

## **REFEREE STATEMENT**

### **On an application for the position of “associate professor” in Professional Field “4.1 Physical Sciences” at the Faculty of Physics of Sofia University “St. Kliment Ohridski”, opening call published in „State Gazette“, issue 63 of July 30, 2021**

This Referee Statement was prepared by: Prof. Dr. Sc. Emil Rafaelov Nissimov, corresponding member of Bulgarian Academy of Sciences (BAS), assoc. member of the Institute for Nuclear Research and Nuclear Energy of BAS, in his quality as a member of the Selection Committee in Professional Field “4.1 Physical Sciences” according to Order No.RD-38-488/01.10.2021 of the Rector of Sofia University “St. Kliment Ohridski”.

For the currently announced position there is a single applicant – Dr. Tsvetan Ivanov Vetsov, senior assistant professor at the Faculty of Physics of Sofia University “St. Kliment Ohridski”.

#### **I.General Description of the Application Documents**

##### **1. Information about the Application**

The submitted application documents for the current academic procedure match the official requirements according to the National Law for Academic Staff Development and the Regulations for the application of the latter Law, as well as the Regulations for Acquisition of Academic Staff Positions in Sofia University “St. Kliment Ohridski”.

For participation at the competition for the current position the applicant has submitted 18 scientific publications out of his complete list of 23 publications altogether in leading international journals with a high impact-factor (IF) or impact-rank (JSR). Among the submitted publications there are 12 papers in Q1, 1 paper in Q2, 2 papers in Q3, 4 papers in Q4, further 3 publications with IF and/or JSR, as well one publication being a separate chapter in a published book.

The applicant has also submitted a list of independent citations, a list of his principal research contributions, teaching work load reference, a reference on fulfilment of the Minimal National Requirements for the “Associate Professor” position, as well as a statement by his collaborator Prof. Dr.Sc. Radoslav Rashkov confirming the applicant’s contributions in their collaborative works.

The submitted application documents support the conclusion that the scientific achievements of the applicant apparently satisfy the Minimal National Requirements according to the National Law for Academic Staff Development.

##### **2. Information about the Applicant**

Tsvetan Ivanov Vetsov has been born on August 08, 1996, in the town of Razlog, Blagoevgrad Region of Bulgaria. He graduated in 2011 at the Faculty of Physics of Sofia University “St. Kliment Ohridski” as M.S. in theoretical and mathematical physics. In 2015 he successfully defended his Ph.D. thesis again at the Faculty of Physics of Sofia University “St. Kliment

Ohridski". Since 2015 until today he holds the position of senior assistant-professor at the Department of Theoretical Physics at the Faculty of Physics. He has been a scientific supervisor of 3 B.A. students with successfully defended B.A. theses.

The applicant has been an active participant in 7 research projects financed by the Bulgarian National Science Foundation, where in one of these projects he has been a project leader. Also he has been project leader of 2 research projects financed by Sofia University "St. Kliment Ohridski". He has been an organizer of the international event "PhD Training Seminar-School , New trends in High Energy Theory"" at the Faculty of Physics in Sofia, 2017.

The applicant is an author of 9 invited talks at several respectable international conferences abroad as well as in Bulgaria.

### **3. General Description of the Research Papers and Achievements of the Applicant**

The scientific papers of the applicant belong to some of the most actively developing worldwide modern areas of theoretical and mathematical physics, such as string theory of elementary particles at ultra-high energies, including the celebrated gauge-gravity duality ("holography") and its numerous applications in:

- (1) Gravity, cosmology and theoretical astrophysics – black hole physics in modern modified gravity theories substantially generalizing the classic Einstein's general relativity to incorporate the effects of the "dark matter" (see also below in Sec.5);
- (2) Condensed matter physics – specifically the effects of quantum entanglement (entanglement entropy) (see also below in Sec.5).

On the basis of the supplied reference documents one can definitively conclude that:

- (a) The scientific publications of the applicant satisfy (even with some excess) the Minimal National Requirements (according to art. 2b (2) and (3) of the National Law for Academic Staff Development) as well as satisfy the additional regulations by Sofia University "St. Kliment Ohridski" regarding acquisition of the "associate professor" position in the Professional Field "4.1 Physical Sciences";
- (b) The submitted research papers by the applicant have not been previously submitted in other procedures for academic degrees and/or academic positions.
- (c) There is no legally detected plagiarism of any kind in the submitted scientific publications by the applicant.

### **4. General Assessment of the Teaching Experience of the Applicant**

The submitted administrative reference about the teaching activity shows a fairly intense teaching work load of the applicant – around 1660 teaching hours in the period 2017-2020, most of them lectures and/or seminars in class. The applicant has been a lecturer on various modern topics of theoretical and mathematical physics, in particular lectures on modern elementary particle theory at ultra-high energies, as well as on quantum field theory in curved spacetime. The applicants has also been an instructor in seminars on basic lecture courses for undergraduate students, as well he has been a scientific supervisor of 3 successfully defended B.A. theses.

## **5. Detailed Analysis of the Scientific Achievements of the Applicant Contained in the Submitted Documents**

The scientific research of the applicant belongs to the following fundamental modern topical areas:

### *(1) Information Geometry – Fisher Metric*

Fisher information metric on statistical manifolds of classical and quantum systems is a basic instrument for a study of their thermodynamic properties, including their behavior in the neighborhood of phase transition points. The applicant has original contributions in the application of this fundamental approach to the investigation of black hole thermodynamics in nontrivial modifications of the standard Einstein general relativity taking into account the effects of the “dark matter” and “dark energy”. The same approach has been applied to calculate of the physical characteristics (thermodynamical stability, mass estimates, nonperturbative corrections to the entropy) of 3-dimensional “holographic” black holes in the context of gauge-gravity duality. Fisher information metric has been also employed to study the properties of the dynamics of a quantum string system on homogeneous plane wave gravitational background – entanglement entropy in the ground state, identifying phase transition points. Further applications of information geometry are the calculation of Fisher metric in discrete systems such as coupled Pais–Uhlenbeck oscillators as well as in holographic models with non-relativistic symmetry in Schroedinger spaces.

### *(2) Entanglement Entropy*

The applicant has calculated the entanglement entropy in discrete systems of higher-derivative oscillators, the entanglement entropy in the quantum dynamics of string systems in homogeneous plane wave spacetime as well as in systems with condensed bosonic or fermionic matter and the non-equilibrium entanglement entropy in dissipative quantum systems.

### *(3) Physics of Black Holes and Compact Dark Objects in Astrophysics*

The thermodynamics of black holes in 4-dimensional modified gravitational theories is thoroughly investigated and generalized in order to take into account the effects of “dark matter”. The thermodynamics of 3-dimensional rotating Lifshitz black hole in massive gravity has been studied and the pertinent Smarr relations among the thermodynamic parameters and non-perturbative entropy corrections have been calculated. Further, within the context of topical current observational astrophysical experiments investigating the properties of dark compact objects – black holes, wormholes, boson stars, “naked” singularities - the applicant has noticeable contribution for the numerical and graphical modelling of relativistic images of thin accretion disks in strong gravitational fields around dark compact objects.

### *(4) String Theory and Gauge-Gravity Duality*

The applicant has significant contributions for the study of string dynamics within the context of the “holographic” gauge-gravity duality via semiclassical quantization of strings moving in non-trivial gravitational backgrounds in various spacetime dimensions. For this purpose string solutions of types “spikes”, magnons and “folded” are studied in detail, where the explicit form of the equations of motion has been derived and the anomalous dimensions of the operators in the corresponding dual quantum field theory have been found. Also the 3-point correlation

functions of the quantum field operators in the dual theory corresponding to the folded string solutions have been calculated.

#### *(5) String T-Duality and Supergravity*

String T-duality (target-space duality) is one of the most fundamental symmetries in string theory relating two different string theory models with different geometries of the embedding gravitational background but possessing equivalent physical properties. In this respect it is of essential interest to study new non-trivial solutions with non-abelian T-duality in the context of supergravity theories, which represent low-energy limits of string theory models. Here the applicant has noticeable contribution in the publications on this topic, specifically in exhibiting the explicit form of the non-abelian T-duality transformations for the fields of the supergravity multiplet, as well as explicitly finding of a nonabelian T-duality supergravity solution dual to the Penrose limit of the well-known Pilch-Warner supergravity solution.

As an overall evaluation of the scientific achievements of the applicant one certainly can classify the latter as contributions to the formulation of novel theoretical models and proposing novel methods for studying the fundamental laws of Nature at ultra microscopic or cosmological scales of spacetime. The topics of the scientific research of the applicant belong to the long-term all-encompassing program of the worldwide community of scientists in the area of elementary particles and high-energy physics, astrophysics and cosmology in searching answers to such ground-laying issues as the intrinsic nature of “dark matter” and “dark energy”, possible discovering of extra spacetime dimensions, presence or absence of supersymmetry, etc.

#### **Impact of the research results of the applicant in the international scientific literature:**

According to the principal most reliable scientific data base in the area of high-energy and theoretical physics INSPIRE-HEP the works of the applicant so far have 125 independent citations with h-index 6. On the other hand Web-of-Science, being less complete as a data base in the scientific areas in question, yields 81 independent citations with h-index 5. I definitely recommend to take into consideration the more adequate data from INSPIRE-HEP.

#### **6. Critical Remarks and Recommendations**

I don't have certain significant critical remarks. On the contrary, I would like to stress the appropriate professional knowledge by the applicant of the main advances in the international scientific literature on the topics of his research, as well as I would note the applicant's skills for an adequate formulation of the pertinent scientific problems, choosing the right tools for analysis and achievement of the end results. Also the applicant has demonstrated his ability for an efficient team work.

#### **7. Personal Impressions about the Applicant**

My personal impressions are entirely positive judging from my direct contacts and discussions with the applicant in the course of our previous collaborative scientific projects financed by the Bulgarian National Science Foundation. The applicant had a significant contribution for the

successful completion of these research projects by demonstrating professionalism, persistence and communicability skills.

### **8. Concluding Remarks about the Application**

Upon getting acquainted with the submitted material by the applicant including the full texts of his publications, and based on the analysis of the merits and the presence of nontrivial significant scientific results contained therein, **I reiterate without hesitation my statement**, that these scientific achievements definitely satisfy the requirements by the National Law for Scientific Staff Development, the Regulations for enforcing the latter, as well the corresponding Regulations of Sofia University “St. Kliment Ohridski” for acquisition of the position of “associate professor” in the Professional Field “4.1 Physical Sciences”. In particular, the applicant does satisfy the Minimal National Requirements for obtaining the academic position in question, and no traces of plagiarism have been detected in the submitted scientific publications.

**Therefore, I declare my positive evaluation of the present application.**

## **II. OVERALL CONCLUSION**

On the basis of the above consideration, without hesitation I do request the honorable Selection Committee to recommend to the competent Selection Body at the Faculty of Physics of Sofia University “St. Kliment Ohridski” to award the position of “associate professor” to Tsvetan Ivanov Vetsov in the Professional Field “4.1 Physical Sciences”.

November 12. 2021

Referee: Corr. Member of BAS, Prof. Dr. Sc. Emil Nissimov