

## OPINION

by **assoc. prof. Elena Boyanova Lilkova, PhD**  
(**Institute of Information and Communication Technologies at BAS**)

**on the competition for the academic position "Associate Professor"  
in professional field 4.5 Mathematics,  
scientific specialty "Mathematical Modeling  
and Application of Mathematics (Mathematical Biology)"**

The opinion was prepared by me in my capacity as an external member of the Scientific Jury for the competition according to Order No. 184/07.04.2023 of the Director of IMI – BAS.

The competition for associate professor was announced in the State Gazette, no. 14/10.02.2023 for the needs of the Institute of Mathematics and Informatics of the Bulgarian Academy of Sciences. The only candidate in the competition is **assist. Prof. Milen Kolev Borisov, PhD**, from the Department "Mathematical Modeling and Numerical Analysis" of the same institute.

### **1. Brief biography of the applicant**

Milen Borisov completed his higher education in informatics at the Faculty of Mathematics and Informatics of Sofia University "St. Kliment Ohridski" - in 2004 received a bachelor's degree, and in 2008 a master's degree. At the end of the same year, he began his doctoral studies in mathematics at IMI – BAS with Prof. Neli Dimitrova for a scientific supervisor. In 2013, he acquired the educational and scientific degree "doctor" in professional field 4.5. Mathematics after successfully defending a thesis on "Investigating Food Chains in a Hemostat: Stability and Bifurcation of Equilibrium Points". In the period 2012 – 2020, Milen Borisov was an assistant at IMI - BAS, and since 2020 until present he has been holding the academic position of assistant professor at the same institute, where he conducts scientific research in the field of mathematical modeling of biological processes, bifurcation analysis of dynamical systems and computer simulations of biological models.

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

The applicant has submitted the following mandatory documents:

- 1) application to the director of IMI – BAS to participate in the competition;
- 2) professional European CV;
- 3) diploma of completed higher education (master's degree);
- 4) PhD diploma;
- 5) list of all the candidate's publications;
- 6) list of publications with which the candidate participates in the competition;
- 7) reference for the original scientific contributions in the publications with which he participates in the competition;
- 8) abstracts of the publications with which he participates in the competition in Bulgarian and in English;
- 9) copies of the publications with which he participates in the competition;
- 10) list of all citations of the candidate;
- 11) list of citations of the publications for participation in the competition;
- 12) copy of the competition announcement in the State Gazette;

- 13) certificate of work experience in the specialty in accordance with the Law for development of the academic personnel in Bulgaria (LDAPB);
- 14) other documents and references;
- 15) reference form for the fulfillment of the minimum national requirements for associate professor of LDAPB, as well as of IMI - BAS;
- 16) declarations.

The documents submitted by the candidate for participation in the competition correspond to the requirements of the LDAPB, the regulations for application of the law and the Regulations for the terms and conditions for acquiring scientific degrees and occupying academic positions at IMI – BAS.

### **3. . General characteristics of the publications submitted for the competition**

The candidate submitted eleven publications for participation in the competition. Of these, one has been accepted for publication, and the rest have already been published. A large part of the scientific output presented for consideration is in impact factor scientific journals – seven out of eleven scientific articles, of which one is in journals in quartiles Q1 and Q3 of the Web of Science database, and five are in Q2. Two publications are in series without an impact factor but with a Scientific Journal Rank (SJR) and are indexed in the Scopus database. One of the candidate's research papers is in a journal indexed in the MathSciNet and Zentralblatt databases and one publication is in a non-indexed international issue. The publications presented for the competition have a total impact factor of over 19.

In his scientific career, Dr. Borisov authored a total of 19 publications, again a high proportion of which (~68%) are in the so-called "visible" journals and series, indexed in the two major international databases Web of Science and Scopus. It makes a good impression that since 2017, this share has been growing, and of the publications to be considered in the competition, more than 80% are in this category.

Currently, the candidate has a total of 50 citations, 32 of which have been submitted for participation in this competition. Auto-citations are not noticeable among the list of citations for consideration. The candidate's overall H-index is 4 in Web of Science and 5 in Scopus.

The submitted publications for participation in the competition are from the period 2017-2023 and were not used to acquire the educational and scientific degree "doctor". It is important to note that no plagiarism is detected for them. With this, the candidate satisfies the minimum national and also the specific BAS and IMI – BAS requirements for occupying the academic position "associate professor" in professional field 4.5 Mathematics, and by some criteria significantly exceeds them.

### **4. Principal scientific contributions**

The main contributions in the scientific papers of assist. Prof. Milen Borisov, Ph.D., which he participates in the competition with, are related to research from the interdisciplinary scientific field "Mathematical Biology (Biomathematics)", and can be classified in the following main categories:

#### **4.1 Mathematical modeling of continuous bioreactors**

Most of the candidate's scientific results and contributions are a natural continuation of the topic of his doctoral dissertation and are devoted to modeling of bioprocesses occurring in a continuous bioreactor. Dr. Borisov researches three sub-areas of this topic in particular, namely:

##### **1) Continuous bioreactor models for wastewater treatment**

The candidate participated in the improvement of mathematical models of the process of biological treatment of wastewater contaminated with two pollutants. New aspects of the

processes in the bioreactor are accounted for – the mutual influence of the two substrates and the natural biological time delay in the growth rate of the biomass, as well as competitive inhibition between the two pollutants. The properties of the new models were analyzed. The obtained results can be used to better understand the dynamics of biological degradation of a mixture of two chemical compounds in a continuous bioreactor.

## **2) Models of continuous bioreactors for the production of methane (biogas)**

A mathematical model for wastewater treatment with biogas production was modified and analyzed by adding two different discrete time delays to model the delay in the conversion of consumed substrate to viable biomass. A mathematical model of a bioreactor describing an anaerobic fermentation process for biological degradation of organic waste with biogas production was stabilized by introducing feedback or piece-wise constant feedback. For each of the models an iterative numerical algorithm for searching for an extremum that maximizes methane (biogas) production in real time is proposed. The algorithms are implemented in the SmoWeb software platform.

## **3) Continuous bioreactor models for methane and hydrogen production**

A new mathematical model describing a biotechnological process, occurring in two constantly connected bioreactors, of two-phase anaerobic biodegradation (ABD) with production of hydrogen (in the first phase occurring in the first bioreactor) and methane (in the second phase occurring in the second bioreactor) was proposed and analyzed. The model was extended to take into account the production of additional products and the running of additional processes in the two bioreactors, which allowed to optimize their volume. These two models are also included in specially developed applications in the SmoWeb platform.

## **4.2. Reaction networks and applications in biomathematics**

The candidate uses reaction network theory to investigate various biological growth processes. For example, reaction networks and their corresponding growth models – VM and VSM – obtained through the law of mass action are considered, which in some sense are close to the growing Gompertz model. Both models are shown to be suitable for modeling biological growth processes that grow more slowly at the beginning and end, and where growth depends on more than one resource.

The dynamic system 2SED is analyzed, after which the model is compared with the classical epidemiological SIR model. SIR has been shown to describe well epidemics related to the spread of communicable diseases, while 2SED is suitable for modeling epidemics due to non-communicable diseases. On this basis, a new epidemiological model (G-SIR) is proposed, obtained by replacing in the SIR model the logistic contact mechanism (of the human-to-human type) with a catalytic contact mechanism of the Gompertzian type.

## **4.3 Mathematical Epidemiology**

A model of the immune response to dengue fever was developed that takes into account the two types of dengue virions in infected cells – mature and immature. The base reproductive number of the two infection scenarios was calculated. The immune response in primary and secondary dengue infection was studied in detail.

## **5. Other**

### **5.1 Scientific projects**

For the competition, the candidate submitted participation in two nationally funded scientific projects – one with the Scientific Research Fund and one national scientific program. In addition, he led two projects under the Young Scientists Support Programme of BAS.

### **5.2. Teaching activity of the candidate**

Dr. Milen Borisov has teaching experience from FMI of SU – he has been teaching the exercises of the elective course "Mathematical Modeling in Biology" with main lecturer Prof. DSci. Svetoslav Markov since 2018, except for 2020.

## **6. Critical remarks**

I have no critical remarks on the substance.

## **7. Personal impressions of the candidate**

I know Dr. Borisov vaguely in a personal capacity as a serious and calm person. I have no personal professional impressions of him.

## **8. Conclusion**

I find that the materials and scientific publications submitted by the candidate in the competition, as well as their scientific contributions, meet the requirements of the Law for development of the academic personnel in Bulgaria and the Regulations on its a, the Regulations for the conditions and the procedure for acquiring scientific degrees and for occupying academic positions at the Bulgarian Academy of Sciences and the specific regulations for IMI-BAS for occupying the academic position of "associate professor" in the scientific and professional field of the competition. I give my positive assessment to the candidacy of assist. prof. Dr. Milen Borisov.

In view of the above, I recommend the Scientific Jury to propose to the Scientific Council of IMI – BAS to elect assist. Prof. Milen Kolev Borisov, PhD, to the academic position of "Associate Professor" in the professional field 4.5. Mathematics, scientific specialty "Mathematical Modeling and Application of Mathematics (Mathematical Biology)".

25.05.2023 г.  
Sofia

Signature:.....  
/assoc. prof. Elena Lilkova/