SCIENTIFIC OPINION

Concerning competition for the Academic Position ‘‘Professor‘‘in the area of higher education 4 ’’Natural Sciences, Mathematics and Informatics’’, professional field 4.5 ’’Mathematics’’, scientific specialty ’’Mathematical Analysis (Application of Fractional Calculus) for the needs of the „Analysis, Geometry and Topology’’ section at Institute of mathematics and informatics, Bulgarian Academy of Sciences

The competition is announced in the State Gazette, issue 43 of May 17, 2024 with the only candidate Assoc. Prof. Emilia Bazhlekova from the Institute of mathematics and informatics.

Author of the scientific opinion: Prof. Dr. Petia Simeonova Dineva from Institute of Mechanics at Bulgarian Academy of Sciences, appointed to a member of a Scientific Jury, formed with Order 205/16.07.2024 г. of the Director of the Institute of Mathematics and Informatics Prof. Peter Boyvalenkov.

1. Short CV data and general description of the applicant‘s scientific interests

Assoc. Prof. Emilia Bazhlekova has presented all the documents required for the participation in the competition according to the requirements of the Act for the Development of the Academy Staff in the Republic of Bulgaria and of the Regulations for its implementation. All they are carefully prepared and give a clear idea of the scientific activity of the candidate. The candidate holds an educational and scientific degree "doctor" since 2001. The doctoral degree was defended at Eindhoven University of Technology, the Netherlands and was legalized in Bulgaria in 2011.The topic of the PhD thesis is in the scientific specialty "Mathematical Analysis". The candidate works successively as a mathematician, assistant and since 2014 as an associate professor at a section „Analysis, Geometry and Topology’’ at Institute of mathematics and informatics. In 2022, Emilia Bazhlekova obtained the highest scientific degree "Doctor of Science" in the scientific specialty ’’Mathematical Analysis’’ with her dissertation “Subordination principle for generalized fractional evolution equations”.

The scientific activity of the candidate is in the following research fields:

(1) Analysis of fractional evolution equations solutions and their Duhamel-type representations via convolutional calculus of Dimovski;
(2) Analysis of linear viscoelastic models by fractional derivatives;
(3) Uniqueness and existence of inverse problems described by fractional derivatives equations;
(4) Numerical methods for solution of fractional evolution equations;
(5) Application of fractional calculus in modelling of complex processes.

2. Analysis and evaluation of the scientific contributions and achievements of the candidate

The evaluation of the scientific contributions will follow the division into 5 main directions proposed by the candidate himself in her author's reference.

First direction concerns papers [1, 2, 3, 9, 12, 13] from the List of publications in the author's reference. The base original contributions here are: *(a)* Duhamel-type representations of solutions of different boundary-value problems of mathematical physics concerning the following mechanical problems: (i) modelling of the velocity distribution of a viscoelastic flow in [1]; (ii) analysis of the inverse problem based on the heat equation in [2]; (iii) solution of an initial-boundary value problem for the one-dimensional time-fractional diffusion equation of distributed order in [9]; *(b)* Numerical and simulation experiments based on the obtained Duhamel-type representations illustrate clearly the potential of the proposed methodology for solution of different boundary-value problems describing a variety of mechanical and physical models; *(c)* a pure mathematical study of various analytical solutions of equations with fractional derivatives is presented in [3, 12, 13], and this study, although it has a more abstract form, is open for application in solving specific boundary problems of mathematical physics.

Second direction ([7, 8, 10, 19, 20]) is connected with a family of rheological models realized via the fractional calculus.

In models of memory materials, the basic equations are various constitutive laws representing fractional generalizations of classical models describing the stressed and deformed state of the studied object. The following contributions are visible in this direction:

(a) analytical solutions are derived for the wave propagation problem in viscoelastic continuum based on the well-known Maxwell [8], Jeffrey [10], Burgers [7] and Zener [19,20] constitutive models; *(b)* the obtained results in a closed form can serve as a basis for solving more complex boundary-value problems describing real and complex mechanical and physical dynamic processes.

In the third direction ([15, 16, 22]) contributions have a purely abstract mathematical character related to proving the existence and uniqueness of a number of inverse problems in which the governing equations have fractional derivatives. The results are obtained by considering the problems in the classical sense in spaces of continuous functions and in Sobolev spaces.

Fourth direction includes publications [4, 5, 17], where there are obtained solutions with a contribution to the development of an original numerical methodology for solving fractional differential equations. A numerical toolkit for solving linear and non-linear fractional differential equations has been developed and verified. In the cited articles, a study was made on the accuracy and convergence of the obtained numerical solutions based on comparisons with existing analytical ones.

Fifth direction concern papers [6, 11, 14, 18, 21] where the effectiveness of fractional calculus and its applicability in modeling various complex processes, which are the subject of research in physics, theoretical and applied mechanics, materials science, engineering sciences, are illustrated. The contribution here is mainly in the successful application of the fractional calculus method in modeling the following problems: *(a)* The two-dimensional Rayleigh-Stokes problem for a generalized fractional Oldroyd-B fluid. Peristaltic flow of

viscoelastic fluid through a uniform channel is considered under the assumptions of long wavelength and low Reynolds number; *(b)* The Ward-Tordai integral equation governing the diffusion-controlled surfactant adsorption at air/liquid interfaces; *(c)* Bioreaction-diffusion processes; *(d)* Deformation and drainage of film between interacting drops is presented in the case when dispersed or continuous phases are viscoelastic fluids; *(e)* Jeffreys equation and its fractional generalizations providing extensions of the classical diffusive laws of Fourier and Fick for heat and particle transport.

For the application of the candidate's theoretical results can be judged by her participation in a number of projects with funding at the national and international level, reference in the attached documents to the competition. Of particular interest is the project financed by the National Science Foundation with Russia "Investigation of the dynamic behavior of deformable solids taking into account the effects of material heredity". This is an indicator that the results obtained by the candidate treat equally both the purely mathematical aspects of the fractional calculus and its direct application in the mechanics of continuous media.

3. Fulfilment of the requirements for holding the academic position ''Professor''

A serious portion of the articles are published in renowned journals, and thus they have passed the normal serious peer review process. Published in such journals, the findings of them are exposed to the attention of the international academic community. From the presented in the competition 22 publications 18 are in scientific journals with ISI IF or ISI SJR, 2 are without IF/SJR but with index in Scopus or Web of Science, 2 are with index in ZentralBlatt. The total number of points collected by the candidate is 686 and they are as follows: 9 are in Q1 (450 p.), 2 in Q4 (48 p.), 7 are with SJR (140 p.), 4 are without IF/SJR (48 p.). After the date of the candidate's last procedure (11/15/2022 - acquisition of the scientific degree "Doctor of Sciences"), 6 articles with IF/SJR have been published, of which 5 are with IF. The candidate has 4 publications without co-authors, 2 with two co-authors and 16 with one co-author.

4. Impacts of the candidate's results on scientific works of other researchers

The candidate's publications on the subject of the contest have 220 citations (without self-citations): 220 (x 6p.)=1320p. 219 of them are in publications indexed in the Scopus database and 1 in Web of Science. None of the citations presented have been used in other procedures of the LADASRB.

The information reported above clearly demonstrate that the number of citations definitely exceed the legislative requirements. One can conclude that the candidate's results ate well-known in the corresponding scientific community working in her research area.

5. Personal impression for the applicant

I do not know the candidate personally. I became familiar with her research activity based on the excellently organized documentation, as well as the clearly and concisely written author's reference for the original contributions in the candidate's works.

6. Critical remarks and recommendations

I have no critical remarks about the candidate's research activity. I would recommend that, along with continuing her scientific activity, she spends time publishing a monograph covering and focusing the main and most significant innovative achievements in the field of fractional calculus. Of particular interest would be the applications of fractional calculus in rheology and in the continuum mechanics, in particular mechanical models describing: (a) diffusive processes in materials and media with complex behaviour; (b) heat transfer processes in memory materials; (c) elastic wave propagation in a viscoelastic continuum.

7. Conclusion

The materials submitted by Assoc. Prof. Emilia Bazhlekova for the current procedure demonstrate that she is satisfying the requirements of the Law Act for Development of the Academic Staff in the Republic of Bulgaria (LADASRB), the Statutes for application of LADASRB, the Statutes for the conditions and regulations for acquiring academic degrees and occupying academic posts in BAS, and the Statutes for the conditions and regulations for acquiring academic degrees and occupying academic posts in IMI-BAS, for occupying the academic post " Professor". There is no data for plagiarism.

The overall candidate’s activity, including scientific-research and scientific-applied contributions, expert and organizational skills, give me reason to believe that Assoc. Prof. Emilia Bazhlekova deserves to be awarded the academic position of 'professor' in the scientific specialty "Mathematical Analysis (Applications of fractional calculus)" for the needs of the section "Analysis, Geometry and Topology (AGT)" at the Institute of Mathematics and Informatics, BAS.

I recommend with conviction to the honorable jury to propose to the Scientific Council of IMI-BAS to elect Assoc. Prof. Emilia Bazhlekova as a "Professor"in the Area of Higher Education: 4. Natural Sciences, Mathematics and Informatics, Professional Area: 4.5 Mathematics, Scientific Specialty:’’Mathematical Analysis (Application of Fractional Calculus) for the needs of the „Analysis, Geometry and Topology’’ section at Institute of mathematics and informatics, Bulgarian Academy of Sciences

26.08.2024 г.

Sofia Signature:

(*Prof. Dr. Petia Dineva*)