

Review Template

Recommended length: six to seven pages

REVIEW

By: **Prof. Shahn Majid, PhD (Harvard), Professor of Mathematics (Full), Queen Mary University of London**

Regarding: The application of the following candidates for the academic position of **FULL PROFESSOR OF MATHEMATICS** according to the Bulgarian legislation at the American University in Bulgaria in Area of Higher Education 4. Natural Sciences, Mathematics, and Informatics in Professional Field 4.5 Mathematics. The procedure has been announced in the State Gazette issue 69 dated September 8, 2015

Candidate 1: **Assoc. Prof. Dr. Tatyana Gateva-Ivanova**

I present the evaluation below in my capacity as a member of the Academic Jury appointed for the above mentioned procedure by a letter of the AUBG President dated November 6, 2015. This evaluation is based on the *Development of Academic Staff in the Republic of Bulgaria Act*, the Rules for its implementation, the internal AUBG rules, regulations, and policies, including the *Habilitation Procedure* and the advertisement on the AUBG website regarding the procedure.

Evaluation of the Applicant

*The evaluation is carried out according to the **Primary Indicators** and **Additional Indicators** included in the document **Guidelines for the Academic Jury**.*

I. Basis for Evaluation and general description of the publications and professional activities, submitted for consideration for this procedure

*Please indicate on what information this evaluation is based - documents submitted by the Candidate, professional activities, publications, **as ticked***

- monograph(s);
- **articles in refereed journals specialized in the area;**
- non-refereed publications;
- conference reports;
- other publications (*please specify*);
- citations (by publications abroad);
- reviews, recommendations, opinions for the applicant's works; (**in the application pack eg teaching evaluations**)
- projects (Bulgarian, international, project leader);
- professional memberships;
- theoretical and applied works;
- other activities (*please specify*). **international visits and grants showing a high international profile and esteem**

I used the materials provided, notably the publications (1)-(11) dating after the candidate became Associate Professor, as primary research indicators; teaching evaluations and reports as provided, and esteem indicators such as from the applicant's cv as secondary indicators.

II. Eligibility

- 1. Please fill it out the enclosed **Eligibility Checklist** (Enclosure 1) and submit together with your Review. It combines eligibility conditions set forth in the Law and the University regulations.*
- 2. Please state your opinion with regard to the Candidate's eligibility.*

The candidate seems to me to meet all the relevant eligibility requirements (I did not comment on the last one on the checklist since this is for AUBG not me to say. But I see no reason why this should not be possible).

III. Areas of Research of the Candidate. Evaluation of the Contributions of the Candidate.

- 1. Please describe the principal areas of the Candidate's research.*
- 2. Please fill out the enclosed **Additional Requirements list** (Enclosure 2) and submit it with your review. Include here a statement whether the Candidate's areas of research correspond to the specific requirements of the current procedure.*
- 3. Please include evaluation of the monograph(s) as an individual subject of evaluation. Include evaluation of publications other than the monograph, if submitted instead of or together with the monograph. (Evaluation according to Primary Indicators.)*
- 4. For applicants to Full Professor: include evaluation of other original research works, publications, and other theoretical or applied-theoretical works, which are evaluated in their entirety. (Evaluation according to Primary Indicators.)*
- 5. Please include evaluation according to the Additional Indicators related to research, such as participation in research projects, delivered conference reports, professional memberships and other applicable professional activities.*
- 6. Please include a summary evaluation of the theoretical and applied results of the Candidate's research and the Candidate's theoretical and applied contributions .*

The principal areas of the candidate's research is in the theory of non-commutative algebras, particularly the homological and growth properties of quadratic algebras and their links with set-theoretic braid group representations and combinatorics, as pioneered by the candidate. These are all areas of Pure Mathematics but the candidate's work also makes her an expert in very useful areas like Groebner basis techniques in modern algebra that could have wider applications. The candidate's work also impinges on the theory of Hopf algebras (quantum groups) and 'non-commutative geometry' (this refers to geometric properties of non-commutative algebras), but with the candidate's own special focus on finite sets, graphs and combinatorics. While quantum groups and noncommutative geometry in its different flavours are extensively studied, this particular finite set and combinatorics side is relatively open. The candidate's work is gradually developing this direction, which is both interesting and important.

The areas listed in the Additional Requirements document correspond with the candidate's particular research expertise and experience.

Citations-wise, the candidate quotes more than 300, which demonstrates a high level of international visibility (this is in line with 213 for the more selective Math Reviews count operated by the American Mathematics Society, which does not log all citations). This is an excellent level for an appointment to Full Professor in Pure Mathematics (where the citation culture is very different from other subjects, including from Applied Mathematics).

The candidate has not provided a monograph but has provided a large body of 20 articles, of which (1)-(11) should date after the candidate's application for her 2004 appointment as Associate Professor (numbering from the supplied publication list). The remaining works speak to the candidate's cumulative achievement. We particularly noted the 2012 work (3) published in *Advances in Mathematics* as a major contribution in a very high impact journal for Pure Mathematicians. The 2012 work (4) with Cameron is in *Communications of Mathematical Physics*, another world class journal, and most of the other works are in respected international journals including 2 since 2004 in *J. Algebra* (of 7 altogether), a top algebra journal. The overall quality of outputs is at a high international level on these indicators alone.

The candidate's specific results build on her foundational works on Artin-Schelter regular algebras. These are an important class of graded algebras where the dimensions of the graded components are bounded by a polynomial in the degree, and which also have other nice homological properties. The candidate's works (15)-(16) were the first to introduce an important new class of 'binomial skew polynomial rings' and (12) proved that these are Artin-Schelter regular. The candidate also found a very different proof using the theory of semigroups of 'type I' in her celebrated work (14) with the top ranking pure mathematician M. Van den Bergh. (11) presents an interesting third proof via properties of the Koszul dual algebra and speaks to the candidate's versatility.

These works of the candidate also introduced a close connection between such algebras and set-theoretic involutive solutions of the braid relations (or ‘Yang-Baxter equations’) and (10) gave an important and systematic account of this. It had been proposed already in 1991 by the Fields medalist V.G. Drinfeld to study solutions of these equations at the level of set maps (they had already been key at the linear algebra level to revolutions in knot theory and quantum groups). The involutive case relates to the symmetric group (the group of permutations) but the topic can also include strictly braided ones which feature heavily in the currently developing non-commutative differential geometry of finite groups and quandles. Among the results in (10), the candidate made a celebrated conjecture about the ‘multipermutation level’ of square-free involutive solutions which was eventually proven by Rump, building on the candidate’s work. Her works (9),(6),(4) notably developed multipermutation level as a way to classify solutions. Here (4), with a top ranking group theorist, P. Cameron, particularly includes a characterization of finite multipermutation level solutions in terms of group orbits in the case where the group generated by the set-theoretic solution is Abelian. It should be pointed out that after 25 years, the moduli of all linear solutions of the braid or Yang-Baxter equations remains as mysterious as ever. But in the candidate’s setting where vector spaces are replaced by finite sets, multipermutation level has provided some of the first classification results. The candidate is an acknowledged authority on such set-theoretic solutions.

The work (8) formulated and studied properties of the semigroups associated to set-theoretic solutions in terms of ‘matched pairs’, and developed other interesting parallels with the theory of quantum groups. Following on, the candidate in (5) opened a new front by connecting these semigroups with the theory of ‘Garside monoids’. The main theorem concerns quadratic set maps with certain ‘binomial’ properties. Among these maps, (5) establishes a remarkable equivalence between solving the Yang-Baxter equations, Garside properties of the semigroup and the associated quadratic algebra being of skew polynomial type. This is interesting and original work.

The work (3) is a particularly major contribution of the candidate (and was cited as best IMI BAS paper of 2012). The candidate considers quadratic algebras of an important Poncare-Birkoff-Witt type, where the algebra can be given a basis in terms of monomials in a particular enumeration of the generators. In this class of algebras, the candidate shows that polynomial growth and a homological property (finite global dimension) are equivalent to a standard commutative form of Hilbert series (i.e. where the dimensions in each degree have a classical form). The candidate then studies a larger class of ‘quantum binomial quadratic algebras’ generalizing both the above and her earlier work. The candidate shows in this setting that the algebra defining relations determine a solution of the Yang Baxter equations if and only if the algebra is Artin-Schelter regular and of Poincare-Birkoff-Witt type, among several other characterizations. This is a general and memorable result that depends on powerful new methods introduced by the candidate and building on her expertise in Groebner bases.

More recently, (2) relates the growth properties of graded algebras to Lyndon words. This is a concept that had previously been used in the study of enveloping algebras of Lie algebras. I would rate this is an interesting new direction that is likely to lead to more results. The most recent work presented, (1), is a preprint rather than a publication but develops an interesting connection between solutions of the Yang-Baxter equations on finite groups and groups equipped with a second 'additive' structure (a brace). The paper shows an equivalence between involutive solutions on groups and brace structures, among other results on their multipermutation level.

Also evaluated was the candidate's extended 30-page summary, which came across as very precise and well-written. On primary indicators, the candidate's work is of international significance and written at a high level. The candidate has shown great originality in her work with new methods, solved existing problems of interest in algebra and has provided stimulating conjectures (a valuable technique in Pure Mathematics).

Among secondary indicators, the candidate is well-known on the international pure mathematics scene through research visits and conferences. Since 2004, the candidate has been Visiting Scholar four times at the ICTP in Italy, the prestigious Newton Institute in Cambridge, twice at the Max Planck institute in Bonn and most recently at the world-class IHES in Paris, among other places. This builds on a track record that has included Visiting Scholar at MIT and Harvard in earlier years. Most of these are associated with grants or personal fellowships. Apart from demonstrating great energy and commitment, this list of institutions demonstrates the candidate's high international level and can be seen as a very highly positive.

Overall, the candidate's research achievement and level is evaluated as excellent and in my view exceeds the required level for a Full Professor at the AUBG.

IV. Evaluation of the Candidate's teaching

1. *Please include evaluation according to the Additional Indicators related to teaching, with emphasis on teaching in recognized liberal arts institutions and student-centered approach.*
2. *Please indicate your opinion as to whether the Candidate's areas of teaching correspond to the **Additional Requirements** (Enclosure 2) set forth by AUBG for this procedure.*
3. *Please indicate your opinion with regard to the correspondence between the overall teaching experience of the Candidate and the requirements of the current procedure.*

The candidate demonstrates excellent teaching as shown in the 2011 contract renewal memo from the Faculty Evaluation Team (memorandum 1 to the Provost), where she was assessed excellent for teaching (as well as for research). She has taught extensively from elementary linear algebra to upper level courses, including abstract algebra, and has shown a professional effort in course development and delivery. Her student evaluations are positive and her enthusiasm and passion for teaching are illustrated in her teaching philosophy and, for example, by 'student seminars' that the candidate has run. The candidate appears to have an excellent rapport with students on more advanced courses, which is an important quality for AUBG to reach a high level, but I believe her enthusiasm for mathematics comes out across the range.

The areas listed in the Additional Requirements document correspond with the candidate's particular teaching expertise and experience.

Overall, the candidate has ample teaching experience for the position applied for, most of it at AUBG itself.

V. Critical notes and recommendations

VI. Conclusion:

1. *Appropriateness to the specific requirements of the American University in Bulgaria.*

The application is fully appropriate to the requirements of AUBG showing both international class leading research, high levels of research activity, and excellent teaching.

2. *Recommendation is "for" granting the academic rank.*

Signature and date:

Jan 25, 2016

By signing here I also declare that writing this review does not represent conflict of interest.

Eligibility Checklist

Name of the Candidate: **Assoc. Prof. Dr. Tatyana Gateva-Ivanova**

Applying for: **Full Professor in Mathematics**

In the Professional Field: **4.5 Mathematics**

Check below what applies. Sign and submit together with your review or opinion.

- The Candidate has Ph.D;
- The Candidate has served five years as (Senior) Assistant Professor (for applicants for Associate Professor) or six years as Associate Professor (for applicants to Full Professor) at a recognized academic institution;
- The Candidate has published a monograph or publications of equal standing in specialized journals. These should not repeat publications based on which Ph. D., or Doctor of Science degree, or Associate Professor Rank was granted;
- For applicants for Full Professor: The Candidate has other original research works, publications, and other theoretical or applied-theoretical works;
- The Candidate has experience from recognized academic liberal arts institution(s);
- The Candidate has experience in student-centered teaching approach;
- The Candidate has undergone at least one successful evaluation in teaching, research and service at a recognized academic liberal arts institution, including positive student evaluations of teaching.
- The Candidate has experience in teaching in English at a higher education institution with instruction in English language.
- AUBG can ensure teaching and research load according to its internal rules and regulations.

Signature and date:

23 Jan 2016

Additional Requirements

For Professor Academic Position in Professional Field 4.5 Mathematics

- Additional specifications: algebra, noncommutative algebra, quantum algebra, Yang-Baxter equations and related algebraic objects, Artin-Schelter regular algebras, combinatorial methods in noncommutative algebra: finitely presented algebraic structures , quadratic algebras

Name of the Candidate: **Assoc. Prof. Dr. Tatyana Gateva-Ivanova**

Check below what applies. Sign and submit together with your review or opinion.

Research

The Candidate has conducted research in the following areas:

- Algebra;
- Noncommutative algebra;
- Quantum algebra;
- Yang-Baxter equations and related algebraic objects;
- Artin-Schelter regular algebras;
- Combinatorial methods in noncommutative algebra: finitely presented algebraic structures;
- Quadratic algebras.

Teaching

The Candidate has teaching experience in the following areas:

- Yang-Baxter equations and associated algebraic objects;
- Abstract Algebra;
- Group Theory;
- Galois Theory;
- Lie algebras;
- Ideals, varieties, and algorithms;
- Finite presentability, Groebner bases, normal forms (diamond lemma);
- Linear algebra;
- Multivariate Calculus and Geometry.

Signature and date:

23 Jan 2016