

PEER REVIEW

on a competition for occupation of the academic position “Associate Professor” in professional field 4.1. Physical Sciences (Gravity, Theory of Relativity) for the needs of the Faculty of Physics of St. Kl. Ohridski University of Sofia (announced in the Newspaper of State No. 65 on August 16, 2019)

with a candidate: Assist. Prof. Petya Georgieva Nedkova, PhD
Department of Theoretical Physics, Faculty of Physics, St. Kl. Ohridski University of Sofia

reviewer: Assoc. Prof. Boyko Milkov Mihov, PhD
Institute of Astronomy and NAO, BAS

Professional biography. The candidate Petya G. Nedkova has acquired Master degree in Theoretical and Mathematical Physics in 2008 at the Faculty of Physics of St. Kl. Ohridski University of Sofia and PhD degree in professional field 4.1. Physical Sciences (Theoretical and Mathematical Physics) in 2012 at the Faculty of Physics of St. Kl. Ohridski University of Sofia with a thesis entitled “Exact solutions of the Einstein-Maxwell equations describing black holes in a space-time with an additional dimension and their thermodynamics” and a supervisor Prof. Stoytcho Yazadjiev, DSc. P. Nedkova was appointed at a post-doctoral position at the University of Oldenburg, Germany, with a DAAD research scholarship between June 2012 and February 2013. From March 2013 to January 2014 she is an assistant at the Department of Theoretical Physics of the Faculty of Physics of St. Kl. Ohridski University of Sofia. In February 2014 she was elected as Assist. Prof. at the Department of Theoretical Physics, Faculty of Physics, St. Kl. Ohridski University of Sofia.

P. Nedkova has 7 visits as a guest scientist in the field theory group at the University of Oldenburg, Germany, for the period July 2013 - December 2019 (approximately 24 months in total). She also has 3 visits as a guest scientist in the theoretical astrophysics group at

University of Tübingen, Germany, for the period June 2013 - August 2015 (approximately 3 months in total). P. Nedkova has won 2 scholarships - a scholarship from the Danish Ministry of Education and Science for student exchange and a DAAD research scholarship - and a Dr. Michael Klett award for student excellence.

Scientific publications. Assist. Prof. P. Nedkova has submitted 15 journal articles, 5 publications in conference proceedings, and the monograph “Mathematical Aspects of Static and Stationary Higher Dimensional Space-times” (in English, co-authored with Prof. Yazadjiev) for participation in the competition.

Most of the journal articles are those published in the journal *Physical Review D* - 10 papers. In a total of 12 articles the candidate is the leading (corresponding) author. It is noteworthy that only one article is from Quartile Q2 - all others are from Q1, which, combined with the large percentage of articles in which the candidate has a leading role, speaks to the high quality of the scientific output presented. Only 3 of the submitted articles have been published prior to obtaining a PhD degree by the candidate.

There are also 5 publications in conference proceedings. All they have impact-rang and are based on talks presented at international scientific forums. In 3 of them the candidate is the leading (corresponding) author.

The submitted monograph has not yet been published, but it should be recognized as habilitation work, because the candidate has submitted the necessary documents in the assurance that the monograph is in print, as well as a certificate from the co-author, Prof. Yazadjiev, about the candidate’s contribution.

Assist. Prof. P. Nedkova has submitted a list of 147 independent citations of the publications being used in the competition. Four of the articles were cited more than 10 times (A.2, A.3, A.10, and A.14), and article A.10, in which Assist. Prof. P. Nedkova is the first author, has 63 independent citations. According to the *INSPIRE High Energy Physics Database* the *h*-index of Assist. Prof. P. Nedkova (with self-citations excluded) is 6.

In addition, the candidate has submitted a complete list of her journal articles (a total of 17) and publications in conference proceedings (a total of 7), with them the independent citations being 157.

The monograph, publications, and citations submitted fully cover the minimum national requirements under Art. 2b, par. 2 of the Law for the Development of the Academic Staff in the Republic of Bulgaria for occupation of the academic position “Associate Professor”, as well as the specific requirements for the occupation of the academic position “Associate Professor” at the Faculty of Physics of St. Kl. Ohridski University of Sofia regarding the publications and citations.

Scientific activity. The scientific activity of Assist. Prof. P. Nedkova is focused mainly in the field of gravitational physics and general theory of relativity, achieving significant results in the mathematical theory of gravity and in relativistic astrophysics. The candidate has expertise in (i) the mathematical foundations of general relativity and alternative gravity theories with applications to compact object physics and in (ii) the study of phenomenological effects in strong gravity field mode that can be experimentally verified. The candidate’s scientific contributions are in the following fields:

I. Obtaining new accurate solutions to the generalized gravity field equations in a high-dimensional space-time (publications A.7, A.11, A.12, A.13, A.14, A.15, B.5, C.1 and publications A.16, B.6, B.7 of the complete list);

II. Investigation of the thermodynamic properties of compact objects, including black holes and gravitational instantons (publications A.7, A.12, A.13, A.14, B.5 and publications A.16, A.17 of the complete list);

III. Obtaining and investigating the exact solutions to gravity field equations describing black holes interacting with astrophysically relevant environments (publications A.6, A.8, A.9, B.1, B.4);

IV. Classification of the solutions describing space-time tunnels (“wormholes”) within Einstein-Maxwell-dilaton gravity (publications A.5, B.3);

V. Investigation of the scalarized black holes in generalized tensor theories of gravity (publication A.2);

VI. Construction and investigation of the shadows of compact objects, including black

holes, space-time tunnels, and naked singularities (publications A.3, A.4, A.10, B. 2);

VII. Construction and investigation of the relativistic images of accretion disks in a space-time of compact objects (publication A.1).

The candidate's main scientific contributions are in the first two fields - a total of 12 publications out of 15 being used in the competition and 5 publications from the complete list presented. The monograph, currently in print, is related to the first field and provides a systematic analysis of the exact solutions describing stationary and axially symmetric compact objects possessing event horizons in a space-time with an additional dimension, The monograph includes candidate's original results.

From an astrophysical point of view, the candidate's contributions in the following fields deserve attention:

Field III. In astrophysics black holes interact with the surrounding matter most often forming accretion disks. Such configurations are described with so-called deformed black holes. These are accurate solutions that describe a specific area of space-time in the vicinity of the black hole horizon. Within this field, the first exact solution describing a rotating deformed black hole in the presence of an additional dimension of space-time was constructed. Furthermore, accurate solutions that represent black holes interacting with both matter and magnetic field have been obtained for the first time. These solutions describe the vicinity of a black hole horizon surrounded by a massive accretion disk and a strong magnetic field - such a situation is realized, for example, near the supermassive black holes in radio-loud active galactic nuclei, resulting in radio jets generation extending up to tens of kiloparsecs. These results are fundamental because they show how gravimagnetic interaction changes the properties of isolated black holes;

Field VI. Here I will mention article A.10, in which the first study of the shadows of rotating space-time tunnels has been done. This work was cited in the analysis of the first observed image of a black hole shadow by the Event Horizon Telescope Collaboration (see The Astrophysical Journal Letters, 875:L5 (31pp), 2019 April 10), which indicates the quality of the scientific output presented. The study of the black hole shadows, where the black hole interacts with the surrounding matter shows that the presence of interaction leads to a qualitative change in the images of the shadows;

Field VII. The presence of an accretion disk around massive compact objects results in specific relativistic images. The comparison of theoretically predicted and actually observed images provides valuable information about the nature of the compact object itself. In the paper A.1, such a comparison was made for the images generated by a naked singularity and a Schwarzschild black hole, indicating the corresponding differences.

Here I will point out that observational verification of the results obtained in the fields VI and VII is hampered both by the small spatial scales at which the phenomena under consideration occurs (e.g., in the vicinity of the event horizon) and by the large distances to the corresponding cosmic objects. This results in very small angular dimensions of shadows and images - in the order of microseconds of arc or smaller. For comparison, the angular resolution of the Hubble Space Telescope is about 0.05 seconds of arc. In spite of these observational difficulties, theoretical studies and numerical modeling of the shadows of compact objects and of the relativistic images formed by them will become increasingly important, because with the advancement of the observational technique, their observation becomes possible. As an example, I will mention the first image of the shadow of the supermassive black hole in the center of the active galaxy M87, obtained by Event Horizon Telescope Collaboration in 2019 and its good agreement with theoretical predictions; I will note that the shadow radius is 18.8 microseconds of arc. With these observations, it is possible to test directly the theoretical models and, accordingly, to further investigate the properties of self-gravitational systems in strong-field mode.

Teaching and other activities. The teaching activity of Assist. Prof. P. Nedkova started in 2013 and continues to this day. She has delivered lectures and seminars in the following subjects (some of them in English): Mathematics I, Applied Mathematics I, PDE, MMP, MMP-2, Theoretical Astrophysics, Mathematical Methods for Engineer-physicists, Introduction to the Black Hole Physics. The candidate has been supervisor or co-supervisor of 2 Bachelor theses (Simeon Petrov, Christian Knoll), one of which being defended at the University of Oldenburg during her regular visits. The publication of the monograph presented will undoubtedly benefit future students and specialists in the field of gravitational physics.

Assist. Prof. P. Nedkova has been head of 2 scientific projects funded by the Scientific Research Fund at the Ministry of Education and Science (“Deformed black holes: accurate solutions and observational consequences”) and by the St. Kl. Ohridski University of Sofia (“Gravitational Lensing of Accretion Disks”) and has participated as a member of the scientific team in 12 others, including 2 COST Actions, in one of which as a Management Committee Substitute (CA16214 “The multi-messenger physics and astrophysics of neutron stars”).

Assist. Prof. P. Nedkova has been an organizer or co-organizer of 3 scientific (section “Gravity and Cosmology” at the 10-th Conference of the Balkan Physical Union) and popular-science forums.

Conclusion. Based on the materials submitted under the procedure, I am convinced that the overall activity of Assist. Prof. P. Nedkova meets the requirements for occupying the academic position “Associate Professor” under the Law of Development of the Academic Staff in the Republic of Bulgaria and the relevant Regulations and Specific Requirements, and I give a **positive** assessment to her application. I recommend to the Honorable Faculty Council of the Faculty of Physics of St. Kl. Ohridski University of Sofia **to elect** Assist. Prof. Petya Georgieva Nedkova, PhD, on the academic position “Associate Professor”.

November 22, 2019

Sofia

Reviewer:

/Assoc. Prof. Boyko Mihov, PhD/