REVIEW

on a competition for the occupation of the academic position "Professor"
in the professional field 4.5. Mathematics (Mathematical Logic)
for the needs of Sofia University (SU) "St. Kliment Ohridski",
Faculty of Mathematics and Informatics (FMI),
announced in the State Gazette, issue 59 dated 26.07.2019,
and on the websites of FMI and SU

The review was prepared by Prof. Dr. habil. Dimiter Genchev Skordev, pensioner, professional field 4.5. Mathematics (Mathematical Logic), as a member of the scientific jury for the competition according to Order no. RD 38-555/2019-09-25 of the Rector of SU.

Documents for participation in the announced competition have been submitted only by Assoc. Prof. Dr. Alexandra Andreeva Soskova, a member of the Department of Mathematical Logic and its Applications at FMI of SU.

I. General Description of Submitted Materials

The documents submitted by the candidate comply with the requirements of the Act of the Development of the Academic Personnel of the Republic of Bulgaria (ADAPRB), the Rules for the Implementation of ADAPRB (RIADAPRB) and the Rules on the Conditions and Procedures for Acquiring Degrees and Occupation of Academic Positions at SU "St. Kliment Ohridski" (RCPADOAPSU).

To participate in the competition, the candidate submitted 11 publications in foreign scientific editions, namely:

- Four articles in volumes from the Lecture Notes in Computer Science series – three papers of her own and one co-authored with Maria Soskova (the three papers of her own reflect scientific communications of the candidate at international conferences Computability in Europe, and the joint one is of an overview nature).
- Three articles in proceedings of Panhellenic Logic Symposia – two in co-authorship with Ivan Soskov and one in co-authorship with Alexander Terziivanov and Stefan Vatev.
- Four articles in the Journal of Logic and Computation – one of her own, two co-authored with Ivan Soskov and one co-authored with Wesley Calvert, Andrey Frolov, Valentina Harizanov, Julia Knight, Charles McCoy and Stefan Vatev (the article of her own is an extended version of one of the articles in Lecture Notes in Computer Science, and one of the joint papers with Soskov – of one of the articles in proceedings of Panhellenic Logic Symposia).

She also provided a file with abstracts of all these articles in Bulgarian and English.

The following documents were also submitted: application for admission to the competition, creative CV, diploma for higher education in mathematics with specialization “Mathematical Logic”, diploma for PhD degree in Mathematics, certificate for the scientific title “Associate Professor ”, a certificate for the available work experience in the specialty, a certificate that A. Soskova has been working at the Sofia University since 1994-02-01 and continues to work on an employment contract, two additional agreements to the employment contract, a list of scientific papers, a list of submitted scientific papers for the competition, a copy of the information on the scientific contributions of Assoc. Prof. Alexandra Soskova in the system “Authors ” of the SU, Declaration under Article 115, Paragraph (1), Item 5 of RCPADOAPSU, reference for the minimum national requirements under Article 2b of the ADAPRB, copy of information for the applicant in the National Centre for Information and Documentation, list of observed citations of the candidate’s publications, two references to citations reflected in SCOPUS, SCOPUS scientometric information for the Lecture Notes in Computer Science series, two references to citations reflected in Web of Science, Web of Science scientometric information for the Journal of Logic and Computation, a detailed author’s report on the scientific contributions in the articles submitted for the competition, a reference to the additional indicators of Article 122, Paragraph 2 of RCPADOAPSU, recommendations from Prof. Antonio Montalbán of UC Berkeley (1 page) and Prof. Valentina Harizanov of George Washington University (6 pages), copy of a part of issue 59/2019-07-26 of the State Gazette containing the announcement of the competition.

With regard to the list of submitted works contained in the above-mentioned documents, I note that the principle of their arrangement is not clear. In general, it is not chronological because the years of publication of the works listed therein are in the following order: 2013, 2017, 2008, 2006, 2007, 2007, 2007, 2009, 2009, 2015, 2018. The order is also not the one of mention in the introduction of the author’s report on the scientific contributions, where the numbers of the cited submitted works appear in the following order: 2, 1, 4, 7, 3, 5, 6, 8, 9, 10, 11 (the matching of the numbering with the rest of the summary is not better).

The candidate was born in 1956. She graduated in 1979 with a Master’s degree in Mathematics at the Faculty of Mathematics and Mechanics of the SU, defending a thesis on “Some problems concerning the definition of prime computability” at the Sector of Mathematical Logic. Until 1986, she works consecutively (in the position of “mathematician” and as a research associate) at the Electronic Computing Center of the Computer Engineering Plant in Sofia and at the Institute of Applied Systems “Systemizot”. In the period 1990-1991, she is in the position of “mathematician” at the Research Sector at SU. In 1991 she has been awarded a PhD degree in Mathematics after a full-time graduate study in mathematical logic and the defence of a thesis under the title “Effective Algebraic Systems”. From 1993 to 2005 she is consecutively Assistant Professor, Senior Assistant Professor and Chief Assistant Professor at the Department of Mathematical Logic and its Applications of the FMI in SU. From 2005 on, Dr. Alexandra Soskova is an Associate Professor at the same department. The candidate’s creative CV lists dozens of works that she authored or co-authored:

27 scientific articles, two biographical articles, two books in support of teaching and 11 abstracts. She was the scientific adviser of two successfully defended graduates and one successfully defended doctoral student, while another doctoral student supervised by her has been dismissed with the right of a defence. She has listed dozens of her visits to foreign universities and research centers, as well as 11 research and structural projects in which she has participated (most of them with international involvement, with Mrs. A. Soskova as head of one of them, and in several others – coordinator of SU). She has participated in three contracts with the Ministry of Education and Science and in five contracts with the NSF-SU (in one of them as a manager). She has repeatedly served on the program or organizing committee of international scientific forums (several times as chair of the committee). She is a member of the association Computability in Europe and the Association for Symbolic Logic, as well as of the American Mathematical Society. At the Association for Symbolic Logic, she is chairman of a committee, and has held other administrative positions there.

From 2008 to 2016 Alexandra Soskova was the Head of the Department of Mathematical Logic and its Applications at FMI of SU. At various times she was Deputy Dean of FMI, member of the Academic Council of SU, member of the Faculty Council of FMI, member of the General Assembly of SU. She has been a member of various committees at the FMI and also an Erasmus Coordinator.

The candidate has an active teaching career at the FMI of SU, which includes Master's courses in Computability Theory and Model Theory and over the years has included about ten different courses in Bachelor's Degree. He is the head of the Master's Program "Logic and Algorithms" for computer science students.

The scientific field in which the candidate works is the theory of computability - one of the main parts of mathematical logic. The results presented to the competition mainly relate to the estimation of the degree of non-algorithmicity of the primary relations in countable mathematical structures, the estimation being made by the so-called spectra of degrees. About four decades ago, Linda Richter's studies at the University of Illinois at Urbana-Champaign began this area of computability theory. The first Bulgarian works in this area are the invited talk of Ivan Soskov and the contributed talk of Alexandra Soskova at the Fourth Panhellenic Symposium, held in 2003, as well as an article by Ivan Soskov and a joint article of Soskova and Soskov, published in 2004 in the Annual of FMI (earlier, in the previous decade, a slightly different approach was proposed by Ivan Soskov and was used in some MSc theses defended at the Department of Mathematical Logic and its Applications and in relevant publications). The basis of these studies of Ivan Soskov and Alexandra Soskova is the enumeration reducibility instead of the more particular in some sense Turing reducibility, which is the base of the earlier studies in the direction in question, and all the enumerations of the structure domain are taken into account, not only the injective ones as it is in those earlier studies.

For any countable structure $\mathfrak{A}$ and a natural juxtaposition of a set of natural numbers $f^{-1}(\mathfrak{A})$ to each enumeration f of its carrier, the degree spectrum of $\mathfrak{A}$ is defined as the set of the enumeration degrees of the sets $f^{-1}(\mathfrak{A})$ corresponding to the various enumerations of the carrier of $\mathfrak{A}$.

We will look at the works submitted by the candidate in the following sequence of numbers: 4, 7, 5, 6, 8, 3, 9, 1, 10, 2, 11 (this sequence enters into conflict with the order of the years of publication only through considering work no. 8, which expands work no. 6, immediately after it – before work no. 3).

Work no. 4: *Relativized degree spectra.* Published in Logical Approaches to Computational Barriers, CiE 2006, Lecture Notes in Computer Science, **3988** (2006), 546–555.

This is a shorter version of the work no. 7 published the next year and bearing the same title (but not mentioning the former). A citation of work no. 4 in the MSc thesis of Stefan Vatev is indicated.

Work no. 7: *Relativized degree spectra.* Published in Journal of Logic and Computation, **17** (2007), 1215–1234.

The notion of degree spectrum of a structure is generalized by defining the spectrum of a structure $\mathfrak{A}$ with respect to given structures $\mathfrak{A}_1, \ldots, \mathfrak{A}_n$ (all structures considered are assumed to have as their carrier the set $\mathbb{N}$ of the natural numbers). The relative spectrum of $\mathfrak{A}$ with respect to $\mathfrak{A}_1, \ldots, \mathfrak{A}_n$ is the set of the enumeration degrees of the sets $f^{-1}(\mathfrak{A})$ corresponding to those of the enumerations f of $\mathbb{N}$, for which $f^{-1}(\mathfrak{A}_i)$ is enumeration reducible to the ith jump of $f^{-1}(\mathfrak{A})$ for $i = 1, \ldots, n$. It is shown that this generalized notion of spectrum of a structure has all general and specific properties of the spectrum. A syntactical characterization is presented of the elements of the co-spectrum of the relative spectrum by means of computable infinite formulas. A theorem about the minimal pairs and the existence of a quasi-minimal degree with respect to the relative spectrum is proved. The introduced notion is compared with the notion of the joint spectrum of $\mathfrak{A}$ with respect to $\mathfrak{A}_1, \ldots, \mathfrak{A}_n$, introduced in the joint paper of Soskova and Soskov from 2004, and a similarity of the properties is established.

Two citations of this work are indicated - in the MSc thesis of Stefan Vatev and in Journal of Logic and Computation.

Work no. 5: *A jump inversion theorem for the degree of spectra.* Published in Computation and Logic in the Real World, CiE 2007, Lecture Notes in Computer Science, **4497** (2007), 716–726.

The jump spectrum of a countable structure means the set of the enumeration jumps of the degrees in the spectrum of that structure. For arbitrary countable structures $\mathfrak{A}$ and $\mathfrak{B}$, such that the spectrum of $\mathfrak{A}$ is contained in the jump spectrum of $\mathfrak{B}$, a countable structure is constructed with spectrum contained in the spectrum of $\mathfrak{B}$ and jump spectrum coinciding with the spectrum of $\mathfrak{A}$. The proof of this result cleverly uses ideas and results of Marker, Goncharov and Khoussainov. A number of interesting applications of the above result are given.

For this work, ten citations from other authors are announced in the competition materials, but the following nine are actually confirmed: in the Siberian Electronic Mathematical Notices, in Siberian Advances in Mathematics, in the works of CiE 2007 and CiE 2013, in Philosophical Transactions of the Royal

Society A, in the Journal of Symbolic Logic, in a volume of the Lecture Notes in Logic series, in Algebra and Logic, and in the manuscript of a monograph prepared by Antonio Montalbán. The announced citation in a Montalbán article in the Notre Dame Journal of Formal Logic is not confirmed – this can be seen, for instance, by accessing the relevant web site indicated in the citations list and using the "References" link therein. I think the article in question was mentioned at this position in the list by mistake.

Work no. 6 (jointly with I. Soskov): *Jump spectra of abstract structures.* Published in Proceedings of the 6th Panhellenic Logic Symposium, Volos University, (2007), 114–117.

This is a shorter version of the later work no. 8 without being cited in it. The author's report states that the contributions of the two authors to these works are equal.

Work no. 8 (jointly with I. Soskov): *A jump inversion theorem for the degree spectra.* Published in Journal of Logic and Computation, **19** (2009), 199–215.

In this work, one considers as the degree spectrum of a countable structure $\mathfrak{A}$ the set of Turing degrees of the sets $f^{-1}(\mathfrak{A})$ corresponding to all enumerations f of the carrier of $\mathfrak{A}$, and as the jump spectrum of $\mathfrak{A}$ – the set of the Turing jumps of these degrees. The relationship between the spectrum and the jump spectrum of a structure is studied. The first result is that every jump spectrum of a structure is a spectrum of some structure. Namely, it is proved that the jump spectrum of an arbitrary countable structure $\mathfrak{A}$ is the spectrum of a structure obtained by adding an appropriate primitive set to the Moschovakis extension of $\mathfrak{A}$. The main result in the article sounds like the main result in work no. 5, but refers to the Turing degrees and jumps discussed here, not to the enumeration ones. A skillful use of ideas and results of Marker, Goncharov and Khoussainov is present in its proof again.

For this work, 24 citations from other authors were noted in the competition materials – in the above mentioned in connection with the work no. 5 ten sources, once more in the works of CiE 2013, once more in Algebra and Logic, twice more in the Journal of Symbolic Logic, once more in a volume of the series Lecture Notes in Logic, as well as in the proceedings of CiE 2011, in the PhD thesis of Stefan Vatev (defended at SU), in the Annual of FMI, in the monograph "Algebraic Computability and Enumeration Models: Recursion Theory and Descriptive Complexity" by Cyrus F. Nourani, in the collection "The Incomputable. Journeys Beyond the Turing Barrier", in the volume "Computability and Complexity" of the Lecture Notes in Computer Science series, in the PhD thesis of Matthew Harrison-Trainor (defended at UC Berkeley)[1], in the journal Computability and in Mathematical Logic Quarterly.

Work no. 3: *ω-degree spectra.* Published in Logic and Theory of Algorithms, CiE 2008, Lecture Notes in Computer Science, **5028** (2008), 544–553.

[1]In A. Soskova's citations list, an abstract of the thesis in the Bulletin of Symbolic Logic is indicated, however, there are no citations in the abstract (the thesis itself can be found at `http://homepages.ecs.vuw.ac.nz/~harrism1/thesis.pdf`).

One introduces the notion of ω-spectrum of a structure with respect to a sequence of sets. If $\mathfrak{A}$ is a structure with carrier $\mathbb{N}$ and $B_0, B_1, B_2, \ldots$ is a sequence of subsets of $\mathbb{N}$, then the ω-spectrum of $\mathfrak{A}$ with respect to the sequence $B_0, B_1, B_2, \ldots$ is the set of enumeration degrees of the sets $f^{-1}(\mathfrak{A})$ corresponding to the enumerations f of $\mathbb{N}$ such that the pre-image of B_n under f is enumeration reducible to the nth enumeration jump of $f^{-1}(\mathfrak{A})$ for every n and the reducibility is uniform in n. It is noted that the relative spectra considered in work no. 7 are a particular case of ω- spectra (in which the initial term of the sequence $B_0, B_1, B_2, \ldots$ and all other its terms but finitely many are empty). The ω-spectrum is shown to be upwards closed with respect to total enumeration degrees. A normal form representation of the elements of the ω-co-spectrum of a structure is given. It is proved that some spectrum properties, such as the minimum-pairs theorem and the existence of a quasi-minimal degree with respect to the spectrum, are present also for ω-spectra.

A citation in the MSc thesis of Stefan Vatev is indicated.

Work no. 9 (jointly with I. Soskov): *Some applications of the Jump inversion theorem.* Published in Proceedings of the 7th Panhellenic Logic Symposium, Patra University, (2009), 157–161.

The nth jump spectrum of a structure $\mathfrak{A}$ means here the set of the nth Turing jumps of degrees in the spectrum of $\mathfrak{A}$, and the nth jump degree of $\mathfrak{A}$ is the smallest element of the nth jump spectrum of $\mathfrak{A}$, when such a smallest element exists. This article shows two applications of results from work no. 8. The first application provides a method to construct for any positive integer n a structure with nth jump degree $\mathbf{0}^{(n)}$ and without kth jump degrees for $k < n$ (this is a particular instance of an earlier result of Downey and Knight, whose proof, however, is much more complicated). The second application is a generalization of the result of Wehner and Slaman that a structure exists, whose spectrum is the set of all non-computable degrees. Namely, for every natural number n and every degree $b \geq \mathbf{0}^{(n)}$, a structure is constructed, whose nth jump is the set of degrees greater than b. This is achieved by relativizing the construction used by Wehner.

I did not find information in the author's report about the participation of the two authors in this work.

Work no. 1 (jointly with I. Soskov): *Quasi-minimal degrees for degree spectra.* Published in Journal of Logic and Computation, **23** (2013), 1319–1334.

For enumeration degrees, the term quasi-minimality has been introduced in connection with a result of Yuri Medvedev.[2] In his 2004 article in the Annual of FMI Ivan Soskov defines the notion of quasi-minimality of an enumeration degree with respect to a set of enumeration degrees, the usual quasi-minimality being equivalent to quasi-minimality with respect to the set of nonzero enumeration degrees. In work no. 1, the properties of quasi-minimal degrees with respect to spectra of structures are considered. These properties generalize the

[2]In relation with this, the following phrase occurs in the paper: "the existence of quasi-minimal e-degrees, first shown by Medvedev (1955)"; however, no source with this author is included in the references section.

classical ones in degree theory. It is shown that there are uncountably many quasi-minimal degrees with respect to each spectrum of structure, that the first jump spectrum of each structure consists of the enumeration jumps of quasi-minimal degrees with respect to its spectrum, and any one of them can be represented as the least upper bound of two such quasi-minimal degrees.

The author's report states that the participation of the two authors can be divided equally.

Work no. 10 (jointly with A. Terziivanov and S. Vatev): *Generalization of the notion of jump sequence of sets for sequences of structures.* Published in Proceedings of the 10th Panhellenic Logic Symposium, University of Aegean Press, (2015), 25–29.

A generalization is proposed of the notion of jump sequence of sets to jump sequence of structures. The jump sequence of such a sequence $\vec{\mathfrak{A}} = \{\mathfrak{A}_i\}_{i<\omega}$ is a sequence of structures $\mathcal{P}_0(\vec{\mathfrak{A}}), \mathcal{P}_1(\vec{\mathfrak{A}}), \mathcal{P}_2(\vec{\mathfrak{A}}), \ldots$, defined (by Definition 1.3) in the following inductive way:

$$\mathcal{P}_0(\vec{\mathfrak{A}}) = \mathfrak{A}_0,\ \mathcal{P}_{n+1}(\vec{\mathfrak{A}}) = \mathcal{P}_n(\vec{\mathfrak{A}})' \oplus \mathfrak{A}_{n+1}$$

(unfortunately, the two operations on structures in the right-hand side of the second equality are defined only a few pages later – in Definitions 2.6 and 2.10, without accompanying Definition 1.3 by information about this; actually, in Definition 2.10, the $\oplus$-operation is defined only for structures with disjoint carriers, that is why the jump sequence of $\vec{\mathfrak{A}}$ is actually defined under the additional assumption that the terms of the sequence $\vec{\mathfrak{A}}$ are with disjoint carriers). Two structures are called equivalent if they have the same relative intrinsically recursively enumerable sets in the intersection of their carriers (however, I find this terminology inappropriate because the defined equivalence of structures is not transitive, and, due to the essential role of intersection of carriers in its definition, one cannot assume without loss of generality that the carriers of the structures considered further in the paper do not intersect).

Using Soskov's generalization of Marker's extensions for a sequence of structures, it is proved that, for any sequence $\vec{\mathfrak{A}}$ of structures that have disjoint carriers, a structure $\mathfrak{M}$ exists such that the structures $\mathcal{P}_n(\vec{\mathfrak{A}})$ and $\mathfrak{M}^{(n)}$ are equivalent for any n (in Theorem 1.5 this result is formulated without the assumption that the carriers of the structures of $\vec{\mathfrak{A}}$ are disjoint). In fact, however, formally speaking, the claim that under the assumption in question there is a structure $\mathfrak{M}$ with the above property is true for trivial reasons – to have this property, it is sufficient the carriers of $\mathfrak{M}^{(n)}$ and $\mathcal{P}_n(\vec{\mathfrak{A}})$ to be disjoint for each n.

The candidate states in the author's report: "This article is based on Terziivanov's MSc thesis, and as Vatev and me helped in the formulation of the task and in the proofs, the contributions can be considered equal" (the thesis in question, defended in 2014, is written under the supervision of Assoc. Prof. Alexandra Soskova). Unfortunately, the contributions in this work are questionable.

Work no. 2 (jointly with M. Soskova): *Enumeration reducibility and Computable Structure Theory.* Published in Computability and Complexity, Lecture

Notes in Computer Science, **10010** (2017), 271–301.

The paper is an overview on the subject mentioned in the title and aims to represent an overall picture of results of the group in Computability in Sofia, as well as the relation of the enumeration degrees with the Computable Structure Theory. One considers the properties of the enumeration reducibility, the enumeration degree spectra and co-spectra of structures, some generalizations of the notion of the degree spectra of a structure, the jump inversion theorem of an abstract structure, ω-enumeration reducibility for the sequences of sets, and the generalized Marker extensions for sequences of structures. Special attention is paid to the last paper of Ivan Soskov (published after his death), where he solves a number of problems concerning the Turing spectrum, the enumeration spectrum, and the spectrum of sequences of structures. Soskov's ideas are presented on an example. Work no. 2 has an extensive bibliography of 101 sources.[3]

A citation of this work in Siberian Electronic Mathematical Reports is indicated.

Work no. 11 (jointly with Calvert, Frolov, Harizanov, Knight, McCoy and Vatev): *Strong jump inversion.* Published in Journal of Logic and Computation, **28** (2018), 1499–1522.

It is said that a structure $\mathfrak{A}$ admits strong jump inversion if, whenever the jump of the atomic diagram of a copy of $\mathfrak{A}$ in the natural numbers is Turing reducible to the jump of a set X of natural numbers, the atomic diagram of some copy of $\mathfrak{A}$ is Turing reducible to X (obviously it should be assumed that $\mathfrak{A}$ is countable; the same applies to other structures considered in the work). Jockusch and Soare show that there are low linear orderings without computable copies, hence non-admitting strong jump inversion. Downey and Jockusch, on the other hand, show that Boolean algebras admit strong jump inversion. In an article published in 2017, Marker and Miller prove that all countable models of DCF_0 (the theory of differentially closed fields of characteristic 0) admit strong jump inversion. In work no. 11 a general result is presented with sufficient conditions a structure to admit strong jump inversion. The result is applied to known structures, including some classes of linear orderings and trees. One does not get the result of Downey and Jockusch for arbitrary Boolean algebras, but gets a result for a special class ones along with additional information. The general result implies the one of Marker and Miller. A consequence is that the saturated model of DCF_0 has a decidable copy.

The author's report states that the authors' contributions to the article are equal in value. I observed that the article is cited in Anand Pilay's preprint "A note on the effective listing of complete types", arXiv:1904.09949 [math.LO].

[3]However, there are some errors therein – as can be seen (for instance, from the archive available at `https://www.fmi.uni-sofia.bg/en/node/6810`), the volume with the article [7] is from 2004, not 2001, the article is on pages 41–51, not pages 35–44, the volume with the article [72] is not **91** from 1997, but **89** from 1998, the article [84] is on pages 23–40, not pages 15–32. As to the article [8], it would be well if a volume number and page numbers were given for it (even though a DOI link is given).

Having examined the materials and scientific works presented in the competition and analysed their importance and the scientific contributions contained therein, I confirm that there are sufficient scientific achievements that meet the requirements of the ADAPRB, its Implementing Regulations and the relevant Rules of SU "St. Kliment Ohridski" for the occupation by the candidate of the academic position "Professor" in the scientific field and professional direction of the competition. In particular, the candidate meets the minimum national requirements in the professional field and no plagiarism has been identified in the scientific papers submitted at the competition. I estimate positively the candidate's application.

II. Overall conclusion

On the basis of the above, I recommend that the scientific jury propose to the competent electoral body of FMI at SU "St. Kliment Ohridski" to elect Assoc. Prof. Dr. Alexandra Andreeva Soskova for the academic position "Professor" in the professional field 4.5. Mathematics (Mathematical Logic).

November 20, 2019 Reviewer:

(Prof. Dimiter Skordev)