

# **OPINION**

**on thesis**

**for acquiring the educational and scientific degree “doctor” (PhD degree)**

**in professional field 4.1 Physical Sciences,**

**regarding a thesis defense procedure at the Faculty of Physics**

**of Sofia University “St. Kliment Ohridski”**

The opinion was prepared by: Prof. DSc. Lilia Kirilova Anguelova – Institute for nuclear research and nuclear energy, Bulgarian academy of sciences,

(academic position, scientific degree, first name, middle name, surname – home institution)

in her capacity as a member of the scientific juri

in accordance with Order № RD 38-323/17.06.2024 of the Rector of Sofia University.

**Topic of the thesis: “Optical effects in curved spacetime: gravitational lenses, shadows and the polarization of light”**

**Author of the thesis: Valentin Olegov Deliyski**

## **I. General description of the presented materials**

### **1. Application documents data**

The candidate Valentin Olegov Deliyski has submitted a dissertation and an autoreferat, as well as the mandatory tables for the Faculty of Physics from the Regulations regarding the Terms and Conditions for Acquiring Scientific Degrees and Holding Academic Positions at SU "St. Kliment Ohridski". The presented materials include a CV, a higher education diploma, a declaration of authorship by the candidate, a certificate from the Faculty of Physics that Valentin Deliyski was a full-time doctoral student with the right of defense, four publications, as well as the necessary set of documents certifying that the "Report of Similarity" (generated from the plagiarism prevention system) does not suggest any signs of plagiarism.

The documents presented by the candidate satisfy completely all national requirements, as well as the specific additional requirements of SU “St. Kliment Ohridski” contained in its rules for acquiring scientific degrees and occupying academic positions there.

## **2. Applicant data**

Valentin Deliyiski has acquired the educational qualification degrees "Bachelor" and "Master" at Sofia University "St. Kliment Ohridski" under the supervision of Corresponding member Prof. Stoicho Yazadzhiev. The topics of his studies were respectively "Shadows of black holes" (for bachelor) and "Gravitational lenses" (for master). After that, he continued his education through the doctoral program in "Theoretical and Mathematical Physics" at the Faculty of Physics of SU "St. Kliment Ohridski" with supervisors Corresp. member Prof. DSc. Stoicho Yazadzhiev and Assoc. Prof. Galin Gyulchev. During his doctorate, the candidate taught recitation sections on Statistical Physics. It is also interesting to note that the candidate has significant professional experience in the industry, also acquired during his PhD studies.

## **3. General characteristics of the scientific achievements and works of the candidate**

The thesis of the candidate is devoted to the study of possible observable effects that could distinguish exotic compact objects from black holes. This topic is extremely timely, because the resolution of modern observations has reached a level that already allows direct observation of the immediate surroundings of supercompact objects, such as galactic nuclei. Exotic objects, of the types studied in the dissertation, can be found in generalized theories of gravity. Therefore, the question of their existence is related to the fundamental nature of the gravitational interaction.

The thesis is based on three papers, two of which have already been published in Physical Review D - a scientific journal with quartile Q1 and a high impact factor. I personally have no doubt that the third paper (which appeared on the arXiv in 2024) will also be published in a journal with quartile Q1 and a high impact factor. It should be noted that the candidate has made a significant contribution to one of the two publications in Physical Review D. Also, he has given a talk at a conference, with which the additional requirements of SU "St. Kliment Ohridski" are completely satisfied. More specifically, regarding the necessary requirements for acquiring the educational and scientific degree "doctor", I am completely convinced that:

- a) the scientific publications, included in the thesis, are in complete compliance with the minimal national requirements, as well as the additional requirements of SU "St. Kliment Ohridski" for acquiring the educational and scientific degree "doctor" in the relevant scientific area and professional field.
- b) there is no legally established plagiarism in the presented thesis and autoreferat.

#### **4. Characteristics and assessment of the candidate's teaching activity**

Teaching activity is not necessary, in order to acquire the educational and scientific degree "doctor". Despite that, the candidate has teaching experience (he has taught recitations in "Statistical Physics"), which is commendable.

#### **5. Content analysis of the applicant's scientific and scientific-applied achievements contained in the thesis**

The research of the candidate is focused mainly on two types of exotic compact objects: wormholes and naked singularities. Both types of objects do not have an event horizon, unlike black holes. In the thesis, the optical properties of these objects are studied in depth, in order to find differences in the morphology of their images (compared to black hole images) that could be detected observationally by the Event Horizon Telescope (EHT) collaboration. In addition, the polarization of the radiation of these exotic objects is investigated, to determine to what extent the nature of space-time affects this polarization.

The results of the above studies show that only the indirect, but not the direct, images of the emitting objects are significantly influenced by the nature of space-time, and the effect can reach an order of magnitude depending on the geometry of the magnetic field. It is also shown that observations at 230 GHz (even with a larger array of telescopes than the 2017 EHT collaboration) are unable to detect the studied exotic compact objects. Even more important is the result that at an observation frequency of 345 GHz, as planned for ngGHz, it becomes possible to distinguish unique features of these exotic objects. Observational evidence for such features not only would confirm the existence of these compact objects, but also would open a window into the properties of gravity in the strongly non-perturbative regime. Because of all this, the research in this thesis is particularly timely and of exceptional scientific interest.

The achievements of the candidate can be characterized as developing new methods for testing new theories, as well as enriching existing knowledge. Moreover, since they are a very important bridge for connecting theoretical studies with observational data, they can also be characterized as the application of scientific achievements in practice. Although the three papers on which the thesis is based are quite recent (they were published within the last two years), they already have a total of 30 independent citations. This is indicative of the great interest they attract within the scientific community.

## 6. Critical notes and recommendations

I have no critical notes and recommendations.

## 7. Personal impressions of the candidate

I do not have personal impressions - I do not know the candidate.

## 8. Conclusion

After familiarizing myself with the presented thesis, autoreferat and other materials of the candidate, and based on the analysis of their significance and the scientific contributions contained in them, **I confirm** that the scientific achievements meet the national requirements and the relevant regulations of SU “St. Kliment Ohridski” **for acquiring the educational and scientific degree “doctor”**. In particular, the candidate satisfies all minimal national requirements in the relevant professional field and there are no indications for plagiarism in the presented thesis, autoreferat and scientific papers.

Therefore, my assessment of the thesis is **positive**.

## II. GENERAL CONCLUSION

Based on the above, **I recommend** that Valentin Olegov Deliyski be awarded, by the Faculty of Physics of SU “St. Kliment Ohridski”, **the educational and scientific degree “Doctor”** in professional direction 4.1 Physical Sciences (Theoretical and Mathematical Physics).

11.09.2024 г.

The opinion was prepared by: .....

Prof. DSc. Lilia Anguelova

(academic position, scientific degree, name, surname)