Application forms – Part 2

„COMPETITION FOR FINANCIAL SUPPORT FOR RESEARCH PROJECTS– 2017"

Scientific description of the project

Competition:
Competition for financial support of research projects – 2017
Main research/thematic area, of the project:
Physical Sciences/Theoretical and Mathematical Physics
Additional research/thematic area – for interdisciplinary projects:
Mathematical Sciences and Informatics/Applications of Mathematics in Physics
Project title:
Symmetries of the Fundamental Laws of Nature
Type of the planned research (fundamental or applied):
Fundamental
Applying organization:
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences
Partner organizations:
Faculty of Physics, Sofia University "St. Kliment Ohridski"
Coordinator of the research team (academic position and degree, name):
Corresponding member of BAS, Prof., Dr.Sc. NISSIMOV Emil Rafaelov

Coordinator of the research team:

(signature)

/……/

Table of Content

1. Analysis of the current state of research on the problem area

1.1. Timeliness and relevance of scientific problems addressed by the project

● Quantum field theory and relativistic gravity and cosmology (Einstein's theory of relativity and its modern generalizations) are the two main pillars on which the modern comprehensive knowledge about the fundamental building blocks of matter in the Universe and the intrinsic laws governing their interactions and dynamics are based. They in turn are closely intertwined with the research at the forefront of almost all branches of modern mathematics (algebraic and differential geometry, topology, functional analysis, group theory, number theory, etc.).

Symmetries embody the essence of the fundamental laws of Nature. In most broad sense symmetries are understood:

(i) from physical point of view – as the principles of gauge invariance and reparametrization (general coordinate) invariance;

(ii) from mathematical point of view – as the basic structures of Lie groups and Lie algebras, algebraic geometry, quantum groups, special functions, symmetries of linear and nonlinear partial differential equations, arising in the mathematical description of natural phenomena.

In view of the above facts our proposal will be composed naturally of several main areas in close symbiosis: (a) fundamental mathematical structures revealing the intrinsic nature and meaning of the symmetries of the fundamental physical forces ; (b) extended theories of gravity beyond Einstein's general relativity and their applications in modern quantum cosmology (the evolution of the Universe), as well as in black hole and "wormhole" physics; (c) string theory in its modern disguise – primarily the ubiquitous gauge/gravity duality

Gravity plays a central role in physics [S.Weinberg, Cosmology, (Oxford Univ.Press, 2008); G.Calcagni, Classical and Quantum Cosmology (Springer, 2017)]. Essentially all challenges in astrophysics, cosmology and fundamental physics include gravity as a key ingredient, making it a subject of strong interdisciplinarity. The synthesis of the results of the comprehensive studies in modern theories of gravity and cosmology, extending by far the classical Einstein theory of general relativity, as well as the advance in modern fundamental mathematics, offer exciting opportunities and scientific prospects to answer some of the most pressing issues in our understanding of the cosmos and the laws of Nature: (i) acquiring new knowledge about the structure and behavior of matter at ultra-microscopic and galactic distances; (ii) contributing to a solution of the most challenging "mysteries" and cardinal problems of modern physics with a global conceptual significance - "supersymmetry", "extra space-time dimensions", black holes and "wormholes", "dark matter" and "dark energy" in the universe.

As some of the most important innovative fields of science the studies of gravitational waves [B. Abbott et.al., Phys. Rev. Lett.116(2016)061102] and the emerging radically novel gravitational-wave astronomy are destined to dominate the whole complex of space- and astrophysics research for many decades to come.

Our research programme as part of the worldwide efforts of the scientific community of gravity and space-time physics experts aims at revising and extending the theory of gravitational interactions in order to overcome the shortcomings of the classical Einstein's general relativity at quantum and cosmological scales [A. De Felice, S. Tsujikawa, Liv. Rev. Rel.13(2010)3; S.Capozziello, V. Faraoni, "Beyond Einstein Gravity", Springer(2011)]. Experimental searches for direct evidence of dark candidates, based on the assumption of overall validity of the classical Einstein's general relativity,

have not yielded up to now any conclusive results. Therefore it makes sense to pursue alternatives beyond Einstein's gravity to explain astrophysical observations and phenomenology.

We ourselves are proposing novel classes of Extended Theories of Gravity [E.Guendelman, E.Nissimov, S.Pacheva, Eur.J.Phys.C75 (2015) 472; C76:90 (2016); Int. J. Mod. Phys. D25 (2016) 1644008] already proved to have a significant potential for plausible explanations of various basic cosmological evolutionary scenarios. From a theoretical viewpoint, we intend to study how Extended Theories of Gravity emerge from Quantum Field Theory, and how mechanisms produced by the latter may explain cosmological dynamics without assuming exotic ingredients. In particular, we want to compare the standard cosmological Lambda-CDM model, based on the need of dark matter and dark energy with various nontrivial extensions of general relativity.

- A long-standing conjecture is that at Planck energies all the fundamental interactions are unified. The efforts of the physics community in this direction resulted in a promising candidate - string theory. String theory is currently our best candidate for a theory describing all fundamental interactions, including a quantum theory of gravity. String theory possesses a large number of symmetries. Along with the known – gauge, reparametrization, discrete etc. - specific symmetries, namely dualities became of conceptual importance.

The discovery of string/gauge theory duality has been profound boost in our thinking not only about those theories but also about fundamental laws of Nature and particularly space-time itself [J. M. Maldacena, Adv. Theor. Math. Phys. 2, 231 (1998); Int. J. Theor. Phys. 38, 1113 (1999); S. S. Gubser, I. R. Klebanov and A. M. Polyakov, Phys. Lett. B 428, 105 (1998); E. Witten, Adv. Theor. Math. Phys. 2, 253 (1998); S. S. Gubser, I. R. Klebanov and A. M. Polyakov, Nucl. Phys. B 636 (2002) 991]. The concepts and methods of string/gauge theory duality have been applied with increasing sophistication to many phenomena in a broad range of questions in many fields.

Currently, the only available approach for studying strongly interacting quantum systems is by using a variety of dualities. Dualities are essentially equivalences between interacting sectors of two (or more, trialities etc.) theories. It allows to use the results obtained in sectors where efficient tools are available by using dualities to transfer them to another theory whose sector is hard to study. In string theory, there are many dualities relating different corners of the theory, but there are also dualities between gauge theories and string theory constructions. The latter are roughly dualities between gauge theories on branes and string theory. A concrete realization of the gauge/string duality is the AdS/CFT (Anti-de-Sitter/Conformal Field Theory) correspondence, which puts together string theory, gravity, and gauge fields in a single framework. Thus, at present the holographic principle serves as one of the most promising concepts that goes beyond the standard theory of gravity [G.'t Hooft, arXiv: gr-qc/9310026, hep-th/0003004, 2000; L. Susskind, J.Math.Phys.36:6377-6396, 1995]. The striking feature is that the theories living on the two sides of the duality are completely different and even live in space-times of different dimensions. The interpretation of this phenomenon is that the subspace where the gauge theory lives serves as a "holographic screen" for the theory in the bulk. It offers an invaluable insight into the behaviour of the field theory in the regime of strong M. Van Raamsdonk, "Building up spacetime with quantum entanglement,"
Gen. Rel. Grav. 42 (2010) 2323 [Int. J. Mod. Phys. D 19 (2010) 2429].coupling where quantum effects dominate and traditional methods prove inadequate.

In holographic duality to reconstruct the bulk gravity from boundary field theory is extremely difficult task. In such a program we face one of the most challenging problems in modern physics - the intrinsic property of quantum systems to develop entanglement between their subsystems. A well-suited quantity characterizing this process is the so-called geometric or entanglement entropy (EE), which is usually obtained by a trace over the degrees of freedom located in a subspace of the whole system. In the context of holography, there are clues that entanglement entropy might be the underlying mechanism of emergent space-time. It is argued that entanglement of holographic degrees of freedom leads to emergence of classically connected space-times [M. Van Raamsdonk, Gen. Rel. Grav. 42 (2010) 2323 [Int. J. Mod. Phys. D 19 (2010) 2429].

1.2. Current state of the research on the problem area

- Einstein's theory of General Relativity celebrated its 100th anniversary last year being the most spectacular attempt by science to capture the basic laws of physics. It was thoroughly tested to very high precision in the regime of weak fields. On the other hand, its fundamental geometric structure is explicitly manifested in the regions of strong gravitational fields, primarily around black holes. Thanks to many decades of dedicated theoretical efforts a consistent and elegant mathematical theory of black holes and their perturbations has been born. Together with this, important breakthroughs in successful numerical treatment of Einstein field equations have revealed to us various intrinsic details of black holes' interaction and merging, and most importantly – about the release of enormous amounts of gravitational-wave energy.

As of now it seems that black holes are fairly abundant in our universe, playing a major role in stellar and galaxy evolution. Since they are truly generally-relativistic objects, they play a key role in the novel emerging field of gravitational-wave astronomy. Let us recall that on September 14, 2015, the two interferometers of the LIGO collaboration detected a gravitational wave signal GW150914 from a merging pair of black holes This was definitely a great historical discovery marking the dawn of the era of gravitational-wave astronomy and the opening of a new window onto the currently still invisible landscape of the "Gravitational Universe". If we assume that general relativity (classical Einstein's and/or its modern extensions) as the correct theory of gravity, then the signal GW150914 is the first direct observation of black holes in Nature, as well as the first observation of merging black holes.

The above spectacular event highlights the timeliness of the current theoretical gravity research based on the modern extensions of the classical Einstein's general relativity, and it also underscores the enormous progress over the last few decades in building cutting-edge technological marvels of experimental science.

Another related important issue are the gravitational shock waves mainly because of their key role in the description of impulsive ultrarelativistic signals in general relativity, in the high-energy scattering of matter at the Planck scale and in energetic collisions of ultrarelativistic heavy ions. Members of the team already have interesting results in this area - new type electro-vacuum gravitational shock wave confining electrically charged matter at finite distance from the wave front [E.Guendelman, E.Nissimov. S.Pacheva, Mod.Phys.Lett.A29 (2014) 1450020].

Apart from black holes, other no less important gravitational objects related to the latter are the so-called space-time portals ("wormholes") connecting by "short-cut" two or more universes with in general different space-time geometry or "short-cutting" two very distant regions of the same universe with non-trivial topology. In various solutions of "wormhole" type the pertinent space-time contains closed time-like curves meaning "traveling back in time". This is one of the still unresolved most outstanding paradoxes in the history of science. In particular, from the point of view of information theory the existence of closed time-like curves would violate the famous Church-Turing thesis.

Unlike the case of black holes, we are still lacking observational evidence of the existence of wormholes in the known Universe. Yet there are solid theoretical arguments about the possibilities of their appearance, among others – as gravitational entities of the class of the so called lightlike "thin-shell wormholes" as suggested in various recent papers by the members of the proposed project [Phys. Lett. B673 (2009) 288; Phys. Lett. B681 (2009) 457; Int. J. Mod. Phys. A25 (2010) 1405; Gen. Rel. Grav. 43 (2011) 1487; Springer Proc. Math. Stat. 191 (2016) 245].

It is known that lightlike membranes (lightlike "thin-shells") are of fundamental interest in general relativity, where they describe lightlike impulse signals arising from catastrophic astrophysical events. They play an essential role in a number of other important cosmological and astrophysical phenomena, among them - in the "membrane paradigm" of the physics of black holes and in the membrane approach to the problem of gravitational domain walls. Recently lightlike membranes began to play an important role in the context of modern string theory of fundamental forces of nature.

One of the main paradigms of modern elementary particle physics and cosmology is the spontaneous breaking of supersymmetry – a fundamental symmetry unifying the building blocks of matter with integral spin (bosons) and half-integral spin (fermions). Team members already have interesting results in this area – they proposed qualitatively new mechanism of dynamical spontaneous breaking of supersymmetry (the supersymmetric Brout-Englert-Higgs effect) in the context of supergravity based on application of the formalism of non-Riemannian space-time volume forms [E.Guendelman, E.Nissimov. S.Pacheva, et.al., Bulg. J. Physics 41 (2014) 123]. The latter naturally generates a dynamical cosmological constant as an arbitrary dimensionful integration constant, triggering dynamical spontaneous supersymmetry breaking and mass generation for the gravitino - the supersymmetric partner of the graviton. In this way we succeed to realize a prototype of expected physically significant properties of matter in today's era of evolution of the universe – a very small observable cosmological constant and at the same time – a very large mass of the gravitino.

Dark energy and dark matter, occupying around 70% and 25% of the matter content of the Universe, respectively, continue to be the two most unexplained "mysteries" in cosmology and astrophysics. In most loose terms dark energy is responsible for the accelerated expansion of today's Universe, i.e., dark energy acts effectively as repulsion force among the galaxies – a phenomenon completely counterintuitive w.r.t. the naive notion about gravity as an attractive force. And vice versa, dark matter holds together the matter objects inside the galaxies. The adjective "dark" is due to the fact that both these fundamental matter components of the Universe interact only gravitationally, and they do not directly interact with ordinary (baryonic) matter, in particular, they do not interact electromagnetically and thus they remain "dark".

There exist a multitude of proposals for an adequate description of dark energy's and dark matter's dynamics within the framework of standard general relativity or its modern extensions – "Chaplygin gas" models, "purely kinetic k-essence" models, "mimetic" dark matter models, etc. We have already recently proposed to achieve unified description of dark energy and dark matter based on a class of generalized non-canonical models of gravity employing a very successful previously introduced by us novel method of non-Riemannian volume-forms on space-time manifolds [E.Guendelman, E.Nissimov, S.Pacheva, Euro Phys. J. C75 (2015) 472; C76 90 (2016)].

We have also investigated a mixed system of parabosons and parafermions [N.Stoilova, J.Van der Jeugt, J.Phys. A: Math. Theor. 48 155202 (2015)]. Such systems, corresponding to order of statistics p=2 are candidates for particles of dark matter and energy [C.A. Nelson, M. Kraynova, C.S. Mera and A.M. Shapiro, Phys. Rev. D 93 034039 (2016)].We will actively explore also these latter research frameworks as outlined in section 2.

- Holographic dualities relate weak and strong coupling regimes on both sides of duality. To prove, or at least to provide a dictionary between the two sides is notoriously complicated and difficult. The reason for that is the lack of universal tools for strong coupling sectors. An efficient way to attack the problems is based on integrability. The narrower topic of integrability in the context of holography is a subject of vigorous activity worldwide. The underlying integrable structures help to interpolate between weak to strong coupling, thus making possible the quantitative checks on both sides of the correspondence. A remarkable breakthrough was made by Minahan and Zarembo. They were able to map the problem of finding anomalous dimensions to spin chains and use the Bethe ansatz to obtain particular anomalous dimensions. Subsequently the Bethe ansatz approach was extremely useful for obtaining not only the dimensions but some correlation functions in N=4 SYM. For some particular cases, of giant magnons for instance, the problems has been also reduced to integrable models, see for instance [G. Arutyunov, J. Russo and A. A. Tseytlin, Phys. Rev. D 69 (2004) 086009; C. Ahn, P. Bozhilov and R. C. Rashkov, JHEP 0809 (2008) 017]. The methods of integrability have been intensively used in finding spectra of holographic models with maximal supersymmetry, for intensive review see for instance [N. Beisert, C. Ahn, L. Alday, Z. Bajnok, J. Drummond, et al., "Review of AdS/CFT Integrability: An Overview," Lett. Math. Phys., vol. 99, pp. 3–32, 2012; arXiv:1012.3982 [hep-th]].

The next problem currently under investigation is the description of the OPE, or the 3-point functions, see for recent breakthrough [B. Basso, Sh.Komatsu, P.Vieira, arXiv:1505.06745]. There are indications that the dual, string theory formulation of the supersymmetric gauge theory, based on an integrable sigma model, retains its classical conformal invariance after quantization. This string theory (so far understood only in certain limits and some gauge choices) requires an extension of the 2d conformal field theory (CFT) techniques. One of us (V. Petkova) intends to exploit its expertise in CFT in this direction.

Higher spin (HS) theories have attracted considerable interest in the past few years. They have richer structures than Gravity, but are much simpler than String theory. Cosidered as tensionless limit of string theory, higher spin theories [Fradkin, E.S. and Vasiliev, M.A., Nucl. Phys. B291 (1987) 141; M.A. Vasiliev, Phys. Lett. B 567 (2003) 139] appear to be susceptible to holography [E. Sezgin and P. Sundell, Nucl. Phys. B 644 (2002) 303]. A striking conjecture was made by Klebanov and Polyakov [Phys. Lett. B 550 (2002) 213]: higher spin theory on AdS_4 might be exactly dual to sectors of the free and interacting O(N) vector model in 2+1 dimensions at large N realized under specific boundary conditions. A very efficient way to study HS holography is to restrict considerations to 3d where many of the dual theories are exactly solvable. For instance, a program for studying the duals of minimal model CFT's was initiated in [M.R. Gaberdiel and R. Gopakumar, Phys. Rev. D83 (2011) 066007], considerably extending and sharpening the earlier results [M. Henneaux and S.J. Rey, JHEP 1012 (2010) 007]. Recent developments can be traced in [S. Giombi, I.R. Klebanov and A.A. Tseytlin, Phys. Rev. D90 (2014) no.2, 024048] and references therein. So far, nearly all papers on higher spin holography are devoted to asymptotically AdS spacetimes. Since the holographic principle is not restricted to AdS spaces, it is important to go beyond that cases. Two notable developments are considerations of de Sitter space [D. Anninos, T. Hartman and A. Strominger, arXiv:1108.5735] and of Schrödinger, Lifshitz, warped and Lobachevsky spaces pioneered by Grumiller, Rashkov and collaborators [M. Gary, D. Grumiller and R. Rashkov, JHEP 1203 (2012) 022; H. Afshar, M. Gary, D. Grumiller, R. Rashkov and M. Riegler, JHEP 1211 (2012) 099; H. Afshar, M. Gary, D. Grumiller, R. Rashkov and M. Riegler, Class. Quant. Grav. 30 (2013) 104004]. Some advances in this direction can be found, for instance, in M. Beccaria, M. Gutperle, Y. Li and G. Macorini, Phys. Rev. D92 (2015) no.8, 085005 and references therein. The integrable structures has been uncovered in various holographic models and in particular in the higher spin theories. For instance, it has been shown that KdV hierarchies appear in AdS3 higher spin theories in the context of BTZ black holes [G. Compere and W. Song, JHEP 1309 (2013) 144].

The reconstruction of bulk theory from boundary data is one of the central issues in holography. To do that however, one should understand how string/gravity emerges from quantum field theory degrees of freedom at the boundary (or lower dimensional spacetime). Variety of oblects entering duality are used to define main properties of bulk theory. Such objects are related via holography and are subject of intensive study, for instance Wilson lines and conformal blocks, see [A. L. Fitzpatrick, J. Kaplan, D. Li and J. Wang, arXiv:1612.06385; M. Ammon, A. Castro and N. Iqbal, JHEP 1310 (2013) 110; A. Hegde, P. Kraus and E. Perlmutter, JHEP 1601 (2016) 176]. In three dimensional case the Wilson lines are also geodesics ending on the boundary. An example of how global and local structures come together to define a local bulk physics is given, for instance in [D. Kabat and G. Lifschytz, arXiv:1703.06523]. Using the intersecting modular hamiltonians, the local bulk operators are constructed using solely CFT data. The symmetry group-theoretical approach of the boundary-bulk correspondence is developed in [V.K. Dobrev, Nucl. Phys. B553 (1999) 559-582, Int. J. Mod. Phys. A29 (2014) 1430001; N. Aizawa & V.K. Dobrev, Nucl. Phys. B828 (2010) 581–593, Rept. Math. Phys. 75 (2015) 179-197].

1.3. Focus of proposed research in line with the objectives of the National Research Strategy and with regional, national and European research priorities

We firmly believe that our current proposal is completely in line with the basic goals of the National Research Strategy 2020, namely with the principal vision about high quality scientific research as primary driving force for the economic and social advancement of modern Bulgarian society. Among the main directions and priorities of the National Research Strategy 2020 we would stress on the firm ambitions of initializing and stimulating a complete overhaul and modernization of Bulgarian scientific research.

All of the senior members of our research team possess an extensive collaborative research (and teaching) experience in having spent a number of years as visiting scientists, including as visiting professors, in various world renown leading foreign academic institutions. Therefore, we most certainly realize the urgent need for a radical improvement and thrust of Bulgarian science research towards international levels of excellence and world-wide competitiveness.

Specifically, our project will contribute to the modernization of Bulgarian science in the areas of theoretical and mathematical physics and, in particular, in gravity, cosmology and string theory by directing the research efforts of the elementary particles group at INRNE, BAS, and the Physics Department of Sofia University towards the main contemporary topics that are of principal interest to the leading scientists in the field from the United States and Western Europe.

Our vast research experience abroad and the already established networks of international collaborations – among others through our active participation in the management committees of several respectful European COST actions, will most certainly contribute towards realization of several basic objectives of the National Research Strategy 2020:

a) enhanced scientific productivity – publications in the world leading scientific journals and maximal popularization of Bulgarian scientific achievements towards wide international recognition and raising the image of the Bulgarian schools in modern science disciplines;

b) extension of international collaborations and fostering the competitive potential of Bulgarian science – building-up of a competitive science research infrastructure as an integral part of the European science research areal.

c) Fostering integration among Bulgarian scientific research institutions – in our case between Bulgarian Academy of Sciences and Sofia University.

d) Modernizing the structure of scientific research institutions and elevating the social status of scientists in Bulgaria.

Finally, we believe that financing our project will encourage more young talented Bulgarian theoretical physicists, currently working abroad, to consider returning back to Bulgaria, which undoubtedly would be to the enormous benefit of Bulgarian science.

2. Project objectives, hypotheses and approaches for accomplishment of project objectives

2.1. Project objectives and hypotheses

Extended theories of gravity beyond Einstein's general relativity, applications in quantum cosmology (the evolution of the Universe)

Employing the powerful formalism of non-Riemannian space-time volume-forms, developed by members of the project team [E.Guendelman, E.Nissimov, S.Pacheva, et.al., Gen.Rel.Grav. 47 (2015) art.10] leads to the construction of a new class of "quintessential" inflationary gravity-matter models, producing an effective scalar "inflaton" potential with two infinitely large flat regions describing the "early" inflationary and the "late"/present dark energy dominated epoch in Universe's evolution, respectively, as well as it naturally provides a self-consistent unified description of dark energy and dark through the dynamics of a single "darkon" scalar field [E.Guendelman, E.Nissimov, S.Pacheva, Eur.J.Phys.C75 (2015) 472; C76:90 (2016)].

The above non-conventional "quintessential" "inflaton" model can be extended to include the fields comprising the bosonic sector of the electroweak theory. In this way we exhibit a very interesting fundamental feature of space-time - **gravity-assisted generation in the "late" Universe of Higgs-like spontaneous gauge symmetry breaking** effective potential for the SU(2)xU(1) scalar iso-doublet Higgs-like field [E.Guendelman, E.Nissimov, S.Pacheva, Int.J.Mod.Phys. D25 (2016) 1644008]. Here we will pursue the following principal challenging objectives:

a) Within our "quintessential" "inflaton" model with the unified description of dark energy and dark matter dynamics, the transition between the "early" and "late" Universe's epoch is not well understood because of the utmost complexity of the corresponding cosmological evolution equations which we plan to investigate more systematically with the help of numerical methods.

b) Further, more interesting challenge is the study, at least semiclassically within the WKB approximation, of the pertinent Wheeler-De Witt equation for the wave function of the Universe describing the **cosmological evolution on quantum level**. We expect to uncover certain quantum tunneling transition in the evolution of the Universe between the "early" and "late" epochs.

c) We shall also consider mixed systems of paraparticles. The commutation relations among paraoperators were studied by Greenberg and Messiah [*Phys. Rev.* **138** B1155–67] and they came to the result that for each pair of paraoperators there can exist at most four types of relative commutation relations: straight commutation, straight anticommutation, relative paraboson, and relative parafermion relations. The case with relative parafermion relations and the corresponding Fock representations has been investigated in [N.Stoilova, J.Van der Jeugt, J.Phys. A: Math. Theor. 48 155202 (2015)]. Our objective is to investigate the other three types of relative relations and the hypothesis is that such systems would be of interests as candidates for particles of dark matter and energy.

● **Tensile Lightlike Membranes and the Physics of Black Holes and "Wormholes"**

We will employ the reparametrization-invariant world-volume formalism for lightlike membranes with dynamical variable brane tension, introduced in our previous works [E.Guendelman, A.Kaganovich, E.Nissimov, S.Pacheva, Phys.Rev.D72 (2005) 086011], to study in detail the impact of lightlike membranes on various basic interesting gravitational objects and phenomena, such as:

a) **Non-singular black holes** – black holes free of space-time singularities behind the (inner-most) horizon. We have already found explicit simple examples of non-singular black hole solutions [E.Guendelman, A.Kaganovich, E.Nissimov, S.Pacheva, Int.J.Mod.Phys.A25(2010)1405].

b) **"Tube-like wormholes" and gravity-assisted electric charge confinement**. In the simplest cases [E.Guendelman, A.Kaganovich, E.Nissimov, S.Pacheva, Int.J.Mod.Phys.A26(2011)5211] we have already found physically intriguing solutions describing QCD-like confining effects.

c) We plan to employ our lightlike membrane formalism to the study of **gravitational waves from lightlike "thin-shell wormholes"**. In this case we can combine our expertise in the lightlike

membrane formalism with the well-established methods of treatment of gravitational perturbations in Schwarzschild and other spherically symmetric black holes.

● **Holography, Integrable models (IM) and Entanglement entropies (EE)**

The methods of integrable hierarchies, whenever applicable, provide invaluable information for the physics on both sides of holographic duality. In particular, integrable models have been used for obtaining the anomalous dimensions and some correlators in the correspondence [N. Beisert et al., "Review of AdS/CFT Integrability: arXiv:1012.3982]. In the context of entanglement entropy it has been exploited for instance in [A. Coser, L. Tagliacozzo and E. Tonni, J. Stat. Mech. 1401 (2014) P01008]. All these together provide a solid basis for bulk reconstruction which however, remains a challenging task so far. The objectives that will be pursued here are as follows:

a) It has been noticed that the entanglement entropy satisfy a local equation - Liouville equation. The HS theories from Toda perspective have been also briefly discussed. Combined with our results in [R.C. Rashkov, arXiv:1607.08373] these remarks lead to the idea that appearance of integrable models (Liouville, sinh-Gordon-Lioville, Toda etc), deserve thorough study in this context. We will study in which systems and how general is the appearance of equations of integrable models as equations satisfied by entanglement entropy. The investigations will be carried out within the framework of bulk theory reconstruction and lift to string theory.

In the Chern-Simons formulation the boundary conditions fix the solutions of the Toda equations. On the other hand, the Toda theory gives a pair of connections directly related to the Drinfeld-Sokolov reduction, and thus to W-algebras. We will study the relations between these objects and their meaning for holography.

b) From the **symmetry** point of view the main objective is to represent the AdS/CFT correspondence as action of operators intertwining the group representations in the bulk with those on the boundary. This was realized first in the Euclidean AdS/CFT where the symmetry is the Euclidean conformal group in R^d [V.K. Dobrev Nucl. Phys. B553 (1999) 559-582]. Later it was realized in the non-relativistic case where the Schroedinger group was used in 1+1 dimensions [N. Aizawa and V.K. Dobrev, Nucl. Phys. B828 [PM] (2010) 581–593]. Recently the Minkowskian AdS/CFT was achieved in 2+1 dimensions [N. Aizawa and V.K Dobrev, Rept. Math. Phys. 75 (2015) 179-197]. We plan to attack the problem in higher dimensions and for arbitrary spins.

c) Another purpose of the present Project is to develop and apply CFT methods to the computation of the quasiclassical approximations of the 3-point correlation functions in the string framework. Following an observation in [FP: P. Furlan and V.B. Petkova, JHEP 12 (2015) 079] a key quantity used in the computation of the 3-point function in the sl(2) subsector of the theory [R. Janik and A. Wereszczynski JHEP 12 (2011) 095; S. Kazama and Sh. Komatsu JHEP 01 (2012) 110] obeys a standard identity for the braiding matrices in the related conformal field theory (CFT), with solutions now depending uniformly on a spectral parameter. This opens a possible way of generalizations to higher rank sectors, combining the integrable sigma models approach with CFT technique, in particular in sl(4) related conformal Toda and WZW theories. Vice versa, recent progress on the quantum separation of variables in higher rank integrable spin chains [N. Gromov, F. Levkovich-Maslyuk and G, Sizov, arXiv:1610.08032 may provide the clue to understanding the quantum Drinfeld- Sokolov reduction on the level of correlators.

d) The decomposition of the global characteristics as entanglement into series of SL(2) invariants can be though of as "anatomy" of these characteristics. On the other hand, various types tau-functions have an interpretation of CFT conformal blocks. With an emphasis on the relations between these quantities and their impact on holography, we will study in details how the local degrees of freedom of CFT's get organized to produce global quantities. These investigations assume also the study of the role of the OPE conformal blocks.

● **Strings, T-dualities and holography: E**mbedding of above models to gravity, or lift to string theory would provide important knowledge about quantum properties of gravity and strong coupling phenomena of gauge theories. From string theory point of view, there are certain deformations of the holographic backgrounds which are of interest to the correspondence, namely abelian and non-abelian

T-duality. For instance, TsT-dualities applied to isometries along and transverse to the branes defining the background lead to dipole theories.

a) We will initiate calculation of the global and local characteristics of deformed models in the holographic context. Prticular emphasis will be will be given to dipole deformed theories. Integrability of these models is crucial and therefore will be underlying task of the investigations.

b) The same question can be asked for non-abelian T-duality, where noting that the original and the dual theories may be different, the situation is much more complicated. These studies are planned mainly (but not restricted to) for the second part of the project.

c) To provide a deeper understanding of the holographic duality we will initiate lift of the investigations above to string theory. We will investigate whether brane realization of such models exist and what they teach us about duality.

2.2. Approaches for accomplishment of the research goals including interdisciplinarity of the project

In a series of previous papers members of the present project team in collaboration with known foreign experts have already developed powerful new formalisms extending the classical Einstein's general relativity, as well as the theory of lightlike relativistic extended objects (membranes) – cf. above citations. These new approaches have a significant impact on the gravitational dynamics creating new physically relevant effects unattainable in ordinary Einstein's general relativity.

Treatment of the Wheeler-De Witt equation for the quantum wave function of the Universe within the WKB approximation amounts to solving the corresponding Hamilton-Jacobi equation associated with the effective particle-like mini-superspace system of our "quintessential" "inflaton" model with the unified description of dark energy and dark matter . This itself is a very complex problem involving a complicated non-linear partial differential equation for the Hamilton-Jacobi principle action-function the latter being the phase of the wave function of the Universe. It most probably will require invoking numerical methods using the symbolic packages *Mathematica* and *Maple*.

To achieve the goals of the holographic part of the project we will use the powerful methods of integrable systems appearing in the context of holograpgy. From the field theory side we will use Wilson lines and conformal blocks approach to holographic correspondence, and for the bulk theory reconstruction we will use elements of integral geometry. Members of this proposal, together with known foreign experts, already suggested a new approach to HS holography essentially generalizing it to non-AdS cases. Bulk reconstruction uses EE to unravel quantum properties of Gravity. This has direct relation to information spaces and information geometry, and indirect to quantum computing, chaos, combinatorics even biological systems. All these clearly indicate broad interdisciplinarity of the project.

3. Methods, research equipment and techniques

3.1. Research methodology and techniques

The interdisciplinary nature of the proposed research defines the great variety and range of arsenal of powerful methods and approaches from the cutting edge of modern theoretical physics and mathematics: nonperturbative approaches in quantum field theory; renormalization theory of ultraviolet divergences; nonperturbative methods in string theory; modern mathematical concepts and approaches in general relativity; methods from the theory of integrable systems (soliton theory) and Hamiltonian dynamical systems with constraints; methods of differential geometry and topology; algebraic geometry; methods from group theory - representation theory, incl. representations of infinite-dimensional Lie algebras; abstract algebra and number theory; methods of the theory of special functions.

More specifically, the methodology of the research project includes the following:

(a) For treatment of systems of gravity and gauge-field matter, interacting self-consistently with a lightlike membrane matter, we shall use methods from the theory of dynamical systems with constraints in order to explore extended objects with world-volume reparametrization invariance.

(b) For the examination of quasi-normal modes in gravitational perturbations mainly direct methods will be used for integrating, possibly numerically, time independent wave equations for the field perturbations.

(c) In the study of gauge/gravity duality the methods developed by the team members, and also by leading scientists in the field, including methods of string theory, integrable systems, algebraic and differential geometry, Lie groups and algebras and their representations, techniques and methods of gauge theories and of two-dimensional conformal models will be used.

(d) For the calculation of the characters of superconformal algebras the most recent developments in the theory of representations, including ones developed by team members, will be used.

3.2. Previous accomplishments and competencies of the research team in the research area of the project

Senior members of the research team are leading Bulgarian scientists of international reputation in the field of theoretical and mathematical physics. They have major contributions in several actively developed worldwide scientific fields: quantum conformal field theories in two or more space-time dimensions, study of nonperturbative properties of string theory of the fundamental interactions at ultrahigh energies - gauge-gravity duality and integrable structures, mathematical structures of string theory, the latter implications in cosmology and astrophysics, the role of conformal symmetry in the physics of condensed media, algebraic aspects and geometric structure of integrable dynamical systems.

The scientific papers (numbering more than 500) of the members of the team cover the whole range of issues related to this project and were published mainly in the world's leading international scientific journals with high impact factor in the field of physics and mathematics: Journal of High Energy Physics, Physical Review D, Nuclear Physics B, Physics Letters B, Communications in Mathematical Physics, etc. The results have been reported (some in plenary talks) at hundred prestigious international conferences and have been cited more than 7,000 times in the papers of foreign scholars, including - from leading experts.

3.3. Capacity of the applying and partner organizations to conduct the proposed research

The Institute for Nuclear Research and Nuclear Energy (INRNE) of Bulgarian Academy of Sciences (BAS) is the leading institute in Bulgaria in the field of fundamental and applied research in particle physics, nuclear physics, high energy physics, and many other areas related to applications of nuclear physics and its methods. Teams of INRNE scientists work together with their colleagues from leading research centers like CERN, JINR Dubna, the Joint Research Centre of the European Commission (EC), laboratories and universities around the world. INRNE scientists have participated in projects under the Fifth, Sixth and Seventh Framework Programme of the EC. There is a fast internet connection, as well as opportunities for numerical calculations - along with modern PCs access is provided to a computer cluster and the network GRID. The Institute has the administrative capacity to support many local and international research projects. The majority of the scientists who will work on the proposed project are employees of the Laboratory "Theory of elementary particles" in INRNE. It is the undisputed leader in Bulgaria in theoretical research in elementary particle physics at high and ultrahigh energies.

Sofia University "St. Kliment Ohridski" is the largest and most prestigious educational and scientific center in the country. The University educates students in all three levels of higher education and performs research in the natural, mathematical and social sciences and humanities. Many of the best Bulgarian specialists in all areas of natural and mathematical sciences work in Sofia University. By the number of teachers and students, theoretical and practical achievements, national influence, international contacts, library and information services, facilities and equipment and opportunities, as well as the success of graduates, Sofia University is comparable to the best universities in Europe and is one of the leaders in Southeastern Europe.

The main tasks of the project are to perform advanced mathematical analysis. This requires working space with internet access and standard computer capabilities, blackboard and other standard office supplies. Both INRNE and Sofia University provide most of the basic necessary infrastructure like internet access. They do not provide computational equipment, like PCs, laptops, printers, scanners which are indispensable for an advanced scientific research. To fill in these gaps we have requested enough money to buy personal laptops, desktops, etc. for our needs.

4. Research plan and tasks to be executed by the research team

4.1. Description of the project's outline and work break down structure

The detailed research plan is divided into three interrelated work packages (WPs). Scientific collaboration between the packages as well as external to the project Bulgarian and international researchers is anticipated.

a). WP1 entitled "Extended Theories of Gravity and Quantum Cosmology" will be based on the expertise in various areas of theoretical and mathematical physics of Prof. E. Nissimov and Prof. S. Pacheva, with the essential participation of Dr. D. Staicova and Ph.D. student K. Marinov, where the expertise of the younger members in application of modern numerical methods will be very relevant. WP1 will focus on:

- Systematic study of the Wheeler-De Witt quantization of our "quintessential" "inflaton" model with the unified description of dark energy and dark matter dynamics, specifically - numerical treatment of the Hamilton-Jacobi equation for the WKB phase of the quantum wave function of the Universe.
- Gravity-assisted generation in the "late" Universe of Higgs-like spontaneous gauge symmetry breaking – an important task is to incorporate the dynamics of the fermion fields of the electroweak model (until now only the bosonic electroweak sector has been considered).
- The next important step after our recent proposal [Bulg.J.Phys.41(2014)123] of a new venue of dynamical spontaneous breaking of supersymmetry in supergravity based on the non-Riemannian volume-form formalism, is extending these results to the case of more realistic phenomenologically feasible supergravity models involving matter supermultiplets.
- Non-singular black holes – we will extend our formalism of gluing together at their common horizon of de Sitter interior region (no spacetime singularity at the center of the geometry) to exterior Reissner-Nordstroem region to more physically interesting cases. As before, the dynamically self-consistent glue-together of the geometrically distinct interior and exterior spacetime regions will be realized through placing an appropriate lightlike membrane on the common horizon.
- Gravity-assisted charge confinement via "tube-like" wormholes - due to the presence of lightlike brane(s) as material source(s) of gravity and gauge forces, the very special lightlike brane worldvolume dynamics triggers one or more transitions between noncompact and compactified "tube-like" spacetime regions in the form of special wormhole configurations with the lightlike brane(s) sitting at the "throat(s)". The latter in combination with the special properties of an additional nonlinear gauge field action (nonlinear elecetrodynamics) cause the whole flux generated by the charged branes to be entirely confined within the compactified "tube-like" region.
- Study of gravitational waves produced by lightlike "thin-shell" wormholes – we will use, adapt and further develop the powerful generally coordinate-covariant and gauge-invariant formalism of E.Poisson et.al. [Phys.Rev. 71 (2005)104003] for metric perturbations of Schwarzschild and other spherically symmetric spacetimes.

b).WP2 entitled "Holographic correspondence: semiclassical and quantum features" will be based on the expertise of Prof. R. Rashkov in several areas of theoretical and mathematical physics and essential participation of PhD student Stefan Mladenov. The main focus will be on several issues of particular interest which are however, of conceptual importance.

- The first circle of problems we will concentrate on is integrable models in holographic correspondence and what they mean for it. The best playground for checking and deeper understanding the correspondence on both sides are low-dimensional models which are frequently solvable. The emphasis here will be on integrable structures arising from local field

theories and sophisticatedly organized to produce global features. Via holography, this can be thought as emergent gravity, or bulk theory reconstruction. Based on known achievements and our recent results, particular attention will be given to KdV and Toda hierarchies, which appear, for instance in calculations of EE, SYK-like models with random tensor couplings etc. Interestingly, the above characteristics are aslo related to Wilson lines, conformal blocks, extremal surfaces etc. With the help of elements of integral geometry, all these serve as ingredients for bulk theory reconstruction from boundary data. Going slightly beyond gravity, we will investigate the same issues in certain HS theories.

• The second main theme in this WP concerns issues of more general setup where more direct involvement of string theory is assumed. The lift of the topics studied in the first circle to certain string models will be the focus of investigations in this part. We will investigate the characteristics mentioned above (when possible) from worldsheet and D-brane point of view. A wide class of theories with broken supersymmetry produced by T-dualities is the class of β-deformed holographic backgrounds. The solution generating technique consists of T-duality, shift with parameter β followed by another T-duality (TsT transformation) applied to isometry directions. Depending on which directions are involved in TsT transformations, the dual theory is β-deformed Yang-Mills (all isometries along the D3 branes), dipole-deformed (one isometry is along the branes and other in the transverse space) or non-commutative (both isometries are in the transverse space). The field products in the latter two are expressed in terms of the conserved charges. While integrable properties of the β-deformed theories is (to some degree) studied, the other two cases still need systematic investigations. Our focus in this direction will be on integrable structures, some of which are inherited from the parent theory but some are new. Among all these theories we will pay particular attention to dipole theories, their local and global features and possible reduction to quantum-mechanical models. Along this line of development we conjecture relations to some SYK-like models. Although it is not expected the N-AT-D to be a symmetry of the full string perturbation theory, it is important at least as a solution-generating technique. Holographic interpretation of N-AT-D is as RG flows between conformal fixed points. A possible extension of our investigation to the case of N-AT-D is also anticipated.

c). WP3 entitled "Symmetry aspects of the project" will be based on the expertise of Prof. V. Petkova, Prof. V. Dobrev, Assoc. Prof. N. Stoilova.

• The first cicle of problems in WP3 will be the construction of solutions of the polynomial equations for a fundamental class of braiding/fusing matrices in the higher rank theories, in particular, the sl(4) conformal Toda and WZW theories. This would give constraints for the spectrum dependent solutions of these equations, relevant in the computation of the quasiclassical 3-point correlators of the maximally supersymmetric gauge theory in the dual picture, involving integrable sl(4) related sigma models.

• The second circle of problems would be concentrated on the symmetry aspects of holography. In particular, on the group-theoretical reconstruction of bulk objects from those on the boundary. More precisely, on the construction of the integral and differential invariant operators relevant for the holography. We should note also that both the relativistic and the non-relativistic settings are important.

• The third circle of problems would be concentrated on Lie (super)algebraic structures behind mixed systems of parafermions and parabosons with straight commutation, straight anticommutation and relative paraboson relations. The corresponding Fock type representations would be constructed by induced module constructions of Verma modules.

4.2. Schedule

Because of the multitude of different interrelated nontrivial tasks in each WP we estimate that the work for successfully completing all those task would require essentially the whole time span of the project as indicated on the diagram below. The estimated time-frame includes all necessary steps:

a) acquiring the relevant additional knowledge beyond our current expertise;
b) writing and preparing scientific articles for publication (mainly in international journals);
c) preparing talks and presentations of our results at seminars and (international) conferences;
d) dealing with possible temporary delays due to certain technical/mathematical difficulties until successfully overcome.

Gantt diagram

WP/month	01-03	04-06	07-09	09-12	13-15	16-18	19-21	22-24	25-27	27-30	31-33	34-36
WP 1												
WP 2												
WP 3												

4.3. Project management plan

The senior members of the project team have extensive experience in various scientific and organizational activities; they have been organizing many international conferences, they have been and continue to be members of the Standing/Management Committees of many large European networks and members of the scientific committees of international conferences.
Also, the senior team members have rich experience from participating in the management and organizational structures that have already successfully functioned in previous research projects with the Bulgarian NSF and other international collaborations.

The main coordinator of the project will be Prof. E. Nissimov – head of the Laboratory "Theory of Elementary Particles" of INRNE-BAS. All members of the project team have discussed in advance the Project Management Plan, the main objectives and goals of the project, as well as the set of all specific tasks. Thus, after the start of the project the whole team will be fully aware of the research role of everyone and will be ready to immediately start dealing with the individually allocated specific activities.

We plan the following regular organizational events:

a) Meetings of members of the project: In addition to regular meetings of the members of each of the 3 WPs, it is planned once in 3 months all project members to hold joint meetings where they can discuss current problems in the performance of specific tasks, and coordinate the cooperation and interaction between the different working groups.

b) Weekly seminars: The partners of the project have traditional regular scientific seminars, which will be extended to all participants, so that they can report and evaluate the results obtained so far within the project.

c) Lectures: We plan lecture courses for master and doctoral students in the Faculty of Physics of Sofia University. Their goal will be the training of students and young scientists at the highest level, to enter the forefront of research in the proposed project areas.

Apart from the above events:

d) In the framework of envisaged series of seminars, small workshops we plan to organize visits of prominent scientists from abroad – leading experts on the research topics of the proposed project. These visits will be used both for an important exchange of know-how with the senior team members, as well as for setting up informal meetings to allow direct contact between the guests and students and young scientists.

e) **International Workshop** series "Lie Theory and Its Applications in Physics": As Chair of the international board of the series Prof. V. Dobrev plans to organize the scheduled 13th Workshop in June 2019. This series of international scientific events has already gained considerable popularity throughout the World. The main goal is for students and young scientists to come into direct contact with prominent members of the international scientific community in the proposed areas of research. Among other benefits of such a prestigious international event is the organization of a poster session for the young scientists.

f) We plan maintenance of a website with regular updates to inform partners of seminars, lectures, defense of dissertations and other events and activities related to the project

5. Expected results from the project

5.1. Description of the results related to acquiring new knowledge, potential for practical application or solving social problems

Due to the nature of the present project, which focuses entirely on fundamental research, the primary value of the expected results will be exclusively accumulation and advancement of fundamental scientific knowledge.

The results of the planned basic research will contribute to the long-term programme of the international community of researchers in the field of particle physics and high energy, astrophysics and cosmology searching for **answers to such important conceptual scientific problems** as the nature of "dark matter" and "dark energy" in the Universe, the existence of extra dimensions of space-time, supersymmetry, microscopic black holes and space-time portals ("wormholes").

Specifically, we expect the following essential results:

(a) Quantum tunnelling transitions in the evolution of the Universe, understanding the meaning of the quantum wave function of the Universe;

(b) Deeper understanding through physically realistic cosmological models of the intrinsic unified nature of "dark energy" and "dark matter";

(c) Elucidating the impact of lightlike membranes and lightlike thin-shell wormholes on the fundamental physical phenomena in the Universe - black holes free of space-time singularities, spontaneous space-time compactification, gravity-assisted charge confinement via "tube-like" wormholes, lightlike braneworlds, gravitational shock waves;

(d) Gravitational waves from perturbed lightlike thin-shell wormholes, in particular, Einstein-Rosen "bridge" wormhole

(e) Finding entropy by making use of tau-functions of certain integrable hierarchies; developing a new method for computation of global and local characteristics necessary for bulk reconstruction; to compute the Virasoro OPE block for various operators using Wilson lines and tau-functions;

(f) To reconstruct elements of the bulk theory, especially using symmetry group-theoretical methods;

(g) To obtain embeddings of integrable structures from SL(2,R) models in models with SL(N,R) symmetry and their HS counterparts.

(h) to develop a new worldsheet approach to complement the dictionary of holographic correspondence.

(i) to construct and investigate holographic properties of 2- and 3-dimensional dipole models; study the lift to higher dimensions.

(j) to compute the full brading matrix associated with the 6-dimensional sl(4) representation.

(k) to clarify the Lie (super)algebraic structures behind mixed systems of parafermions and parabosons with straight commutation, straight anticommutation and relative paraboson relations and construct the corresponding Fock type representations.

5.2. Increasing the research capacity of the applying and/or partner organizations, as well as improving team members qualification

The research related to the project possesses significant potential for further development and excellence of the project team. It will expand existing knowledge with new significant results in the described areas. Professional experience and the results will be used in future fundamental research of the group since project topics in quantum field theory and relativistic gravity will undoubtedly be hot also in the next decade.

Another important aspect concerning the further development of the team, is the fact that this project will give the younger members of the research group valuable international experience in science, which is crucial for their future development as researchers. After completion, the young scientists will have acquired the skills to adapt to the highly competitive and creative environment typical of European and global science research area.

An important consequence of the successful completion of the project will be the consolidation of the fruitful cooperation of the scientific team with leading scientists and groups in the world working in similar research areas.

Success of the project will definitely increase the interest among students towards the subject of the research team, which will allow us to attract the most talented of them to choose careers in the fundamental areas of physics and mathematics. This turns out to be of utmost importance for the intellectual preservation of quality Bulgarian science on a competitive European level. In the recent years we witness a dangerous outflow of young people - to the risk of collapse of the genetic link between scientific generations and loss of positions and gained international prestige of the Bulgarian school in theoretical and mathematical physics.

Younger members of the team will develop their research potential and teaching ability to train future scientists. By recruiting, training and developing of new scientists the project will be a valuable contribution to the core mission of the Sofia University "St. Kliment Ohridski" and INRNE BAS.

6. Plan for realization and dissemination of the results from the project

All studies within the present project will be conducted in the framework of a broad international cooperation with renowned institutes and universities around the world, which undoubtedly is a major platform for a wide dissemination of the results of this project. In particular, international scientific cooperation provides excellent opportunities for the members of the project team to visit established foreign research groups working in similar areas. During these visits the participants in the project will deliver talks presenting the current research results, which will enable valuable exchange of expertise and know-how. Such events are crucial not only for raising the prestige of Bulgarian science in the world, but are also essential elements in building up the international reputation of our young scientists.

Here is an incomplete list of active or recently completed international collaborations of team members through European science networks:

(a) COST Action MP1210 "*The String Theory Universe*" (2013-2017);

(b) COST Action MP1405 "*The Quantum Structure of Spacetime (QSPACE)*" (2015-2019);

(c) COST Action CA16104 "*Gravitational waves, black holes and fundamental physics (GWniverse)*" (2017-2021),

which complement numerous bilateral or multilateral research agreements with leading academic institutions in Austria, Belgium, France, Germany, Greece, Israel, Italy, Japan, Russia, United Kingdom and U.S.A.

We expect that all results obtained within the project will be published in the most prestigious international refereed journals with impact factor such as Physical Review D, Physical Review Letters, Journal of High Energy Physics, Nuclear Physics B, Physics Letters B, Communications in Mathematical Physics, Journal of Mathematical Physics, International Journal of Modern Physics A, Classical and Quantum Gravity, General Relativity and Gravitation, and/or in Proceedings of prestigious international scientific events.

Related important opportunity for the dissemination of research results on the topics of the project is their reporting at prestigious international scientific events (conferences, workshops, schools). It is here that the financial support of the project from the National Science Fund will be very essential. In addition, members of the project team have extensive experience in organizing numerous international conferences, workshops and schools in quantum field theory, mathematical physics, group theoretical methods, including quantum groups, superstrings, supergravity, integrable systems. These meetings have always been on a very high level and were attended by a large number of world-renowned experts. We expect the same high scientific level to be maintained at the planned for June 2019 in Varna 13th International Conference on the subject of this project, where the organizing committee will include a significant number of members of the project team.

7. Justification of project budget

7.1. Description of the financial plan and the allocation of costs between the applying organization and partner organizations

The costs for equipment and consumables will be shared equally to make sure each of us is adequately equipped for the research needs. As a result we propose the following allocation of cost between both partners:

1. **Fixed tangible and intangible assets, incl. equipment:**
   BGN 17 100 for the applying organization, BGN 4 900 for the partner organization
2. **Materials, consumables and other eligible costs (including costs of organizing workshops, seminars, conferences, etc.):**
   BGN 17 400 for the applying organization, BGN 5 000 for the partner organization

Each team member will manage her/his own portion of the budget under the guidance of Prof. Nissimov following the terms and conditions of the Grant. As a result we propose the following allocation of cost between both partners:

3. **Trips for Scientific purposes:**
   BGN 34 200 for the applying organization, BGN 9 800 for the partner organization
4. **Remuneration of team members:**
   BGN 17 100 for the applying organization, BGN 4 900 for the partner organization.

5. **Administrative expenses** - deductions for the applying organization INRNE - BGN 8 400 (7% of the total amount).
6. **Administrative expenses** - for project audit - BGN 1 200 (1% of the total amount).

7.2. Justification of eligible direct costs in types of expenses

1. **Fixed tangible and intangible assets, incl. equipment:**

   total 22 000 leva for both stages (1st stage - 11 000, 2nd stage - 11 000)

Normal research performance implies maintaining equipment and networks for the processing and transfer of information to a sufficiently high and reliable advanced level. We provide funds for the build-up, upgrade and update of this technique in the two participating units. We plan a sufficient number of new personal computers (desktops and laptops). Another important part of the necessary equipment are printers, copiers, scanners - they are a daily necessity. The availability of quality network equipment needs no justification. Much of the now available personal computers are in urgent need of updating.

Equipment:	items	item price (leva)	total price (leva)
Laptop/notebook	8	~2 400 lv	19 200 lv
Desktop	1	~1 390 lv	1 390 lv
Printer	1	~ 600 lv	600 lv
HDD External	3	~ 270 lv	810 lv

2. **Materials, consumables and other eligible costs (including costs of organizing workshops, seminars, conferences, etc.):**

   total 22 400 leva for both stages (1st stage - 11 200, 2nd stage - 11 200)

   5 000 lv (1st stage – 2 500, 2nd stage – 2 500)- the main part of the consumables are associated with printing and photocopying, i.e., toners, cartridges, paper, repair and maintenance of this equipment. A smaller portion are for optical media of large amounts of information.

   17 400 lv (1st stage – 8 700, 2nd stage – 8 700) - organizational costs for scientific events organized by the team, e.g., the International Conference in Varna in 2019, and other seminars and workshops.

3. **Trips for Scientific purposes:**

   total 44 000 leva for both stages (1st stage - 22 000, 2nd stage – 22 000)

   Participation in international events is obviously one of the most important forms of promotion of our results, also to maintain important scientific contacts with foreign partners and rapid information to the team about the latest developments in science. The planned money provide within the two stages for each of the 9 participants in total two trips to participate in international conferences with about 1,200 euros per trip for travel and subsistence - this corresponds approximately to the cost of a seven days trip.

4. **Remuneration of team members:**

   total 22 000 leva for both stages (1st stage - 11 000, 2nd stage – 11 000)

   A major problem of fundamental science in Bulgaria is that it is extremely difficult and often impossible to attract young people and to detain senior scholars. We have in mind the most educated and capable part - people who can easily find work abroad and even at home and get much bigger salary - in many cases ten times higher. We plan modest additions to the salaries of the team members.

Work packages

Work package 1: Extended Theories of Gravity and Quantum Cosmology
Start and end of the work package: from Month 01 to Month 36
Work package leader: NISSIMOV Emil Rafaelov
Participants in the implementation of the work package:
PACHEVA Svetlana Jordanova STAICOVA Denitsa Rumenova MARINOV Kalin Kamenov
Planned tasks:
Task 1.1 Wheeler-De Witt equation for the wave function of the Universe Looking for tunnelling transitions from the "early" to the "late" Universe
Deliverable **Internal Report**
Task 1.2 Gravity, Nonlinear Gauge Fields and Wormholes with Lightlike Membranes Non-singular black holes, Spontaneous space-time compactification via lightlike membranes, Gravity-assisted charge confinement via "tube-like" wormholes, Lightlike braneworlds, gravitational shock waves
Deliverable **Internal Report**
Task 1.3 Gravitational waves from lightlike "thin-shell wormholes" Solving equations for the perturbed lightlike thin-shell wormhole metric
Deliverable **Internal Report**

Results, which will be used for evaluation of the intermediate or final report of the project
Publications in international journals with impact factor and in proceedings of international conferences

Work package 2: Holographic correspondence: semiclassical and quantum features
Start and end of the work package: from Month 01 to Month 36
Work package leader: Rashkov Radoslav Christov
Participants in the implementation of the work package:
Mladenov Stefan Budyoniev
Planned tasks:
Task 2.1 States and models in low dimensions and their classical and quantum characteristics Finding of entanglement entropies of certain states and models in terms of elements of integrable models (such as tau-functions, Wilson lines and OPE conformal blocks), extracting their properties and investigating their formal relations and physical meaning.
Deliverable **Internal Report**
Task 2.2 Local versus Global in low-dimensional holographic models We will study classes of models with global symmetry containing SL(2,R) (SL(N,R) models, HS models etc) and their possible reductions to (higher)Schwarzian theories (such as SYK-like models). We will investigate their local and global properties in the holographic context.
Deliverable **Internal Report**
Task 2.3 Higher dimensions and beyond gravity Developing string framework for duality: constructing worldsheet vertices via intersecting modular hamiltonians and relating worldsheet and boundary OPE coefficients, extracting properties and information for the OPE conformal blocks.
Deliverable **Internal Report**
Task 2.4 Deformed theories and holography Investigating holographic properties of dipole deformed theories. We conjecture that, after appropriate reduction, some of these theories are related to bi-local realizations of SYK-like models. Studiyng integrable structures of these models and their meaning on holography.
Deliverable **Internal Report**

Results, which will be used for evaluation of the intermediate or final report of the project
Publications in international journals with impact factor and in proceedings of international conferences

Work package 3: Symmetry aspects of the project
Start and end of the work package: from Month 01 to Month 36
Work package leader: Petkova Valentina Borissova
Participants in the implementation of the work package:
Dobrev Vladimir Krastev, Stoilova Nedialka Ilieva
Planned tasks:
Task 3.1 To compute the full brading matrix associated with the 6-dimensional sl(4) representation
Deliverable **Internal Report**
Task 3.2. To clarify the Lie (super)algebraic structures behind mixed systems of parafermions and parabosons with straight commutation, straight anticommutation and relative paraboson relations and construct the corresponding Fock type representations.
Deliverable **Internal Report**
Task 3.3 To reconstruct elements of the bulk theory, especially using symmetry group-theoretical methods.
Deliverable **Internal Report**

Results, which will be used for evaluation of the intermediate or final report of the project
Publications in international journals with impact factor and in proceedings of international conferences.

Financial plan for phase 1

Type of expenses / organization	*AO[1]*	*PO1[2]*	*PO2*	*Total*
Direct eligible costs				
1. Personnel costs including: *Remuneration of young scientists for doctoral work, post-doctorant or researchers recruited from a project for a main employment contract* *Remuneration of the project team (up to 30% of the direct eligible costs)*	8 550	2 450		11 000
2. Travel costs up to 40% of the direct eligible costs	17 100	4 900		22 000
3. Costs for material and immaterial assets, including equipment (up to 20% of eligible direct costs)	8 550	2 450		11 000
4. Costs for external services, directly connected with the implementation of the project (up to 20% of eligible direct costs)				
5. Costs for materials, consumables and other eligible costs, directly connected with the implementation of the project (up to 45% of eligible direct costs)	8 700	2 500		11 200
Indirect eligible costs				
6. Costs for administrative service of the project by the applying organization and partner organizations (up to 7% of the total cost of the project)	4 200			4 200
7. Costs for financial audit of the project (up to 1% of the total cost of the project)	600			600
Total	*47 700*	*12 300*		*60 000*

Coordinator of the research team:

(Emil Nissimov)

[1] Appling organization
[2] Partner organization

Financial plan for phase 2

Type of expenses / organization	*AO*	*PO1*	*PO2*[2]	*Total*
Direct eligible costs				
1. Personnel costs including: *Remuneration of young scientists for doctoral work, post-doctorant or researchers recruited from a project for a main employment contract* *Remuneration of the project team (up to 30% of the direct eligible costs)*	8 550	2 450		11 000
2. Travel costs up to 40% of the direct eligible costs	17 100	4 900		22 000
3. Costs for material and immaterial assets, including equipment (up to 20% of eligible direct costs)	8 550	2 450		11 000
4. Costs for external services, directly connected with the implementation of the project (up to 20% of eligible direct costs)				
5. Costs for materials, consumables and other eligible costs, directly connected with the implementation of the project (up to 45% of eligible direct costs)	8 700	2 500		11 200
Indirect eligible costs				
6. Costs for administrative service of the project by the applying organization and partner organizations (up to 7% of the total cost of the project)	4 200			4 200
7. Costs for financial audit of the project (up to 1% of the total cost of the project)	600			600
Total	*47 700*	*12 300*		*60 000*

Coordinator of the research team:

(Emil Nissimov)

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
NISSIMOV Emil Rafaelov **Corresponding member of Bulg. Academy of Sciences, professor, Doctor of Sciences (Dr.Habil.)**
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences (INRNE-BAS) Laboratory "Theory of Elementary Particles", head
Education
(1) MSc in theoretical physics – Sofia University, Faculty of Physics (Bulgaria), 1973 (2) PhD in theoretical and mathematical physics – St. Peterburg University and Steklov Mathematical Institute, St. Peterburg Branch (Russia), 1978
Academic positions in the last five years
Professor, head of Laboratory – INRNE-BAS, since 2008 Corresponding member of BAS, since 2014
Main research area and subareas
Generalized gravity and nonlinear gauge theories, generalized string and p-brane models (strings/branes with dynamical tension, lightlike branes) - with applications in elementary particle physics, black hole and wormhole physics, and cosmology; Completely integrable models; Covariant quantization of strings with manifest space-time supersymmetry; Covariant quantization of constrained Hamiltonian systems
Additional research areas and subareas
Group-theoretical approach to conformal field theories based on the method of group coadjoint orbits; Stochastic quantization ; Non-perturbative aspects of gauge theories - renormalization of non-renormalizable theories, anomalies in odd dimensions, dynamical mass generation, dynamical generation of gauge bosons and Chern-Simmons terms, 1/N expansion, dynamical symmetry breaking; Field-theoretic approach in the theory of phase transitions and critical behaviour
Specializations abroad and international collaborations
International Center for Theoretical Physics, Trieste (Italy) – 1980,1984, 1986,1987 Service de Physique Theorique, C.E.N. Saclay (France) - 1983 C.E.R.N. Geneva (Switzerland) – 1985-1986, 1989, 1992 Russian Academy of Sciences – Steklov Mathematical and Lebedev Physics Institutes, Moscow (Russia) – 1981,1985,1987 Joint Institute for Nuclear Reseach, Dubna (Russia) - 1981/2/3/4/5/7/8 Weizmann Institute of Science, Rehovot (Israel) – 1987,1988; 1989-1990 (visiting professor) Hebrew University, Jerusalem (Israel) – 1991 (visiting professor) University of Freiburg, Germany – DAAD Fellow – 1993,1995 University of Illinois, Chicago (USA) – 1995,1997; 1997-2000 (U.S. NSF grant) University of Patras, Patras (Greece) - NATO CLG fellow - 2003 Ben-Gurion University of the Negev, Beer-Sheva (Israel) – 1991-1999 (visiting professor) Ben-Gurion University of the Negev, Beer-Sheva (Israel) – 2002-2019 (exchange agreements with Bulg. Acad. Sci.)
Scientific awards and membership in scientific societies
Bulgarian National Prize for Young Scientists (1984) Israel Ministry of Science - "Shapiro" Fellowship (1991-1994) Israel Ministry of Immigrant Absorption – "Giladi" Fellowship (1996-1999) Member of Bulgarian Union of Physicists

Name, used in publications in foreign language: ***Emil Nissimov***
H index (according to Scopus or Web of Science)*: 18* **Complete H index: 20 (http://theo.inrne.bas.bg/~nissimov/CV-Publ/H-factor_emil_[EN].pdf)**
Internet address with list of scientific publications (ResearcherID, Research gate, etc.)*:* **http://theo.inrne.bas.bg/~nissimov/papers_emil-list.htm**
Total number of scientific publications*: 138*
From them with impact factor or impact rang*: 83*
Number of citations of the scientific publications*: 1302* **http://theo.inrne.bas.bg/~nissimov/CV-Publ/Ref-emil_[EN].pdf**
Number of scientific publications in the last five years: 23
From them with impact factor or impact rang*: 12*
Number of citations of the scientific publications in the last five years*: 101*

Selected scientific publications in the field of the research project
1. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Stoilov, "*Einstein-Rosen 'Bridge' Revisited and Lightlike Thin-Shell Wormholes*", Bulgarian Journal of Physics 44 (2017) 85-98 **2. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Quintessential Inflation, Unified Dark Energy and Dark Matter, and Higgs Mechanism*"**, Bulgarian Journal of Physics 44 (2017) 15-30 **3. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Gravity-Assisted Emergent Higgs Mechanism in the Post-Inflationary Epoch*"**, International Journal of Modern Physics D25 (2016) 1644008, honorable mention in ***2016 Gravity Research Foundation Competition for Essays on Gravitation*** **4. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Stoilov, "*Kruskal-Penrose Formalism for Lightlike Thin-Shell Wormholes*"**, Springer Proceedings in Mathematics and Statistics, vol. 191 (2016) 245-259, 15 p., ed. V. Dobrev, Springer **5. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Metric-Independent Spacetime Volume-Forms and Dark Energy/Dark Matter Unification*"**, Springer Proceedings in Mathematics and Statistics, vol. 191 (2016) 261-273, 13 p., V. Dobrev, Springer **6. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Unified Dark Energy and Dust Dark Matter Dual to Quadratic Purely Kinetic K-Essence*"**, European Physics Journal C76:90 (2016) **7. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Cosmology via Metric-Independent Volume-Form Dynamics*"**, arXiv:1509.01512 [gr-qc], Proceedings of Karl Schwarzschild Meeting 2015 **8. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Dark Energy and Dark Matter From Hidden Symmetry of Gravity Model with a Non-Riemannian Volume Form*"**, European Physics Journal C75 (2015) 472-479 **9. E.I. Guendelman, R. Herrera, P. Labrana, E. Nissimov and S. Pacheva, "*Stable Emergent Universe - A Creation without Big-Bang*"**, Astronomische Nachrichten 336 (2015) 810-814 **10. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Metric-Independent Volume-Forms in Gravity and Cosmology*"**, Bulgarian Journal of Physics 42 (2015) 14-27, **11. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Vacuum Structure and Gravitational Bags Produced by Metric-Independent Spacetime Volume-Form Dynamics*"**, International Journal of Modern Physics A30 (2015) 1550133 **12. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Vasihoun, "*A New Venue of Spontaneous Supersymmetry Breaking in Supergravity*"**, in "Eight Mathematical Physics Meeting", pp. 105-115, B. Dragovic and I. Salom (eds.), Belgrade Inst. Phys. Press (2015)

13. E.I. Guendelman, R. Herrera, P. Labrana, E. Nissimov and S. Pacheva, "*Emergent Cosmology, Inflation and Dark Energy*", General Relativity and Gravitation 47 (2015) art.10
14. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Unification of Inflation and Dark Energy from Spontaneous Breaking of Scale Invariance*", in "Eight Mathematical Physics Meeting", pp. 93-103, B. Dragovic and I. Salom (eds.), Belgrade Inst. Phys. Press (2015)
15. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Vasihoun, "*A New Mechanism of Dynamical Spontaneous Breaking of Supersymmetry*", Bulgarian Journal of Physics 41 (2014) 123-129
16. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*f(R)-Gravity: "Einstein Frame" Lagrangian Formulation, Non-Standard Black Holes and QCD-like Confinement/Deconfinement*", in Springer Proceedings in Mathematics and Statistics, Vol. 111, ed. V. Dobrev (Springer, Tokyo, Heidelberg) 2015
17. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Dynamical Couplings and Charge Confinement/Deconfinement from Gravity Coupled to Nonlinear Gauge Fields*", Bulgarian Journal of Physics 40 (2013) 127-133
18. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Membranes in Black Hole and Wormhole Physics, and Cosmology*", Bulgarian Journal of Physics 40 (2013) 134-140
19. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Vasihoun, "*Dynamical Volume Element in Scale-Invariant and Supergravity Theories*", Bulgarian Journal of Physics 40 (2013)
20. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Charge-Confining Gravitational Electrovacuum Shock Wave*", Modern Physics Letters A29 (2014) 1450020
21. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Gravity, Nonlinear Gauge Fields and Charge Confinement/Deconfinement*", in "Seventh Mathematical Physics Meeting", pp.197-213, B. Dragovic and Z. Rakic (eds.), Belgrade Inst. Phys. Press (2013)
22. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Dynamical Couplings, Dynamical Vacuum Energy and Confinement/Deconfinement from R^2-Gravity*", Physics Letters B718 (2013) 1099-1104
23. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Braneworlds in Anti-de Sitter Bulk Space-Times*", Springer Proceedings in Mathematics and Statistics 36 (2013) 215-230, ed. V. Dobrev, Springer
24. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Hiding and Confining Charges via "Tube-like" Wormholes*", International Journal of Modern Physics A26 (2011) 5211-5239
25. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Hiding Charge in a Wormhole*", The Open Nuclear and Particle Physics Journal 4 (2011) 27-34
26. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Asymptotically de Sitter and anti-de Sitter Black Holes with Confining Electric Potential*", Physics Letters B704 (2011) 230-233 ; erratum B705 (2011) 545
27. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Space-Time Compactification, Non-Singular Black Holes, Wormholes and Braneworlds via Lightlike Branes*", in "Sixth Mathematical Physics Meeting", pp. 217-234, B. Dragovic and Z. Rakic (eds.), Belgrade Inst. Phys. Press (2011)
28. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Space-Time Compactification/Decompactification Transitions Via Lightlike Branes*", General Relativity and Gravitation 43 (2011) 1487-1513
29. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Space-Time Compactification Induced By Lightlike Branes*", Invertis Journal of Science and Technology 3 (2010) 91-100

30. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Asymmetric Wormholes via Electrically Charged Lightlike Branes*", in "Lie Theory and Its Applications in Physics VIII", pp.60-75, V. Dobrev ed., AIP Conference Proceedings vol.1243, Melville, New York (2010)

31. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Non-Singular Black Holes from Gravity-Matter-Brane Lagrangians*", International Journal of Modern Physics A25 (2010) 1571-1596

32. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Einstein-Rosen "Bridge" Needs Lightlike Brane Source*", Physics Letters B681 (2009) 457-462

33. .I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Spherically Symmetric and Rotating Wormholes Produced by Lightlike Branes*", International Journal of Modern Physics A25 (2010) 1405-1428

34. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Branes as Natural Candidates for Wormhole Throats*", Forschritte der Physik 57 (2009) 566-572

35. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Variable-Tension Lightlike Brane as a Gravitational Source of Traversable Misner-Wheeler-Type Wormholes*", Physics Letters B673 (2009) 288-292

36. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike p-Branes: Mass "Inflation" and Lightlike Braneworlds*", in "Fifth Mathematical Physics Meeting", pp.171-183, B. Dragovic and Z. Rakic (eds.), Belgrade Inst. Phys. Press, 2009

37. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*"Mass Inflation" With Lightlike Branes*", Central European Journal of Physics 7 (2009) 668-676

38. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Braneworlds*", in "Lie Theory and Its Applications in Physics VII", pp.79-88, V. Dobrev and H. Doebner eds., Heron Press (2008)

39. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Generalized Gauge Field Approach To Lightlike Branes*", in "Fourth Summer School in Modern Mathematical Physics", pp.215-228, B. Dragovic and B. Sazdovic (eds.), Belgrade Inst. Phys. Press, 2007

40. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Weyl-Invariant Lightlike Branes and Soldering of Black Hole Space-Times*", Fortschritte der Physik 55 (2007) 579-584

E-mail address for registration in the database of the Bulgarian National Science Fund
nissimov@inrne.bas.bg
Participation in projects supported by BNSF in the last five years
Competition (type and year): Financing fundamental research in priority areas, 2014 **Number and date of the contract: DFNI T02/6 , 14.12.2014** **Title:** **New Paradigms for the Fundamental Structure of Matter** **Project coordinator:** **Corresponding member of BAS, Prof. Valentina Petkova** **Status of the project:** running – second term **Evaluation of the project implementation (for completed projects):**
Competition (type and year): **Number and date of the contract:** **Title:** **Project coordinator:** **Status of the project:** (running, with intermediate or final report under review, completed) **Evaluation of the project implementation (for completed projects):**

Participation in projects supported by other sources in the last five years
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2013** **Number or acronym of the project: COST Action MP1210** **Title: "*The String Theory Universe*" (2013-2017)** **Project coordinator:** Prof. Silvia Penati (University of Milano-Bicocca, Italy) **Status of the project:** final report under review, completed
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2014** **Number or acronym of the project: COST Action MP1405 "QSPACE"** **Title: "*The Quantum Structure of Spacetime*" (2015-2019)** **Project coordinator:** Prof. Richard Szabo (Co-Director, Maxwell Institute for Mathematical Sciences, Heriot-Watt , Edinburgh, United Kingdom) **Status of the project:** running
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2017** **Number or acronym of the project: COST Action CA16104 "GWniverse"** **Title: "*Gravitational waves, black holes and fundamental physics*" (2017-2021)** **Project coordinator:** Prof. Vitor Cardoso, Instituto Superior Tecnico CENTRA (Multidisciplinary Center for Astrophysics), Departamento de Fisica, Instituto Superior Tecnico, Lisboa, Portugal **Status of the project:** running

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
PETKOVA, Valentina Borissova **Corresponding member of Bulg. Academy of Sciences, professor, Doctor of Sciences (Dr. Habil.)**
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences (INRNE-BAS) Laboratory "Theory of Elementary Particles"
Education
(1) MSc in Atomic physics – Sofia University, Faculty of Physics (Bulgaria), 1971 (2) PhD in theoretical and mathematical physics - INRNE, 1976
Academic positions in the last five years
Professor Corresponding member of BAS, since 2012
Main research area and subareas
Quantum field theory. Conformal invariant theories in euclidean space of arbitrary dimenions: group-theoretical approach.Classification of the unitary representations of the superconformal algebra sl(2,2|N). Quantum groups and fusion rules in 2d confotmal field theories. Brading matrices and quantum 6j symbols. Minimal representations of the Virasoro algebra and realization of 2d local 4-point functions, corresponding to the field spectrum of ADE modular invariants. ADE structure constants and eigenvectors of Cartan matrices. Quantum hamiltonian (Drinfeld-Sokolov) reduction of WZW model: singular vectors, correlators. Fusion rules for admissible representations of Kac-Moody algebras with rational level. 2D conformal theories with boundaries. Defects and Ocneanu algebras. Noncritical strings (Liouville gravity) and tachion correlators. Correlators and brading matrices in conformal Toda theory.
Additional research areas and subareas
Lattice gauge models and the problem of quark confinement.
Specializations abroad and international collaborations
2nd Institute for Theoretical Physics, Хамбург, 11мес. 1978. Short visits (from 2 weeks to 1 month): ОИЯИ, Дубна, 1974 – 1982; INFN, 1983 – 2006, 2011, 2012, 2015; ICTP,Триест, 1997, 1998, 2000, 2002,2007; 2nd ITP, Hamburg, 1989; CERN, 1990, 1996, 2000, 2006; Univ. Karlsruhe, 1991; SISSA, Trieste, 1992; Univ. Paris – VI, 1992, 2006, 2009: ESI, Vienna 1996, 1999; King's College, London, 1998, 1999; IPhT Saclay, 1994, 1999, 2003-2009, 2010, 2015, 2016; Univ. Goettingen, 2009 (invited course of lectures, 42 hours).
Scientific awards and membership in scientific societies
Bulgarian National Prize for Young Scientists (1982)

Name, used in publications in foreign language: ***V.B. Petkova***
H индекс (според Scopus или Web of Science):): ***21*** **Complete H index: 27 (see Most cited publications related to the project below)**
Internet address with list of scientific publications (ResearcherID, Research gate, etc.): ***http://theo.inrne.bas.bg/~petkova/refs-vp.pdf***
Total number of scientific publications: ***79***
From them with impact factor or impact rang: *46 with IF, 3 with IR, 2 monographs*
Number of citations of the scientific publications: *2648* ***http://theo.inrne.bas.bg/~petkova/cit-vp.pdf***
Number of scientific publications in the last five years: ***5***
From them with impact factor or impact rang: ***3 with IF, 2 with IR***
Number of citations of the scientific publications in the last five years: *around* ***550***

Selected scientific publications in the field of the research project

Recent papers in the field of the research project:

I.K. Kostov and V.B. Petkova, Non-rational 2d quantum gravity: I. World sheet CFT, Nucl. Phys. B 770 [FS] (2007) 273-331, hep-th/0512346.

I.K. Kostov and V.B. Petkova, Non-rational 2d quantum gravity: II. Target space CFT, Nucl. Phys. B 769 [FS] (2007) 175-216, hep-th/0609020.

P. Furlan, V.B. Petkova and M. Stanishkov, Non-critical string pentagon equations and their solutions, J. Phys. A: Math. Theor. 42 (2009) 304016, arXiv:0805.0134 [hep-th].

V.B. Petkova, On the crossing relation in the presence of defects, JHEP 04 (2010) 061, arXiv: 0912.5535.

P. Bozhilov, P. Furlan, V.B. Petkova and M. Stanishkov, On the semiclassical 3-point function in AdS_3, Phys. Rev. D 86 (2012) 066005, arXiv:1204.1322.

P. Furlan and V.B. Petkova, On some 3-point functions in the W_4 CFT and related braiding matrix, (23 pages) JHEP 12 (2015) 079, arXiv:1504.07556.

P. Furlan and V.B. Petkova, W_4 Toda example as hidden Liouville CFT, Physics of Particles and Nuclei Letters Vol. 14, No. 2 (2017) 286 - 290, arxiv:1606.02535.

Most cited publications related to the project:

1.(Ref. 21.) V.K. Dobrev and V.B. Petkova, All positive energy unitary irreducible representations of the extended conformal supersymmetry, Phys. Lett. B162 (1985) 127-132.

citations: 274

2.(Ref. 43). R.E. Behrend, P.A. Pearce, V.B. Petkova and J.-B. Zuber, Boundary conditions in rational conformal field theories, Nucl. Phys. B579 [FS], (2000) 707-773, hep-th/9908036. citations: 242

3.(Ref. 11.) G. Mack and V.B. Petkova, Comparison of lattice gauge theories with gauge groups SU(2) and Z_2, Ann. Phys. 123 (1979) 442-467.

citations: 188

4.(Ref. 12.) G. Mack and V.B. Petkova, Sufficient condition for confinement of static quarks by a vortex condensation mechanism, Ann. Phys. 125 (1980) 117-134. citations: 161

5.(Ref. 45.) V.B. Petkova and J.-B. Zuber, Generalised twisted partition functions, Phys. Lett. B504 (2001) 157-164, hep-th/0012021.

citations: 131

6.(Ref. 10.) I.T. Todorov, M.C. Mintchev and V.B. Petkova, book, Conformal invariance in quantum field theory, SNS Pisa, (1978). citations: 127

7.(Ref. 8.) V.K. Dobrev, G. Mack, V.B. Petkova, S.G. Petrova and I.T. Todorov, Harmonic analysis on the n-dimensional Lorentz group and its application to conformal quantum field theory, monograph, Lecture Notes in

Physics, 63 (1977).

citations: 114

8.(Ref. 46.) V.B. Petkova and J.-B. Zuber, The many faces of Ocneanu cells, Nucl. Phys. B603 (2001) 449-496, hep-th/0101151.

citations: 103

9.(Ref. 28.) P. Furlan, A.Ch. Ganchev and V.B. Petkova, Quantum groups and fusion rules multiplicities, Nucl. Phys. B343 (1990) 205-227.

citations: 102

10.(Ref. 6.) V.K. Dobrev, V.B. Petkova, S.G. Petrova and I.T. Todorov, Dynamical derivation of vacuum operator product expansion in euclidean conformal quantum field theory, Phys. Rev. D13 (1976) 887-912,

citations: 98

11.(Ref. 20.) V.K. Dobrev and V.B. Petkova, Group-theoretical approach to extended conformal super-symmetry: function space realizations and invariant differential operators, Fortschr. Phys. 35 (1987) 537-572.

citations: 91

12.(Ref. 41.) R.E. Behrend, P.A. Pearce, V.B. Petkova and J.-B. Zuber, On the classification of bulk and boundary conformal field theories, Phys. Lett. B444 (1998) 163-166, hep-th/9809097.

citations: 75

13. (Ref. 31.) P. Furlan, A.Ch. Ganchev, R. Paunov and V.B. Petkova, Solutions of the Knizhnik - Zamolod-chikov equation with rational isospins and the reduction to the minimal models, Nucl. Phys. B394 (1993) 665-706, hep-th/9201080.

citations: 71

14. (Ref. 13.) G. Mack and V.B. Petkova, Z_2 - monopoles in the standard SU(2) lattice gauge theory model, Zeit. Phys. C12 (1982), 177-184.

citations: 71

15.(Ref. 27.) A.Ch. Ganchev and V.B. Petkova, $U_q(sl(2))$ invariant operators and minimal theories fusion matrices, Phys. Lett. B233 (1989) 374-382. citations: 69

16.(Ref. 32.) A.Ch. Ganchev and V.B. Petkova, Reduction of the Knizhnik - Zamolodchikov equation - a way of producing Virasoro singular vectors, Phys. Lett. B293 (1992) 56-66, hep-th/9207032.

citations: 47

17.(Ref. 30.) P. Furlan, A.Ch. Ganchev, R. Paunov and V.B. Petkova, Reduction of the rational spin sl(2,CI) WZNW conformal theory, Phys. Lett. B267 (1991) 63-70.

citations: 46

18.(Ref. 19.) V.K. Dobrev and V.B. Petkova, On the group-theoretical approach to extended conformal supersymmetry: classification of multiplets, Lett. Math. Phys. 9 (1985) 287-298.

citations: 46

19.(Ref. C15.) V.B. Petkova and J.-B. Zuber, Conformal Boundary Conditions and what they teach us, in Non-Perturbative QFT Methods and their Applications, Proceedings of the 24th Johns Hopkins Workshop, Bolyai College, Budapest, 19-21 August 2000, Z. Bajnok, P. Bantay, Z. Horvath and L. Palla eds., p. 1-35, (World Scientific, 2001), hep-th/0103007.

citations: 43

20.(Ref. 37.) V.B. Petkova and J.-B. Zuber, From CFT to graphs, Nucl. Phys. B463 (1996) 161-193, hep-th/9510175.

citations: 38

21.(Ref. 38.) P. Furlan, A.Ch. Ganchev and V.B. Petkova, $A_{(1)}$ admissible representations - fusion transformations and local correlators, Nucl. Phys. B491 , no. 3 [PM] (1997) 635-658, hep-th/9608018.

citations: 37

22.(Ref. C16.) V.B. Petkova and J.-B. Zuber, “Conformal field theories, graphs and quantum algebras”,

invited publication in MATHPHYS ODYSSEY 2001 –Integrable Models and Beyond, eds. M. Kashiwara and T. Miwa, p. 415-436 (Volume dedicated to Barry M. McCoy on the occasion of his 60th birthday), (Progress in Math., Birkhauser, 2002), hep-th/0108236.

citations: 29

23.(Ref. 17.) P. Furlan, V.B. Petkova, G.M. Sotkov and I.T. Todorov, Conformal quantum electrodynamics and nondecomposable representations, Riv. del Nuovo Cim. 8 No 3, (1985) 1-50. citations: 28

24.(Ref. 26). P. Furlan, A.Ch. Ganchev and V.B. Petkova, Fusion matrices and $c < 1$ (quasi) local conformal theories, Int. J. Mod. Phys. A5 (1990) 2721-2735.

citations: 28

25.(Ref. 36.) V.B. Petkova and J.-B. Zuber, On structure constants of sl(2) theories, Nucl. Phys. B438 (1995) 347-372, hep-th/9410209.

citations: 28

26.(Ref. C17.) V.B. Petkova and J.-B. Zuber, Boundary conditions in charge conjugate sl(N) WZW theories, hep-th/0201239.

citations: 28

27.(Ref. 48). I.K. Kostov and V.B. Petkova, "Bulk correlation functions in 2D quantum gravity", Theor. Math. Phys. 146 (1) (2006) 108-118, hep-th/0505078.

citations: 27

E-mail address for registration in the database of the Bulgarian National Science Fund
petkova@inrne.bas.bg
Participation in projects supported by BNSF in the last five years
Competition (type and year): Financing fundamental research in priority areas, 2014 **Number and date of the contract: DFNI T02/6 , 12.12.2014** **Title: New Paradigms for the Fundamental Structure of Matter** **Project coordinator: Corresponding member of BAS, Prof. Valentina Petkova** **Status of the project:** running – second term **Evaluation of the project implementation (for completed projects):**

Participation in projects supported by other sources in the last five years
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2013** **Number or acronym of the project: COST Action MP1210** **Title: "*The String Theory Universe*" (2013-2017)** **Project coordinator:** Prof. Silvia Penati (University of Milano-Bicocca, Italy) **Status of the project:** final report under review, completed
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2014** **Number or acronym of the project: COST Action MP1405 "QSPACE"** **Title: "*The Quantum Structure of Spacetime*" (2015-2019)** **Project coordinator:** Prof. Richard Szabo (Co-Director, Maxwell Institute for Mathematical Sciences, Heriot-Watt , Edinburgh, United Kingdom) **Status of the project:** running

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
DOBREV Vladimir Krastev **Professor, Dr. Habil. (1995, Germany), Doctor of Sciences (1997, Bulgaria)**
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences (INRNE-BAS) Laboratory "Theory of Elementary Particles"
Education
(1) MSc in theoretical physics – Moscow State University, Faculty of Physics, 1971 (2) PhD in theoretical and mathematical physics – INRNE-BAS, 1978
Academic positions in the last five years
Professor – INRNE-BAS, since 2002
Main research area and subareas
Group-theoretical approach to quantum field theory, especially to conformal field theories; construction and study of representations of various objects: Lie groups and algebras, supergroups and superalgebras, quantum groups, infinite-dimensional (super-)algebras
Additional research areas and subareas
Grassmannians, homogeneous spaces and generalizations, Clifford algebras, multilinear algebras, Grassmann algebras, polynomial algebras, Jordan algebras
Specializations abroad and international collaborations
International Center for Theoretical Physics, Trieste (Italy) – many visits almost every year starting from 1974 with duration from 1 month to 10 months; Technical University of Clausthal (Germany) – many visits starting from 1984 as Humboldt Fellow (14 months), longer visits as assistant professor 1993-1995, Professor 1998-2000. Northumbria University in Newcastle (UK): research positions: 2000-2001 (17 months), 2003-2004 (12 months); Joint Institute for Nuclear Reseach, Dubna (Russia) - many visits almost every year starting from 1973 usually for 14 days; University of Goettingen (Germany) – Humboldt Fellow – 1990-1991 (10 months); C.E.R.N. Geneva (Switzerland) – 2000 & 2001 (1 month), 2012 (4 months); Penn State University (USA) – many visits between 1990-2009;
Scientific awards and membership in scientific societies
Bulgarian National Prize for Young Scientists (1982); Raccah Award of the International Science Centre in Erice, Italy (1982); Member of Bulgarian Union of Physicists; Member of the International Union of Mathematical Physicists.

Name, used in publications in foreign language: ***Vladimir Dobrev, V.K. Dobrev***
H index (according to Scopus or Web of Science)*: 19*
Internet address with list of scientific publications*:* **http://theo.inrne.bas.bg/~dobrev/personal/list-vkd.pdf**
Total number of scientific publications*: 212*
From them with impact factor or impact rang*: 4 monographs, 103 with IF, 10 with IR*
Number of citations of the scientific publications*: 1718* **http://theo.inrne.bas.bg/~dobrev/personal/cit-vd.pdf**
Number of scientific publications in the last five years: 30
From them with impact factor or impact rang*: 2 monographs, 9 with IF, 10 with IR*
Number of citations of the scientific publications in the last five years*: 400*

Internet address with list of organized conferences*:*
http://theo.inrne.bas.bg/~dobrev/personal/VD-ORG.pdf

Selected scientific publications in the field of the research project
Recent scientific publications in the field of the research project:

Vladimir K. Dobrev, *Invariant Differential Operators, Volume 1: Noncompact Semisimple Lie Algebras and Groups*, De Gruyter Studies in Mathematical Physics vol. **35** (De Gruyter, Berlin, Boston, 2016, ISBN 978-3-11-042764-6), 409 pages.

Vladimir K. Dobrev, *Invariant Differential Operators, Volume 2: Quantum Groups*, De Gruyter Studies in Mathematical Physics vol. **39** (De Gruyter, Berlin, Boston, 2017, ISBN 978-3-11-043543-6 (h.c.), 978-3-11-042770-7), 395 pages.

V.K. Dobrev, Invariant Differential Operators for Non-Compact Lie Algebras Parabolically Related to Conformal Lie Algebras, J. High Energy Phys. 02 (2013) 015

V.K. Dobrev, Group-Theoretical Classification of BPS and Possibly Protected States in D=4 Conformal Supersymmetry, Nucl. Phys. **B854** (3) (2012) 878-893, arXiv:1012.3685 [hep-th].

V.K. Dobrev, Explicit Character Formulae for Positive Energy UIRs of D=4 Conformal Supersymmetry, J. Phys. **A46** (2013) 405202.

V.K. Dobrev, Non-Relativistic Holography (A Group-Theoretical Perspective), Invited review, Int. J. Mod. Phys. **A29** (3\&4) (2014) 1430001.

N. Aizawa and V.K. Dobrev, ``Intertwining Operator Realization of anti de Sitter Holography," Rept. Math. Phys. **75** (2015) 179-197.

V.K. Dobrev, Invariant Differential Operators for Non-Compact Lie Groups: the Main SU(n,n) Cases, Physics of Atomic Nuclei, **76**, No 8, 983-990 (2013).

V.K. Dobrev, "Classification of Conformal Representations Induced from the Maximal Cuspidal Parabolic", Physics of Atomic Nuclei, **80**, No. 2 (2017) 347–352.

V.K. Dobrev, Group-Theoretical Classification of BPS States in D=4 Conformal Supersymmetry: the Case of (1/N)-BPS, Phys. Part. Nucl. **43** (5) (2012) 616--620.

V.K. Dobrev and I. Salom, "Positive Energy Unitary Irreducible Representations of the Superalgebra osp(1|8,R)", Publications de l'Institut Mathematique, Belgrade, to appear (2017), (IF 0.195), arXiv:1607.03008, DOI: 10.2298/PIM161217003D.

V.K. Dobrev, Invariant Differential Operators for Non-Compact Lie Groups: the Reduced SU(3,3) Multiplets, Phys. Part. Nucl. Lett. **11** (7) 864–871 (2014).
V.K. Dobrev, "Invariant Differential Operators for Non-Compact Lie Groups: Summary of SU(4,4) Multiplets", Phys. Part. Nucl. Lett. **14**, (2) (2017) 277–285.
V.K. Dobrev, Invariant Differential Operators for Non-Compact Lie Groups: the Sp(n,R) Case, in: Proceedings of the IX International Workshop Lie Theory and Its Applications in Physics, (Varna, Bulgaria, June 2011), "Springer Proceedings in Mathematics and Statistics", Vol. **36** (ISBN 978-4-431-54269-8), (Springer, Tokyo-Heidelberg, 2013) pp. 311-335.
N. Aizawa and V.K. Dobrev, Schrödinger Algebra and Non-Relativistic Holography, Invited talk (by V.K.D.) at the VII International Symposium "Quantum Theory and Symmetries" (Prague, 7-13.8.2011); J. Phys.: Conf. Ser. **343** (2012) 012007.
V.K. Dobrev, Invariant Differential Operators for Non-Compact Lie Groups: Euclidean Jordan Groups or Conformal Lie Groups, Plenary talk at the 20th Colloquium `Integrable Systems and Quantum Symmetries', Prague, 17-23.6.2012; Proceedings, eds. C. Burdik et al.,
J. Phys.: Conf. Ser. **411** (2013) 012012.
V.K. Dobrev, Classification of Invariant Differential Operators for Non-Compact Lie Algebras via Parabolic Relations, J. Phys.: Conf. Ser. **512** (2014) 012020.
V.K. Dobrev and I. Salom, Positive Energy Unitary Irreducible Representations of the Superalgebras osp(1|2n,R) and Character Formulae for $n=3$, Plenary talk by V.K.D. at the 24-th International Conference on Integrable Systems and Quantum Symmetries, (Prague, June 2016),
J. Phys.: Conf. Ser. **804** (2017) 012015.
V.K. Dobrev, Special Reduced Multiplets and Minimal Representations for SO(p,q), in: Proceedings of the X International Workshop *Lie Theory and Its Applications in Physics*, (Varna, Bulgaria, June 2013), "Springer Proceedings in Mathematics and Statistics", Vol. **111** (ISBN 978-4431552840) (Springer,Tokyo-Heidelberg, 2014) pp. 475--504.
V.K. Dobrev, Multiplet classification for SU(n,n), J. Phys.: Conf. Ser. **563** (2014) 012008, Review paper based on Plenary talk at the International Conference on Integrable Systems and Quantum Symmetries, Prague, June 2014.
V.K. Dobrev, Invariant Differential Operators for Non-Compact Lie Groups: the SO*(12) Case, Invited talk at the XXX International Colloquium on Group Theoretical Methods in Physics (Ghent, July 2014), J. Phys.: Conf. Ser. **597** (2015) 012032.
V.K. Dobrev and P. Moylan, "Anti de Sitter holography via Sekiguchi decomposition in: Proceedings of the XI International *Workshop Lie Theory and Its Applicationsin Physics*, (Varna, Bulgaria, June 2015), "Springer Proceedings in Mathematics and Statistics" Vol. **191** (Springer, Tokyo-Heidelberg, 2016, ISSN: 2194-1009, ISBN: 978-981-10-2635-5 (Print) pp. 413-421.

Most cited publications related to the project:

V.K. Dobrev and V.B. Petkova, All positive energy unitary irreducible representations of extended conformal supersymmetry, Phys. Lett. **B162** (1985) 127-132. *274 citations*
V.K. Dobrev, G. Mack, V.B. Petkova, S.G. Petrova and I.T. Todorov, *Harmonic Analysis on the n - Dimensional Lorentz Group and Its Applications to Conformal Quantum Field Theory*, Lecture Notes in Physics, No 63, 280 pages (Springer Verlag, Berlin-Heidelberg-New York, 1977). *114 citations.*

V.K. Dobrev, Characters of the unitarizable highest weight modules over the N=2 superconformal algebras, Phys. Lett. **B186** (1987) 43-51. *104 citations*

V.K. Dobrev, V.B. Petkova, S.G. Petrova and I.T. Todorov, Dynamical derivation of vacuum operator product expansion in Euclidean conformal quantum field theory, Phys. Rev. **D13** (1976) 887-912. *98 citations*

V.K. Dobrev and V.B. Petkova, On the group-theoretical approach to extended conformal supersymmetry : function space realizations and invariant differential operators, Fortschr. d. Phys. **35** (1987) 537-572. *91 citations*

V.K. Dobrev, Intertwining operator realization of the AdS/CFT correspondence, Nucl. Phys. **B553** (1999) 559-582. *76 citations*

V.K. Dobrev, Canonical q-Deformations of Noncompact Lie (Super-) Algebras, J. Phys. **A26** (1993) 1317-1334. *54 citations*

V.K. Dobrev and V.B. Petkova, On the group-theoretical approach to extended conformal supersymmetry : classification of multiplets, Lett. Math. Phys. **9** (1985) 287-298. *46 citations*

V.K. Dobrev, Duality for the matrix quantum group GL_{p,q}(2,C), J. Math. Phys. **33** (1992) 3419-3430. *45 citations*

V.K. Dobrev, H.-D. Doebner and C. Mrugalla, Lowest weight representations of the Schrödinger algebra and generalized heat equations, Rept. Math. Phys. **39** (1997) 201-218. *39 citations*

N.S. Craigie, V.K. Dobrev and I.T. Todorov, Conformallycovariant composite operators in quantum chromodynamics, Ann. Phys. (N.Y.) **159** (1985) 411-444. *35 citations*

V.K. Dobrev, Canonical construction of intertwining differential operators associated with representations of real semisimple Lie groups, Rept. Math. Phys. **25** (1988) 159-181. *24 citations*

V.K. Dobrev and P. Parashar, Duality for multiparametric quantum GL(n), J. Phys. **A26** (1993) 6991-7002 & Addendum, 32 (1999) 443-444. *24 citations*

V.K. Dobrev, New q - Minkowski space-time and q - Maxwell equations hierarchy from q - conformal invariance, Phys. Lett. **B341** (1994) 133-138 & B346 (1995) 427. *23 citations*

V.K. Dobrev, q - difference intertwining operators for U_q(sl(n)): general setting and the case n=3, J. Phys. **A27** (1994) 4841-4857 & 6633-6634. *22 citations*

V.K. Dobrev, Positive energy unitary irreduciblerepresentations of D=6 conformal supersymmetry, J. Phys. **A35** (2002) 7079-7100. *21 citations*

N. Chair, V.K. Dobrev and H. Kanno, SO(2,C) invariant ring structure of BRST cohomology and singular vectors in 2D gravity with c < 1 matter, Phys. Lett. **B283** (1992) 194-202. *20 citations*

V.K. Dobrev, Representations of the Jordanian quantum algebra U_h(sl(2)), Proceedings of the 10th International Conference`Problems of Quantum Field Theory', (Alushta, Crimea, Ukraine, 13-18.5.1996), eds. D. Shirkov, D. Kazakov and A. Vladimirov,(Publishing Department of JINR, Dubna, 1996) pp. 104-110. *19 citations*

E-mail address for registration in the database of the Bulgarian National Science Fund
dobrev@inrne.bas.bg, vkdobrev@yahoo.com
Participation in projects supported by BNSF in the last five years
Competition (type and year): Financing fundamental research in priority areas, 2014 **Number and date of the contract: DFNI T02/6 , 14.12.2014** **Title: New Paradigms for the Fundamental Structure of Matter** **Project coordinator: Corresponding member of BAS, Prof. Valentina Petkova** **Status of the project:** running – second term **Evaluation of the project implementation ("excellent" for 1st term)**
Competition (type and year): Bulgarian-French project "Rila" **Number and date of the contract: D-Rila 01/6, 2013** **Title: Non-Local Symmetries: Mathematical Background and Physical Applications** **Project coordinator: Prof. Vladimir Dobrev** **Status of the project:** running – second term **Evaluation of the project implementation ("excellent" for 1st term)**

Participation in projects supported by other sources in the last five years
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2013** **Number or acronym of the project: COST Action MP1210** **Title: "*The String Theory Universe*" (2013-2017)** **Project coordinator:** Prof. Silvia Penati (University of Milano-Bicocca, Italy) **Status of the project:** final report under review, completed
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2014** **Number or acronym of the project: COST Action MP1405 "QSPACE"** **Title: "*The Quantum Structure of Spacetime*" (2015-2019)** **Project coordinator:** Prof. Richard Szabo (Co-Director, Maxwell Institute for Mathematical Sciences, Heriot-Watt , Edinburgh, United Kingdom) **Status of the project:** running
Financing organization: European Commission - COST Type of the competition and year: COST Action, 2016 Number or acronym of the project: COST Action CA 15213 "THOR" Title: Theory of hot matter and relativistic heavy-ion collisions(2016-2020) Project coordinator: Professor Marcus Bleicher, (Goethe University Frankfurt, Frankfurt Institute for Advanced Studies, Frankfurt, Germany) Status of the project: running

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
PACHEVA Svetlana Jordanova **Professor, Doctor of Sciences (Dr. Habil.)**
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences (INRNE-BAS) Laboratory "Theory of Elementary Particles"
Education
(1) MSc in theoretical physics – Sofia University, Faculty of Physics (Bulgaria), 1973 (2) PhD in theoretical and mathematical physics – Steklov Mathematical Institute, St. Peterburg Branch (Russia), 1979
Academic positions in the last five years
Professor – INRNE-BAS, since 2008
Main research area and subareas
Generalized gravity and nonlinear gauge theories, generalized string and p-brane models (strings/branes with dynamical tension, lightlike branes) - with applications in elementary particle physics, black hole and wormhole physics, and cosmology; Completely integrable models; Covariant quantization of strings with manifest space-time supersymmetry; Covariant quantization of constrained Hamiltonian systems
Additional research areas and subareas
Group-theoretical approach to conformal field theories based on the method of group coadjoint orbits; Stochastic quantization ; Non-perturbative aspects of gauge theories - renormalization of non-renormalizable theories, anomalies in odd dimensions, dynamical mass generation, dynamical generation of gauge bosons and Chern-Simmons terms, 1/N expansion, dynamical symmetry breaking; Field-theoretic approach in the theory of phase transitions and critical behaviour
Specializations abroad and international collaborations
International Center for Theoretical Physics, Trieste (Italy) – 1984,1985,1986,1987 C.E.R.N. Geneva (Switzerland) – 1985-1986, 1992 Russian Academy of Sciences – Steklov Mathematical and Lebedev Physics Institutes, Moscow (Russia) – 1985,1989 Joint Institute for Nuclear Reseach, Dubna (Russia) - 1981/2/3/4/5/7/8 Weizmann Institute of Science, Rehovot (Israel) – 1987,1988; 1989-1990 (visiting professor) Hebrew University, Jerusalem (Israel) – 1991 (visiting professor) University of Freiburg, Germany – DAAD Fellow – 1993 University of Illinois, Chicago (USA) – 1997-2000 (U.S. NSF grant) University of Patras, Patras (Greece) - NATO CLG fellow - 2003 Ben-Gurion University of the Negev, Beer-Sheva (Israel) – 1991-1999 (visiting professor) Ben-Gurion University of the Negev, Beer-Sheva (Israel) – 2002-2019 (exchange agreements with Bulg. Acad. Sci.)
Scientific awards and membership in scientific societies
Bulgarian National Prize for Young Scientists (1984) Israel Ministry of Science - "Shapiro" Fellowship (1991-1994) Israel Ministry of Immigrant Absorption – "Giladi" Fellowship (1996-1999) Member of Bulgarian Union of Physicists

Name, used in publications in foreign language: ***Svetlana Pacheva***
H index (according to Scopus or Web of Science)*: 18* **Complete H index: 20 (http://theo.inrne.bas.bg/~svetlana/CV-Publ/H-factor_svet_[EN].pdf)**
Internet address with list of scientific publications (ResearcherID, Research gate, etc.)*:* **http://theo.inrne.bas.bg/~svetlana/papers_svet-list.htm**
Total number of scientific publications*: 131*
From them with impact factor or impact rang*: 78*
Number of citations of the scientific publications*: 1194* **http://theo.inrne.bas.bg/~svetlana/CV-Publ/Ref-svet_[EN].pdf**
Number of scientific publications in the last five years: 23
From them with impact factor or impact rang*: 12*
Number of citations of the scientific publications in the last five years*: 100*

Selected scientific publications in the field of the research project
1. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Stoilov, "*Einstein-Rosen 'Bridge' Revisited and Lightlike Thin-Shell Wormholes*", Bulgarian Journal of Physics 44 (2017) 85-98 **2. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Quintessential Inflation, Unified Dark Energy and Dark Matter, and Higgs Mechanism*"**, Bulgarian Journal of Physics 44 (2017) 15-30 **3. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Gravity-Assisted Emergent Higgs Mechanism in the Post-Inflationary Epoch*"**, International Journal of Modern Physics D25 (2016) 1644008, honorable mention in ***2016 Gravity Research Foundation Competition for Essays on Gravitation*** **4. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Stoilov, "*Kruskal-Penrose Formalism for Lightlike Thin-Shell Wormholes*"**, Springer Proceedings in Mathematics and Statistics, vol. 191 (2016) 245-259, 15 p., ed. V. Dobrev, Springer **5. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Metric-Independent Spacetime Volume-Forms and Dark Energy/Dark Matter Unification*"**, Springer Proceedings in Mathematics and Statistics, vol. 191 (2016) 261-273, 13 p., V. Dobrev, Springer **6. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Unified Dark Energy and Dust Dark Matter Dual to Quadratic Purely Kinetic K-Essence*"**, European Physics Journal C76:90 (2016) **7. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Cosmology via Metric-Independent Volume-Form Dynamics*"**, arXiv:1509.01512 [gr-qc], Proceedings of Karl Schwarzschild Meeting 2015 **8. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Dark Energy and Dark Matter From Hidden Symmetry of Gravity Model with a Non-Riemannian Volume Form*"**, European Physics Journal C75 (2015) 472-479 **9. E.I. Guendelman, R. Herrera, P. Labrana, E. Nissimov and S. Pacheva, "*Stable Emergent Universe - A Creation without Big-Bang*"**, Astronomische Nachrichten 336 (2015) 810-814 **10. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Metric-Independent Volume-Forms in Gravity and Cosmology*"**, Bulgarian Journal of Physics 42 (2015) 14-27, **11. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Vacuum Structure and Gravitational Bags Produced by Metric-Independent Spacetime Volume-Form Dynamics*"**, International Journal of Modern Physics A30 (2015) 1550133 **12. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Vasihoun, "*A New Venue of Spontaneous Supersymmetry Breaking in Supergravity*"**, in "Eight Mathematical Physics Meeting", pp. 105-115, B. Dragovic and I. Salom (eds.), Belgrade Inst. Phys. Press (2015)

13. E.I. Guendelman, R. Herrera, P. Labrana, E. Nissimov and S. Pacheva, "*Emergent Cosmology, Inflation and Dark Energy*", General Relativity and Gravitation 47 (2015) art.10
14. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Unification of Inflation and Dark Energy from Spontaneous Breaking of Scale Invariance*", in "Eight Mathematical Physics Meeting", pp. 93-103, B. Dragovic and I. Salom (eds.), Belgrade Inst. Phys. Press (2015)
15. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Vasihoun, "*A New Mechanism of Dynamical Spontaneous Breaking of Supersymmetry*", Bulgarian Journal of Physics 41 (2014) 123-129
16. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*f(R)-Gravity: "Einstein Frame" Lagrangian Formulation, Non-Standard Black Holes and QCD-like Confinement/Deconfinement*", in Springer Proceedings in Mathematics and Statistics, Vol. 111, ed. V. Dobrev (Springer, Tokyo, Heidelberg) 2015
17. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Dynamical Couplings and Charge Confinement/Deconfinement from Gravity Coupled to Nonlinear Gauge Fields*", Bulgarian Journal of Physics 40 (2013) 127-133
18. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Membranes in Black Hole and Wormhole Physics, and Cosmology*", Bulgarian Journal of Physics 40 (2013) 134-140
19. E.I. Guendelman, E. Nissimov, S. Pacheva and M. Vasihoun, "*Dynamical Volume Element in Scale-Invariant and Supergravity Theories*", Bulgarian Journal of Physics 40 (2013)
20. E.I. Guendelman, E. Nissimov and S. Pacheva, "*Charge-Confining Gravitational Electrovacuum Shock Wave*", Modern Physics Letters A29 (2014) 1450020
21. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Gravity, Nonlinear Gauge Fields and Charge Confinement/Deconfinement*", in "Seventh Mathematical Physics Meeting", pp.197-213, B. Dragovic and Z. Rakic (eds.), Belgrade Inst. Phys. Press (2013)
22. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Dynamical Couplings, Dynamical Vacuum Energy and Confinement/Deconfinement from R^2-Gravity*", Physics Letters B718 (2013) 1099-1104
23. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Braneworlds in Anti-de Sitter Bulk Space-Times*", Springer Proceedings in Mathematics and Statistics 36 (2013) 215-230, ed. V. Dobrev, Springer
24. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Hiding and Confining Charges via "Tube-like" Wormholes*", International Journal of Modern Physics A26 (2011) 5211-5239
25. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Hiding Charge in a Wormhole*", The Open Nuclear and Particle Physics Journal 4 (2011) 27-34
26. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Asymptotically de Sitter and anti-de Sitter Black Holes with Confining Electric Potential*", Physics Letters B704 (2011) 230-233 ; erratum B705 (2011) 545
27. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Space-Time Compactification, Non-Singular Black Holes, Wormholes and Braneworlds via Lightlike Branes*", in "Sixth Mathematical Physics Meeting", pp. 217-234, B. Dragovic and Z. Rakic (eds.), Belgrade Inst. Phys. Press (2011)
28. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Space-Time Compactification/Decompactification Transitions Via Lightlike Branes*", General Relativity and Gravitation 43 (2011) 1487-1513
29. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Space-Time Compactification Induced By Lightlike Branes*", Invertis Journal of Science and Technology 3 (2010) 91-100

30. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Asymmetric Wormholes via Electrically Charged Lightlike Branes*", in "Lie Theory and Its Applications in Physics VIII", pp.60-75, V. Dobrev ed., AIP Conference Proceedings vol.1243, Melville, New York (2010)

31. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Non-Singular Black Holes from Gravity-Matter-Brane Lagrangians*", International Journal of Modern Physics A25 (2010) 1571-1596

32. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Einstein-Rosen "Bridge" Needs Lightlike Brane Source*", Physics Letters B681 (2009) 457-462

33. .I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Spherically Symmetric and Rotating Wormholes Produced by Lightlike Branes*", International Journal of Modern Physics A25 (2010) 1405-1428

34. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Branes as Natural Candidates for Wormhole Throats*", Forschritte der Physik 57 (2009) 566-572

35. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Variable-Tension Lightlike Brane as a Gravitational Source of Traversable Misner-Wheeler-Type Wormholes*", Physics Letters B673 (2009) 288-292

36. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike p-Branes: Mass "Inflation" and Lightlike Braneworlds*", in "Fifth Mathematical Physics Meeting", pp.171-183, B. Dragovic and Z. Rakic (eds.), Belgrade Inst. Phys. Press, 2009

37. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*"Mass Inflation" With Lightlike Branes*", Central European Journal of Physics 7 (2009) 668-676

38. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Lightlike Braneworlds*", in "Lie Theory and Its Applications in Physics VII", pp.79-88, V. Dobrev and H. Doebner eds., Heron Press (2008)

39. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Generalized Gauge Field Approach To Lightlike Branes*", in "Fourth Summer School in Modern Mathematical Physics", pp.215-228, B. Dragovic and B. Sazdovic (eds.), Belgrade Inst. Phys. Press, 2007

40. E.I. Guendelman, A. Kaganovich, E. Nissimov and S. Pacheva, "*Weyl-Invariant Lightlike Branes and Soldering of Black Hole Space-Times*", Fortschritte der Physik 55 (2007) 579-584

E-mail address for registration in the database of the Bulgarian National Science Fund
svetlana@inrne.bas.bg
Participation in projects supported by BNSF in the last five years
Competition (type and year): Financing fundamental research in priority areas, 2014 **Number and date of the contract: DFNI T02/6 , 14.12.2014** **Title:** **New Paradigms for the Fundamental Structure of Matter** **Project coordinator:** **Corresponding member of BAS, Prof. Valentina Petkova** **Status of the project:** running – second term **Evaluation of the project implementation (for completed projects):**
Competition (type and year): **Number and date of the contract:** **Title:** **Project coordinator:** **Status of the project:** (running, with intermediate or final report under review, completed) **Evaluation of the project implementation (for completed projects):**

Participation in projects supported by other sources in the last five years
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2013** **Number or acronym of the project: COST Action MP1210** **Title: "*The String Theory Universe*" (2013-2017)** **Project coordinator:** Prof. Silvia Penati (University of Milano-Bicocca, Italy) **Status of the project:** final report under review, completed
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2014** **Number or acronym of the project: COST Action MP1405 "QSPACE"** **Title: "*The Quantum Structure of Spacetime*" (2015-2019)** **Project coordinator:** Prof. Richard Szabo (Co-Director, Maxwell Institute for Mathematical Sciences, Heriot-Watt , Edinburgh, United Kingdom) **Status of the project:** running
Financing organization: European Commission - COST **Type of the competition and year: COST Action, 2017** **Number or acronym of the project: COST Action CA16104 "GWniverse"** **Title: "*Gravitational waves, black holes and fundamental physics*" (2017-2021)** **Project coordinator:** Prof. Vitor Cardoso, Instituto Superior Tecnico CENTRA (Multidisciplinary Center for Astrophysics), Departamento de Fisica, Instituto Superior Tecnico, Lisboa, Portugal **Status of the project:** running

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
STOILOVA Nedialka Ilieva, Associate Professor, Dr.Sc.
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences (INRNE-BAS) Laboratory "Theory of Elementary Particles"
Education
(1) MSc in physics – Plovdiv University, Faculty of Physics (Bulgaria), 1987 (2) PhD in theoretical and mathematical physics – INRNE, 1993
Academic positions in the last five years
Associate Professor
Main research area and subareas
group-theoretical approach to quantum theory; generalized quantum statistics; representation theory of basic classical Lie (super)algebras, quantum groups, infinite-dimensional (super)algebras
Additional research areas and subareas
Completely integrable models; orthogonal polynomials
Specializations abroad and international collaborations
-Institute for Theoretical Physics, Clausthal-Zellerfeld, Germany 1989 - 1 month, 1990 - 1 month, 1999 - 3 months: DAAD Fellowship. -Department of Applied Mathematics and Computer Science, University of Ghent, Gent, Belgium 1993 - 3 months: Research grant of the European Community, (Cooperation in Science and Technology with Central and Eastern European Countries, contract N ERB-CIPA-CT92-2011). -The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy 1994 - 1 month, 1995 - 3 months, 1996 - 1 month, 1997 - 2 months, 1998 - 2 months, 1999 - 2 months; 1999--2004: Junior Associate Member of the Abdus Salam ICTP. -Mathematics Department, The University of Queensland, Brisbane, Australia 1996 - 3 months, 1997 - 3 months; 2000 - 1 month: Ethel Raybould Visiting Fellowship. -School of Mathematics, University of Southampton, Southampton, UK, Royal Society Joint Project, Grant between the University of Southampton, England and the Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria, H01R381, 2001 - 2 weeks, 2003 - 2 weeks. -Department of Applied Mathematics and Computer Science, University of Ghent, Gent, Belgium, Collaborative Linkage Grant from NATO, 2001 - 2 weeks, 2002 - 2 weeks. -TH Division, CERN, Geneva - 2000 - 1 month, 2006 - 1 month, 2013 - 1 month, 2014 - 1 month. -Mathematical Physics Group, Technical University Clausthal, Clausthal-Zellerfeld, Germany, Humboldt Fellow - 1/03/2001 -- 31/08/2002; 2008 - 1 month, 2010 - 1 month, 2012 - 1 month. -Department of Applied Mathematics and Computer Science, University of Ghent, Gent, Belgium, Marie Curie individual fellowship MCFI-2001-01291 from the EC under the program ``Improving Human Research Potential and the Socio-economic Knowledge Base''- 1/09/2002 -- 31/08/2004; postdoc positions 1/09/2004 – 30/06/2011. -Department of Applied Mathematics, Computer Science and Statistics, University of Ghent, Gent, Belgium, Project "Representation theory of Lie (super)algebras and generalized quantum statistics", Exchange Agreement between Bulgarian Academy of Sciences and Research Foundation - Flanders (FWO), 2014 - 2 weeks, 2015 - 3 weeks, 2016 - 2 weeks. -Institute of Energy Research and Physical Technologies, TU Clausthal, Clausthal-Zellerfeld, Germany 2016 - 3 months, Alexander von Humboldt Renewed Research Stay. -Department of Applied Mathematics, Computer Science and Statistics, University of Ghent, Gent, Belgium, Project "Lie superalgebras - applications in quantum theory", Exchange Agreement between Bulgarian Academy of Sciences and Research Foundation - Flanders (FWO), 2017 - 2 weeks.

Scientific awards and membership in scientific societies
Member of Bulgarian Union of Physicists

Name, used in publications in foreign language: *N.I. Stoilova*
H index (according to Scopus or Web of Science): 8 **Complete H index: 9 (http://theo.inrne.bas.bg/~stoilova/CiteNStoilova.pdf)**
Internet address with list of scientific publications (ResearcherID, Research gate, etc.): **http://theo.inrne.bas.bg/~stoilova/pubn.htm**
Total number of scientific publications: 76
From them with impact factor or impact rang: 48
Number of citations of the scientific publications: 308
Number of scientific publications in the last five years: 10
From them with impact factor or impact rang: 7
Number of citations of the scientific publications in the last five years: 107

Selected scientific publications in the field of the research project
• S. Lievens , N.I. Stoilova and J. Van der Jeugt, On the eigenvalue problem for arbitrary odd elements of the Lie superalgebra gl(1|n) and applications. **J. Phys. A: Math. Theor. 40** , 3869-3888, (2007) and math-ph/0701013. • S. Lievens , N.I. Stoilova and J. Van der Jeugt, The paraboson Fock space and unitary irreducible representations of the Lie superalgebra osp(1|2n). **Commun. Math. Phys. 281** , 805-826 (2008) and arXiv:0706.4196[hep-th]. • S. Lievens , N.I. Stoilova and J. Van der Jeugt, Unitary representations of the Lie superalgebra osp(1|2n) and parabosons. **Bulg. J. Phys. 35** (s1), 403-414, (2008). • N.I. Stoilova and J. Van der Jeugt, Algebraic generalization of quantum statistics. **J. Phys: Conf. Series 128** , 012061 (13 pp), (2008) • S. Lievens, N.I. Stoilova and J. Van der Jeugt, A class of unitary irreducible representations of the Lie superalgebra osp(1|2n). **Journal of Generalized Lie Theory and Applications 2** , N 3, 206-210 (2008) ISSN 1736-5279. • N.I. Stoilova and J. Van der Jeugt, The parafermion Fock space and explicit so(2n+1) representations. **J. Phys. A: Math. Theor. 41** 075202 (13 pp), (2008) and arXiv:0712.1485[hep-th]. • N.I. Stoilova and J. Van der Jeugt, Parafermions, parabosons and representations of so(∞) and osp(1|∞), **Int. J. Math. 20** , N 6, 693-715 (2009) and arXiv:0801.3909[hep-th]. • R. Chakrabarti, N.I. Stoilova and J. Van der Jeugt, Representations of the orthosymplectic Lie superalgebra osp(1|4) and paraboson coherent states, **J. Phys. A: Math. Theor. 42** 085207 (16pp) (2009) and arXiv:0811.0281v1 [math-ph]. • R.C. King, N.I. Stoilova and J. Van der Jeugt, Representations of the Lie Superalgebra gl(1|n) and Wigner Quantum Oscillators, in: Group Theoretical Methods in Physics 2006, Eds. J.L. Birman, S. Catto, B. Nicolescu, (Canopus Publishing Limited 2009, ISBN 978-0-9549846-8-7), 340-344. • S. Lievens , N.I. Stoilova and J. Van der Jeugt, Finite-dimensional solutions of coupled harmonic oscillator quantum systems,

in: Group Theoretical Methods in Physics 2006, Eds. J.L. Birman, S. Catto, B. Nicolescu, (Canopus Publishing Limited 2009, ISBN 978-0-9549846-8-7), 363-367.

- R. Chakrabarti, N.I. Stoilova and J. Van der Jeugt, Paraboson Coherent States,

Physics of Atomic Nuclei 73 , No. 2, 269-275 (2010), ISSN 1063-7788.

- N.I. Stoilova and J. Van der Jeugt, Parabosons, Parafermions, and Explicit Representations of Infinite-Dimensional Algebras,

Physics of Atomic Nuclei 73 , No. 3, 533-540 (2010), ISSN 1063-7788.

- N.I. Stoilova and J. Van der Jeugt, Gel'fand-Zetlin Basis and Clebsch-Gordan Coefficients for Covariant Representations of the Lie superalgebra gl(m|n),

J. Math. Phys. 51 093523 (15pp) (2010) and arXiv:1004.2381 [math-ph].

- N.I. Stoilova and J. Van der Jeugt, An exactly solvable spin chain related to Hahn polynomials,

SIGMA 7 033 (13pp) (2011) and arXiv:1101.4469 [math-ph].

- E.I. Jafarov, N.I. Stoilova and J. Van der Jeugt, Finite oscillator models: the Hahn oscillator,

J. Phys. A: Math. Theor. 44 265203 (15pp) (2011) and arXiv:1101.5310 [math-ph].

- E.I. Jafarov, N.I. Stoilova and J. Van der Jeugt, The $su(2)_\alpha$ Hahn oscillator and a discrete Hahn-Fourier transform,

J. Phys. A: Math. Theor. 44 355205 (18pp) (2011) and arXiv:1106.1083 [math-ph].

- N.I. Stoilova and J. Van der Jeugt, Explicit representations of classical Lie superalgebras in a Gel'fand-Zetlin basis,

Banach Center Publications 93 (2011), 83-93, ISBN 978-83-86806-11-9.

- E.I. Jafarov, N.I. Stoilova and J. Van der Jeugt, Deformed su(1,1) algebra as a model for quantum oscillators,

SIGMA 8 025 (15pp) (2012) and arXiv:1202.3541 [math-ph].

- N.I. Stoilova, The parastatistics Fock space and explicit Lie superalgebra representations,

J. Phys. A: Math. Theor. 46 475202 (14pp) (2013) and arXiv:1311.4042 [math-ph].

- E.I. Jafarov, N.I. Stoilova and J. Van der Jeugt, The $u(2)_\alpha$ and $su(2)_\alpha$ Hahn harmonic oscillators,

Bulg. J. Phys. 40 115-120 (2013).

- E.I. Jafarov, N.I. Stoilova and J. Van der Jeugt, On a pair of difference equations for the ${}_4F_3$ type orthogonal polynomials and related exactly-solvable quantum systems,

in Lie Theory and Its Applications in Physics, ed. V. Dobrev, Springer Proceedings in Mathematics and Statistics, **111** 291-300 (2014) (Springer, Tokyo, Heidelberg, ISSN 2194-1009, ISBN 978-4-431-55284-0)

- N.I. Stoilova and J. Van der Jeugt, Explicit infinite-dimensional representations of the Lie superalgebra osp(2m + 1|2n) and the parastatistics Fock space,

J. Phys. A: Math. Theor. 48 155202 (16pp) (2015).

- N.I. Stoilova, Generalized Quantum Statistics and Lie (Super)Algebras,

9th Int. Physics Conference of the Balkan Physical Union (BPU-9), AIP Conference Proceedings 1722, 100004-1--100004-4 (2016), doi: 10. 1063/1.4944182 and arXiv:1512.05076.

- N.I. Stoilova and J. Van der Jeugt, Gel'fand-Zetlin basis for a class of representations of the Lie superalgebra gl(∞|∞),

J. Phys. A: Math. Theor. 49 165204 (21pp) (2016).

- N.I. Stoilova and J. Van der Jeugt, The parastatistics Fock space and explicit infinite-dimensional representations of the Lie superalgebra osp(2m+1|2n),

in Lie Theory and Its Applications in Physics, ed. V. Dobrev, Springer Proceedings in Mathematics and Statistics, **191** 169-180 (2016) (Springer, Tokyo, Heidelberg, ISSN 2194-1009, ISBN 978-981-10-2635-5)

- N.I. Stoilova, J. Thierry-Mieg and J. Van der Jeugt, Extension of the osp(m|n) ~ so(m-n) correspondence to the infinite-dimensional chiral spinors and self dual tensors,

J. Phys. A: Math. Theor. 50 155201 (21 pp) (2017).

- N.I. Stoilova and J. Van der Jeugt, Lie superalgebraic approach to quantum statistics. osp(3|2) Wigner quantum oscillator,
Bulg. J. Phys. 44 1-8 (2017).

E-mail address for registration in the database of the Bulgarian National Science Fund
stoilova@inrne.bas.bg
Participation in projects supported by BNSF in the last five years
Competition (type and year): Financing fundamental research in priority areas, 2014 **Number and date of the contract: DFNI T02/6 , 14.12.2014** **Title:** **New Paradigms for the Fundamental Structure of Matter** **Project coordinator:** **Corresponding member of BAS, Prof. Valentina Petkova** **Status of the project:** running – second term **Evaluation of the project implementation (for completed projects):**

Participation in projects supported by other sources in the last five years
Financing organization: BAS/FWO (Flanders) **Type of the competition and year: Exchange Agreement, 2014** **Number or acronym of the project: RTLSGQS** **Title:** Representation theory of Lie (super)algebras and generalized quantum statistics **Project coordinator: N.Stoilova (INRNE), J. Van der Jeugt (Ghent University, BE)** **Status of the project:** completed
Financing organization: BAS/FWO (Flanders) **Type of the competition and year: Exchange Agreement, 2014** **Number or acronym of the project: LS_AQT** **Title:** Lie superalgebras - applications in quantum theory **Project coordinator: N.Stoilova (INRNE), J. Van der Jeugt (Ghent University, BE)** **Status of the project:** running

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
STAICOVA Denitsa Rumenova Assistant Professor, Doctor (PhD)
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences (INRNE-BAS) Laboratory "Theory of Elementary Particles"
Education
(1) Bachelor in Physics, Sofia University (2006) (1) MSc in Theoretical Physics, Sofia University, Faculty of Physics (Bulgaria), 2007 (2) PhD in Theoretical Physic, Sofia University, Faculty of Physics (Bulgaria), 2012
Academic positions in the last five years
Physicist Sofia University, Faculty of Physics 2007 – 2011 Junior Assistant Professor -INRNE – 2013-2016 Assistant Professor – INRNE-BAS, since 2016
Main research area and subareas
Astrophysical jets, Black Hole physics, Quasi-Normal modes, Cosmology, Generalized gravity, Two-measures theory, Minimal Dilaton Gravity
Additional research areas and subareas
Numerical methods, advanced programming with Maple, Gamma-Ray bursts,Teukolsky perturbation theory, Heun functions, numerical relativity
Specializations abroad and international collaborations
University of Alicante, Spain, 2014 (visiting researcher) Goete University, Germany, 2014 (COST action MP1304 short term scientific mission) MC substitute of COST action MP1304 „NewCompStar"
Scientific awards and membership in scientific societies
Member of Bulgarian Astronomical Society
Name, used in publications in foreign language: ***Denitsa Staicova***
H index (according to Scopus or Web of Science): *2* **Complete H index (according to Google Scholar): 4**
Internet address with list of scientific publications (ResearcherID, Research gate, etc.): ***www.linkedin.com/in/denitsastaicova*** ***https://www.researchgate.net/profile/Denitsa_Staicova*** ***http://www.researcherid.com/rid/D-9865-2011***
Total number of scientific publications: *11*
From them with impact factor or impact rang: *5*
Number of citations of the scientific publications: *41*
Number of scientific publications in the last five years: ***5***
From them with impact factor or impact rang: *3*
Number of citations of the scientific publications in the last five years: *34*

Scientific publications

1. "Cosmological aspects of a unified dark energy and dust dark matter model" Denitsa Staicova, Michail Stoilov, Mod. Phys. Lett. A, Vol. 32, No. 1 (2017) 1750006
2. "*The Heun functions and their applications in astrophysics*", Denitsa Staicova, Plamen Fiziev, Proceedings of the XI. International Workshop LIE THEORY AND ITS APPLICATIONS IN PHYSICS (2015)
3. "*Numerical stability of the electromagnetic quasinormal and quasibound modes of Kerr black holes*" , Denitsa R. Staicova , Plamen P. Fiziev, Bulg. Astr. J., 23 (2015)
4. "*New results for electromagnetic quasinormal and quasibound modes of Kerr black holes* " Denitsa R. Staicova, Plamen P. Fiziev Astrophysics and Space Science, June 2015, 358:10
5. „*Solving systems of transcendental equations involving the Heun functions*", P. Fiziev, D. Staicova arXiv:1201.0017,), American Journal of Computational Mathematics Vol. 02 : 02, pp.95 (2012) /a shortened version published as proceeding in: AIP Conference Proceedings, Volume 1458, pp. 395-398 (2012) /
6. „New results for electromagnetic quasinormal modes of black holes", Denitsa Staicova, Plamen Fiziev, arXiv:1112.0310, , Internal Report, Sofia University, 2011
7. „*Application of the confluent Heun functions for finding the quasinormal modes of nonrotating black holes*", P. Fiziev, D. Staicova, Phys. Rev. D 84, 127502 (2011)
8. „*Two-dimensional generalization of the Muller root-finding algorithm and its applications*", P. Fiziev, D. R. Staicova, arXiv:1005.5375, Internal Report, Sofia University, 2011
9. „*The Spectrum of Electromagnetic Jets from Kerr Black Holes and Naked Singularities in the Teukolsky Perturbation Theory*", D. Staicova, P. Fiziev, Astrophys Space Sci (2011) 332: 385-401
10. „*Toward a New Model of the Central Engine of GRB*", P. Fiziev, D. Staicova, Bulgarian Astronomical Journal, 11, pp. 13-21, 2009
11. „*A new model of the Central Engine of GRB and the Cosmic Jets*", P. Fiziev, D. Staicova, Bulgarian Astronomical Journal, 11, pp. 3-11, 2009

E-mail address for registration in the database of the Bulgarian National Science Fund

dstaicova@inrne.bas.bg

Participation in projects supported by BNSF in the last five years

Competition (type and year): Integrated scientific centres in the universities, 2008
Number and date of the contract: DO-02-136/ 15.12.2008
Title:
Integrated Research Center on Computational Sciences in the Microworld
Project coordinator: prof. Ana Proykova
Status of the project: completed
Evaluation of the project implementation (for completed projects):
The report has been submitted in time in the BNSF

Competition (type and year): Financing fundamental research in priority areas, 2014
Number and date of the contract: DN08/17 14.12.2016
Title: „Investigations of the spectra and interactions of atoms and molecules focused on the fundamental characteristics and laws of matter
Project coordinator: Corresponding member of BAS, Prof. D.Sc. Dimitar Bakalov
Status of the project: running
Evaluation of the project implementation (for completed projects):

Participation in projects supported by other sources in the last five years

Financing organization: European Commission - COST
Type of the competition and year: COST Action, 2013
Number or acronym of the project: COST Action MP1304

Title: Exploring fundamental physics with compact stars (NewCompStar) (2013-2018)
Project coordinator: Prof Luciano REZZOLLA (Goethe University, DE)
Status of the project: running

Financing organization: BAS
Type of the competition and year: Young Scientist, 2016
Number or acronym of the project: DFNP-49/21.04.2016
Title: "Generalised models of gravity and cosmology"
Project coordinator: Dr. Michail Stoilov
Status of the project: submitted final report

Financing organization: MINEDU
Type of the competition and year: Young Scientist, 2007
Number or acronym of the project: 605-NI-MU-15 / 2007
Title: "Modelling gama-ray bursts in the Universe"
Project coordinator: prof. Plamen Fiziev
Status of the project: completed

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
Kalin Marinov, PhD student
Affiliation – research organization, department
Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, laboratory "Theory of Elementary Particles"
Education
Master degree, 2014, Sofia University "st. Kliment Ohridski"
Academic positions in the last five years
PhD student, Institute for Nuclear Research and Nuclear Energy Head expert, Bulgarian Institute of metrology Physicist, Institute for Nuclear Research and Nuclear Energy
Main research area and subareas
Theoretical and mathematical physics, gravity, astrophysics
Additional research areas and subareas
Specializations abroad and international collaborations
Joint institute for Nuclear Research, Dubna, Russian Federation, 2016, 3 months Joint institute for Nuclear Research, Dubna, Russian Federation, 2015, 3 months
Scientific awards and membership in scientific societies
Name, used in publications in foreign language:Kalin Marinov
H index (according to Scopus or Web of Science)*:1*
Internet address with list of scientific publications (ResearcherID, Research gate, etc.)*:*
Total number of scientific publications*:6*
From them with impact factor or impact rang*:1*
Number of citations of the scientific publications*:6*
Number of scientific publications in the last five years:6
From them with impact factor or impact rang*:1*
Number of citations of the scientific publications in the last five years*:6*

Scientific publications
1. P. Fiziev, K. Marinov "Compact static stars with polytropic equation of state in minimal dilatonic gravity", Bulg. Asrt. J., 23, 3, 2015 2. P. Fiziev, K. Marinov "Modeling of non-rotating neutron stars in minimal dilatonic gravity", Astrophys Space Sci (2017) 362: 8. https://doi.org/10.1007/s10509-016-2991-x 3. Mladenov A., Stankov D., **Marinov K.**, Nonova Tz., Krezhov K., Radiation Monitoring Program at Nuclear Scientific Experimental and Educational Center – IRT – Sofia, *In Proc. European Medical Physics and Engineering Conference EMPEC-2012*, 18 – 20 October 2012, Sofia, Bulgaria, pp. 348 – 353; 4. Stankov D., Mladenov A., **Marinov K.,** Nonova Tz., Krezhov K., Individual Dosimetric Control and Monitoring of the Working Environment at the Nuclear Site IRT – Sofia, *In Proc. European Medical Physics and Engineering Conference EMPEC-2012*, 18 – 20 October 2012, Sofia, Bulgaria, pp. 354 – 359

5. Nonova Tz., Mladenov Al., Ivanov D., Stankov D., **Marinov K.**, Ivanova S., Krezhov K., 2012. Radiation monitoring at the site IRT-Sofia for the period January 2011 – August 2012, *BgNS Transactions*, 17 (1), 3-10; ISSN 1310-8727.
6. PANTELEEV N., DOCHEV I., **MARINOV K.**, Medzhidieva B., 2015, VALIDATION OF TEST SITE FOR RADIATED POWER MEASUREMENTS WITH ABSORBING CLAMP (ACTS), XXV Национален научен симпозиум с международно участие "Метрология и метрологично осигуряване 2015", Созопол. Сборник доклади, 2015

E-mail address for registration in the database of the Bulgarian National Science Fund

marinov.kalin@gmail.com

Participation in projects supported by BNSF in the last five years

Competition (type and year):
Number and date of the contract:
Title:
Project coordinator:
Status of the project: (running, with intermediate or final report under review, completed)
Evaluation of the project implementation (for completed projects):

Competition (type and year):
Number and date of the contract:
Title:
Project coordinator:
Status of the project: (running, with intermediate or final report under review, completed)
Evaluation of the project implementation (for completed projects):

Participation in projects supported by other sources in the last five years

Financing organization: Bulgarian Academy of Sciences
Type of the competition and year: Program for carrier development of young scientists, Bulgarian Academy of Sciences, 2016
Number or acronym of the project: DFNP-51/21.04.2016
Title: Extended theories of gravity and their application to physics of compact stars

Project coordinator: Kalin Marinov
Status of the project: final report under review

Financing organization:
Type of the competition and year:
Number or acronym of the project:
Title:

Project coordinator:
Status of the project: (running, with intermediate or final report under review, completed)

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
Radoslav Christov Rashkov, professor, D. Sc.
Affiliation – research organization, department
Sofia University "St. Climent of Ohrid", Faculty of Physics, Department of Theoretical Physics, 5 J. Bourchier Blvd., 1164 Sofia, Bulgaria;
Education
Sofia University "St. Climent of Ohrid", Faculty of Physics, Department of Theoretical Physics, Master degree in theoretical and mathematical physics, 1986; Landau Institute for Theoretical Physics, Moscow, Russia, Ph.D. in physics and mathematics,1991; D. Sc., 2009
Academic positions in the last five years
Sofia University "St. Climent of Ohrid", Department of Theoretical Physics, professor, 2011
Main research area and subareas
Theoretical physics, Quantum field theory, String and superstring theory, Supergravity
Additional research areas and subareas
Mathematical physics, Integrable systems, Differential and algebraic geometry, Lie groups and algebras
Specializations abroad and international collaborations
ICTP – Trieste Italy Simon Fraser University - Vancouver, Canada (Prof. S.K. Wiswanathan) Vienna University of Technology (Project leader, group leader) Internatianal E. Schroedinger Institute for mathematical Physics (senior fellow) NORDITA – Stockholm, Sweden (Prof. K. Zarembo) ITEP and Lebedev Institute– Moscow, Russia (Corr. member Prof. A. Morozov and Prof. A. Mironov) Seoul National University (Prof. SoJong Rey)
Scientific awards and membership in scientific societies

Name, used in publications in foreign language: R. Rashkov
H index (according to Scopus or Web of Science): *22*
Internet address with list of scientific publications (ResearcherID, Research gate, etc.): http://arxiv.org/find/all/1/all:+AND+R+Rashkov/
Total number of scientific publications: *>80*
From them with impact factor or impact rang: *>70*
Number of citations of the scientific publications: *>1500*
Number of scientific publications in the last five years: *>27*
From them with impact factor or impact rang: *>18*
Number of citations of the scientific publications in the last five years: *>600*

Selected scientific publications in the field of the research project

1. V. G. Filev, C. V. Johnson, R. C. Rashkov, K. S. Viswanathan, "Flavoured Large N Gauge Theory in an External Magnetic Field", JHEP 0710:019,2007.
2. N. P. Bobev, R. C. Rashkov, "Multispin giant magnons" Physical Review D 74 (2006), 046011.
3. H. Dimov, R. C. Rashkov, "A note on spin chain/string duality" International Journal of Modern Physics A 20 (2005), 4337-4353.
4. M. Gary, D. Grumiller, R. Rashkov, "Towards non-AdS holography in 3-dimensional higher spin gravity" JHEP 1203 (2012) 022
5. H. Afshar, M. Gary, D. Grumiller, R. Rashkov, M. Riegler, "Semi-classical unitarity in 3-dimensional higher-spin gravity for non-principal embeddings" Class.Quant.Grav. 30 (2013) 104004.
6. H. Afshar, M. Gary, D. Grumiller, R. Rashkov, M. Riegler, "Non-AdS holography in 3-dimensional higher spin gravity: General recipe and example" JHEP 11, 099.
7. R. C. Rashkov, "Notes on entanglement entropy for excites holographic states in 2d" arXiv:1607.083723
8. H. Dimov, S. Mladenov, R. C. Rashkov, T. Vetsov, "Entanglement of higher-derivative oscillators in holographic systems", Nucl. Phys. B **918** (2017) 317–336.
9. R. C. Rashkov, M. Stanishkov, "Three-point correlation functionsin N=1 super-Liouville theory" Physics Letters B380 (1996) 49-58.
10. H. Dimov, R. C. Rashkov, "Generalized pulsating strings", JHEP 0405 (2004) 068.
11. R. C. Rashkov, Note on the boundary terms in AdS/CFT correspondence for Rarita-Schwinger field" Modern Physics Letters A, 1999, 1783-1796.
12. N. P. Bobev, H. Dimov, R. C. Rashkov, "Semiclassical strings, dipole deformations of N=1 SYM and decoupling of KK modes", JHEP 0602 (2006) 064.
13. Changrim Ahn, P Bozhilov, RC Rashkov, „Neumann-Rosochatius integrable system for strings on AdS_4 × CP^3", JHEP 0809 (2008) 017.
14. H Dimov, V Filev, RC Rashkov, KS Viswanathan, „Semiclassical quantization of Rotating Strings in Pilch-Warner geometry", Physical Review D 68 (2003) 066010.

E-mail address for registration in the database of the Bulgarian National Science Fund

rash@phys.uni-sofia.bg

Participation in projects supported by BNSF in the last five years

Competition (type and year): Competition "IDEAS", 2008
Number and date of the contract: № DO 02-257 / 18.12.2008
Title: Quantum structure and geometric nature of fundamental forces

Project coordinator: Professor Ivan Todorov Todorov, INRNE- BAS
Status of the project: completed
Evaluation of the project implementation (for completed projects): excellent

Competition (type and year): Competition for financial support of scientific research in priority areas— 2014
Number and date of the contract: № T 02/6 from 12.12.2014
Title: "New paradigms for the fundamental structure of matter"

Project coordinator: Prof. Valentina Borisova Petkova, INRNE, BAS
Status of the project: second phase running
Evaluation of the project implementation (for completed projects):

Participation in projects supported by other sources in the last five years
Financing organization: Sofia University Research Fund **Type of the competition and year:** research project for support of PhD students **Number or acronym of the project:** Grant № 85/2016 **Title:** “Aspects of string dualities, field theory models, and information spaces” **Project coordinator:** Prof. DSc Radoslav Rashkov **Status of the project:** completed
Financing organization: Sofia University Research Fund **Type of the competition and year:** research project for support of PhD students **Number or acronym of the project:** Grant № 80.10-116 **Title:** “Minimal surfaces, Wilson loops, and the Ryu-Takayanagi conjecture” **Project coordinator:** Prof. DSc Radoslav Rashkov **Status of the project:** running

Curriculum vitae of the coordinator or member of the research team

Name, academic position and degree
Stefan Budyoniev Mladenov, PhD student
Affiliation – research organization, department
Sofia University "St. Kliment Ohridski", Department of Physics
Education
Master of Science, Sofia University, 2012 – 2014 Bachelor of Science, Sofia University, 2008 – 2012
Academic positions in the last five years
Physicist, Scientific and Research Centre, Sofia University, March 2012 – March 2014
Main research area and subareas
High-energy physics, AdS/CFT, string theory, quantum field theory, information geometry
Additional research areas and subareas
Mathematical physics, differential geometry, integrable systems
Specializations abroad and international collaborations
Scientific awards and membership in scientific societies

Name, used in publications in foreign language: Stefan Mladenov
H index (according to Scopus or Web of Science):
Internet address with list of scientific publications (ResearcherID, Research gate, etc.): https://arxiv.org/find/hep-th/1/au:+Mladenov_S/0/1/0/all/0/1
Total number of scientific publications: 3
From them with impact factor or impact rang: 2
Number of citations of the scientific publications: 6
Number of scientific publications in the last five years: 3
From them with impact factor or impact rang: 2
Number of citations of the scientific publications in the last five years: 6
Scientific publications
1. H. Dimov, S. Mladenov, R. C. Rashkov, *"Large J expansion in ABJM theory revisited"*, Eur. Phys. J. C **74**:3042, 2014. 2. H. Dimov, S. Mladenov, R. C. Rashkov, T. Vetsov, *"Non-abelian T-duality of Pilch-Warner background"*, Fortschr. Phys., 1–17 (2016)/DOI 10.1002/prop.201600032. 3. H. Dimov, S. Mladenov, R. C. Rashkov, T. Vetsov, *"Entanglement of higher-derivative oscillators in holographic systems"*, Nucl. Phys. B **918** (2017) 317–336.

E-mail address for registration in the database of the Bulgarian National Science Fund
smladenov@phys.uni-sofia.bg
Participation in projects supported by BNSF in the last five years
Competition (type and year): Competition for financial support of scientific research in priority areas—2014 **Number and date of the contract:** № T 02/6 from 12.12.2014 **Title:** "New paradigms for the fundamental structure of matter" **Project coordinator:** Prof. Valentina Borisova Petkova, INRNE, BAS **Status of the project:** second phase running **Evaluation of the project implementation (for completed projects):**
Participation in projects supported by other sources in the last five years
Financing organization: Sofia University Research Fund **Type of the competition and year:** research project for support of PhD students **Number or acronym of the project:** Grant № 85/2016 **Title:** "Aspects of string dualities, field theory models, and information spaces" **Project coordinator:** Prof. DSc Radoslav Rashkov **Status of the project:** completed
Financing organization: Sofia University Research Fund **Type of the competition and year:** research project for support of PhD students **Number or acronym of the project:** Grant № 80.10-116 **Title:** "Minimal surfaces, Wilson loops, and the Ryu-Takayanagi conjecture" **Project coordinator:** Prof. DSc Radoslav Rashkov **Status of the project:** running