation of applied mathematicians in our country. I really admire Stanislav's enthusiasm for working with our Olympians, which consumes a lot of time and energy, and also for promoting mathematics through various initiatives, including the Researchers Night, Open Days, etc. Last but not least, I would like to mention his remarkable work ability, his ability to work well under pressure, his collegiality and positive disposition, with a fresh sense of humor capable of brightening even the most tense atmosphere.

8. Conclusion

The presented materials unequivocally prove the high professionalism of Assoc. Prof. Dr. Stanislav Harizanov, the importance of his scientific achievements in the field of computational mathematics and their high evaluation by the scientific community. His diverse research interests are a guarantee of significant potential for further development and willingness to take on new challenges.

The requirements laid down in the Law on the Development of the Academic Staff for candidates for the academic position of "Professor", as well as the specific requirements for this position of IICT-BAS, are fulfilled by the candidate with a large reserve.

I am convinced that Assoc. Prof. Dr. Stanislav Harizanov is worthy to occupy the academic position of "Professor" in professional direction 4.5. Mathematics, specialty "Computational Mathematics", and I propose that the Scientific Jury recommend to the highly respected Scientific Council to take a positive decision on his candidacy for the competition announced for this position for the needs of the Department "Scientific Computations with Laboratory on 3D Digitization and Microstructure Analysis" at the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences.

13.07.2022

Reviewer:

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