

PEER REVIEW

on a competition for occupation of the academic position “Associate Professor” in professional field 4.1. Physical Sciences (General theory of relativity and relativistic astrophysics) for the needs of the Faculty of Physics of St. Kl. Ohridski University of Sofia (announced in the Newspaper of State No. 67 on July 28, 2020)

with a candidate: Assist. Prof. Galin Nikolaev Gyulchev, 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 Galin N. Gyulchev has acquired Master degree in Theoretical and Mathematical Physics in 2005 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 2010 at the Faculty of Physics of St. Kl. Ohridski University of Sofia with a thesis entitled “Gravitational Lenses” and a supervisor Prof. Stoytcho Yazadjiev, DSc. Over the period 2004-2008 the candidate is a physicist in the Stars and Stellar Systems Department at the Institute of Astronomy and National Astronomical Observatory, BAS. Over the period 2008-2011 G. Gyulchev is an Assistant at the Physics, Biophysics and Radiology Department at the Medical Faculty of St. Kl. Ohridski University of Sofia, and over the period 2011-2019 he is Assist. Prof. at the same department. Since November 2019, G. Gyulchev is Assist. Prof. at the Theoretical Physics Department at the Faculty of Physics, St. Kl. Ohridski University of Sofia. In November 2019, the candidate was on a short scientific visit as a guest scientist in the Theoretical Astrophysics group of the University of Tübingen, Germany.

Scientific publications. Assist. Prof. G. Gyulchev has submitted 10 journal articles, 8 publications in conference proceedings, and the monograph “Gravitational Lenses” (first author, co-authored with Prof. Yazadjiev) for participation in the competition.

Most of the journal articles are those published in the journal Phys. Rev. D – 6 papers; the other papers are published as follows: Eur. Phys. J. C – 2, Annals of Physics – 1, and Phys. Rev. Lett. – 1. In a total of 7 articles the candidate is the leading (corresponding) author. It is noteworthy that all of the articles are from Quartile 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. Three of the submitted articles have been published prior obtaining a PhD degree by the candidate. The full list of G. Gylchev's publications includes 5 more titles published in electronic archives. For one of these works, in which the candidate is a leading author, on 20.10.2020 a notice was received from the journal Eur. Phys. J. C that it has been accepted for publication (according to an e-mail presented to the jury in this competition).

There are also 8 publications in conference proceedings, 6 of which are published in AIP Conf. Proc. In a total of 7 of the publications the candidate is a leading (corresponding) author. The complete list of publications in refereed and indexed conference proceedings includes 4 more titles.

The monograph “Gravitational Lenses”, co-authored with Prof. Yazadjiev is also presented. The monograph is dedicated to the theory of gravitational lenses and is the first professional book of its kind in Bulgarian, dedicated to this rapidly evolving field of modern astrophysics. The monograph provides a detailed analysis of the relativistic effect of the gravitational lens in alternative theories of gravity, realized in the vicinity of the photon regions of compact objects, where the space-time has a significant curvature.

Assist. Prof. G. Gylchev has submitted a list of 337 independent citations of the articles being used in the competition. Six of the articles have been cited more than 20 times (A.1, A.4, A.6, A.7, A.9 и A.10), 3 of them have been cited more than 50 times, and the article A.10, in which Assist. Prof. G. Gulchev is a first author, has 70 independent citations. The candidate is not a first author only in A.7 of the above mentioned 6 papers. According to the INSPIRE High Energy Physics Database, the h-index of Assist. Prof. G. Gulchev (with autocitations excluded) is 7.

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 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. G. Gylulchev is mainly related to research in the field of alternative theories of gravity and the general theory of relativity, covering phenomena from relativistic astrophysics as well. The candidate has expertise in both classical and relativistic theory of gravitational lenses, applied within both the general theory of relativity and alternative theories of gravitation for the study of compact astrophysical objects and related phenomenological effects in a regime of strong gravitational field that can be experimentally confirmed. The scientific contributions of the candidate can be characterized as enrichment of the existing knowledge and are in the following fields:

I. Research on the relativistic effect of the gravitational lens, created by compact objects, including black holes and naked singularities, at large angles of light rays deflection (publications A.6, A.9, A.10, B.2, B.6, B.7, B.8, B.1);

II. Research on the frequencies of the quasi-normal modes of black holes and their connection to the relativistic effect of the gravitational lens and study of the quasi-periodic oscillations (publications A.5, A.7, B.5);

III. Obtaining shadows of compact objects, including black holes and wormholes (publications A.4, B.1);

IV. Construction and study of relativistic images of accretion disks in space-time of compact objects, including black holes and naked singularities (publication A.1);

V. Research on the effect of the gravitational lens, created by compact objects, including black holes, naked singularities and wormholes at small angles of deflection of light rays and massive particles (publications A.2, A.3, A.8, A.9, B.4);

VI. Research on the non-relativistic effect of the gravitational lens, created by clusters of galaxies at small angles of light rays deflection (publication B.3).

The main scientific contributions of the candidate are in the fields I and V, to which a total of 12 of the publications used by the candidate in the competition are related, including the monograph. In this series of papers, relativistic and non-relativistic effects of the gravitational lens created by different types of compact objects at large and small deflection angles of light rays, respectively, are studied. In the relativistic case, the work is done within the framework of alternative theories of gravity. In each case the observable quantities, characterizing the effect on the gravitational lens, are obtained. The comparison of the theoretically calculated values of these quantities with those obtained from astronomical observations can be used to confirm or reject the alternative theories of gravity and to establish the nature of the compact object causing the effect of the gravitational lens in each case. In this context, the publication A.9 can be mentioned, which considers the effect of the gravitational lens caused by the compact and massive (with a mass of more than one million solar masses) object Sgr A*, located in the center of our Galaxy. This study is especially relevant in the light of the latest advances in astronomical observation technology. Here I am referring to Event Horizon Telescope: the Schwarzschild radius for Sgr A* is about 10 microseconds of arc, and the resolution of Event Horizon Telescope is expected to reach about 15 microseconds of arc, i.e. the theoretical models for the compact object Sgr A* can be confirmed or rejected in the near future.

In the field II, an interesting connection is made between the frequencies of the quasi-normal modes of the gravitational waves emitted by compact objects and the relativistic effect of the gravitational lens. The quasi-periodic oscillations of the X-ray flux emitted by Galactic binary stellar systems with a putative black hole were also studied in order to investigate the nature of the space-time in the vicinity of compact objects. In the field VI, the effect of the gravitational lens in the classical Newtonian approximation is considered.

The fields III and IV consider the construction and study of the shadows of compact objects and the relativistic images of accretion disks in the space-time of compact objects; the presence of an accretion disk around massive compact objects leads to specific relativistic images. In this context, I will note the paper A.1, in which the image of an accretion disk around a compact object that is not a black hole was studied for the first time. With such studies it becomes possible to specify the type of compact object by comparing the theoretical

images and shadows with the observed ones. From an astrophysical point of view, this is extremely important because the high luminosity of active galactic nuclei is thought to be a result of a “compact object – accretion disk” configuration.

In summary, in his scientific works Assist. Prof. G. Gylchev uses the gravitational lens effect to study the nature of the compact objects and space-time and the existence of alternative theories of gravity – these are problems fundamental to modern physics. In most of the presented works the expertise of the candidate in the fields of relativistic astrophysics and the gravitational lens effect is of fundamental importance. A key factor in verifying the theoretical conclusions presented by the candidate will be astronomical observations. Unfortunately, the observational verification of the results is difficult because of the the small spatial scales, in which the phenomena under consideration take place (e.g. in the vicinity of the event horizon) and of the large distances to the respective astronomical objects. This results in very small angular size of the images formed by the gravitational lens – on the order of microseconds of arc or less. In comparison, the resolution of the Hubble Space Telescope is about 0.05 arcseconds. With the advancement of the observation technique, the observation of the images formed by the compact objects acting as gravitational lenses, the shadows of the compact objects and the relativistic images of the accretion disks becomes more and more real. 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.

Teaching and other activities. The teaching activity of Assist. Prof. G. Gylchev started in 2015 and continues till now. He has delivered lectures and seminars in 5 different disciplines, seminars and practical classes, including lectures in English and courses in Theoretical Astrophysics and Introduction to the Physics of Black Holes. According to the submitted documents, the total teaching load of the candidate over the period 2015-2020 is equivalent to 12 years and exceeds twice the annual standard for full-time employment at St. Kl. Ohridski University of Sofia. Assist. Prof. G. Gylchev has been a supervisor of Veselina Kalinova's thesis on “Gravitational aberration of galactic clusters”, defended in 2010 in the Astronomy Department at the Faculty of Physics, St. Kl. Ohridski University of Sofia. The candidate has

been head of a research project (“Determining the status of plants grown in the Svet-3 space greenhouse by thermal image analysis”) and of a project for a scientific forum (“National Forum for Modern Space Research”), funded by the scientific research programme of St. Kl. Ohridski University of Sofia and has participated as a member of the research team of 10 other projects. Over the period 2012-2018, Assist. Prof. G. Gylchev was a reviewer of the “1000 Scholarships” competition of the “Communitas” Foundation in the scientific field “Physics and Astronomy”.

As a significant contribution to the training of specialists in the field of the gravitational lenses I will mention the monograph “Gravitational Lenses”, which is, as I have already said, the first professional book of its kind in Bulgarian in this field of astrophysics.

My personal impressions of the candidate are excellent and date back to his student years, when he asked me for advice on issues related to gravitational lenses and the possibilities of astronomical instruments to observe the gravitational lens effect .

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

November 15, 2020

Sofia

Reviewer:

/Assoc. Prof. Boyko Mihov, PhD/