

REFEREE REPORT

by Corresponding Member of BAS Svetozar Dimitrov Margenov,
Professor at IICT - BAS,
on materials submitted for competition
to take the academic position "Professor" at IICT - BAS
in professional field 4.5 Mathematics, scientific specialty
"Mathematical Modeling and Application of Mathematics (in ecology)"

In accordance with Order № 209/16.08.2019 of the Director of IICT - BAS and Decision of the Scientific Jury, I was appointed as a reviewer of a competition for Professor, announced in the State Gazette (issue 49 of 21.06.2019). Documents for participation in the competition are submitted by Dr. Krassimir Todorov Georgiev, Associate Professor at IICT - BAS.

1. Brief biographical information

Assoc. Prof. Krassimir Todorov Georgiev has graduated in 1978 from the Faculty of Mathematics and Mechanics at Sofia University "St. Kliment Ohridski" holding a Master's Degree in Mathematics with specialization in Mathematical Modelling. From 1981 to 1984 he is a post graduate student at the Institute of Water Problems (IWP) at the Bulgarian Academy of Sciences, where he defends his dissertation for a doctorate degree.

In the period 1979 - 1987 he is employed at the IWP, after which he has worked in the IICT (including CCICE, CLPP and IPP to which it is a successor). Since 1996 he is Associate Professor at Scientific Computing Department. He has been a part-time lecturer at TU-Sofia, SU, SWU, BSU and UniBIT. He has held a number of leadership positions at ICT and his predecessors, including two terms deputy director, chairman of the General Assembly of Scientists, chairman of the Attestation Commission, and member of the General Assembly of Scientists of BAS. He has been a member of Expert Commission in Mathematics and Informatics of the Bulgarian National Science Fund.

2. General description of the materials presented

The materials presented by Assoc. Prof. Krassimir Georgiev are prepared in accordance with the Development of Academic Staff in the Republic of Bulgaria Act (DASRBA), the Regulations for the Application of DASRBA (RADASRBA), as well as with the specific requirements of the Regulations of BAS and IICT - BAS. They include: European CV; copy of Diploma for the educational and scientific degree

"Doctor"; a certificate of work experience; list of scientific publications for participation in the competition; list of citations noted; abstracts of scientific publications for participation in the competition – in Bulgarian and English; copies of the scientific publications submitted for participation in the competition; reference for the fulfillment of the minimum national requirements under Art. 26, para. 2 and 3, and the requirements of IICT - BAS under Art. 26, para. 5; reference to the original scientific, and applied scientific contributions; statement that there is no proven plagiarism; supporting material under item 8; list of selected scientific publications for the period of his work at BAS.

Assoc. Prof. Krassimir Georgiev has presented 51 scientific publications covering the period 1999 – 2019 (including 18 published during last 5 years). All publications are in English. There are 22 papers in specialized scientific journals with Impact Factor (IF), 13 of which are in Quartile Q1 (Computers and Mathematics with Applications - 9, Journal of Computational and Applied Mathematics – 2, Applied Mathematical Modelling – 1, International Journal of Environment and Pollution - 1). Among others, 25 are in specialized series with SJR. Out of the submitted publications, 2 are with a single author, 8 are with 2 co-authors, 14 - with 3, 11 - with 5 and 16 are with more than 4 co-authors.

The reference for compliance with the minimum national requirements and the requirements of IICT - BAS for the Academic Position "Professor" contains information in tables regarding the data for the groups of indicators A, B, Г, Д and E. The points for each of the indicators significantly exceed the required.

3. General characteristics of the applicant's activities

Assoc. Prof. Krassimir Georgiev is an established scientist in the field of Mathematical Modeling and application of Mathematics. The research methodology in the presented works is based on high performance numerical methods, efficient parallel methods and algorithms, as well as, supercomputer simulations. Important role in these studies take: estimate of discretization error; stability of solution methods for non-stationary problems; computational complexity analysis; techniques for improving parallel efficiency. Assoc. Prof. Georgiev actively participates in research projects, managing projects funded by the National Science Fund, the National Innovation Fund, as well as contracts with industrial partners. He is actively involved in the establishing and development of the Bulgarian Section of Society for Industrial and Applied Mathematics (BG SIAM), of which he is Secretary in the period 2011 - 2014 and Chairman in the period 2014 - 2018.

He has actively participated in the organization of international scientific conferences and forums as a member of organizing or program committees (including the LSSC, NM&A series), and has chaired the organizing committees of: Annual Meeting of the Bulgarian Section of SIAM (BGSIAM'15, BGSIAM'16, BGSIAM'17, BGSIAM'18);

Numerical Methods for Scientific Computing and Advanced Applications (NMSCAA'16, NMSCAA'18).

4. Scientific and applied scientific contributions

The presented scientific and applied scientific contributions of Assoc. Prof. Krassimir Georgiev are in accordance with the scientific specialty "Mathematical Modeling and Application of Mathematics (in Ecology)".

I will follow a thematic classification of the presented results in the following five groups:

- I. Mathematical and computer modeling of air pollution transport processes. Relationship between the air pollution and the climate changes. Simulations on various types of supercomputer architectures (B1);
- II. Mathematical and computer modeling of processes and phenomena in mechanics, medicine, etc. with computer experiments on parallel computer architectures (B2);
- III. Studies of Richardson extrapolation and Runge-Kuta methods in solving important for the computing practice problems (B3);
- IV. Research related to problems arising in seismic mechanics of structures (B4);
- V. Theoretical and applied research in the field of design, analysis and use of artificial wetlands (A).

The related number in the reference for the candidate's original scientific and applied contributions is shown in brackets. Thus, the last Group V corresponds to publications equivalent to habilitation work.

The number of publications presenting results in the separate groups is 19, 17, 9, 4 and 5, respectively.

I. Mathematical and computer modeling of air pollution transport processes. Relationship between the air pollution and the climate changes. Simulations on various types of supercomputer architectures

The results presented in this section are published in papers [1–3, 6, 8, 10–11, 13, 14–17, 19, 21, 22, 36, 41, 44, 45]. They are related to the long-standing involvement of the applicant in a team working on the development and refinement of the Danish Eulerian model for transboundary air pollution transport. The model is known as *UNI-DEM*. The aim is to achieve higher accuracy, taking into account increasing number and type of pollutants. The arising discrete problems (systems of linear equations) have very large number of unknowns. For example, even in the two-dimensional in space model, the number of unknowns reaches orders of magnitude $O(10^9)$ - $O(10^{11})$. *Operator Splitting* is applied for efficient solution of the problem. This leads to

a series of subtasks for which specialized numerical methods are applied, taking into account their specific properties. In addition, in the parallel implementation, *domain decomposition* is applied. In the case of distributed memory or hybrid architecture computing systems, MPI or MPI and OpenMP libraries (computational models) are used respectively, in order to implement the communications. A special attention is paid to the efficient use of the hierarchical cache memory in the developed algorithms. The parallel *UNI-DEM* code is portable, showing good performance and scalability on supercomputers with various architectures.

II. Mathematical and computer modeling of processes and phenomena in mechanics, medicine, etc. with computer experiments on parallel computer architectures

This part of the results is published in the works [3-7, 12, 20, 23, 24, 26, 29, 32, 34, 35, 37, 39, 46]. They are related to creating of new and further developing of existing mathematical and computer models and numerical methods for their implementation. Numerical methods and parallel algorithms for *LU* factorization, iterative methods using domain decomposition, adaptive time stepping algorithms, methods for coupled linear (non-stationary Stokes equation) and nonlinear systems are investigated. The applications include problems in computational mechanics, image processing, ecology, and biomedical engineering. I will note two of them: a) The process of vacuum freeze drying is described by a system of nonlinear partial differential equations [9]. Effective adaptive algorithms for numerical and computer modeling of highly non-linear and non-monotonous heat and mass transfer in the absorber chamber are developed; b) The radio-frequency hepatic tumor ablation is a technic for low-invasive surgical treatment. The results presented in [26] concern the mathematical modeling of nonlinear heat transfer in strongly inhomogeneous media and unstructured tetrahedral finite element mesh. The developed adaptive time stepping algorithm is based on a local error estimate based on approximations obtained by Krank-Nicolson and implicit Euler methods.

III. Studies of Richardson extrapolation and Runge-Kuta methods in solving important for the computing practice problems

Here are presented results published in papers [13, 18, 25, 27, 28, 31, 38, 42, 43]. The studies are focused on improving efficiency of the numerical solution of time dependent problems. It is proven and experimentally confirmed, that the approximation accuracy can be improved up to fourth order when the Krank-Nicolson scheme is combined with Richardson extrapolation. A fundamentally new class of algorithms has been proposed and investigated, based on a repeated Richardson extrapolation in combination with explicit Runge-Kuta schemes. Although the computational complexity of each step could be higher, the improved total efficiency is due to the higher accuracy of the combined methods. The area of absolute stability of the new methods has been proven to be substantially larger. The results of these studies allow for computer simulations of complex coupled processes with larger time

steps, which can lead to a significant reduction of the overall computational complexity.

IV. Research related to problems arising in seismic mechanics of structures

To this group are concerned publications [30, 33, 35, 40]. They present numerical methods and algorithms for seismic analysis of structures, reinforced with a system of cable elements. In particular, buildings and structures that have been subject to seismic effects are investigated. Damage indices are evaluated by comparing the seismic response of structures before and after reinforcement with cable elements. The goal is to choose optimal reinforcement schemes. A computational model is proposed to evaluate the seismic impact on adjacent buildings and structures, taking into account the accumulated effects of multiple earthquakes. Some results of numerical analysis of structural solutions for reinforcement of buildings and structures declared as cultural and historical heritage are presented.

V. Theoretical and applied research in the field of design, analysis and use of artificial wetlands

The results of this group are presented in works [A1-A5], which are singled out in the applicant's author's reference as equivalent to habilitation work. They are devoted to mathematical and computer modeling of artificial wetlands. At the heart of the mathematical model are the partial differential equations, describing the transport of pollutants in groundwater flows in porous media. The results presented here include comparative analysis of numerical solutions with experimental data on biochemical oxygen consumption. An optimized model, taking into account reactions with geothermal effects has been developed. The reliability bounds of the input parameters are investigated.

In conclusion, it is important to note that the scientific and applied results of Assoc. Prof. Krassimir Georgiev have a complex nature, and the applications are of great importance for the society. A substantial part of the research is highly interdisciplinary.

5. Impact of the applicant's scientific publications

The candidate has provided a list of 52 citations in publications that are referred and indexed in the scientific information databases WoS and Scopus. It is noted that 16 of them are in papers with IF in Quartile Q1. In the framework of this procedure, the citations are presented in a table of data related to indicator group E. If 140 points are required, the citation evaluation submitted is 416 points, where 8 points are reported for citations in works visible in WoS or Scopus, while 6 points are assumed in the regulation. Thus, the evaluation should be adjusted to 312 points. Almost all (except 1) of the citations in the table are in works of foreign authors, including such

that are published in a number of most highly ranked specialized international journals and series.

6. Evaluation of the applicant's personal contribution

I accept, that in the joint works, Assoc. Prof. Krassimir Georgiev has an equal role.

7. Critical remarks

In item 7, the error in calculating the points for citations was noted. Inaccurate calculation of points for scientific publications in the table under indicator Γ is also made. The evaluation of 1881 thus presented should be adjusted by a factor of $2/3$, ie. to be 1254 points where the minimum required points are 200. A similar mistake is made in calculating the points for the papers, which are presented as equivalent to habilitation work. Another omission is made here – in the table are provided 4 out of the 5 papers with SJR, that are included in the list. Thus, after the correction, 100 points are obtained.

I don't have any essential critical remarks about the materials of Assoc. Prof. Krassimir Georgiev, presented within the present procedure. And after the necessary correction of the points, they substantially exceed the requirements of the DASRBA, RADASRBA, the regulations of BAS and the specific requirements of IICT – BAS.

8. Personal impressions

I have known Krassimir Georgiev since 1968. In the past years we have worked successfully on a number of joint projects. I highly evaluate his scientific and professional achievements, which determine him as an eroded, correct and responsible scientist and colleague with proven teamwork capabilities.

9. Conclusion

After getting acquainted with the materials of the competition, the complex evaluation of the applicant's qualities, including the scientific and scientific applied contributions, **I strongly recommend Assoc. Prof. Dr. Krassimir Todorov Georgiev to be elected to the academic position of "Professor" at IICT – BAS in professional field 4.5 Mathematics, scientific specialty "Mathematical Modeling and Application of Mathematics (in Ecology)".**

14.10.2019

Sofia

Reviewer:

/Prof. Svetozar Margenov
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