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**OPINION**

**of a dissertation**

**for the acquisition of the educational and scientific degree "doctor"**

**in professional direction 4.1 Physical Sciences,**

**by defense procedure at the Faculty of Physics (FzF)**

**of Sofia University "St. Kliment Ohridski" (SU)**

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The opinion was prepared by: **Prof. Angela Slavova Popivanova - IMI-BAN,**

in her capacity as a member of the scientific jury according to Order No. RD 38-30/ 24.01.2023 of the Rector of Sofia University.

**Dissertation topic: "Structure and astrophysics of self-gravitating objects in multiscalar theories"**

**Author of the dissertation: Radostina Zhekova Zheleva**

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

**1. Data on the submitted documents**

The candidate, Radostina Zhekova Zheleva, has submitted a dissertation and an author's abstract, as well as the mandatory tables for Physical Sciences from the Regulations for the Terms and Conditions for Acquiring Scientific Degrees and Holding Academic Positions at SU "St. Kliment Ohridski". Nine other documents supporting the applicant's achievements are also presented.

The documents presented by the candidate for the defense correspond to the requirements of the ZRASRB, PPZRASRB and the Regulations for the terms and conditions for acquiring scientific degrees and occupying academic positions at SU "St. Kliment Ohridski" (PUR-PNSZADSU).

## 2. Applicant's data

Radostina Zheleva graduated from the profiled high school of natural sciences and mathematics in the city of Stara Zagora in 2013. In 2017, she obtained a bachelor's degree in physics, specializing in quantum and space theoretical physics, at the Faculty of Physics of SU "Kliment Ohridski", and in 2018 she became a Master of Physics, specializing Theoretical and Mathematical physics at the same faculty. Since 2019, she has been enrolled in doctoral studies at the Faculty of Physics with a supervisor, Cor. Member Prof. Stoycho Yazadzhiev.

Radostina Zheleva has 3 published articles in refereed journals and 20 independent citations. She gave a report at a scientific seminar.

## 3. General characteristics of the candidate's scientific achievements

The dissertation shows the existence of scalarized self-gravitating compact objects and supporting non-trivial scalar fields in multiscalar theories of gravity and especially in Einstein-Gauss-Bonnet gravity, where scalar fields interact with space-time curvature by means of the topological invariant of Gauss-Bonnet. The existence of scalarized black holes and neutron stars with a rapidly decreasing "scalar hair" in multiscalar Gauss-Bonnet theories, whose scalar space is a maximally symmetric three-dimensional Riemannian space, is shown numerically. Solutions have been constructed enabling the study of the astrophysics around them, with the goal being to search for astrophysical effects with a distinct signature of the scalar fields, which could be observed with the next generation of gravity detectors and/or electromagnetic telescopes.

The dissertation consists of 3 chapters, contributions and literature of 136 titles.

There is no proven plagiarism in the submitted dissertation and abstract.

## 4. Content analysis of the scientific and scientific-applied achievements of the candidate contained in the materials for participation in the competition

The main contributions of the dissertation work can be classified as scientific and scientific-applied.

A. Scientific contributions

In Chapter 1, quasi-periodic oscillations from the accretion disk around rotating traversable space tunnels were investigated using resonance models. The linear stability of circular geodesic orbits in the equatorial plane for a general class of space tunnel geometries is investigated. Analytical expressions for epicyclic frequencies are derived. The properties of the quasi-circular oscillating motion compared to the Kerr black hole are analyzed.

In Chapter 2, Einstein-Gauss-Bonnet multiscalar gravity is introduced. The dimensionally reduced field equations that describe black holes under appropriate assumptions are presented.

Chapter 3 is dedicated to neutron stars in Einstein-Gauss-Bonnet multiscalar gravity, presenting the dimensionally reduced field equations describing the structure of neutron stars in the theory.


B. Scientific and applied contributions

In Chapter 2, the solutions describing black holes, as well as their physical characteristics - horizon area, entropy, radius of the photon sphere, are numerically constructed. Chapter 3 presents numerical solutions for neutron stars and the main dependencies – mass-central density, mass-radius, binding energy-baryon mass.


There are 3 articles published on the dissertation work, of which 2 in Phys. Rev. D and 1 in Eur. Phys. J. C. The three articles are in quartile Q1. The scientific publications included in the dissertation meet the minimum national requirements (according to Art. 2b, paras. 2 and 3 of the RASRB) and, accordingly, the additional requirements of SU "St. Kliment Ohridski" for the acquisition of the educational and scientific degree "doctor" in professional direction 4.1 Physical sciences.

The total impact factor of the dissertation publications is 15.8. There are 20 quotes citations.

There is no document presented about the participation of Radostina Zheleva in the joint publications, which is why I assume that she is equal to the other co-authors.

## 5. Critical notes and recommendations

I have no particular critical remarks on the dissertation work and the abstract. It would be good to have some kind of introduction at the beginning of the dissertation and the abstract.

## 6. Personal impressions of the candidate

I have no personal impressions of Radostina Zheleva.

## 7. Conclusion

After having familiarized myself with the presented dissertation work, abstract and other materials, and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I confirm that the scientific achievements meet the requirements of ZRASRB and the Regulations for its application and the relevant Regulations of the SU "St. Kliment Ohridski" for the acquisition of the educational and scientific degree "Doctor". In particular, the candidate satisfies the minimum national requirements in the professional field and no plagiarism has been found in the dissertation, abstract and scientific works submitted for the competition.

I give my **positive** assessment of the dissertation work.

## II. GENERAL CONCLUSION

Based on the above, I recommend the scientific jury to award the educational and scientific degree "doctor" in professional field 4.1 Physical sciences to Radostina Zhekova Zheleva.

27.03. 2023                                    Prepared the opinion:

                                                      (Prof. Angela Popivanova)