

## 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. 103/12.12.2023 with a **single candidate Assoc. Prof. Dr. Ivan Georgiev Georgiev**

Prepared the review: **Prof. Dr. Nevena 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. 40/09.02.2024, of the Director of IICT-BAS, in implementation of the decision of the SC of IICT-BAS from Protocol No. 1/24.01.2024 for the approval of a scientific jury.

### 1. Brief biographical data about the candidate

Associate Professor Dr. Ivan G. Georgiev completed his higher education in 1999 at the Faculty of Mathematics and Informatics (FMI) at Sofia University "St. Kliment Ohridski" with a degree in Mathematics. After graduating, he entered a doctoral program at the Institute of Parallel Processing, IPP-BAS (2000-2002). In 2003, he started working as a mathematician at the Institute of Mathematics and Informatics, IMI-BAS. At the same time, he also conducted exercises in numerical methods at FMI (2003, 2004, and 2007). In 2007, he obtained the educational and scientific degree of Doctor of Computational Mathematics under the supervision of (then) Senior Research Scientist I Deg. DrSci Svetozar Margenov with a thesis on "Iterative Methods for Nonconforming Finite Elements." For his research, Assoc. Prof. I. Georgiev was awarded the "Ivan Evstatiev Geshov" Prize for Young Scientists by the Bulgarian Academy of Sciences (2006). His teaching activities also include supervising two defended diploma theses at FMI, Sofia University "St. Kliment Ohridski." He pursued a postdoctoral fellowship at the Johann Radon Institute for Computational and Applied Mathematics of the Austrian Academy of Sciences in Linz, Austria (38 months in the period from 2008 to 2013). In 2015, Dr. Ivan G. Georgiev was appointed as an Associate Professor at the Institute of Information and Communication Technologies, IICT-BAS. Since 2021, he has been the Scientific Secretary of the Information and Communication Sciences and Technologies Division of the Bulgarian Academy of Sciences.

Assoc. Prof. Ivan G. Georgiev possesses significant experience in project-oriented scientific research, having participated in four national projects and led four international scientific projects. His scientific and organizational qualities are evidenced by his leadership role in two major national scientific projects: the National Interdisciplinary Research E-Infrastructure for



Resources and Technologies for Bulgarian Linguistic and Cultural Heritage, integrated within the European infrastructures CLARIN and DARIAH (CLaDA-BG) (member of the Management Board), and the Center of Excellence in Informatics and Information and Communication Technologies, BG05M2OP001-1.001-00 (head of the Laboratory for 3D Digitization and Microstructural Analysis), as well as one international project – HORIZON-WIDERA-2022-ACCESS-04, Grant Agreement: 101087146, BCThubs: Blue Culture Technology Excellence Hubs in EU Widening Member States (team leader at IICT). Assoc. Prof. I. Georgiev is a co-organizer and member of the program committees of several international scientific forums, including LSSC (editions 2015, 2017, 2019, 2021, 2023), NSFDE&A (editions 2020 and 2022), NM&A'22, and others. He is a member of the Scientific Council of IICT-BAS, chair of the "Biomathematics and Scientific Computing" section of the Union of Bulgarian Mathematicians since 2016, and chair of the Bulgarian section of SIAM (2019-2022). He has served as a guest editor for seven Springer-Series volumes and one issue of a journal by Elsevier.

## **2. General description of the presented materials**

For participation in the competition, the candidate has submitted all required documents, both electronically and in hard copy, as mandated by the Law on the Development of Academic Staff and the specific requirements for the respective procedure according to the Regulations for the Acquisition of Academic Degrees and Occupying Academic Positions at IICT-BAS. These documents include a scientific autobiography, a doctorate diploma, an official note of the academic position held (Associate Professor), a list of scientific publications submitted for the competition, noted independent citations, and an author's statement regarding contributions to the publications submitted for the competition. In my opinion, the materials presented comply with regulatory requirements, as confirmed by the commission appointed by IICT-BAS, which has verified the regularity of the candidate's documents.

For participation in the competition, Assoc. Prof. Ivan G. Georgiev has presented 21 publications: 18 articles in scientific journals and series indexed in the scientific databases Clarivate Analytics (Web of Science) and Scopus, one article in a series indexed in the ACM Digital Library, and two articles in international publications not indexed in the reference databases for scientific information – Table 1. These publications have not been used in previous procedures.

According to the requirements of the Law on the Development of Academic Staff and its implementing regulations, seven of the submitted publications, totaling 120 points, focus on the theme of applications of scientific computations, including high-performance computing, and the latest tools for 3D digitization, visualization, and prototyping in microstructural analysis of porous and composite materials. These publications substitute for the habilitation work required for the respective procedure.



Table 1

Publication type	Number	Point/un	Points/category (all)
Q1	1	50	50
Q2	1	40	40
SJR	16	20	320
Other/indexed	1	12	12
Other/not indexed	2	-	-
Total	21		302

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

The publications submitted for the competition demonstrate the candidate's scientific focus on developing computational approaches and methods based on large-scale (microstructural) data for conducting modeling studies of complex environments and processes. This is in complete accordance with the theme of the announced competition, "Mathematical Modeling and Application of Mathematics in 3D Digitization and Microstructural Analysis."

The publications can be divided into several groups. I will adhere to the numbering introduced by the candidate (numbers 1 to 22), despite the absence of publication number 1.

The first group of publications represents the candidate's strongest focus. This group includes 13 publications (2-4, 7, 9-14, 16-22) dedicated to issues in the study of porous and composite materials based on images obtained through industrial X-ray computed tomography. These publications cover methods for image segmentation, homogenization strategy for determining the elastic characteristics of specific materials, methods for three-dimensional reconstruction, and specific applications for silicate materials, materials with closed pores, objects with high-density inclusions, and bone samples. The highest-impact publication by the candidate also belongs to this group. These publications serve as a good example of interdisciplinary research involving the development and utilization of complex numerical methods and modern tools for 3D digitization, visualization, and prototyping to address research problems across a wide range of fields.

The second group of publications (11, 12, 18, 19) is related to an important ecosystem problem – the design, study, and utilization of artificial wetlands. These wetlands are one of the possible solutions for treating household wastewater, allowing for the elimination of two main types of pollutants: biochemical oxygen demand and phosphorus concentration. From a computational perspective, this involves simulating fluid flow in a porous medium and



mathematically and computationally modeling the transport processes in this medium. The created computer model has been validated with in silico and real experiments.

Two articles (5 and 6, omitted in the author's statement regarding the candidate's scientific contributions) are dedicated to the study of composite materials. They explore the possibility of enhancing the ductility of typically brittle cement-containing composites by incorporating steel macro- and micro-fibers with a structural function and utilizing non-destructive techniques to investigate the dependence of the modulus of elasticity on the internal structure of the composites.

One publication each (13 and 15, respectively) has been selected as representative of two other research groups: the processing of medical tomographic data (simulation of blood flow using real data on the geometry of blood vessels obtained through computer tomography) and the analysis of possibilities for creating lightweight broadband polymer antenna prototypes through 3D printing and metallization.

The articles submitted for the competition not only reflect the candidate's scientific focus, combined with proficiency in a complex and diverse set of methods and techniques for modeling research and data analysis but also demonstrate his skills in working collaboratively with colleagues from various scientific backgrounds at research institutes in Bulgaria and abroad. Specific information about the contributions of individual co-authors is not provided, although (with only three exceptions) there are between two and five co-authors. However, in 15 of the publications, the candidate is listed as the first, last, or corresponding author, indicating his significant contribution to the respective research. I assume that his contribution to the other six articles is substantial, given the results contained within them and the profile of the other co-authors.

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

The publications submitted for the competition allow for a sufficiently comprehensive understanding of the candidate's scientific qualities and current research interests. The obtained results are original, represent a significant contribution, and deepen knowledge in the respective scientific fields.

I will focus primarily on the results from the first two groups of publications.

##### ***(1a) Studies on Porous and Composite Materials Based on Tomographic Images***

- Two parallel algorithms based on a 2-Laplacian graph model have been proposed, implemented, and validated for biphasic segmentation of 3D images with a fixed number of voxels in the phases;



- An iterative algorithm of the fastest descent type has been proposed, with convergence to the exact solution of the discrete l0 optimization problem for image segmentation using graph Laplacians, allowing for significant improvement in segmentation quality;
- A new approach for grayscale image segmentation using a recurrent neural network has been proposed. Its application to a real task—tomographic imaging of bone—shows improved results for the internal structure of the object;
- A 3D hybrid numerical-experimental strategy for homogenization to determine the elastic characteristics of materials with closed cells has been developed, using data from micro-computed tomography (micro-CT) and instrumental indentation testing (IIT);
- An algorithm for numerical homogenization of anisotropic linear elastic materials with highly heterogeneous microstructure has been developed and applied to the case of a two-phase composite material – a nanocomposite based on epoxy resin, including Cloisite nano clay;
- A technology for three-dimensional Bayesian tomographic reconstruction of homogeneous objects with high-density inclusions has been developed. An original method for selecting points for interpolation and an algorithm ensuring the application of two-dimensional interpolation correction to projections have been proposed.

### ***(2) Computer Modeling in the Design, Study, and Utilization of Artificial Wetlands***

- A computer model based on solving inverse problems has been created, through which linear and nonlinear absorption models for simulating total phosphorus removal in flow through horizontal subsurface flow constructed wetlands have been obtained. The model has been validated with experimental data from actively monitored horizontal subsurface flow constructed wetlands in Xanthi, Greece.

Briefly, I will also touch upon the main contributions from the remaining publications.

### ***(3) Processing of Medical Tomographic Data***

- An innovative scheme for simulating blood flow through intracranial aneurysms with implicit coupling between blood flow and the elasticity of the blood vessel wall has been proposed. This was achieved through an iterative technique that deforms the fluid mesh at each step depending on the movement of the vessel wall.

### ***(4) Prototyping through 3D Printing and Metallization***



- Based on the first known comprehensive analysis of the feasibility of printing 3D lightweight broadband polymer antenna prototypes with stable chemical metallization and radio properties very close to those of the original, a high-quality polymer prototype has been produced, ten times lighter than the original.

## 5. Scientific indicators

In the materials for the competition, there is a reference to the compliance of the presented scientific publications and citations with the requirements of the ZRASRB and the Regulation for its application, as well as a reference to the scientific and scientific-applied contributions. According to Clarivate Analytics, the h-index of Assoc. Prof. Ivan G. Georgiev is 7 (citations only in indexed publications), while according to Google Scholar, where self-citations are not excluded but citations in non-indexed Web of Science and Scopus publications are counted, it is 8.

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

Table 2

Group of indicators	Requirements/IICT-BAS	Candidate's data
A	50	50
Б	-	-
B	100	120
Г	260	302
Д	140	342
E	150	200

## 6. Critical remarks

The scientific contributions could be formulated more distinctly, as they currently resemble more of a summary. As already noted, articles 5 and 6 did not find a place in the author's statement regarding the scientific and scientific-applied contributions of the candidate. However, these omissions in no way affect my overall positive assessment of the candidate.

## 7. Personal impressions

I have known Assoc. Prof. Ivan G. Georgiev since the beginning of 2015 when I started working at IICT-BAS. Back then, he was appointed to the academic position of "associate

professor". From the very beginning, my impressions were positive – he was an enthusiastic and ambitious young colleague with excellent qualifications, broad interests, and ideas for new research. Our participation over the years in joint working seminars, conference presentations, various discussions, and our collaborative work on organizing scientific forums not only confirmed these impressions but also convinced me of the candidate's potential both in terms of research and organizational skills.

His dedication to the issues of the scientific community deserves respect – serving as the chairman of the Biomathematics and Scientific Computing Section of the Union of Bulgarian Mathematicians, chairman of the Bulgarian section of SIAM, editor of scientific publications, and now as the scientific secretary of the Department of Information and Communication Sciences and Technologies at BAS. Additionally, his attention to promoting the potential of scientific computing through exhibitions, open days, and other activities is noteworthy. Not least, I would like to mention his calm demeanor, collegiality, and contagious optimism – qualities that are extremely important in our dynamic daily environment.

## 8. Conclusion

The materials presented testify to the high professionalism of Assoc. Prof. Dr. Ivan G. Georgiev, the significance of his scientific achievements in the field of computational mathematics, and their high esteem within the scientific community. His in-depth and focused methodology, approaches, and techniques in scientific research, combined with the wide range of scientific problems to which they are applied, create prospects for future new and interesting scientific and applied results.

The requirements laid down in the Law on the Development of the Academic Staff for candidates for the position of "professor," as well as the specific requirements for this position at IICT-BAS, have been met by the candidate with a significant reserve.

I am convinced that Assoc. Prof. Ivan G. Georgiev is worthy of occupying the academic position of "professor" in the professional field 4.5. Mathematics, specialization "Computational Mathematics," and I recommend that the Scientific Jury advise the esteemed Academic Council to make a positive decision regarding his candidacy in the announced competition for the needs of the Section "Scientific Computing with Laboratory for 3D Digitization and Microstructure Analysis" at the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences.

08.04.2024

Reviewer:

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