

## REPORT

on a competition for the occupation of the academic position “Professor” in the professional direction 4.5 Mathematics (scientific specialty: Probability and Statistics) for the needs of Sofia University “St. Kliment Ohridski” (SU), Faculty of Mathematics and Informatics (FMI), announced in the State Gazette No. 21 on March 13, 2020 (with continued deadline for application and submission of documents until July 14, 2020) and on the websites of FMI and SU

This report is prepared by **Prof. DrSci in Mathematics Ljuben Mutafchiev**, Professor Emeritus at the American University in Bulgaria, with a deserved right for pension, in the capacity of a member of a scientific jury on 4.5 Mathematics (Probability and Statistics) under the Competition in accordance with Order No. ПД – 267/10.07.2020 of the Provost of Sofia University

**Only one candidate** has applied for participation in the announced competition, namely: **Assoc. Prof. DrSci Mladen Svetoslavov Savov** (Institute of Mathematics and Informatics, BAS).

### I. General description of the submitted materials

#### 1. Data on the application

The documents submitted by the applicant comply with the requirements of ЗПАЧРБ (the Republic of Bulgaria Academic Staff Development Law), ППЗПАЧБ (Regulation for its Implementation) and the Regulation on the conditions and procedures for acquiring scientific degrees and occupying academic positions at SU (ПВРПНЧЗАДСУ).

For the participation in the competition, the applicant **Assoc. Prof. DrSci Mladen Svetoslavov Savov** has presented a list of the titles of **14** publications in international editions (journals) with a positive impact factor. Among all 14 articles submitted for the competition, 13 have been already published in the period 2013-2020 and 1 was accepted for publication. All 14 articles are in co-authorship. A great impression is made by the high level of the journals in which Assoc. Prof. Savov has published and by his successful collaboration with 14 scientists from Bulgaria and abroad. **All** other required documents in support of the applicant’s achievements are also presented (e.g., diplomas for PhD and DrSci degree, documents for his associate professor promotion and length of service, citation inquiry, information on the fulfillment of the minimal national requirements, copies of applicant’s scientific works, information on supervision and successful applications of international scientific projects, inquiries and documents on the teaching activity and supervision of a PhD student).

## **2. Details on the applicant**

Assoc. Prof. Savov has received his bachelor degree in Mathematics from the FMI of SU in 2004 and his PhD in the area of Probability Theory from the University of Manchester (UK) in 2008. In 2008-2009 he has been a Post Doc at “Pierre and Marie Curie University” in Paris and from 2009 to 2012 – Esmee Fairbairn Junior Research Fellow in New College, Oxford (UK). In the period 2012-2014 he has been a lecturer at the University of Reading (UK) and then he has returned in Bulgaria. In 2014 he has been elected as an Associate Professor at the Institute of Mathematics and Informatics (IMI) of the BAS and in 2017 he has defended his thesis entitled “Theory of the Exponential Functionals of Levy Processes” at the same Institute and has been acquired the Academic Degree “Doctor of Sciences” in the professional area “Mathematics” with specialty “Probability and Statistics”. Assoc. Prof. Savov has worked as a research fellow on the project AKOMIN at the Institute of Information and Communication Technologies of the BAS (2014-2015) and on an individual grant of the Program “Marie Skłodowska Curie”, Horizon 2020 at the IMI of the BAS (2015-2017). In 2014 he has participated in a joint project with the “National Science Fond”. During the last 5 years Assoc. Prof. Savov has presented several invited and plenary talks at conferences and seminars in Belgium, Bulgaria, Germany, Greece, Spain, USA and France.

## **3. General characteristics of the applicant’s scientific work and achievements**

The author’s inquiry (see 14 from the materials submitted for the competition: InquiryResearchContributions) reflects correctly on the applicant’s research contributions. The scientific interests and publications of Assoc. Prof. Savov (including also those from the list of all publications – see 10: ListPublications) are in the scientific area of the announced competition: 4.5 Mathematics – Probability and Statistics. Generally speaking, they are from the area of the theory of random processes and their applications. In particular, Assoc. Prof. Savov has studied classical properties of Levy processes, stochastic models of diffusion and anomalous diffusion, properties of classes of non-self-similar Markovian semigroups and processes, models of a random change of particles in Monte Carlo simulations, stochastic models of birth and death populations, combinatorial enumeration problems interpreted as limit theorems from Probability Theory, and stochastic differential equations and Levy processes that appear in problems from financial mathematics.

The scientific interests of Assoc. Prof. Savov are diverse and aimed at different topics of stochastics and its applications. His results show his clearly expressed individuality and mathematical depth and the mathematical tools that he uses are based on a rich mathematical

culture. Further on, I shall describe the statutory and complementary requirements for the academic position “Professor” at the FMI of SU are satisfied.

a) First, I shall note that Assoc. Prof. Savov is included in the Register of the Academic Staff of the Republic of Bulgaria with the individual numerical values of his scientific-metric characteristics for the minimum national requirements (MNR) for groups of indicators in order to occupy the academic position of an Associate Professor and to possess the academic degree “Doctor of Sciences”. In the materials submitted for the competition he included an inquiry for the fulfillment of the MNR for the academic position “Professor” (see 12 and Supplements 1 – 7). From this inquiry it follows that:

- for the group of characteristics **A**, Assoc. Prof. Savov has **50** points (p.) and the MNR is **50** p.;

- for the group of characteristics **B**, Assoc. Prof. Savov has **100** p. and the MNR is **100** p.;

- for the group of characteristics **B**, Assoc. Prof. Savov has **516** p., while the MNR is **100** p. (1 article in the region of Q1, 6 – in Q2, 1 – in Q3 and 1 – in Q4);

- for the group of characteristics **Г**, Assoc. Prof. Savov has **315** p., while the MNR is **200** p. (3 articles in the regions Q1 and 2 - in Q3);

- for the group of characteristics **Д**, Assoc. Prof. Savov has **456** p., while the MNR is **100** p. (57 quotations in the period 2017-2019, indexed by the international data base Scopus);

- for the group of characteristics **E**, Assoc. Prof. Savov has **160** p., while the MNR is **100** p.

Here  $Q_i$ ,  $i=1,2,3,4$ , is the  $i$ -th quartile of the distribution of the impact-factor of the scientific editions (journals) in which Assoc. Prof. Savov has published.

From the facts presented above it is clear that the scientific works of Assoc. Prof. Savov comply with the MNR (under Art. 2b, paragraphs 2 and 3 of the 3PACPB) and respectively with the additional requirements of the FMI of SU for the occupation of the academic position “Professor” in the scientific area Probability and Statistics and professional direction 4.5 Mathematics.

b) The scientific works submitted by the applicant do not repeat those of previous procedures for the acquisition of the academic position “Associate Professor” and for the academic degree “Doctor of Sciences”. Assoc. Prof. Savov has submitted the necessary declaration for this (see Declaration\_candidate\_professor from the materials submitted for the competition).

c) There is no proven plagiarism, established by the law, in the scientific works submitted for the competition.

#### **4. Characterization and evaluation of the applicant's teaching activity**

Assoc. Prof. Savov's has submitted the following documents which justify the fulfillment of the requirements of Art. 115, paragraph 1, item 2 of ПУРПНЦЗАДЦУ: a) a certificate for the length of service for more than 5 years at the IMI of the BAS; b) contracts for the position of guest-faculty member at the FMI of SU for the academic years 2017-2018, 2018-2019 and 2019-2020. He started his work as an Associate Professor at the IMI in September, 2014. In the period 2017-2020 he has been lecturing on: Probability Theory 2, Random Processes, Stochastic Processes 2 – courses from the Program on Probability and Statistics at the FMI. Assoc. Prof. Savov has also a long pedagogical experience in UK: he has been lecturing at the University of Reading (the courses that he had were equivalent to the general course on Probability and Statistics at the FMI and to the course Probability Theory 2). Before this, he has performed exercises on Probability and Statistics, Calculus, Partial Differential Equations, Functional Analysis, etc. at the Universities of Oxford and Manchester. The last but not the least, I shall note that Assoc. Prof. Savov has been a research supervisor of the PhD thesis of Dr. Adam Barker who has successfully defended it in September, 2019 at the University of Reading (see Supplement 15.1.3).

The facts given above allow me to conclude without any hesitation that Assoc. Prof. Savov will be very helpful as a mathematician and teacher in the team of the FMI of SU.

#### **5. Comprehensive analysis of the scientific and applied scientific achievements of the candidate contained in the materials for participation in the competition**

The distribution of the impact-factor of the journals, where all 14 applicant's articles for participation in the present competition (1 of them is accepted for publication), is as follows: 4 articles are in the region of Q1, 6 –in Q2, 3 – in Q3 and 1 – in Q4. The articles are published in highly prestigious journals as Annals of Probability, Chaos, Solitons and Fractals, SIAM Journal of Mathematical Analysis, Random Structures and Algorithms, Annals de L'Institut Henri Poincare, Probabilites et Statistiques, Journal of Statistical Physics, Bernoulli, etc. The list of quotations of Assoc. Prof. Savov (see 13 InquiryQuotations) during the last 3 years is also respectful. It includes 57 publications from various topics (theoretical and applied) like Transactions of the American Mathematical Society, Stochastic Processes and Their Applications, Annals of Probability, Probability Theory and Related Fields, Insurance: Mathematics and Economics, SIAM Journal on Financial Mathematics, Journal of

Applied Probability, Scandinavian Actuarial Journal, Journal of Theoretical Probability, Journal of Industrial and Management Optimization, Annals of Applied Probability, Theory of Probability and Its Applications, Annals de L'Institut Henri Poincare, Probabilites et Statistiques, Bernoulli, Communications in Mathematical Physics, etc. This shows the interdisciplinary goals in the research interests of Assoc. Prof. Savov who has also submitted a list of all quotations containing 235 titles of publications. Further, I shall make a brief review of the scientific contributions of the applicant following the subject list given in the author's inquiry (see 14).

*Classical properties of Levy processes.* This series of articles continues the subject area of the dissertation of Assoc. Prof. Savov defended at the University of Manchester. Article [13] is devoted to the investigation of the behavior of the minimum increase of the current maximum of a Levy process at the initial moment of time (the moment  $t=0$ ). The aim is to find a deterministic function, which, for small values of  $t$ , gives the greatest lower bound of the process. An exact prescription for the construction of such a function using the Levy measure is given. In [12] is proved that the probability that a Levy process stays  $t$  units of time in a finite interval almost surely decreases exponentially if  $t$  increases and the error of the approximation is of exponential order. The novelty in the method of proof is the application of the spectral theory of compact Markov semigroups to the theory of Levy processes. Article [11] is devoted to the study of the asymptotic of the probability that a Levy process remains above/below an increasing/decreasing curve for a period of time tending to infinity. For Levy processes belonging to the domain of attraction of the stable distributions, the class of curves, for which this asymptotic can be estimated, is extended essentially. In article [1] is obtained an analytical criterion for the almost sure convergence of an improper integral with infinite upper bound of a locally bounded function of a Levy process. The method of proof is based on a non-trivial generalization of an approach solving a similar problem for integrals of functions of the Brownian motion.

*Diffusions, anomalous diffusions and stochastic processes with restrictions.* In article [2] are studied processes which describe the movement of particles in an environment of obstacles (traps). In this case a typical diffusion behavior is not observed and the model describes the movement of particles in a pore environment. The movement of each particle follows a Markov process until it reaches a trap which keeps the particle there for certain time period whose length depends on the strength of the trap. It is proved that the mathematical expectations of the process are solutions of integral-differential equations of a certain type. Special attention is paid on the case when the Markov process is a Brownian motion for

which an expression for the typical strength of the traps is obtained so that the process can be watched around them with a dominant probability. In [8] is considered a Brownian motion with a drift  $h$  when the traps appearances follow the behavior of a Poisson process with given intensity. The case when this intensity is equal to the absolute value of  $h$  is called critical. When the dimension of the processes is 1, the cases of inequality between the absolute value of  $h$  and the intensity of the Poisson process are extensively studied in the literature. Therefore, in article [8] is studied in detail the limiting behavior of the random process defined above in the critical case. Article [9] is also devoted to unsolved problem from the theory of the one-dimensional Brownian motion (a hypothesis of Benjamini-Beresticki). The limiting behavior of the Brownian motion is established whenever its local time at zero until moment  $t$  is less than  $f(t)$ , as  $t$  tends to infinity, where  $f(t)$  is a deterministic and non-decreasing function. This gives an exhaustive answer of the above mentioned hypothesis. In article [14] is considered a model of production of filters created after putting fibres on an area by a turbulent stream described by concrete stochastic differential equation. It is proved that the process defined by this equation is ergodic with geometric rate of convergence, which practically means that filters with a small gap (eye) will be formed relatively fast.

*Spectral theory of Markov semigroups and applications of exponential functionals of Levy processes.* Article [7] discusses typical properties of Markov semigroups with a common regularity point at which the corresponding Markov processes are destroyed (they disappear). Such semigroups are called intertwining. It is proved that if these processes can be extended arbitrarily in the sense of Ito, then their local times coincide in distribution at the regularity point. This result is further illustrated with several important and concrete examples of Markov processes. In article [5] is considered a class of self-similar stochastic processes, which are non-Markovian. A complete description of the Mellin transform of their time until disappearing is obtained and properties of the asymptotic densities of the times until disappearing, smoothness, etc., are studied. In the proofs of the results of both articles are used methods connected with exponential functional of Levy processes.

*Some applications of branching and similar processes.* In article [3] are studied properties of the method of particles in Monte Carlo simulations in order to obtain approximate values of characteristics connected with the solution of the Wigner equation from Quantum Mechanics. The characteristics under consideration are expanded in an infinite series whose terms have a probabilistic interpretation connected with the evolution of a given particle. It is assumed that the particle is a subject of random changes. An upper bound for the number of terms in the sum approximating this infinite series is found, so that, as a whole, the

approximation is sufficiently good. In article [10] is studied a point process as a model of a population of individuals, where births and deaths can occur. The dependency of the mutations, births, deaths of the individuals and the competition between them on the phenotype, are taken into account. In addition to a known result related to the strong law of large numbers, the central limit theorem for the corresponding characteristic is obtained.

*Contributions to financial mathematics and probabilistic combinatorics.* Article [4] is of combinatorial nature. The class of all representations of an  $n$ -element set as a union of its disjoint subsets (blocks) is considered. The uniform probability measure is introduced on this class. The limiting behavior of the maximal multiplicity of blocks (i.e. the maximum number of blocks with one and the same number of elements) in a random partition of an  $n$ -element set is studied as  $n$  tends to infinity. Under suitable normalization and centralization, it is proved that the maximal multiplicity converges weakly to the maximum of 2 independent and standard normally distributed random variables, one of which is shifted from the origin with an explicitly given constant. The convergence is valid for subsequences of the sequence of natural numbers that satisfy certain given conditions. Article [6], which is from the area of financial mathematics, presents two different schemes leading to partial differential equations for the so called default derivatives. The first scheme uses a stochastic differential equation, stopping at a random moment of time. In the second one the effect of addition of a process with jumps is studied, assuming that the stopping moment coincides with the first jump of the process. The dependences between the asset, the time of stopping and the degree of the loss are studied if the price is defined by a Brownian motion and by a Levy process, respectively.

The above review shows that the applicant's contributions in the materials submitted for this competition are characterized by introducing and proving the validity of new hypotheses and claims and by the development of new approaches and methods.

I consider that the authors have equal contribution in each one of all joint publications.

## **6. Critical remarks and recommendations**

The materials submitted for the present competition, which are required by 3PACPE (68 files I total) are prepared correctly and accurately by Assoc. Prof. Savov. I have no critical remarks and recommendations on the scientific publications of the applicant.

## **7. Personal impressions on the applicant**

I know Assoc. Prof. Savov and I have worked with him jointly. I am impressed by the variety of his mathematical skills and knowledge and by his great persistence for solving difficult mathematical problems. My personal impressions from his work are excellent.

## **8. Conclusion on the application**

After becoming acquainted with the materials and scientific works submitted for this competition and on the basis of the above given analysis of their significance and scientific and scientific-applied contributions, **I confirm** that the scientific achievements of the applicant cover the requirements of ЗРАСРБ, the Regulation for its implementation and the corresponding Regulation of the SU “St. Kl. Ohridski”, so that the applicant can occupy the academic position of a Professor in the scientific area and in the professional direction of the competition. In particular, the applicant satisfies the minimum national requirements for the professional direction and it is not established plagiarism in the scientific works, submitted for the competition.

My evaluation for this application is **positive**.

## **II. GENERAL CONCLUSION**

On the basis of the report given above, I **recommend** to the Scientific Jury to suggest to the body of competence of the election from the Faculty of Mathematics and Informatics at Sofia University “St. Kl. Ohridski” **to elect Mladen Svetoslavov Savov** to occupy the academic position “Professor” in the Professional Direction 4.5 Mathematics (Probability and Statistics).

01.08.2020

The report is prepared by: Prof. DrSci in Mathematics, Ljuben Mutafchiev