

REVIEW

in competition for the academic position of Associate Professor,
announced by the Institute of Mathematics and Informatics at BAS
in SG 82 of 27.09.2024.

Field of higher education: **4. Natural Sciences, Mathematics and Informatics**

Professional field: **4.5. Mathematics**

Research specialty: **Equations of mathematical physics (Mathematical modelling in general relativity and quantum physics)**

Reviewer: **Prof. Dr. Stoytcho Stoyanov Yazadjiev**, IMI-BAS and FZF-SU

Only candidate: **Dr. Hamed Ahmad Pejhan**, researcher at the Institute of Mathematics and Informatics at BAS.

1. Biographical data

Dr. Hamed Pejhan was born in 1983 in Iran. In 2007, he completed his undergraduate degree in Physics at the University of Urmia, Iran. Three years later, in 2010, he received his M.Sc. degree in mathematical physics from Azad University, Tehran, Iran. From 2011 to 2015, he was a PhD student at the same university. After defending his dissertation on "Krein quantization approach to vacuum energy", he received his PhD.

After his PhD, Dr. Pejhan was a postdoctoral fellow at several places. In 2015-2018, he was a postdoctoral fellow at Azad University, Tehran, Iran. From 2018 to 2021, he was a postdoctoral fellow at Zhejiang University of Technology, Hangzhou, China. From 2021 to 2023, he also worked as an independent researcher at Azad University, Tehran, Iran. From 2023 to present, he has been a postdoctoral fellow (R3 level) at the Institute of Mathematics and Informatics, BAS.

2. General description of the submitted materials.

The documents submitted for the competition by the candidate Dr. Hamed Pejhan comply with the requirements of the Academic Staff Development Act in the Republic of Bulgaria and the Regulations on the Conditions and Procedure for the Acquisition of Scientific Degrees and Academic Positions at the Institute of Mathematics and Informatics.

The submitted documents include: application for participation in the competition, curriculum vitae, diplomas of graduated higher education, certificate of recognized educational and scientific degree "PhD", list of all publications and of the publications for participation in the competition, hand-signed statement of original scientific contributions in the works submitted for the competition, abstracts of the publications for participation in the competition (in Bulgarian and English), copies of the scientific works, general list of citations, list of citations for participation in the competition, the announcement of the competition in the State Gazette, certificate of experience in the specialty, a reference in a standard form for the fulfilment of the minimum national requirements under the Academic Staff Development Act in the Republic of Bulgaria and the minimum requirements of IMI-BAS, a declaration in a standard form and a declaration of consent for the storage and processing of personal data.

3. General characteristics of the candidate's research activities

The main activity of the candidate is scientific research and falls within the area of modern mathematical physics, and more precisely is related to general relativity and quantum theory, which meets the specification of the competition.

Overall, the candidate has 21 publications, with two in the peer-review process and 19 accepted or already published in international peer-reviewed journals. Publications in conference proceedings are 2. The candidate has also co-authored 2 monographs published by the prestigious Springer publishing house.

For the competition, the candidate has presented 9 research articles in foreign peer-reviewed journals, 8 are from quartile Q1 and one Q2. The distribution of publications for the competition is as follows: 5 in Phys. Rev. D, 2 in Phys. Lett. B, 1 in Int. J. Mod. Phys. A, and 1 in Int. J. Mod. Theor. Phys.

The publications submitted for the competition have 20 independent citations. All publications of the applicant have attracted a total of 31 independent citations.

Based on the documents presented, it can definitely be said that:

a) the scientific works satisfy the minimum national requirements (under Article 2b, paragraphs 2 and 3 of the Academic Staff Development Act) and respectively the additional requirements of IMI-BAS for the academic position of Associate Professor in the scientific field and professional field of the competition;;

(b) the scientific works submitted by the candidate do not repeat those to satisfy the requirements previous procedures for the acquisition of a scientific title and an academic position;

(c) I am not aware of any "legally proven plagiarism in the scientific works submitted to the competition".

4. Main scientific contributions

I will make a brief summary of the main scientific contributions in the works of the candidate.

The scientific contributions of Dr. Hamed Pejhan can be classified into three thematic areas.

A) Covariant quantization of the gravitational field in de Sitter spacetime

The papers [2], [3], [4], [6] and [9] belong to this direction. The main scientific contributions here can be summarized as a rigorous, covariant formulation of the two-point function of the graviton in de Sitter spacetime. Infrared finiteness has also been studied and progress has been made in understanding massless spin-2 fields on a de Sitter background.

Let us describe in more detail some of the contributions in this direction. In [2] a Gupta-Bleuler type covariant and causal quantization of a massless field with spin 2 in a de Sitter background space is presented. It is shown that the theory does not suffer from infrared divergences. Despite the appearance of states with negative norm, the energy operator is positive for all physical states and vanishes in the vacuum.

The paper [3] considers linearized Einstein equations in de Sitter spacetime. Possible vacuum states for the graviton field are studied in terms of invariance under the action of the de Sitter group. It is shown that there is no natural de Sitter invariant vacuum state for the graviton field. On the basis of rigorous group-theoretic reasoning, it is shown that the requirement for covariance as well as causality of the theory are incompatible with the requirement for positivity of the norm. However, one can still look for states that are covariant and invariant with respect to some maximal subgroup of the full de Sitter group, respectively.

Using a covariant quantization procedure based on group-theoretic considerations, the two-point functions for the linearized Einstein equations in de Sitter spacetime were found in explicit form in [4,6]. It is shown that by a suitable adaptation of the Krein-Gupta-Bleuler procedure, the two-point functions can satisfy the conditions of locality, covariance, transversality and tracelessness.

B) Study of conformal symmetry and the de Sitter gravitational field within an extended group of symmetries

The articles [10] and [12] are devoted to this direction. In these papers, the de Sitter gravitational field is considered in a broader group of symmetries, in which de Sitter symmetries form a subgroup.

C) Quantization in Krein space and the vacuum energy problem

This includes articles [1], [5], [7], [8] and [11]. A comprehensive analysis of the vacuum energy problem is made within the framework of the Krein quantization approach, which is closely related to the fundamental dark energy problem. The results in these publications also help in general to better understand quantum field theory in de Sitter spacetime and its implications for gravitational dynamics.

In [1], a potential connection between the Krein-Gupta-Bleuler vacuum state leading to a fully covariant quantum field theory of gravity in de Sitter spacetime and the fact that the observed value of the cosmological constant is extremely small is pointed out.

In [5], an estimate is made for the Casimir energy-momentum tensor for a conformally coupled scalar field in a system of two D-dimensional Dirichlet branes in a background D+1 - dimensional Friedman-Robertson-Walker spacetime of negative spatial curvature.

The paper [7] is devoted to the study of the Hawking effect in the framework of Krein-Gupta-Bleuler quantization. By computing the Casimir energy-momentum tensor for a conformally coupled massless scalar field near a non-rotating event horizon of a black hole and using Krein-Gupta-Bleuler quantization, it is shown in this work that the black hole emits radiation as an absolute black body whose temperature exactly matches the result obtained by Hawking.

In paper [8], the vacuum expectation value of the energy-momentum tensor for a conformally coupled scalar field in de Sitter spacetime is studied by the Krein-Gupta-Bleuler construction. The effects of the boundary conditions are also investigated. The Casimir energy-momentum tensor induced by the Dirichlet boundary condition on a curved brane is also evaluated in this way.

In [11] a simple method is developed to study the Casimir effect on a spherical shell for a massless scalar field with Dirichlet boundary condition by applying the Krein quantization technique.

The main contributions in the publications submitted for the competition can be formally categorized as:

- (i) proving by new means significant new aspects of existing scientific problems and theories
- (ii) obtaining and proving new scientific facts.

5. Teaching and supervision of PhD students

Dr. Hamed Pejhan was the supervisor of a successfully defended PhD student. This has been confirmed by the official letter from Prof. Mahmood Ghoranneviss - Dean of the Faculty of the Plasma Physics Research Center, Science and Research Branch, Islamic Azad University, which certifies that Dr. Pejhan was the scientific supervisor of Dr. Surena Rahbardehgha, who successfully defended his PhD thesis in 2018.

6. Critical comments and recommendations

I have no critical comments or recommendations for the candidate.

7. Personal impressions of the reviewer

I have no personal impressions of the candidate.

8. Conclusion

Having read the materials and scientific works submitted in the competition, and on the basis of the analysis of their significance and scientific contributions contained therein, I confirm that the scientific achievements meet the requirements of the Academic Staff Development Act in the Republic of Bulgaria, the Regulations for its application and the relevant requirements of IMI-BAS for the candidate to hold the academic position of Associate Professor in the scientific field and professional field of the competition.

On the basis of the above, **I recommend** the Scientific Jury to propose to the competent selection body of IMI-BAS to elect **Dr. Hamed Ahmad Pejhan** to hold the academic position of Associate Professor in the professional field 4.5 **Mathematics**, scientific specialty **Equations of Mathematical Physics**.

21. 01. 2025.

Reviewed by:

(Prof. Dr. Stoytcho Stoyanov Yazadjiev)