SCIENTIFIC OPINION

Concerning competition for the Academic Position ‘‘Associate professor ‘‘in the area of higher education 4 ’’Natural Sciences, Mathematics and Informatics’’, professional field 4.5 ’’Mathematics’’, scientific specialty’’Mathematical physics (Mathematical modeling in general theory of relativity and quantum mechanics) for the needs of the Department „Differential equations and mathematical physics’’ at Institute of mathematics and informatics, Bulgarian Academy of Sciences

The competition is announced in the State Gazette, issue 82 of September 27, 2024 with the only candidate Dr. Hamed Pejhan, postdoctoral researcher at the Institute of mathematics and informatics, Bulgarian Academy of Sciences.

Author of the scientific opinion: Prof. Dr. Petia Simeonova Dineva from Institute of Mechanics at Bulgarian Academy of Sciences, appointed to a member of a Scientific Jury, formed with Order 435/26.11.2024 of the Director of the Institute of Mathematics and Informatics Prof. Peter Boyvalenkov.

1. Short CV data and general description of the applicant‘s scientific interests

Dr. Hamed Pejhan has presented all the documents required for the participation in the competition according to the requirements of the Act for the Development of the Academy Staff in the Republic of Bulgaria and of the Regulations for its implementation.

The candidate holds an educational and scientific degree "doctor" since 2015. The doctoral degree was obtained at Azad University (Science and Research Branch), Tehran, Iran. The topic of the PhD thesis is in the scientific specialty "Mathematical Physics" under the title ’’Krein quantization approach to vacuum energy’’.

After defending his doctoral dissertation, the candidate continued to work on the topic of his doctoral thesis at the following scientific institutes: *(a)* Islamic Azad University, Tehran, Iran, from 2015 to 2018; *(b)* Zhejiang University of Technology, Hangzhou, China, from April 2018 to August 2021; *(c)* Islamic Azad University, Tehran, Iran, from 2021 to 2023; *(d)* since May 2023, he has been working as a researcher at the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences (BAS).

The scientific activity of the candidate is in the following research fields:

(1) Covariant quantization of the graviton field in *de Sitter* space-time;

(2) Exploration of conformal symmetry and the dS graviton field in an expanded symmetry context;

(3) *Krein* Space quantization and vacuum energy problem;

2. Analysis and evaluation of the scientific contributions and achievements of the candidate

The evaluation of the scientific contributions follows the division into 3 main topics proposed by the candidate himself in his author's reference.

First topic concerns papers [2, 3, 4, 6, 9] from the List of publications participating in the competition.

In this first group of articles, the candidate's main contribution is the obtained results for models related to the covariant quantization of the gravitational (massless spin-2) field in de Sitter (dS) space. A covariant formulation of the two-point function of the graviton in de Sitter space is presented, as well as a new original author interpretation of massless spin-2 fields in the curved background of de Sitter space. From the perspective of mathematical physics, de Sitter space holds a privileged status as the unique, maximally symmetric solution to Einstein's equation with a positive cosmological constant, for which the use of coordinates covering the entire dS manifold is necessary to describe its characteristics. Causality and covariance of the models are ensured through a suitably chosen adaptation based on Krein spaces and the Wightman-Gärding axiomatic for massless fields (the Gupta-Bleuler structure), see [1].

The topic of quantum field theory in de Sitter space is of paramount importance for the issues discussed in cosmology, for understanding the origin of the early universe, as well as providing insight into the questions of its accelerated expansion (interpreted as the existence of a positive cosmological constant or dark energy).

Second topic ([10, 12]) is related to the expansion of the models and the corresponding mathematical methods developed in the publications cited above from the first topic in the author's research activity. The potential of the methodology proposed by the author is revealed in this second group of articles, where the influence of conformal symmetry, of which the symmetry of de Sitter is a subgroup, is taken into account, thus placing the gravitational field in de Sitter within a broader symmetric framework. The influence of conformal symmetry on the gravitational field is explored. An interesting and useful interpretation of the obtained results is provided for future research. A new and original perspective on the idea of using broader symmetric structures encompassing de Sitter space is presented.

In the third topic ([1, 5, 7, 8, 11]), a comprehensive analysis of the vacuum energy problem is proposed within the framework of the *Krein space* quantization approach, expanding the understanding of quantum field theory in *de Sitter space*. A new perspective on gravitational dynamics based on this approach is presented. A framework is proposed that goes beyond the traditional Hilbert space formalism, leading to a model based on the structure of *Krein space*. This quantization approach in *Krein space* ensures that the theory retains all critical properties of the free field under the high symmetry conditions of *de Sitter space*.

In semi-classical quantum gravity, the expected values of the energy-momentum tensor are essential, as they act as the source of gravity in Einstein's equation. Therefore, understanding vacuum energy in this context is crucial for self-consistent models that include gravitational dynamics. A potential link is revealed between the Krein–Gupta-Bleuler (KGB) vacuum, which leads to a fully covariant quantum field theory for gravity in de Sitter space (dS), and the observed small value of the cosmological constant. This unveils the potential for formulating linear quantum gravity in a framework suitable for developing a more complete theory that determines the value of the cosmological constant.

3. Fulfilment of the requirements for holding the academic position ''Assoc. Professor'' and impacts of the candidate's results on scientific works of other researchers

The candidate participates in the competition with 12 scientific publications in specialized international scientific journals, classified as follows:

- All 12 articles are published in journals with an ISI Impact Factor (IF) or ISI SCImago Journal Rank (SJR).
- Out of these, 10 publications are in Q1 journals, and 2 articles are in Q2 journals.

From the submitted documents regarding the number of articles in reputable international scientific journals and their citations in the global literature, it is evident that all requirements of the Regulations of the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences (IMI-BAS) and the other regulations for the implementation of the Law for the Development of the Academic Staff in the Republic of Bulgaria, concerning publications presented for participation in the competition for Associate Professor in professional field 4.5 Mathematics, have been met.

4. Personal impression for the applicant

I do not know the candidate personally. I became acquainted with his research activities based on the available documentation.

5. Critical remarks and recommendations

I have no critical remarks regarding the candidate's scientific research activities. However, in my opinion, the author's reference summary provided in English (file titled ''Reference-Scientific Contributions'') was incomplete. It should clearly and distinctly present the candidate's scientific contributions, comparing them with existing results in the global literature.

6. Conclusion

The materials submitted by Dr. Hamed Pejhan for the current procedure demonstrate that he is satisfying the requirements of the Law Act for Development of the Academic Staff in the Republic of Bulgaria (LADASRB), the Statutes for application of LADASRB, the Statutes for the conditions and regulations for acquiring academic degrees and occupying academic posts in BAS, and the Statutes for the conditions and regulations for acquiring academic degrees and occupying academic posts in IMI-BAS, for occupying the academic post " Assoc. Professor". There is no data for plagiarism.

The overall candidate's activity, including scientific-research and scientific-applied contributions, expert and organizational skills, give me reason to believe that Dr. Hamed Pejhan deserves to be awarded the academic position of 'associated professor' in the scientific specialty "Mathematical physics (Mathematical modeling in general theory of relativity and quantum mechanics) for the needs of the Institute of Mathematics and Informatics, BAS.

I recommend with conviction to the honorable jury to propose to the Scientific Council of IMI-BAS to elect Dr. Hamed Pejhan as a "Associated Professor"in the Area of Higher Education: 4. Natural Sciences, Mathematics and Informatics, Professional Area: 4.5 Mathematics, Scientific Specialty "Mathematical physics (Mathematical modeling in general theory of relativity and quantum mechanics) for the needs of the „Differential geometry and mathematical physics'' section at Institute of mathematics and informatics, Bulgarian Academy of Sciences

20.01.2025 г.

Sofia Signature:

(*Prof. Dr. Petia Dineva*)