Referee's Report

On the application for the academic position "Associate Professor" competition in the professional field 4.1 Physical Sciences (Theoretical and Mathematical Physics) for the needs of Sofia University "St. Kliment Ohridski", Faculty of Physics, opening call published in the State Newspaper, No 57, 26.06.2020

The report is written by **professor, Dr.Sc. Svetlana Jordanova Pacheva**, member of the Physical Sciences (Theoretical and Mathematical physics) Jury for this competition in accordance with the Sofia University Rector's order No RD 38-323, 27.07.2020 .

Dr. Kiril Petrov Hristov, senior assistant professor in the Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, is the only applicant for this competition.

I. General Description of the Applicant's documents submitted for the competition

1.Application documents

The documents submitted for this competition by the applicant should comply with the requirements of the Law for advancement of the academic staff in the Republic of Bulgaria (LAASRB) , with its Regulations (RLAASRB), as well as with the Additional Regulations of Sofia University "St. Kliment Ohridski" (ARLAASRB).
The applicant has submitted the following documents:

- List of Publications for the competition: a list of 22 publications (co)authored by him, all in Q_1 international journals, wherefrom 18 are published in JHEP, 3- in Phys. Rev. D, 1- in Nucl. Phys. ;
- List of all publications;
- List of the author's scientific contributions in the competing publications;
- List of independent citations on the competing publications;
- Materials proving that the minimal requirements of LAASRB, RLAASRB and ARLAASRB) are satisfied;
- Document from The University Milano-Bicocca for 3 year postdoc employment;
- Document for employment from INRNE, BAS;
- PhD Diploma from the University of Utrecht, The Netherlands;
- Certificate for senior assistant professor at INRNE, BAS;
- Certificate for the Bulgarian State "Pythagoras Prize for Excellent Young Scientist";
- CV .

2. Applicant's data

Dr. Kiril Hristov was born on March 30, 1985 in Sofia, Bulgaria. He got his Bachelor degree at the University of Bremen, Germany , where his main studies during 2003-2006 were in Physics, Mathematics, Computer sciences, Geology and Astronomy. His Diploma work was "*BlackHoles in 5 Dimensions"*.Then he had a 3-month internship in the Group of Quantum Dynamics in Intense Laser Fields at the Max Planck Institute for Nuclear Physics in Heidelberg, which ended successfully with a joint publication in ***J. Phys. B: At. Mol. Opt. Phys.***. Kiril Hristov got his Master Degree in Theoretical Physics in 2008 at the University of Utrecht, the Netherlands, after defending *cum laude* his thesis entitled "*On Moduli Stabilization in Type IIB String Theory*".

There he defended his PhD thesis "*Lessons from the Vacuum Structure of D = 4 N = 2 Supergravity"*, on which he worked during 2008-2012. The following 3 years Kiril Hristov was employed as a postdoc at the University Milano-Bicocca, Italy. During this time of an active research, he was also a co-supervisor of one PhD student. Kiril Hristov returned to Bulgaria in 2015 to work as an assistant and later as senior assistant professor at the Elementary Particles Theory Laboratory at INRNE, BAS and as a lecturer at the Faculty of Physics of Sofia University "St. Kliment Ohridski".

Dr. Kiril Hristov was endowed numerous stipends and scholarships for his excellent achievements during his studies and later during his professional work: at the universities of Bremen, Utrecht and Milano-Bicocca. These stipends came both from these universities and from the government of the Netherlands; one stipend was from the Shell company. In 2017 he was awarded the European "Marie Sklodowska-Curie" seal for excellence. The same year he was awarded the "Pythagoras" prize for excellent young scientist from the Bulgarian government and in 2019 – the "Marin Drinov" prize, the highest prize of the Bulgarian Academy of Sciences for young scientists. For his 5 years work at INRNE he got twice the prize for best scientific publication in theoretical physics.
To conclude this point, one can definitely state that the applicant has got substantial knowledge and deep understanding in theoretical physics which have lead him to highest achievements in his research performed in some of the most outstanding universities in Europe and in INRNE-BAS.

3. General Description of the Scientific Publications and Achievements of the Applicant

Dr. Kiril Hristov is already an established specialist with high achievements in one of the hottest and rapidly developing field of modern theoretical and mathematical physics: AdS/CFT correspondence in string theory and its application for description of the fundamental interactions between elementary particles at super-high energies.
To emphasize the place and importance of this field we recall that the superstring theory in 10 dimensional space-time (or in more general terms, the embedding "M-theory" in 11 dimensional space-time) is considered most perspective candidate for a unified description of all fundamental interactions which incorporates in a natural and systematic way quantum field theory of elementary particles and gravity. String theory could be connected and give answers to fundamental questions in different fields of physics: in cosmology(evolution of the early Universe, cosmological constant); in nuclear physics (collisions between heavy ions); in condensed matter physics (Hall effect, nonstandard mechanisms of superconductivity).
The main concept is the gauge-gravity duality, or holographic correspondence between quantum gravity (more exactly, string dynamics in a specific gravitational background) in (d+1)-dimensional space-time and quantum gauge field theory in d-dimensional flat space – time (quantum gauge field theory living at asymptotic boundary of the (d+1)-dimensional gravitational background. The string theory at strong coupling is dually equivalent to a weakly coupled quantum field theory and vice versa, the gauge-gravity duality is a very important tool to get an insight in the physics of quantum gauge systems at strong coupling. This duality also suggests that the properties of gravity at very small distances should not depend on the specific behavior at large distances. Therefore the gauge-gravity duality might shed light on quantum gravity and, in particular, the creation and evaporation of black holes and the information paradox connected with these processes.

All scientific works of the applicant are 33. 28 of them at the moment of submission of the application were published in Q_1 journals (23 – in JHEP, 3 – in Phys. Rev. D, 1 – in Nucl. Phys. B, 1 – in Phys. Lett. B) , Meanwhile, 2 of these works, listed as preprints in the data base https://arxiv.org/, have been published – one in JHEP, one - in Phys. Rev. Lett.

The applicant has submitted for the competition **22** out of his 33 publications in the document *10B.SelectedPublicationList.pdf* : **18** publications in JHEP, **3** publications in Phys. Rev D and **1** publication in Nucl. Phys. B. All are in Q_1 journals. He has submitted informative document proving that the minimal requirements of LAASRB, RLAASRB and ARLAASRB for the academic position "associate professor" are satisfied.
One can find some inaccuracies:

(1) In group G the check I the data base gives Total 434 points instead of filled in Total 262 points;
(2) The Total points in group E is 85 instead of the filled in Total 65 points;
(3) The Total number of publications in the last 3 years (2017-2019) is 7 instead of the filled in 5.

However, these inaccuracies only show thet the requirements in the abovementioned sections are **overfulfilled**.

To conclude this section, after checking of the submitted documents and comparing with the data from the database *inspire*, I confirm that:

(a) the minimal requirements of LAASRB, RLAASRB and f for the academic position "associate professor" are satisfied. Most of the requirements are oversatisfied;
(b) All applicant's competing publications [11]-[22] from *10B.SelectedPublicationList.pdf* do not coincide with publications used in previous competitions of the applicant. In his case, for his PhD thesis and for the academic position "senior assistant professor";
(c) There is no plagiarism in his publications

4.Characterization and Assessment of the Teaching Experience of the Applicant

Dr. Kiril Hristov has a considerable and multi-subject teaching experience. His teaching activity begins during his bachelor studies at the University in Bremen, where he was a teaching assistant for the bachelor level courses in General Physics, Classical Mechanics,Quantum Mechanics and Special Relativity. During his PhD research he teaching assistant for the masters level courses in Quantum Field Theory and Theory of Elementary Particles, Theory of Gravitation, Statistical Field Theory. Since 2016 he lecturing master courses on Advanced Quantum Field Theories at the Physical Faculty of Sofia University. He also gave a series of lectures for the participants of the International School for Young Scietntists at Sofia University.
Conclusion. The Teaching experience of Dr. Kiril Hristov is 1500 hours and overfulfills the requirents of ARLAASRB of 540 hours.

5. Detailed Analysis of Scientific Achievements of the Applicant According to the Submitted Documents

5.1 The Principal Scientific Contributions of Dr. Kiril Hristov May be Categorized According to the Following Main Research Topics:

5.1.1. Study of Various Aspects of Moduli Stabilization in String Compactifications (papers [1,2]).

Compactification is a fundamental problem in 10-dimensional superstring theory and 11-dimensional M-theory, namely, representation of the embedding d=10,11 dimensional embedding spacetime manifold as a factor space of 4-dimensional "observable" spacetime times (d-4)-dimensional compact "internal" space. Upon compactification the effective 4-dimensional theory contains a number of moduli – scalar fields corresponding to deformations of the internal space geometry. The a priori absence of potentials for the moduli fields causes huge degeneracy of the vacuum ground state, which inhibits predictability for the physically relevant quantities (e.g., coupling constants in the effective 4-dimensional theory). This is the notorious problem about moduli stabilization. One feasible solution is the generation of an appropriate superpotential for the moduli via introduction of fluxes of higher-rank gauge fields compatible with the symmetries of the theory.

In paper [1] a new scenario is proposed for stabilization of the so called axionic (non-geometric) moduli in the context of stringy flux compactifications. It is achieved through perturbative corrections to the pertinent Kaehler potential as well as non-perturbatively via calculations of the D3-instanton contributions to the corresponding superpotential. An additional motivation for the study of the axionic (non-geometric) moduli is due to their role in cosmology as possible candidates for driving inflation.

5.1.2 New maximally supersymmetric solutions and BPS black holes of N = 2 gauged supergravities (papers [2,3,4,5,6,7,10,14,22])

Here central objects of study are the 4-dimensional supersymmetric stringy ground states ("vacuums") and their low-energy effective description by classical solutions in supergravity theories. In short, the main results here are as follows:

(a) In paper [2] explicit maximally supersymmetric solutions in 4-dimensional N=2 gauged supergravity are derived. Some of these solutions are identified as vacuum solutions of flux compactifications in string theory.

(b) Paper [3] constructs explicit solutions for BPS black holes in N=2 D=4 gauged supergravities. Here one of the main motivations is the understanding of the microscopic nature of entropy of asymptotically flat black holes.

(c) The BPS constraints for spherically symmetric black hole solutions in N = 2 gauged supergravity are thoroughly studied in papers [4,5,6]. The general form of the asymptotic charges for asymptotically flat, anti-de Sitter (AdS_4) and magnetic anti-de Sitter spacetimes are derived.

(d) Paper [7] studies the general solution for non-BPS extremal asymptotically flat static and under-rotating black holes in abelian gauged D=4 N = 2 supergravity, in the limit of vanishing scalar potential. It is explicitly ahown that some supersymmetries are preserved in the near horizon region of all the asymptotically flat solutions above, which exhibits a close relation between microscopic entropy counting of extremal black holes in Minkowski and BPS black holes in AdS spacetimes.

(e) Paper [10] presents new solutions for rotating black holes in 4-dimensional gauged supergravity. It is found that the pertinent black hole horizons may possess various types of topologies (compact or non-compact).

(f) Paper [14] proposes a simple method of extending AdS_5 black string solutions of 5d gauged supergravity in a supersymmetric way by addition of Wilson lines along a circular direction in space.

(g) Paper [22] constructs new explicit solutions for rotating four-dimensional anti–de Sitter space (AdS_4) black holes in gauged N=2 supergravity coupled to Abelian vector multiplets with a symmetric scalar manifold. It is found that entropy function, which upon extremization gives the black hole entropy, to be holographically reproduced by the leading N contribution of the generalized superconformal index of the dual theory.

5.1.3 Black Hole Thermodynamics

(5.1.3а) Microscopic Bekenstein-Hawking Entropy (papers [11,12,13,15,17,20])

(a) Paper [11] studies attractors, black objects (black holes, branes, strings, rings) and holographic RG flows in 5d maximal gauged supergravities.

(b) Papers [12,13] study in some detail the dimensional reduction of the BPS attractors in gauged supergravity with AdS and flat Minkowski asymptotics. The pertinent relation between black strings and black holes is an important tool for the microscopic understanding ot black hole entropy.

(c) In paper [15] higher derivative corrections to BPS black hole attractors in 4d gauged supergravity are discussed. The resulting corrections to the Bekenstein-Hawking entropy are calculated.

(d) Paper [17] derives Bekenstein-Hawking entropy for a class of BPS black holes in the massive type IIA supergravity background $AdS_4 \times S^6$ from a microscopic counting of supersymmetric ground states in a holographically dual field theory.

(5.1.3б) Phase Transitions (paper [9])

Paper [9] studies in detail the thermodynamical properties of a class of spherically-symmetric static blackholes in 4-dimensional AdS spacetime with magnetic chanrges and a scalar “hair”. A new phase transition of first order is found between small and large black holes with a “hair”. In the corresponding dual 3-dimensional theory the counterpart of this phase transition appears as a liquid-gas phase transition.

(5.1.3в) Bekenstein-Hawking Entropy via Extremization (papers [16,18,19])

(a) In paper [16] it is shown that Bekenstein-Hawking entropy for a class of electrically charged rotating BPS black holes in $AdS_5 x S^5$ can be derived via a self-contained extremization principle, correspond to the attractor mechanism for rotating BPS black holes in 5-dimensional gauged supergravity.

(b) Paper [18] studies BPS black hole attractors in the conformal 4d gauged supergravity formalism by using the well-known technique “supergravity localization” in order to evaluate quantum entropy function in the $AdS_2 x S^2$ near-horizon geometry.

(c) The approach and the results in paper [16] are systematically extended in paper [19], where it is shown that the entropy of electrically charged rotating BPS black holes in $AdS7 x S^4$ can similarly be derived from a self-contained extremization principle.

5.1.4 Holographic Duality for 4-dimensional Black holes and Superconformal Field Theories (papers [8,21])

(a) Paper [8] studies N=1,2 superconformal and supersymmetric field theories in 3-dimensional Lorentz manifolds from the point of view of black hole holography. It is found that the pertinent conformal Killing spinors do exist when a conformal Killing vector exists, which is lightlike ot timelike. It is shown that the results in the 3-dimensional context match the results expected from holography in the corresponding 4-dimensional asymptocially AdS black holes.

(b) It is explicitly found the supergravity background which is dual to the so called Omega-deformation (Nekrasov deformation) of 4-dimensional superconformal field theory in Minkowski spacetime.

5.2 The main Results of the Applicant Could be Characterized as:

(a) obtaining and proving new scientific results;
(b) proving with new methods important new features of existing problems and theories.

5.3 Importance of the Applicant's Results for Science and Practice

The main merit of Dr. Hristov's scientific results is in their contribution towards the consistent proof of fundamental concept of "holographic' duality between theories with gravitational interaction "in the bulk space-time manifolds" and various kinds of gauge theories living at the border of of the bulk manifold, i.e. in space-times of 1 dimension less. This duality is important both in the context of elementary particles physics at(super)high energies and in the context of condensed matter physics. In particular, the results of Dr. Hristov constitute a nontrivial theoretical contribution for extracting experimentally falsified results of the candidate theory of unified interactions in the Universe. They also provide numerous examples of models description in modern cosmology.

5.4 Impact of Applicant's Scientific Results on Other Authors' Publications

All publications of Dr. Kiril Hristov have until now **721 independent citation**; those submitted for the competition ([11]-[22]) have **217 independent citations** according to *INSPIRE-HEP* data base*:* **https://inspirehep.net/authors/1061224?ui-citation-summary=true&ui-exclude-self-citations=true**

INSPIRE-HEP is the basic most complete and reliable freedata base in the field of theoretical physics and high energy physics.

Dr. Kiril Hristov had **h-index 14** according to *INSPIRE-HEP* at time of submitting his documents. Meanwhile his h-index has grown to 15.

6. Critical Remarks

I don't have any substantial critical remarks. Some inaccuracies in the document ***10B.SelectedPublicationList.pdf*** were presented in section 3. As noted there, the corrected data, make the fulfillment of the requirements in this application even more convincing.

7. Personal Impressions

Dr. Kiril Hristov is my colleague in LTEP of INRNE, BAS. His many talks at the regular seminar of our Laboratory have always been clearly stated, challenging and demonstrating deep understanding of the topics. For me he is an established expert in the field of (super)string theory, supergravity, black hole theory and application of the holographic principle. He has the skills to formulate and solve problems. He can also successfully collaborate with other colleagues. Since 2 years he is in charge of our seminar and in this capacity he has organized the visits of several renowned scientists, whose talks have been of great importance for all of us. Thanks to Dr. Hristov our seminar presently proceeds with the help of ZOOM.

8. Conclusion on the Application

After I got acquainted with all documents submitted for this competition, including the publications [11] – [22] of the applicant and on the basis of the analysis of the latter importance and their scientific achievements **I confirm that the scientific contributions fully comply with the requirements of the Law for advancement of the academic staff in the Republic of Bulgaria and with its Regulations, as well as with the Additional Regulations of Sofia University "St. Kliment Ohridski for Dr. Kiril Hristov to be employed on the academic position "Associate Professor" in the scientific field and professional direction of this competition. I also confirm that Dr. Kiril Hristov fulfills, moreover, he overfulfills, the minimal requirements for this scientific field and professional direction and no plagiarirism was found in his publications submitted for this competition.**
I state my firm positive assessment.

II. General Conclusion

Based on the abovementioned, I firmly recommend to the Scientific Jury to propose to the qualified selection body of the Faculty of Physics of Sofia University **"**St. Kliment Ohridski**"** to select **Dr. Kiril Petrov Hristov** for the academic position "Associate Professor" in the professional field 4.1 Physical Sciences (Theoretical and Mathematical Physics).
Thereby The Faculty of Physics will acquire a talented young researcher and the students – an excellent lecturer and teacher.

05.10.2020 . **Referee: Prof. Dr.Sc. Svetlana Jordanova Pacheva**