Review

Call for Full Professor position in 4.5 Mathematics
of the Faculty of Mathematics and Informatics (FMI) at Sofia University
as published in the State Gazette No 59 of the 26th July 2019

Reviewer: Assoc. Prof. Hristo Ganchev, FMI, Sofia University

The only candidate for the call is **Assoc. Prof. Aleksandra Andreeva Sosokova from FMI at Sofia Univeristy.**

I. General description of the submitted documents

1. Submitted documents

The documents submitted by Prof. Soskova comply with the Bulgarian legislation and internal rules of Sofia University. She has provided 11 publications in international scientific journals and proceedings of conferences. She has also provide 30 more documents among which a CV, copies of her MSc, PhD and Associate Professor diplomas, a copy of her work contract with Sofia University, a list of all her publications, extracts from Scopus and WoS showing the SJR and IF of the journals in which her papers are published, a description of the results in the presented papers, a list of citations, referee reports from two distinguished scientists.

All documents are well aranged and are easy to work with. The description of the results is comprehensive and correctly reflects the contributions of the candidate.

2. Information about the candidate

Aleksandra Soskova was born on the 16th of January 1956 in Sofia. She graduated from the National High School for Mathematics in 1974 and enrolled as a student in FMI at Sofia University the same year. She obtained her MSc degree in Mathematics in 1979. After graduating, she worked for several years in different technical institutes. She obtains her PhD degree in 1990 and from 1993 she is Assistant Professor in the Department of Mathematical Logic, FMI at Sofia University. She is promoted to Associate Professor in 2005. She have been head of the Department of Mathematical Logic, FMI, SU during the period 2008-2016. She have been vice-dean of the Faculty of Mathematics and Informatics at Sofia University during the period 2015-2017.

Prof. Soskova has over 40 scientific publications, including 17 papers in journals with SJR or IF among which at least one is ranked in Q1 of group Mathematics of WoS. She has given over 50 talks at international conferences and suniversities. She has taken part in 26 scinetific projects. She has been the scientist in charge of one project funded by the Bulgarian National Science Fund. Further, she has been the coordinator (of the Bulgarian participants) of 5 projects funded by foreign institutions, including a TEMPUS project.

Prof. Soskova is a member of the Association for Symbolic Logic (ASL). She has been a member of the council of the association during the period 2015-2018. She has been a member of the programme comitees of the biggest conferences in Mathematical Logic and Computability.

3. General characteristics of the scinetific achievments of the candidate.

The scientifc research of Aleksandra Soskova are in the field of Effective Model Theory – a subarea of Mathematical logic investigating the computable complexity of algebraic structures. Presently, this is one of the most active fileds connected with Computability theory. Prof. Soskova has presented 11 publications, from which 10 contain original scientific results. One of the papers is an overview of the results connecting Effective Model Theory with the theory of the Enumeration Degrees.

Among the original reults, the most outstanding are the ones about the jump of a structure (a notion introduced by A. Soskova and indipendently by Montalban and by Stukachev), especially the jump inversion theorm, which gives a technique for obtaining in elegant way many interesting and non-trivial results.

Eight of the presented publications give points according to rules for implementing the Bulgarian law for the Academic Staff. All presented papers are published after 2005 (the year in which A. Soskova is promoted to Associate Professor) and were not used in previous calls. The average points achieved by the candidate with respect to the different groups of indicators are summarized in the following table:

Group	А	Б	В	Г	Д	Е
Minimum points requierd	50	-	100	200	100	100
Points achieved	50	-	120	210	120	>>150

There is no evidence raising any doubts about the originality of the presented results.

4. Teaching experience

Prof. Soskova has a considerable teaching experience. Since her initial appointment to the Department of Mathematical Logic, Prof. Soskova has taught courses in Mathematical Logic, Logical Programming, Semantics of the Programming Languages, Discrete Mathematics, Languages Automata and Computability. She has always made a lot of efforts to make the courses modern and attractive for the students. During the last few years, she is using consistently the Moodle system by providing e-lectures and interactive exercises for the students.

I think that Aleksandra Soskova is an excellent teacher, who is quite popular among the students of FMI as evidenced by the high results she obtains from the students' surveys.

5. Scientific achievments

The scientific achievements of Aleksandra Soskova (presented for this call) are in the field of Effective Model Theory. The main goal in this field is to characterize the computational complexity of algebraic structures. The state of the art approach to this problem ar e the so-called degree spectra. The degree spectrum of a countable structure $\mathcal{A}$ is the mass problem $D(\mathcal{A})$ consisting of all sets that can compute an isomorphic copy of $\mathcal{A}$. Degree spectra a compared using the Muchnnik reducibility (one of the two main reducibilities used for comparing mass problems), so that a $\mathcal{A}$ is said to be simpler than a strucutre $\mathcal{B}$ (written $\mathcal{A} \leq_w \mathcal{B}$) if $D(\mathcal{B}) \subseteq D(\mathcal{A})$, i.e. if every set computing a copy of $\mathcal{B}$ computes a copy of $\mathcal{A}$.

The jump operation on sets gives us an uniform way for obtaining a more complex set A' from a given set A. This operation is well studied and it plays a central role in Degree Theory. Using the jump operation, we can define the jump mass problem M' of a mass problem M by setting $M' = \{X' \mid X \in M\}$. In case of a degree spectrum $D(\mathcal{A})$, the jump mass problem is called first jump spectrum and it is denoted by $D_1(\mathcal{A})$. The following natural question arises: Can we map unifomly a structure $\mathcal{A}$ to a strucure $\mathcal{A}'$ so that $D(\mathcal{A}') = D_1(\mathcal{A})$? A positive answer to this question is give in [6,8]. The structure $\mathcal{A}'$ is obtianed from $\mathcal{A}$ by taking the Moskovakis extension $\mathcal{A}^*$ of $\mathcal{A}$ and then adding a predicate coding the sets in $\mathcal{A}^*$ definable via infinite Σ_1^c formulae. The inclusion $D(\mathcal{A}') \subseteq D_1(\mathcal{A})$ is straightforward, whereas the inclusion $D_1(\mathcal{A}) \subseteq D(\mathcal{A}')$ is proven using a forcing argument.

The next natural question arising is: Given a strucure $\mathcal{A}$, such that $D(\mathcal{A}) \subseteq \{X \mid \emptyset' \leq_T X\}$ (so that $D(\mathcal{A})$ is possibly the spectrum of a jump structure), is there a structure $\mathcal{C}$ such that $\mathcal{C}' \equiv_w \mathcal{A}$. The positive answer to this question is given in [5,6,8]. It is proven even a stronger statement, namely: given $\mathcal{B}' \leq_w \mathcal{A}$ we can find a structure $\mathcal{C}$, such that $\mathcal{B} \leq_w \mathcal{C}$ and $\mathcal{C}' \equiv_w \mathcal{A}$. The proof of this theorem is done using the so-called Marker extensions. As an application, it is proven [8,9] that for every natural n there exists a structure $\mathcal{A}$ such that $D\left(\mathcal{A}^{(n)}\right) = \{X \mid \emptyset^{(n)} \leq_T X\}$ but $D(\mathcal{A}^{(k)})$ has no least element for $k < n$. This a particular case of a more general result by Downey and Knight, but here the proof is a straightforward application of the jump inversion theorem and the existence of a group $\mathcal{G}$, such that $D(\mathcal{G}) \subsetneq \left\{X \mid \emptyset^{(n)} \leq_T X\right\}$ and $D(\mathcal{G}') = \left\{X \mid \emptyset^{(n+1)} \leq_T X\right\}$, whereas the general result requires very compex and dificult to follow construction. Another application of jump inversion [9] is that for every set A there is a structure $\mathcal{A}$ such that $D(\mathcal{A}) = \{X \mid A <_T X^{(n)}\}$. This results generalizes several results by Wener and Slaman.

In [11], some sufficient conditions for a structure $\mathcal{A}$ to be such that if $\mathcal{A} <_w \mathcal{B}$ then $\mathcal{A}' <_w \mathcal{B}'$ are shown. Although, these conditions seem to be unnatural and hard to satisfy, there are a lot of natural examples (as shown in [11]) of strucutres satisfying the conditions, such as linear orderings, Boolean algebras, trees, theories, and differentially closed fields. In many cases, the conditions give us further information on the comlexity of the isomorphism taking a copy of $\mathcal{A}$, computing X and has a jump equivalent to X', into a copy $\mathcal{A}$ equivalent to X.

The papers [1, 3, 4, 7, 10] are dedicated to the notion co-spectrum of a structure as well as some generalizations of the notion spectrum of a structure. For the main degree structures, we have the inclusions $\mathbf{D}_T \subsetneq \mathbf{D}_e \subsetneq \mathbf{D}_\omega \subsetneq \mathbf{D}_w$, where $\mathbf{D}_T$ are the Turing degrees, $\mathbf{D}_e$ are the enumeration degrees, $\mathbf{D}_\omega$ are the ω-enumeration degrees, $\mathbf{D}_w$ are the Muchnik degrees. The degree spectrum maps countable algebraic structures to Muchnik degrees, so that a natural question is what is the relation between the degree spectra and the other degrees of unsolvability. It is easy to see that for a structure $\mathcal{A}$ and a Turing degree **a** we have $D(\mathcal{A}) \leq_w \mathbf{a}$ if and only if **a** computes a copy of $\mathcal{A}$, whereas for an enumeration degree **b** we have $D(\mathcal{A}) \leq_w \mathbf{b}$ if and only if every set X enumerating **b** also enumerates a copy of $\mathcal{A}$. Thus a more interesting question, what properties have the degrees which are bounded from above by $D(\mathcal{A})$. Since the enumeration degrees are downwrads dense, whereas the Turing degrees aren't, it is more interesting to investigate the enumeration degrees bounded above by $D(\mathcal{A})$. The set of the enumeration degrees, which are bounded from above by $D(\mathcal{A})$, is denoted by $CS(\mathcal{A})$ (the co-spectrum of $\mathcal{A}$). Using a forcing construction, it is proved (in [1]) that the quasi-minimal degrees of $D(\mathcal{A})$ (i.e. the enumeration degrees **q** for which turing degree **x** comparable with **q** either is a member of CS($\mathcal{A}$) or is a member of $D(\mathcal{A})$) are uncountably many, determine the spectrum of $\mathcal{A}'$ (in the sense that for very turing degree **x**, $D(\mathcal{A}') \leq_w \mathbf{x}$ if and only if $\mathbf{x} = \mathbf{q}'$ for some quasi-minimal **q** of $D(\mathcal{A})$), and further for every Turing degree **x**, if $D(\mathcal{A}') \leq_w \mathbf{x}$, then **x** is the least upper bound of two quasi-minimal degrees of $D(\mathcal{A})$.

The notion of a spectrum relative to a sqeunce of structures is introduced in the papers [3,4,7,10]. This notion is inspired by the works of Ash and of Soskov about the definability in a structure via $\Sigma^c_{\alpha+1}$ formulae. Given a structure $\mathcal{A}$ and a sequence of structures $\vec{\mathcal{A}} = (\mathcal{A}_0, \mathcal{A}_1, \dots)$ with legth $n \leq \omega$, the relative spectrum $RS(\mathcal{A}, \vec{\mathcal{A}})$ of $\mathcal{A}$ with respect to $\vec{\mathcal{A}}$ is roughly the collection of those copies of $\mathcal{A}$, for which $\mathcal{A}_i$ is Σ^0_{i+1} definable uniformly in i. The degree spectrum of a structure is obtianed when the squence is consists of one and the same trivial structure. The relative structure is once again a mass problem and hence a Muchnik degree, so that we can consider its jump sepctrum and its co-specrum. For finite sequences, these notions are considered in [4,7]. For infinite sequences, the notions are considered in [3,10], where this time the co-spectrum consists of the broader class of ω-enumeration degrees. In each case, the existence of quasi-minimal degrees and of minimal pairs is proven. Further, it is shown that, opposite to the Turing and the enumeration degrees, not every countable ideal of ω-enumeartion degrees is a (relativized) co-spectrum of a structure. The results are proven using forcing techniques and definability via computable infinite formulae.

The papers presented for this call deepen our knowledge about some "classical" areas of Effecive model theory, and furhter initiate investigations about new interesting and non-trivial concepts. All the proves and constructions, presented in the papers, require technical skills as well as ingenuity. They either enhance known proof methods, or introduce new ones.

Prof. Soskova is the only author in four of the presented, and a co-author in other 7 papers. The papers, in which she is a co-author, do not explicitly mention the contributions of the different authors, meaning (as it is accepted in the field) that all results are obtained in colaboration and all authors have equal contributions. The papers are cited over 30 times.

6. Remarks and recommendations

None

7. Personal impressions about the candidate

Aleksandra Soskova is one of the most committed teacher of FMI. She is very active in the university academic life. She has a lot of merits for the development of the department of Mathematical Logic. During the period in which she has been head of the department, six new assitent professors were recruited. Besides, the department organized two major international events in Mathematical Logic and in Computability, which has been a good advertisment for the department and for Sofia Univeristy as a whole. Last but not least, prof. Soskova is an excellent researcher and her results are highly appreciated by the scientific comunity working in the filed of Effective Model Theory.

8. Conclusion

After considering all the materials presented for the call and analizing the impact of the research of the candidate, I **confirm** that the presented scientific achievments comply with the Bulgarian legislation and the inner acts of Sofia University for holding the position “Full Professor”.

My evalaution of the candidate is very positive.

II. GENERAL CONCLUSION

I strongly reccomend Aleksandra Andreeva Soskova **to be elected** for “Full Professor” of Sofia University.

25/11/2019 Hristo Ganchev

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