XXXV International Workshop on High Energy Physics ”From Quarks to Galaxies: Elucidating Dark Sides”

Tuesday 28 November 2023 - Friday 01 December 2023

Book of Abstracts

Contents

Morning session 28/11/2023 / **21**

A class of rotating metrics in the presence of a scalar field

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A class of three parameter metrics can be considered as a generalized form of a scalar field. The rotating form of the class of metrics can be obtained. The rotating JNW metric can be derived by choosing certain values of the parameters. Using the Harrison transformation one may derive charged form of the exact solutions.

Afternoon session 28/11/2023 / **23**

Astrophysical tests of general relativity

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At the initial stage of its development, the general theory of relativity received verification and confirmation in the limit of a weak gravitational field. However, with the development of astronomical observation technologies, predictions of GRT and in a strong gravitational field began to be discussed and confirmed, such as the profile of the X-ray iron Kα line (in the case if the emission region is very close to the event horizon), the trajectories of particles and stars near black holes and the shapes and sizes of shadows of supermassive black holes in M87*and Sgr A*. In 2019 the Event Horizon Telescope (EHT) team presented the first image reconstruction around the shadow for the supermassive black hole in M87. *In 2021 the EHT team constrained parameters ("charges") of spherical symmetrical metrics of black holes from an allowed interval for shadow radius. Earlier, we obtained analytical expressions for the shadow radius as a function of charge (including a tidal one) in the case of Reissner–Nordström metric. Based on results of the shadow size evaluation for M87* done by the EHT team we constrain a tidal charge. We discuss opportunities to use shadows to test alternative theories of gravity and alternative theories for galactic centers.

Afternoon session 30/11/2023 / **45**

Black Dark Matter and Antimatter

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It is shown that the dense population of the early universe with well developed galaxies and supermassive black holes (quasars), observed by HST and JWST, nicely fits the conjecture that the galaxies and quasars are seeded by primordial black holes (PBHs), proposed in our work more than 30 years ago. This idea of galaxy seeding by massive black holes is rediscovered in recent publications by several groups. The predicted log-normal mass spectrum of PBHs very well agrees with the data. Our other prediction of noticeable amount of antimatter in the Galaxy is also supported by the data. It is argued that the cosmological dark matter may fully consist of PBHs.

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2. A.Dolgov, M.Kawasaki, N.Kevlishvili, Inhomogeneous baryogenesis, cosmic antimatter, and dark matter", Nucl. Phys. B807 (2009) 229.
3. A.D. Dolgov, Massive and supermassive black holes in the contemporary and early Universe and problems in cosmology and astrophysics, Phys. Usp. 61 (2018) 2, 115.

4. A.D. Dolgov, Tension between HST/JWST and ΛCDM Cosmology, PBH, and Antimatter in the Galaxy, Contribution to: MULTIF2023, e-Print: 2310.00671 [astro-ph.CO].

Afternoon session 28/11/2023 / **24**

Black holes with electroweak hair

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We review the recent progress in constructing hairy black holes in the Einstein-Weinberg-Salam theory. These black holes are static and axially symmetric, they carry a magnetic charge and support non-linear Yang-Mills and Higgs fields outside the event horizon. Depending on the value of the magnetic charge, their mass and size vary from Planck values up to values typical for planetary mass black holes. Close to the horizon the electroweak symmetry is restored
and geometry is Reissner-Nordstrom-de Sitter. The non-linear fields form an "electroweak corona" located far away from the horizon in the region where the geometry is almost flat. These solutions provide the first example of hairy black holes in a genuinely physical theory.

Morning session 30/11/2023 / **40**

Challenges and problems in charmonium production at the SPD NICA

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The SPD NICA is planned to operate as a universal facility for comprehensive study of the unpolarized and polarized gluon content of the nucleon at large Bjorken-x, using different hard probes. The first one is charmonium
production processes. The experiment aims to provide access to the gluon helicity, gluon Sivers and Boer-Mulders PDFs in the nucleon. In this talk, we present an overview of theoretical predictions for J/ψ, χc, ηc and J/ψ + γ production
in uppolarized and polarized pp-collisions at the √s = 27 GeV. We use collinear parton model and generalized parton model as well as two models of $c^{-}c$ hadronization into the final charmonium, Nonrelativistic QCD and Improved Color Evaporation model.

Information on the subject:

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2. B. A. Karpishkov, M. Nefedov and V. Saleev, Estimates for the singlespin asymmetries in the pp↑ → J/ψX process at PHENIX RHIC and SPD NICA, Phys. Rev. D 104 (2021) no.1, 016008
3. A. Guskov, A. Datta, A. Karpishkov, I. Denisenko and V. Saleev, Probing Gluons at the Spin Physics Detector, Physics 2023, 5, 672-687.
4. A. Karpishkov and V. Saleev, On Transverse Single-Spin Asymmetries in D-Meson Production at the SPD NICA Experiment, Phys. Part. Nucl. Lett. 20, no.3, 360-363 (2023)
5. Anufriev A.V., Saleev V.A. Production of ηc with two-photon decay in the GPM at the energies of NICA, Vestnik of Samara University. Natural Science Series, 2022, vol. 28, no. 1-2, pp. 128-136.
6. Alimov L.E., Saleev V.A. Associative production of J/ψ-mesons and direct photons at the energy of the NICA collider, Vestnik of Samara University. Natural Science Series, 2023, vol. 29, no. 2, pp. 48-61.

Afternoon session 1/12/2023 / **60**

Closing address

Afternoon session 30/11/2023 / **43**

Conformal scalar and spinor fields in curved space

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These fields scale as, $\tilde{\phi}(\psi) = \Omega^{\xi}\,\phi(\psi)$ and the metric tensor as $\tilde{g}_{\mu\nu} = \Omega^2\,g_{\mu\nu}$, where Ω and ξ are called the conformal factor and wight, respectively. The conformal mass in Klein-Gordon mass ($\tilde{m}$) is related to original scalar mass, (m) by $\tilde{m} = \Omega^{-1}\,m$\,. Moreover, the Klein-Gordon equation in the conformal's frame reduces to the quantum Telegraph equation of a particle whose mass is given by, $M = (\xi + 1)\,m$, in Minkowski's frame. The conformal wave equation in 2 dimensions with $\xi = 1$ yields the quantum Telegraph equation with a mass. We have found that the conformal wave equation in 2 dimensions yields the Dirac equation for $\xi = \pm\,i$ in flat space. In 4 dimensions the mass of the conformal spinor field scales as $\tilde{m} = \Omega^{-2}m$. The spinor charge (q) is influenced by the conformal transformation and becomes $Q_c = q\xi/(\xi + \frac{3}{2})$. The conformal factor for a spinor field is found to be equal to the phase factor of the spinor field. Moreover, the conformal transformation preserves the probability of the spinor particle. There exists a certain conformal transformation that transforms the Klein-Gordon equation into the Dirac equation. An Aharonov- Bohm-like effect is found to occur due to a conformal transformation of the spinor field. Breaking of conformal invariance is found to give rise to a mass of the particle that is tantamount to the Higgs mechanism.

Morning session 1/12/2023 / **58**

Contextual realism in physics

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Within the framework of a broadly Wittgensteinian approach, we criticize metaphysical realism, structural realism and Platonism in philosophy of physics and propose to replace them with what we call "contextual scientific realism" (CSR). According to CSR, ontology is sensitive to context. Our view is illustrated with both ordinary and physical examples. In particular, we claim that the Higgs boson is a contextual object within the framework of the Standard Model and the practice of its application, and that, in a sense, the nature of the gravitational waves depends on the choice of a physical theory to describe them. A physical theory is interpreted as a Wittgensteinian rule (norm) for measuring physical reality within the language games if its applications. Contextual realism explains the success of our best scientific theories and (dis)solves the problem of pessimistic induction. It allows one to dissolve the so-called "problem of naturalness". In our view, it also corrects and deepens Porter Williams' "effective realism".

Information on the subject:

https://nasb-by.academia.edu/FrancoisIgorPris

Morning session 30/11/2023 / **38**

Effects of interactions of axion-like dark matter with SM parti-

cles

Corresponding Author(s): alsilenko@mail.ru

An axion is a hypothetical particle being a quant of pseudoscalar field. It has been originally postulated by Peccei and Quinn in 1977 to resolve the strong CP problem in QCD. If axions exist, they are of interest as a possible component of cold dark matter. The axion–photon coupling distorts the electromagnetic field and leads to the inverse Primakoff effect which can be observed with haloscopes. CP-noninvariance of the axion–gluon coupling results in an appearance of oscillating nucleon EDMs which are proportional to the axion field. Axions manifest themselves in direct interactions with particles (so-called axion wind effect). We rigorously determine the relativistic spin dynamics defined by the pseudoscalar field of dark matter axions. We also show that the distortion of the electromagnetic field leads to effective magnetic charges and EDMs of leptons and effective electric charges of magnetic monopoles (the Witten effect). Axion-like dark matter interacts like the axion.

Information on the subject:

A. J. Silenko, Relativistic spin dynamics conditioned by dark matter axions, Eur. Phys. J. C 82, 856 (2022).

S. N. Vergeles, N. N. Nikolaev, Y. N. Obukhov, A. J. Silenko, O. V. Teryaev, General relativity effects in precision spin experimental tests of fundamental symmetries, Phys. Usp. 66, 109 (2023).

A. J. Silenko, Determination of time-dependent effective electric dipole moments conditioned by axion-photon coupling, arXiv:2305.19703 (2023).

A. J. Silenko, Equation of spin motion for a particle with electric and magnetic charges and dipole moments, arXiv:2309.04985 (2023).

Morning session 30/11/2023 / **36**

Electromagnetic properties of neutrino

Corresponding Author(s): studenik@srd.sinp.msu.ru

Afternoon session 1/12/2023 / **55**

Emergent Quantumness in Neural Networks

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In this talk, I will show that equilibrium dynamics of trainable variables (e.g. bias vector or weight matrix) in an artificial neural network can be approximated by Madelung equations if the quantum phase is identified with the free energy of non-trainable variables (e.g. state vector of neurons). In addition, if the number of active neurons changes, then the free energy is multivalued and the equilibrium dynamics is better approximated by Schrödinger equation with "Planck's constant" determined by the chemical potential. This shows that quantum mechanics provides a correct statistical description of the dynamics of the grand canonical ensemble of neural networks at the learning equilibrium. I will also briefly discuss a possibility of using the emergent quantumness for building an artificial quantum computer and a possibility that the entire universe on its most fundamental level is a neural network.

Morning session 29/11/2023 / **30**

Estimation of the hadron contribution to gμ-2 using the IHEP total cross section database

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An up-to-date compilation of the world data on the $e^+e^- \to hadrons$ total cross section is used for dispersive evaluation of the leading order hadronic contribution to the muon anomalous magnetic moment $a_\mu = (g_\mu - 2)/2$. Our value $a_\mu(had, LO) = (696.2 \pm 1.9_{e^+e^-exp.} \pm 2.1_{syst.}) \times 10^{-10}$ is consistent with recent estimates by other groups. An impact of a recent $\sigma(e^+e- \to \pi^+\pi^-)$ measurement by the CMD-3 experiment is discussed.
The SM prediction of a_μ including our $a_\mu(had, LO)$ estimate $a_\mu^{\rm SM} = 11\ 659\ 184(4) \times 10^{-10}$ is in $\sim 4.7\sigma$ tension with the experimental value $a_\mu^{exp} = 11\ 659\ 205.9(2.2) \times 10^{-10}$ [FNAL g-2 Collaboration, Phys. Rev. Lett. 131, 161802 (2023)].

Afternoon session 1/12/2023 / **52**

Fundamental physics asks philosophers new questions

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Modern fundamental physics poses new questions to philosophy, which not only do not have answers yet, but, rather, are not noticed by philosophy of science. This presentation formulates a number of such questions in order to present them to the attention, first of all, of professional philosophers. A rough list of the main themes is as follows: 1) Irreducible uncertainty of cosmological data (cosmic variance) and the meaning of theoretical cosmology; 2) Epistemological status of the concept of Multiverse and other universes in cosmology; 3) Ensemble meaning of measurement in quantum theory and the operational status of quantum macrostates; 4) Quantum gravity and the wave function of the universe as a special case of quantum macrostates; 5) The meaning of the concept of physical reality in the Max Tegmark principle of mathematical democracy; 6)
Application of the item 5 to the physical meaning of string theory.

Information on the subject:

Fundamental physics asks philosophers new questions
A.D. Panov
SINP MSU

Related papers

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http://dec1.sinp.msu.ru/~panov/MethBroblCosm-2011-RusPhil.pdf
A. Panov. The Structure of Reality, or Where to Find the Final Theory? Philosophy and Cosmology. Volume 19, 2017, P. 74-94
http://dec1.sinp.msu.ru/~panov/MathAndReal-2017.pdf
А.Д. Панов. Природа математики, космология и структура реальности: объективность мира математических форм. В кн.: Космология, физика, культура. Под ред. В.В. Казютиского. М.: ИФ РАН, 2011. С. 191-219.
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http://dec1.sinp.msu.ru/~panov/Math-2013-02.pdf

Morning session 28/11/2023 / **22**

General discussion - 1

Discussion leader
Yuri Pokrovsky (NRC KI, Moscow)

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General discussion - 2

Discussion leader
Alexander Zakharov (NRC KI – Alikhanov ITEP, Moscow; JINR, Dubna)

Afternoon session 29/11/2023 / **35**

General discussion - 3

Discussion leader
Oleg Teryaev (JINR, Dubna)

Afternoon session 30/11/2023 / **47**

General discussion - 4

Discussion leader
Vladimir Soloviev (NRC KI - Logunov IHEP)

Afternoon session 1/12/2023 / **59**

General discussion - 5

Discussion leader
V.A. Petrov (NRC KI - Logunov IHEP, Protvino)

Morning session 1/12/2023 / **51**

General solution of the Schrödinger equation

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The wave equation in quantum mechanics and its general solution in the phase space are obtained.

"General solution of the Schredinger equation"
[arXiv:2201.02199v1]

Information on the subject:

M.N.Sergeenko, Semiclassical wave equation and exactness
of the WKB method, Phys. Rev. A, V.53 (1996) P.3798.

M.N.Sergeenko, Relativistic semiclassical wave equation and
its solution, Mod. Phys. Lett. A, V.12 (1997) P.2859.

M.N.Sergeenko, Quantum fluctuations of the angular momentum
and energy of the ground state, Mod. Phys. Lett. A,
V.13 (1998) P.33.

M.N.Sergeenko, Quasiclassical Analysis of the Three-dimensional
Schredinger Equation and its Solution, Mod. Phys. Lett. A,
V.15(2) (2000) P.83.

M.N.Sergeenko, Classical Solution of the Wave Equation,
Int. J. Mod. Phys. A, V.18(17) (2003) pp.3041–3055

Afternoon session 28/11/2023 / **25**

Kerr black holes and massive higher spins

Corresponding Author(s): eugene.d.skvortsov@gmail.com

The recent discovery of gravitational waves calls for developing new techniques to model dynamics of compact binaries.
One of the approaches is to apply effective field theory where a compact and rotating object is modelled by a massive
higher-spin particle interacting with the gravitational field. Kerr black holes were found to feature the most simple interaction
within this paradigm, which gives a hope to find the complete theory describing dynamics thereof without any input from numerical and other approaches. I will present the recent progress in this direction.

Afternoon session 1/12/2023 / **56**

Loop Quantum Gravity and Quantum Information

Corresponding Author(s): ebianchi@psu.edu

Morning session 28/11/2023 / **20**

Mutual dependence of a bosonic black hole with dark matter and explanation of asymptotically flat galaxy rotation curves.

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Dark matter makes itself felt only due to the gravitational interaction. Quanta of ordinary matter in flat space are described by vector fields. Let us assume that the wave function of dark matter quanta is also a vector field. Then it makes sense to find such a vector field in the general theory of relativity, which manifests itself exclusively in curved space-time...(see other details in the articles below)

Information on the subject:
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Vector fields in multidimensional cosmology. Phys. Rev. D84, 064037 (2011) arXiv:1105.4420
2.
Vector fields in multidimensional cosmology. Proceedings of PIRT-2011 Moscow, p.211, (2012)
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Towards the theory of evolution of the Universe. Phys. Rev. D85, 123544 (2012) arXiv:1201.2562
4.
Galaxy rotation curves driven by massive vector fields: Key to the theory of dark sector. Phys. Rev. D87, 103510 (2013) arXiv:1303.7062
5.
Macroscopic theory of dark sector. Physical Interpretation of Relativity Theory Proceedings of International Scientific Meeting PIRT-2013. Moscow: 1-4 July, 2013. p440. Bauman Moscow State Technical University (2013)
6. Macroscopic theory of dark sector. Journ. of Gravity 2014, 586958 (2014)
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Phenomenological description of dark energy and dark matter by vector fields. Physical Interpretation of Relativity Theory. Proceedings of International Scientific Meeting PIRT-2015. Moscow: 29 June - 02 July, 2015. p 384. Bauman Moscow State Technical University (2015)
8.
Description of dark energy and dark matter by vector fields. Proceedings of the Tenth Asia-Pacific International Conference on Gravitation, Astrophysics, and Cosmology. Dedicated to the Centenary of Einstein's General Relativity. p 135 (2016) World Scientific Publishing Co.
9.
Motion in a Central Field with Account of Dark Matter. Gravitation and Cosmology 23(3), 251 (2017)
10. О равновесном состоянии гравитирующего конденсата Бозе-Эйнштейна ЖЭТФ 154(5), 1000 (2018)
11. Static State of a Black Hole Supported by Dark Matter. Universe 5(9), 198 (2019)
12. Black hole in balance with dark matter. International Journal of Modern Physics A35, (2&3), 2040050 (2020)
13. Black Hole and Dark Matter. Phase Equilibrium. J. Phys. CS 1557, 012030 (2020)
14. Guessing the Riddle of a Black Hole. Universe 6(8), 113 (2020)
15. Gravitational Radius in view of Existence and Uniqueness Theorem. J. Phys. CS 2081, 012026 (2021)
16. Bose-Einstein Condensate in Synchronous Coordinates. Phys. Sci. Forum 7, 47 (2023)
17. Черная дыра и темная материя в синхронной системе координат. ЖЭТФ 163(5), 660 (2023)
18.
О гравитационном поле чёрной дыры в синхронной системе координат В книге: Физические интерпретации теории относительности (PIRT-2023) Сборник

Afternoon session 29/11/2023 / **34**

New result from the NA64 experiment

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Thermal dark matter models with particle masses below the electroweak scale can provide an explanation for the observed relic dark matter density. This would imply the existence of a new feeble interaction between the dark and ordinary matter. The main purpose of the NA64 experiment is a search for sub-GeV dark matter production using the method of missing energy signature. The searches are performed at the H4 beam line at the CERN SPS. This beam is mainly designed to pro-

vide 100 GeV electron beam. The analysed statistics corresponds to 9.37×10^{11} electrons on target (EOT) collected during 2016-2022 runs. The analysis of this statistics allowed to probe for the first time the well motivated region of parameter space of benchmark thermal scalar and fermionic dark matter models. Additional statistics of about 6×10^{11} was collected in the 2023 run.

In addition to the main 100 GeV electron-beam measurement, NA64 is also developing a positron-beam program with several runs at different energies, to explore the ~ 100 MeV mediator mass range by exploiting LDM production via resonant e^+e^- annihilation. An early test run already demonstrated the feasibility of the new technique, allowing to set competitive new limits in a limited mass region despite the much lower accumulated statistics.

The variant of the NA64 detector for the searches of DM in the muon beam, called NA64mu, has been developed. It uses part of subdetectors of NA64e and a number of additional subdetectors. The purpose is to search for DM coupled only to second and third generations of leptons,
suggested to explain the (g-2) anomaly and to improve sensitivity in the region of mediator masses above ~300 MeV.

The program of searches for Dark Matter in hadron beams with slightly modified NA64 is been developed. Two test runs have been performed in 2022 and 2023, the analysis of the data is now in progress.

NA64 performed and plans also a number other searches, such as the search for ALP coupled to gammas, search for X boson decaying to electrons, search for mu - tau conversion.

Y. M. Andreev et al. (NA64 Collaboration), Phys. Rev. Lett. 131, 161801 (2023), arXiv:2307.02404 [hep-ex].

Afternoon session 28/11/2023 / **44**

New results on the conformal anomaly and anomaly-induced effective action of gravity

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Trace anomaly is one of the most relevant manifestations of quantum field theory in curved spacetime. It was shown long ago that anomaly is behind such important applications as Hawking radiation from black holes and the full version of the Starobinsky inflationary model. In many cases, such as using conformal anomaly in black hole physics or exploring quantum effects on the gravitational waves in curved space, it is more useful and, in some sense, necessary to work with effective action. In four spacetime dimensions (4D) the relevant forms of anomaly-induced action were derived between 40 and 30 years ago. However, recently we got some new results in this area, including integration of anomaly in 6D and the covariant nonlocal forms of the induced action with external scalar fields and external torsion. On top of that, now we have a better understanding of the ambiguities related to local terms, in both semiclassical theory and conformal quantum gravity.

Information on the subject:

Fabricio M. Ferreira and Ilya L. Shapiro, Integration of
trace anomaly in 6D, Phys. Lett. B772 (2017) 174, arXiv:1702.06892.

Manuel Asorey, Wagno Cesar e Silva, Ilya L. Shapiro, and Publio R.B. do Vale, Trace anomaly and induced action for a metric-scalar background, Eur. Phys. J. C83 (2023) 157, e-Print: 2202.00154.

Guilherme H. S. Camargo and Ilya L. Shapiro, Anomaly-induced vacuum effective action with torsion: covariant solution and ambiguities, Phys. Rev. D106 (2022) 045004, arXiv:2206.02839.

Ilya L. Shapiro, Antisymmetric Tensor Field and Cheshire Cat
Smile of the Local Conformal Symmetry, arXiv:2310.04131.

Afternoon session 30/11/2023 / **42**

Nonlocal gravity. Several aspects

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I review several aspects of nonlocal field theory and nonlocal quantum gravity

Afternoon session 30/11/2023 / **1**

Normalization of the vacuum and the ultraviolet completion of Einstein gravity

Philip Mannheim[1]

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Second-order-derivative plus fourth-order-derivative gravity is the ultraviolet completion of second-order-derivative quantum Einstein gravity. While it achieves renormalizability through states of negative Dirac norm, the unitarity violation that this would entail can be postponed to Planck energies. As we show in this paper the theory has a different problem, one that occurs at all energy scales, namely that the Dirac norm of the vacuum of the theory is not finite. To establish this we present a procedure for determining the norm of the vacuum in any quantum field theory. With the Dirac norm of the vacuum of the second-order-derivative plus fourth-order-derivative theory not being finite, the Feynman rules that are used to establish renormalizability are not valid, as is the assumption that the theory can be used as an effective theory at energies well below the Planck scale. This lack of finiteness is also manifested in the fact that the Minkowski path integral for the theory is divergent. Because the vacuum Dirac norm is not finite, the Hamiltonian of the theory is not Hermitian. However, it turns out to be PT symmetric. And when one continues the theory into the complex plane and uses the PT symmetry inner product, viz. the overlap of the left-eigenstate of the Hamiltonian with its right-eigenstate, one then finds that for the vacuum this norm is both finite and positive, the Feynman rules now are valid, the Minkowski path integral now is well behaved, and the theory now can serve as a low energy effective theory. Consequently, the theory can now be offered as a fully consistent, unitary and renormalizable theory of quantum gravity.

Afternoon session 29/11/2023 / **32**

Odderon-exchange: observations and properties

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Morning session 28/11/2023 / **19**

On a possible explanation of dark matter by means of a gluonic Bose-Einstein condensate in an anti-de Sitter geometry

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The ΛCDM standard model of cosmology involves two dark components of the universe, dark energy, and dark matter. Whereas dark energy is usually associated with the (positive) cosmological

constant Λ associated with a de Sitter geometry, we propose to explain dark matter as a pure QCD effect, namely a gluonic Bose Einstein condensate with the statusof a Cosmic Gluonic Background (CGB). This effect is due to the trace anomaly viewed as an effective negative cosmological constant determining an Anti de Sitter geometry and accompanying baryonic matter at the hadronization transition from the quark gluon plasma phase to the colorless hadronic phase. Our approach also allows to assume a ratio Dark/Visible equal to 11/2.

Information on the subject:

Gilles Cohen-Tannoudji and Jean-Pierre Gazeau, Cold Dark Matter: A Gluonic Bose Einstein Condensate in Anti-de Sitter Space Time Universe 2021, 7, 402

Gilles Cohen-Tannoudji and Jean-Pierre Gazeau, Dark matter as a QCD effect in an anti de Sitter geometry, Cosmogonic implications of de Sitter, anti de Sitter and Poincaré symmetries to appear in Scipost Proceedings.

Gilles Cohen-Tannoudji, Jean-Pierre Gazeau, Célestin Habonimana, and Juma Shabani, Quantum à la Gabor for space-time metric ArXiv 2205/11254v2 [quant-phys]

Gilles Cohen-Tannoudji and Jean-Pierre Gazeau, Scientific cosmogony, the time in quantum relativistic physics, https://hal.science/hal-03538740v2/document

Gilles Cohen-Tannoudji and Jean-Pierre Gazeau, Phénoménotechnique du temps et cosmonie scientifiqueç A paraître dans Etudes Bachelardiennes

Morning session 29/11/2023 / **31**

Overview of recent ALICE results

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The ALICE experiment is dedicated to the studies of the hot and dense QCD medium, the quark-gluon plasma, which can be created in ultrarelativistic heavy-ion collisions at the LHC. In this presentation, we will highlight recent ALICE results from LHC Run 2 that provide an important step towards our understanding of the QCD matter explored with heavy-ion collisions. We will also present latest news on the ALICE performance at the start of LHC Run 3.

As for the list of references, I think it would be appropriate just to mention the recent ALICE review paper:
https://inspirehep.net/literature/2178285

Morning session 28/11/2023 / **16**

Possible manifestations of compact stable dark matter objects in the solar system

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In order to find observable indications for Dark Matter (DM) some possible forms of DM from DM particles (WIMP) to DM planets in the solar system are considered. In particular, a compact DM planet on a specific orbit in the solar system is predicted to be a trigger for the solar dynamo with the 11-year cyclic activity of the Sun. Moreover, gravitational interaction of this compact DM planet with the Sun and other planets of the solar system (especially with Mercury, Venus, Earth, Mars, and Jupiter) leads to explanation of the Maunder minimum and other long-time variations of the solar cycle maxima. This so accurately defines trajectory of the compact DM planet as to open a

possibility to observe this compact DM planet in future due to a specific lensing of the light from some stars at predicted moments of the time.

Information on the subject:

Y E Pokrovsky, Stable Compact Dark Matter Objects in Planetary Systems, Journal of Physics: Conference Series 1557 (2020) 012033

Afternoon session 1/12/2023 / **53**

Quantum Computers

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Quantum computers have the potential for theoretical and experimental high-energy physics. In this talk, I will briefly describe the history of the quantum computers (hardware and software), and discuss how we can use the quantum computer's power for our research for elementary particle physics as Feynman predicted in 1981.

Afternoon session 30/11/2023 / **46**

Quantum Conformality or Asymptotic Safety in Higher Derivative Gravitational Theories

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We present and discuss well known conditions for ultraviolet finiteness and asymptotic safety. The requirements for complete absence of ultraviolet divergences in quantum field theories and existence of a non-trivial fixed point for renormalization group flow in the ultraviolet regime are compared based on the example of a six-derivative quantum gravitational theory in d=4 spacetime dimensions. Here vanishing of beta functions is equivalent to the emergence of conformal symmetry on the quantum level. In this model, it is possible for the first time to have fully UV-finite quantum theory without adding matter or special symmetry, but by inclusion of additional terms cubic in curvatures. We comment on similarities and some apparent differences between the two approaches, but we show that they are both compatible with each other. Some features of conformal theory will be presented as well. Finally, we motivate the claim that actually asymptotic safety needs UV-finite models for providing explicit form of the ultraviolet limit of Wilsonian effective actions describing special situations at conformal fixed points.

Afternoon session 29/11/2023 / **7**

Recent LHCb results on heavy hadron spectroscopy

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The measurements of spectroscopy and decays of hadron states, in particular those formed of heavy quarks, can provide valuable experimental input for QCD. The LHCb detector at the LHC is dedicated

to heavy flavour physics. High luminosity of LHC, high b/c-hadron production cross-section and unique capabilities of LHCb detector in reconstructing heavy hadron decays has unprecedented opportunities for related spectroscopy studies. In the talk the latest results on spectroscopy of b/c-hadron states, including exotic ones, will be reported.

Information on the subject:

https://inspirehep.net/literature/1798040
https://inspirehep.net/literature/1742215
https://inspirehep.net/literature/1960979
https://inspirehep.net/literature/2138845

Afternoon session 29/11/2023 / **33**

Recent results on kaon physics from the OKA experimen

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The talk is devoted to three latest results.

First is a search for the axion like particles in the decay
$K^+ \to \pi^+\pi^0 a$:

A high statistics data sample of the K+ decays is recorded by the OKA collaboration. A missing mass analysis

is performed to search for a light invisible pseudoscalar axion-like particle (ALP) in the decay $K^+ \to \pi^+\pi^0 a$. No signal is observed, the upper limits for the branching ratio of the decay are calculated. The 90% confidence level upper limit is changing from 2.5×10^{-6} to 2×10^{-7} for the ALP mass from 0 to 200 MeV.

Second is $K^+ \to \mu^+\nu g$ decay study and measurement of FV - FA :

A new precise measurement of the vector and axial-vector form factor diff erence FV – FA in the $K^+ \to \mu^+\nu_\mu\gamma$ decay is presented. About 144 K events of $K^+ \to \mu^+\nu_\mu\gamma$ are selected in the OKA experiment.

The result is FV – FA = 0.135 ± 0.017(stat) ± 0.024(syst). The result is considered as preliminary.

The third is $K^+ \to \mu^+\nu\pi^0 g$ decay study.

The $K^+ \to \pi^0\mu^+\nu\gamma(K_{\mu 3\gamma})$ is measured with OKA setup at the RF-separated 17.7 GeV/c momentum kaon beam of the U-70 accelerator. The data corresponds to the flux of 2.62×10^10 «live» kaons entering the decay volume. More than 900 signal events are found with 30-60 MeV energy of the emitted photon in the rest frame of the decaying kaon. Using 4.48×10^6 events of the decay $K^+ \to \pi^0\mu^+\nu(K_{\mu 3})$ the branching ratio Br(Kμ3γ)/Br(Kμ3) is found to be (4.45 ± 0.25(stat)) × 10^{-4}. From this value, using Br($K_{\mu 3}$) = 3.352% we get Br($K_{\mu 3\gamma}$) = (1.492 ± 0.085(stat)) × 10^{-5}. Our result is preliminary, with systematic errors being estimated.

Afternoon session 28/11/2023 / **2**

Regular Black Holes

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Black holes are the natural product of the complete gravitational collapse of matter and today we have a body of observational evidence supporting the existence of these objects in the Universe. However, general relativity predicts that at the center of black holes there are spacetime singularities, where predictability is lost and standard physics breaks down. It is widely believed that spacetime singularities are a symptom of the limitations of general relativity and must be solved within a theory of quantum gravity. Since we do not have yet any mature and reliable candidate for a quantum gravity theory, researchers have studied toy-models of singularity-free black holes and of singularity-free gravitational collapses in order to explore possible implications of the yet unknown theory of quantum gravity. In my talk, I will present some recent models of regular black holes and non-singular gravitational collapses and I will discuss their theoretical and observational implications.

Information on the subject:

https://arxiv.org/abs/2210.05322

This is another paper relevant to my presentation:
https://arxiv.org/abs/2307.12755

Webpage: https://cosimobambi.github.io/

- Editor Springer Series in Astrophysics and Cosmology Webpage: https://www.springer.com/series/17008

Morning session 28/11/2023 / **18**

Results of the Neutrino-4 experiment, sterile neutrinos, dark matter and the Standard Model

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Joint analysis of the results of the Neutrino-4 experiment and the data of the GALLEX, SAGE and BEST experiments confirms the parameters of neutrino oscillations declared by the Neutrino-4 experiment (Δm_14^2= 7.3 eV^2 and sin^2⁡2θ_14 ≈0.36) and increases the confidence level to 5.8σ. Such a sterile neutrino thermalizes in cosmic plasma, contributes 5% to the energy density of the Universe, and can explain 15-20% of dark matter. It is discussed that the extension of the neutrino model by introducing two more heavy sterile neutrinos in accordance with the number of types of active neutrinos but with very small mixing angles to avoid thermalization will make it possible to explain the large-scale structure of the Universe and bring the contribution of sterile neutrinos to the dark matter of the Universe to the level of 27%. This approach to the problem of dark matter means that dark matter can be explained in terms of an extended Standard Model with right-handed neutrinos. An analysis of astrophysical data shows that right-handed neutrinos with a mass less than 7 keV have not yet been disfavored by direct experiments. The dynamic process of the origin of dark matter, consisting of three right-handed neutrinos, is presented. It is shown that, based on modern astrophysical data, it is impossible to draw a definite conclusion in favor of the model of three or four thermalized neutrinos. The influence of lepton asymmetry on the comparison of models of three or four neutrinos is considered. An estimate was made for the upper limit of the lepton asymmetry, in particular for N_ν=3 -0.04<ξ_e<0.04, and for N_ν=4 0.02<ξ_e<0.10. The possibility of the appearance of lepton asymmetry due to CP violation during oscillations into sterile neutrinos is discussed

Information on the subject:

Письма в ЖЭТФ, том 116, вып. 10, с. 644 – 658
с 2022 г. 25 ноября
Результат эксперимента Нейтрино-4 и космологические ограничения на стерильные нейтрино (Миниобзор) А.П.Серебров, Р.М.Самойлов, М.Е.Чайковский, О.М.Жеребцов

The Result of the Neutrino-4 Experiment and the Cosmological Constraints on the Sterile Neutrino
A.P. Serebrov, R.M. Samoilov, M.E.Chaikovskii, O.M. Zherebtsov
https://link.springer.com/article/10.1134/S002136402260224X

Morning session 29/11/2023 / **28**

Results on hadronic flux tube from lattice QCD

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A review of lattice QCD results on the properties of a hadronic flux tube is presented. The results obtained in gluodynamics and QCD at zero and non-zero temperatures are considered. Numerical results are compared with effective string theory predictions.

Morning session 30/11/2023 / **37**

Semi-exclusive cross sections for charged-current quasi-elastic and neutral-current elastic neutrino scattering off 40Ar and a sterile neutrino oscillation study

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Flux-integrated semiexclusive differential cross sections for charged-current quasielastic and neutral-current elastic neutrino scattering on argon are analyzed. The cross sections are calculated using the relativistic distorted-wave impulse approximation and compared with recent MicroBooNE data. It was found that the measured cross sections can be described well within the experimental uncertainties with value of the nucleon axial mass 1<M_A<1.2 GeV.The flux-integrated differential cross sections as functions of reconstructed neutrino energy are evaluated for the far detector of the SBN experiment in Fermilab. The effects of the short base-line neutrino oscillations are taken into account in a 3+1 framework. We found that cross sections depend on oscillation parameters and the ratio of the measured and predicted cross sections can be used in a sterile neutrino oscillation study.

Information on the subject:

1) A.V. Butkevich, Phys.Rev. C105, 025501 (2022); arXiv: 2107.01827
2) A.V. Butkevich, Phys.Rev. D107, 073001 (2023); arXiv: 2212.09300

Afternoon session 30/11/2023 / **6**

Spherically symmetric loop quantum gravity

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We summarize results on spherically symmetric loop quantum gravity, including singularity elimination, Hawking radiation and the Casimir effect.

Information on the subject:

1. R Gambini, J. Olmedo, JP, CQG 31 095009 (2014) arXiv:1310.5996
2. Bambi, Modesto, Shapiro "Handbook of Quantum Gravity" (2023) [gr-qc] 2211.05621
3. R. Gambini, JP, Class.Quant.Grav. 31 (2014) 115003; 1312.3595 [gr-qc]
4. R. Gambini, J. Olmedo, JP arXiv: 1410.4479 CQG 32, 11502 (2015)

Morning session 1/12/2023 / **11**

Standard quantum field theory from entangled relativity

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In this talk, we will explore entangled relativity, a general theory of relativity that offers a more parsimonious approach compared to general relativity when integrated within a quantum field theory framework. Requiring only two universal dimensionful parameters instead of three, entangled relativity retains the key components of general relativity, including a four-dimensional spacetime manifold, a metric tensor representing the mechanical properties of space, inertia, and gravitation, and matter fields generating curvature. The term "entangled" does not directly refer to quantum entanglement but rather emphasizes that matter fields and gravity are intrinsically intertwined and cannot be treated separately at the level of the formulation of the theory. Entangled relativity converges toward, or reduces to, general relativity in most cases but predicts a variable quantum of action ($\hbar$) in response to gravitational phenomena, particularly in dense environments like neutron stars or the early universe. Moreover, one recovers standard quantum field theory in the $\hbar$ constant limit. After presenting and explaining the theory, I will present a few predictions that may become observable in the foreseeable future, and which do not depend on any theoretical parameter.

Information on the subject:

https://arxiv.org/abs/2304.09482
https://arxiv.org/abs/2106.03426
https://arxiv.org/abs/2102.10541
https://arxiv.org/abs/2011.14629
https://arxiv.org/abs/1506.03278
https://arxiv.org/abs/1308.2770

Morning session 30/11/2023 / **39**

Superheavy dark matter in R^2-modified gravity

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Data from the Large Hadron Collider lead to strong constraints on the parameter space of low-energy supersymmetry. In particular, these data practically exclude supersymmetric dark matter (DM) in the traditional cosmology. We argue that in R^2-modified gravity superheavy particles with the interaction strength typical for supersymmetry can be realistic candidates for the role of the carriers of dark matter. For this purpose we examined the heating of the universe at the post-inflationary stage due to decays of the scalaron into several dominant channels and calculated the cosmological density of dark matter. The constraints on the masses of DM particles are obtained for different decay modes. Possible observational manifestations of decays and annihilation of superheavy dark matter particles in the spectrum of high-energy cosmic rays are discussed.

Information on the subject:

1. E.V. Arbuzova, A.D. Dolgov and R.S. Singh,
"Dark matter in $R + R^2$ cosmology,"
JCAP 04 (2019), 014
[arXiv:1811.05399 [astro-ph.CO]].

2. E.V. Arbuzova, A.D. Dolgov and R.S. Singh,
"Superheavy dark matter in $R + R^2$ cosmology with conformal anomaly,"

Eur. Phys. J. C 80 (2020) no.11, 1047
[arXiv:2002.01931 [hep-ph]].

3. E.V. Arbuzova, A.D. Dolgov and R.S. Singh,
"R^2-Cosmology and New Windows for Superheavy Dark Matter,"
Symmetry 13 (2021) no.5, 877

4. E.V. Arbuzova, A.D. Dolgov and A.S. Rudenko,
"Calculations of Scalaron Decay Probabilities,"
Phys. Atom. Nucl. \textbf{86} (2023) no.3, 266-276
[arXiv:2112.11288 [hep-ph]].

5. E.V. Arbuzova, A.D. Dolgov and A.A. Nikitenko,
"Cosmic rays from heavy particle decays,"
[arXiv:2305.03313 [hep-ph]].

Morning session 1/12/2023 / **50**

The Equation of State and Multiple Particle Production

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The connection between the equation of state of fireball
matter produced in collisions of heavy nuclei and the distribution of such fireballs in the net-baryon number is considered on the basis of lattice simulations of QCD at imaginary chemical potential. A particular attention is given to events with great net-baryon numbers. Equations of state are discussed that assume a phase transition with a discontinuity in the net-baryon number density at B1GeV.

Afternoon session 1/12/2023 / **57**

The history of lattice field theory from a statistical perspective

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Researchers working in lattice field theory constitute an
established community since the early 1990s, and around the same time the online open-access e-print repository arXiv was
created. The fact that this field has a specific arXiv section,
hep-lat, provides a unique opportunity for a statistical study of
its evolution over the last three decades.
We present data for the number of entries, E, published papers, P, and citations, C, in total and separated by nations. We compare them to 6 other arXiv sections, (hep-ph, hep-th, gr-qc, nucl-th, quant-ph, cond-mat), and to socio-economic indices of the nations involved, namely the Gross Domestic Product (GDP) and the Education Index (EI).
We present rankings, which are based either on the Hirsch Index H, or on the linear combination Sigma = E + P + 0.05 C. We consider both extensive and intensive national statistics, i.e. absolute and relative to the population or to the GDP.

Morning session 29/11/2023 / **29**

The state-of-the-art covariant tetraquark equations

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We present exact yet practical covariant equations of quantum field theory describing a tetraquark in terms of a mix of four-quark and two-quark states. A feature of our approach is that it avoids the overcounting problems that usually plague quantum field theory formulations of few-body covariant equations (the only exception being the two-body Bethe-Salpeter equation).
Although the model chosen in the current work describes the four-quark dynamics in terms of meson-meson and diquark-antidiquark states, the derived equations have a form that is exact, as all corrections due to the use of a particular model are taken into account through the use of a well-defined special four-point amplitude Δ entering the equations. The equations are in agreement with those obtained previously by consideration of disconnected interactions [Phys.Rev.D 90 (2014) 4, 045042]; however, despite being more general, they have been derived here in a much simpler and more transparent way.
As an example of the universality of our formulation we show, that it is able to unify seemingly unrelated models of the tetraquark, like, for example, the model of the Moscow group [Universe 7, 94 (2021)] and the coupled channel
model of the Giessen group [Phys. Lett. B 718, 545 (2012)].

Information on the subject:

1. Phys.Rev.D 107 (2023) 9, 094014,
2. Phys.Rev.D 106 (2022) 5, 05402,
3. e-Print: 2102.05818 [hep-ph],
4. Phys.Rev.D 105 (2022) 3, 034025

Morning session 1/12/2023 / **48**

The theory of gravity in the limit of Newton's constant tending to zero

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Morning session 29/11/2023 / **27**

Theory of the deconfinement process in QCD

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In this talk we will discuss the temperature dependence of color-magnetic confinement and color-electric confinement in gluodynamics and QCD. In the first case, it will be shown that the spatial string tension in gluodynamics, which is responsible for the color-magnetic confinement, can be calculated from two-gluon gluelump's Green function, both for high and low temperatures. . In the case of color-electric confinement, the possibility of obtaining the behavior of string tension, quark condensate and other parameters will be discussed. This picture will be based on the field correlator method, which takes into account the contribution of the gluon condensate to the free energy of hadrons.

Morning session 30/11/2023 / **41**

Top quark physics

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The current state of top quark physics is considered. The main
experimental results obtained at the Large Hadron Collider (LHC) are summarized.

Morning session 28/11/2023 / **15**

Towards observation of dark matter

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Afternoon session 1/12/2023 / **54**

Wavefunction as a Concrete Object

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In his book Something Deeply Hidden Sean Carroll defends the Everettian concept of a branching multiverse and in doing so makes some contradictory statements about the nature of the quantum wavefunction. He writes: "What the World Is Made Of: a quantum wave function" and "wave functions are superpositions of different possibilities" and "Wave functions may be real but they're undeniably abstract". How can our concrete environment be made of something abstract? How can physical objects be constituted by possibilities? Many Worlds theory has been haunted by the tension between wave functions understood as mathematical objects and wavefunction understood as physical stuff. I describe a recent approach to this problem which involves applying set theory to physics in a novel way. In the 1960s the logician Willard Quine demonstrated that sets need not be thought of as necessarily abstract, non-spatiotemporal objects. A particular type of set can be construed as concrete. It turns out that Quine's idea can be built on to provide a settheoretic interpretation of quantum indefiniteness. The components of a superposition can be understood to be its subsets. Each subset is a set of objects in the same definite state and different subsets have set-theoretic elements in different definite states. The universal wavefunction is interpreted as a set of universes, each of which instances a different configuration of particles and/or fields. Unitary evolution is the partitioning of wavefunction. The talk will be based on a paper to be found at https://arxiv.org/abs/2309.14004

Morning session 28/11/2023 / **17**

• Opening address