International Conference on Particle Physics and Cosmology
dedicated to memory of Valery Rubakov

Book of Abstracts

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Contents

Abstracts

Entanglement islands and black holes

Dmitry Ageev
SMI

Entanglement islands is recently discovered phenomena which is a candidate for resolution of black hole information paradox. In this talk we discuss the appearance of entanglement islands in different types of black holes and their response to the introduction of boundaries surrounding the black hole geometry. Also we discuss how the entanglement islands could be seen in the cosmological inflation geometries.

On the strong coupling problem in cosmologies with "strong gravity in the past"

Julia Ageeva
INR

This study is devoted to the classical cosmological solutions without initial singularity in scalar-tensor theories of gravity (Hordeski theory). Non-singular epochs of the early Universe such as genesis and bouncing Universe were constructed in a certain subclass of the Horndeski theory. Considered solutions are stable at all times, and perturbations propagate subluminally. Moreover, we show that in a specific range of lagrangian parameters there is no strong coupling regime in the constructed models at early times, i.e. the classical field theory description is applicable. For the analysis of strong coupling problem we used naive dimensional analysis. However, this naive dimensional analysis may sometimes badly fail in estimating the strong coupling scale. Indeed, using the example of the bouncing Universe, which is conformally related to some simple inflation model, we show that the dimensional analysis of the strong coupling problem does not always give the correct answer. For an appropriate inflationary scalar potential, the Einstein frame picture guarantees that there is no strong coupling problem, i.e., the classical treatment of the background is fully legitimate. We will see that, on the other hand, the naive dimensional analysis in the Jordan frame would show the opposite. This is the problem of the naive dimensional analysis, however: our direct calculation of tree level amplitude in the Jordan frame shows strong cancellations yielding consistency with the Einstein frame inflationary considerations. Therefore, it is necessary to use more accurate analysis of the strong coupling problem using diagrams techniques and unitarity bounds. Finally, as an interesting and helpful example in the cosmological context, the unitarity relations and unitary bounds were found in a theory that contains scalar fields with different sound speeds.

Novel channels with the Glashow resonance

Ibragim Alikhanov
NCFU

The Glashow resonance is a rapid enhancement of the cross section for scattering of electron antineutrinos on electrons at the W boson production threshold due to the s-channel contribution. The relatively small neutrino flux in the PeV region reaching the Earth together with the necessity of analyzing ultra-high-energy final states make such searches challenging and the resonance is not still observed experimentally. Such an observation would be an important test of the neutrino sector of Standard Model. We point out the existence of additional channels in which the resonance manifests itself. These channels could be complementary to the searches currently carried out or planned in the future at kilometer-scale water/ice neutrino detectors, such as IceCube, KM3NeT and Baikal-GVD.

Standard model at Large Charge

Oleg Antipin
RBI

Quantum field theories with global symmetries simplify considerably in the large-charge limit allowing us to compute correlators via a semiclassical expansion in the inverse powers of the conserved charges. We employ the large-charge expansion to calculate the scaling dimension of the lowest-lying operators carrying U(1) charge Q in the critical Abelian Higgs model in $D = 4 - \epsilon$ dimensions to leading and next-to-leading orders in the charge and all orders in the ϵ expansion. Remarkably, the results match our independent diagrammatic computation of the three-loop scaling dimension of the operator φ^Q in the Landau gauge. We argue that this matching is a consequence of the equivalence between the gauge-independent dressed two-point function of Dirac type with the gauge-dependent two-point function of $\varphi^Q(x)$ in the Landau gauge. We, therefore, shed new light on the problem of defining gauge-independent exponents which has been controversial in the literature on critical superconductors, as well as lay the foundation for large-charge methods in gauge theories. Generalisations to Standard Model will be discussed at the end.

Parton distribution functions in QED

Andrej Arbuzov
JINR

A solution of the next-to-leading order DGLAP evolution equations in pure QED is presented. Higher-order perturbative results for unpolarized electron PDFs and fragmentation functions are shown explicitly. Relations between QED and QCD PDFs are discussed. The results are process independent, they are relevant for future high-precision experiments at electron-positron colliders as well as for studies of muon-electron scattering, muon decay spectrum etc.

Curvature oscillations in modified gravitational baryogenesis and high energy cosmic rays

Elena Arbuzova
DSU & NSU

The instability problem of the gravitational baryogenesis (GBG) is analysed. It is shown that the explosive growth of the curvature scalar, inherent to GBG, can be terminated by introducing the R^2-term into the classical action of General Relativity. As a result, the exponential rising curvature is transformed into a quickly oscillating one. The high-frequency curvature oscillations lead to the production of energetic particles which, according to the estimates presented, could make a noticeable contribution to high energy cosmic rays.

Sub-GeV dark matter search at ILC beam dumps

Kento Asai
U of Tokyo

Light dark matter particles may be produced in electron and positron beam dumps of the International Linear Collider (ILC). We propose an experimental setup to search for such events, the Beam-Dump eXperiment at the ILC (ILC-BDX). The setup consists of a muon shield placed behind the beam dump, followed by a multi-layer tracker and an electromagnetic calorimeter. The calorimeter can detect electron recoils due to elastic scattering of dark matter particles produced in the dump, while the tracker is sensitive to decays of excited dark-sector states into the dark matter particle. We study the production, decay and scattering of sub-GeV dark matter particles in this setup in several models with a dark photon mediator. Taking into account beam-related backgrounds due to neutrinos produced in the beam dump as well as the cosmic-ray background, we evaluate the sensitivity reach of the ILC-BDX experiment. We find that the ILC-BDX will be able to probe interesting regions of the model parameter space and, in many cases, reach well below the relic target.

Non-abelian fermionic T-duality in supergravity

Lev Astrakhantsev

MIPT

Field transformation rules of the standard fermionic T-duality require fermionic isometries to anticommute, which leads to complexification of the Killing spinors and results in complex valued dual backgrounds. We generalize the field transformations to the setting with non-anticommuting fermionic isometries and show that the resulting backgrounds are solutions of double field theory. We give explicit examples of non-abelian fermionic T-duals such as Minkowski space, D-brane and fundamental string. Some of our examples can be bosonic T-dualized into usual supergravity solutions, while the others are genuinely non-geometric.

Shrouded black holes in Einstein-Gauss-Bonnet gravity

Eugeny Babichev

IJCLab

I present black holes in a modified gravity scenario involving a scalar field quadratically coupled to the Gauss-Bonnet invariant. The scalar is assumed to be in a spontaneously broken phase at spatial infinity due to a bare Higgs-like potential. For a proper choice of sign, the non-minimal coupling to gravity leads to symmetry restoration near the black hole horizon, prompting the development of the scalar wall in its vicinity. The wall thickness depends on the bare mass of the scalar and can be much smaller than the Schwarzschild radius. In a weakly coupled regime, the quadratic coupling to the Gauss-Bonnet invariant effectively becomes linear, and no walls are formed. Cosmological implications of the model are discussed and it is shown that the model is fully consistent with the existence of an inflationary stage, unlike the spontaneous scalarization scenario assuming the opposite sign of the non-minimal coupling to gravity. Our model predicts the speed of gravitational waves to be extremely close to unity, – in a comfortable agreement with the observation of the GW170817 event and its electromagnetic counterpart.

Radiation Emission during the Erasure of Magnetic Monopoles

Maximilian Bachmaier

LMU & MPP

I will present our study on the interactions betweent Hooft-Polyakov magnetic monopoles and the domain walls formed by the same order parameter within an SU(2) gauge theory. We observe that the collision leads to the erasure of the magnetic monopoles, as suggested by Dvali, Liu, and Vachaspati. The domain wall represents a layer of vacuum with un-HiggsedSU(2) gauge symmetry. When the monopole enters the wall, it unwinds, and the magnetic charge spreads over the wall. We perform numerical simulations of the collision process and in particular analyze the angular distribution of the emitted electromagnetic radiation. As in the previous studies, we observe that erasure always occurs. Although not forbidden by any conservation laws, the monopole never passes through the wall. This is explained by entropy suppression. The erasure phenomenon has important implications for cosmology, as it sheds a very different light on the monopole abundance in post-inflationary phase transitions and provides potentially observable imprints in the form of electromagnetic and gravitational radiation. The phenomenon also sheds light on fundamental aspects of gauge theories with coexisting phases, such as confining and Higgs phases. The results of the numerical simulations can be found in the following video: https://youtu.be/JZaXUYikQbo

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Astrophobic QCD axion.

Marcin Badziak

U of Warsaw

In minimal models of the QCD axion that solve the strong CP problem the axion decay constant is constrained to be above $O(10^9)$ GeV due to astrophysical constraints from the observation of the neutrino burst in SN1987A and the cooling of neutron stars. Such large values of the axion decay constant exclude a possibility to discover axions in near-future helioscopes such as IAXO and do not allow to explain the observed baryon asymmetry via minimal axiogenesis. I will present models of so-called astrophobic QCD axion in which astrophysical constraints are relaxed and allow for the axion decay constant as small as $O(10^7)$ GeV. I will discuss implications of such models for axion dark matter and axiogenesis and possible experimental probes of astrophobic axions.

All-sky limits on Sterile Neutrino Galactic Dark Matter

Vladislav Barinov

INR

Dark matter sterile neutrinos radiatively decay in the Milky Way, which can be tested with searches for almost monochromatic photons in the X-ray cosmic spectrum. We analyse the data of the SRG/ART-XC telescope operated for two years in the all-sky survey mode. With no significant hints in the Galactic diffuse X-ray spectrum we explore models with sterile neutrino masses in the 12-40 keV range and exclude corresponding regions of sterile-active neutrino mixing. We also discuss the limits that can be obtained in the framework of the correlation analysis and data from other X-ray telescopes.

Valery Rubakov and quantum cosmology: origin of the Universe

Andrei Barvinsky

LPI

This talk is a tribute to Valery Rubakov for his early devotion to quantum cosmology, which has led him to becoming one of the pioneers of the tunneling cosmological wavefunction and the concept of baby universes in Euclidean quantum gravity. This scope of ideas, which can be regarded as a predecessor of modern inflationary cosmology, was initiated already during his student years as a derivation of the quantum matter Schroedinger equation from the famous Wheeler-DeWitt equation in quantum cosmology. Later it found incarnation in the form of the no-boundary cosmological wavefunction and further amounted to the microcanonical density matrix of the Universe as a source of initial conditions for inflationary evolution. So I will focus in the talk on this latter concept, the way how it resolves the paradoxes of the tunneling and no-boundary prescriptions, leads in the model populated by numerous conformal fields to the subplanckian quasi- thermal state preceeding the stage of inflation and intertwines with the ideas of Higgs inflation.

Towards decoding the nature of Dark Matter

Alexander Belyaev
U of Southampton

The nature of Dark Matter (DM) is one of the greatest puzzles of modern particle physics and cosmology. Although overwhelming observational evidence from galactic to cosmological scales point to the existence of DM, after decades of experimental effort only its gravitational interaction has been experimentally confirmed. Currently, we do not have any clue on DM properties, such as its spin, mass, interactions other than gravitational, symmetry responsible for its stability, number of states associated with it, and possible particles that would mediate the interactions between DM and the Standard Model particles. Dark Matter exploration in collider and non-collider experiments requires systematic and consistent theoretical approach. Therefore we suggest the classification of Dark Matter models with mediator multiplets of different spins charged under the weak group. We also suggest a new class of models - Fermionic Portal Vector Dark Matter (FPVDM) which extends the Standard Model with SU(2) dark gauge sector. FPVDM has many important implications for DM direct and indirect detection experiments, relic density and collider searches. Examples of DM models from the suggested classification will be discussed together with the prospects for current and future collider and non-collider experiments to test them. The main point which will be argued in this talk is that systematic classification of DM models and their signatures creates a solid ground for the discovery of DM and its identification in the near future.

Matter, dark matter and antimatter in the Universe and the origin of antinuclei in cosmic rays

Zurab Berezhiani
U L'Aquila & LNGS

There may exist B-L violating interactions which can be at the origin of baryon asymmetry both in the visible and dark sectors in the early universe, and they can also induce the mixing phenomena of the neutral ordinary particles with dark particles. I discuss how such interactions can produce antinuclei in the present universe. In fact, AMS-2 experiment has detected eight antihelium candidates and can be explained by this mechanism which also suggests that the heavier antinuclei as anticarbon or antioxygen may also exist in cosmic rays.

Metastable cosmic strings

Wilfried Buchmueller
DESY

Many symmetry breaking patterns in grand unified theories (GUTs) give rise to cosmic strings that eventually decay when pairs of GUT monopoles spontaneously nucleate along the string cores. These strings are known as metastable cosmic strings and have intriguing implications for particle physics and cosmology. We discuss the current status of metastable cosmic strings, with a focus on possible GUT embeddings and connections to inflation, neutrinos, and gravitational waves (GWs). If the underlying symmetry breaking scale is close to the GUT scale, the resulting GW spectrum can be accessible at current ground-based interferometers as well as at future space-based interferometers, such as LISA, and at the same time account for the signal in the most recent pulsar timing data sets.

Stochastic relaxation of the electroweak scale

Aleksandr Chatrchyan
DESY

Light scalar fields, such as axions, can play an important role in cosmology. In this talk I will discuss the mechanism of cosmological relaxation of the electroweak scale, which provides a dynamical solution to the Higgs mass hierarchy problem. In the simplest model, the Higgs mass is scanned during inflation by a light field, the relaxion, whose slow-roll dynamics selects a naturally small Higgs vev. We revisit the original proposal and investigate the mechanism in a regime where the relaxion is subject to large fluctuations during inflation. We investigate the role of fluctuations for transitions between the local minima of the potential and derive a new stopping condition for the relaxion. We investigate the consequences both for the QCD relaxion and the strong CP problem, as well as for non-QCD models. We identify a new region of the parameter space where the stochastic misalignment of the relaxion from its local minimum due to fluctuations can naturally explain the observed dark matter density in the universe.

Phase transitions between confinement and higgs phases in $\mathcal{N} = 1$ $SU(N_c)$ SQCD with $1 \leq N_F \leq N_c - 1$ quark flavors

Victor Chernyak
BINP

Considered is 4-dimensional $\mathcal{N} = 1$ supersymmetric $SU(N_c)$ QCD (SQCD) with $1 \leq N_F \leq N_c$ quark flavors with masses $m_{Q,i}$ in the bi-fundamental representation. **The gauge invariant order parameter ρ is introduced distinguishing confinement (with $\rho = 0$) and higgs (with $\rho \neq 0$) phases**.

Using a number of independent arguments for different variants of transition between the confinement and higgs regimes in these theories, it is shown that **transitions between these regimes are not crossovers but the phase transitions**.

In [3] the very special $SU(N_c)$ QCD theory with $N_F = N_c$ defective scalar "quarks" in the unitary gayge, $\Phi^i_\beta = \delta^i_\beta(|v| = \text{const} > 0)$, $i, \beta = 1, ..., N_F = N_c$, was considered by E.Fradkin and S.H.Shenker. The conclusion of [3] was that **the transition between the confinement at $0 < |v| \ll \Lambda_{QCD}$ (according to [3] and higgs at $|v| \gg \Lambda_{QCD}$ regimes is the analytic crossover**. And although the theory considered in [3] was very specific, the experience shows that up to now there is a widely spread opinion that this conclusion has general applicability.

This model [3] is criticized as incompatible with and very different from the standard non-SUSY $SU(N_c)$ $N_F = N_c$ QCD theory with standard scalar quarks ϕ^i_β with all $2N_c^2$ their physical degrees of freedom. It is emphasized that this model [3] is really **the Stuckelberg $SU(N_c)$ YM-theory with no dynamical electric quarks and massive all $N_c^2 - 1$ electric gluons with fixed by hands nonzero masses. There is no genuine confinement in this theory, it stays permanently in the completely higgsed by hands phase only. And this is a reason for a crossover in this theory**. While in the theory with standard scalar quarks **there is the phase transition between the confinement and higgs regimes**.

Besides, the arguments presented in [5] by K.Intriligator and N.Seiberg for the standard direct $SU(N_c)$, $N_F = N_c$ $\mathcal{N} = 1$ SQCD in support of the crossover from [3] are criticized as erroneous.

Non-perturbative probability distribution function for cosmological counts in cells

Anton Chudaykin
U of Geneva

We study the one-point probability distribution function (PDF) for matter density averaged over spherical cells. The leading part to the PDF is defined by spherical collapse dynamics, whereas the next-to-leading part comes from the integration over fluctuations around the saddle-point solution. The latter calculation receives sizable contributions from short modes and must be renormalized. We propose a new approach to renormalization by modeling the effective stress-energy tensor for short perturbations. The model contains three free parameters. Two of them are

related to the counterterms in the one-loop matter power spectrum and bispectrum, one more parameterizes their redshift dependence. This relation can be used to impose priors in fitting the model to the PDF data. We confront the model with the results of high-resolution N-body simulations and find excellent agreement for cell radii $r < 10$ Mpc/h at all redshifts down to $z = 0$. Discrepancies at a few per cent level are detected at low redshifts for $r \geq 10$ Mpc/h and are associated with two-loop corrections to the model. Keywords: Large-scale structure of the universe, cosmological perturbation theory, cosmological parameters

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B_c-mesons decays in the SM

Anna Danilina
MSU

TBA

Status of sterile neutrino searches

Mikhail Danilov
LPI

There are several experimental indications of sterile neutrinos with a mass of about one eV. These are the most statistically significant laboratory indications of New Physics beyond the Standard Model. However, there are also strong limits on the parameters of these hypothetical particles. The status of experimental searches for sterile neutrinos with masses of about one eV will be presented.

Testing universal dark-matter caustic rings with galactic rotation curves

Daniil Davydov
INR

Infall of cold dark matter on a galaxy may result in caustic rings where the particle density is enhanced. They may be searched for as features in the galactic rotation curves. Previous studies suggested the evidence for these caustic rings with universal, that is common for different galaxies, parameters. Here we test this hypothesis with a large independent set of rotation curves by means of an improved statistical method. No evidence for universal caustic rings is found in the new analysis.

Self-similar growth of Bose stars

Anton Dmitriev
INR

We analytically solve the problem of Bose star growth in the bath of gravitationally interacting particles. We find that after nucleation of this object, the bath is described by a self-similar solution of the kinetic equation, which is an attractor. Together with the conservation laws, this fixes mass evolution of the Bose star. Our results explain slowdown of the star growth at a certain "core-halo" mass, but also predict formation of the heavier and lighter objects in magistral dark matter models.

The effects of the birth of particles in the field of waves of high intensity.

Ekaterina Dmitrieva
INR

We study the process of masive particle production in a plane wave of massless field of high intensity, in a toy model of two interacting scalar fields. We solve the Heisenberg equation for quantum amplitudes, and find resonantly growing solution similar to parametric resonance. We complement the study of A.Arza (PhysRevD.105.036004) in which only the case of small masses has been considered, extending to the case of arbitrary masses. We present the instability threshold for the plane wave amplitude depending on the mass. It turns out that the threshold amplitude grows with the mass but is still finite. We have shown that the particle production effect is also observed outside the low-mass approximation.

Lifting tension of HST and JWST data with conventional cosmology by PBHs

Alexander Dolgov
NSU & JINR

It is argued that observations of well developed galaxies and quasars in the very young universe can be explained by their seeding with massive primordial black holes (PBHs). The model of creation of such PBHs is presented. The suggested mechanism predicts, as a by-product, possible existence of antimatter in the Galaxy.

Yang-Mills glueballs as closed rotating strings

Sergei Dubovsky
NYU

TBA

Saturons

Gia Dvali
LMU & MPI

We review physics and cosmology of saturons – the QFT object with maximal microstate degeneracy.

Axion-like particle dark matter: Beyond the standard paradigm

Cem Eröncel
ITU

Axions and axion-like particles (ALPs) are among the most popular candidates that explain the origin of the mysterious dark matter. The most popular ALP production mechanism studied in the literature is the misalignment mechanism, where an ALP field with a quadratic or cosine potential has negligible kinetic energy initially, and it starts oscillating when its mass becomes comparable to the Hubble scale. Recently, there has been an interest in models that go beyond the standard assumptions. These models not only extend the ALP dark matter parameter space, but also provide a rich phenomenology which is absent in the standard scenario. In particular, the ALP fluctuations grow exponentially via parametric resonance and tachyonic instabilities. In this talk, after giving an overview of the alternative production mechanisms, I will discuss the observational consequences of this exponential growth and show that a sizable region of the ALP parameter space becomes testable even if ALPs have only gravitational interactions.

Colour structure of three-reggeon cuts in QCD

Victor Fadin

BINP

The pole Regge form of QCD amplitudes with gluon quantum numbers in cross-channels and negative signature, which underlies the BFKL approach to the theoretical description of semi-hard processes, is violated in the next-to-next-to-leading logarithmic approximation by contributions of three-reggeon cuts. The presence of a colour quantum number and gluon reggeization makes structure of Regge cuts in QCD different from the structure of the cuts in the old (before QCD) theory of complex angular momenta. In this talk the colour structure of three-reggeon cuts is analyzed.

Suppression exponent for multiparticle production in $\lambda\varphi^4$ theory

Bulat Farkhtdinov

INR & MIPT

We consider the creation of $n \gg 1$ scalar bosons from a few-particle collision in the (3+1)-dimensional $\lambda\varphi^4$ theory without spontaneous symmetry breaking. When coupling λ is weak, probabilities of these processes can be calculated in the limit of fixed λn using the semiclassical method of singular solutions. We numerically implemented this method and, for the first time, obtained reliable results for probabilities in the region of an exceptionally large number of particles in the final state $\lambda n \gg 1$, where probabilities decrease exponentially with growth of n. The exponent depends linearly on n, and its slope depends on the average kinetic energy ϵ of the created particles. In the opposite limit of $\lambda n \ll 1$, our numerical data agree with the known tree-level results, and data in the region $\lambda n \sim 1$ interpolate between these two limits. Overall, this proves exponential suppression of the multiparticle production probability at $n \gg 1$ and arbitrary ϵ in the unbroken theory.

Possible stable sexaquark

Glennys Farrar

NYU

I will discuss recent developments concerning the possible existence of an absolutely stable or extremely long-lived, spin-0 hadron composed of *uuddss* quarks (sexaquark, S), which may be a component of dark matter. A new variational approach to calculating hadron masses allowing for spatially varying chilral symmetry breaking, developed in collaboration with G. Baym, will be described. Evidence for two narrow 1^- states produced in $e^+e^- \to$ hadrons, at about 4.2 and 4.4 GeV, and a hint of a third at 4.1 GeV revealed by analysis with C. Yuan and Q. Li of BES III precision measurements of $e^+e^- \to \mu^+\mu^-$, but having a much smaller signal in $e^+e^- \to$ detected hadrons will be reported. As time permits, I will also report on a search for exotic isotopes – bound states of S and atomic nuclei – with J. Eiler and constraints from direct detection experiments.

Real-time path integral for semiclassical description of evaporating black holes

Maxim Fitkevich

INR & MIPT

Talk is based on ongoing research including results of paper 2202.00023 [gr-qc] Black bounces and remnants in dilaton gravity We propose a family of dilaton gravity models possessing bouncing solutions with interiors connecting separate asymptotically flat regions. We demonstrate that inner Cauchy horizons are stable given certain initial conditions. We study causal structure and evaluate thermodynamic properties of black bounces using Euclidean methods. Extremal bounces have zero temperature and can be considered as remnants. We speculate that quantum fluctuations can dissolve event horizons in the case of black bounces, providing a possible resolution to the information paradox.

Conformal gauge gravity and hyperdynamos from torsion trace.

Luiz Garcia de Andrade
UERJ

In this paper we take into account the spontaneously broken electroweak (EW) phase by torsion trace given by Kleinert to generalised the hypemagnetic abelian symmety analogous to the EM group U(1) and investigate the dynamo action in these fields. The non-minimal trace torsion coupling is used in the Kleinert lagrangean. Actually the torsion potential is also a conformal factor of the metric. By analogy with cooper pairs from W-gauge bosons in the Einstein-Cartan gravity, we make the analogous U(1), are shown to be given by $B_W \sim m_W^2 e^{-\tau}$. Here, τ represents the chiral torsion potential. If torsion potential is left handed, or negative, it drives a dynamo amplification which reaches 10^8. This estimate is the well-known dynamo amplification, which is able to seed galactic dynamo. Of course, when the torsion potential of the torsion trace vector vanishes the torsionless Enqvist-Olesen result is recovered. Since torsion trace vector is in general linked to gauge bosons as axial torsion is associated to fermions, it seems that the present study could be applied to the recent Cao H. Nam s idea of using Einstein-Cartan portal to produce dark gauge bosons mediated by torsion and dileptons, to include primordial magnetic fields.

False vacuum decay around a black hole

Ratmir Gazizov
MSU

We perform a numerical semiclassical calculation of the decay probability of the false vacuum for a field with a toy potential in the Schwarzschild metric, taking into account the radiation of a black hole and the environment. The calculation method is based on solutions of the classical field equations on a specific contour in the complex plane. The action of such classical solutions makes it possible to obtain the value of the coefficient of exponential suppression of the decay probability.

Muon pair production via the photon fusion at the LHC: weak interaction corrections.

Sergey Godunov
LPI

Analytical formulas describing the correction due to the Z boson exchange to the cross section of the reaction $pp \to p\mu^+\mu^- X$ are presented. When the invariant mass of the produced muon pair $W \geq 150$ GeV and its total transverse momentum is large, the correction is of the order of 20%.

Geometric ways of modifying gravity

Alexey Golovnev
BUE

I will present a brief overview of recent advances in teleparallel and symmetric teleparallel approaches to modified gravity, their interesting features and severe problems associated with them. Then I will also discuss the geometric pictures behind and some controversies around.

Pulsar timing signals from an innverse phase transition in the early Universe

Dmitry Gorbunov
INR

TBA

Primordial black holes from supercooled phase transition

Yann Gouttenoire
Tel Aviv U

Cosmological first-order phase transitions (1stOPTs) are said to be strongly supercooled when the universe undergoes a vacuum-domination stage ended by percolation. The statistical variations in bubble nucleation histories imply that distinct causal patches percolate at slightly different times. Patches which percolate the latest undergo the longest vacuum-domination stage and as a consequence develop large over-densities triggering their collapse into primordial black holes (PBHs). Supercooled 1stOPTs which take more than 12% of a Hubble time to percolate produce observable PBHs.

Acceleration and Black Hole Thermodynamics

Ruth Gregory
KCL

Black hole thermodynamics is at the intersection of gravity and quantum field theory. I will show how one can extend thermodynamics to non-isolated black holes, looking at accelerating black holes. This leads to some interesting new solutions in 3 dimensional gravity.

Hubble tension, modified gravity and satellite testing General Relativity

Vahe Gurzadyan

AANL

The Hubble tension will be discussed within weak-field modified General Relativity with a cosmological constant. It enables to describe the tension as a result of local and global flows, thus indicating possible genuine difference in the late (local) and early (global) Universe. The recent laser ranging satellite experiments to test the General Relativity also will be reviewed.

Topologically Quantized Black Hole

S. Habib Mazharimousavi

EMU

We present a new version of the Schwarzschild solution that involves an intrinsically discrete structure apt for quantization. Our method is the harmonic mapping of the unit sphere (S^2) into itself. This explains the areal quantization whereas the energy quantum derives from the energy of the harmonic map. Likewise, all thermodynamical quantities are naturally quantized at lower orders.

Recent results on a machine learning approach to event position reconstruction in the DEAP-3600 Dark Matter Search Experiment

Aidar Ilyasov

NRC KI & NRNU MEPhI

Machine learning is increasingly being applied in elementary particle physics, and the DEAP-3600 dark matter detector is no exception. One application of the new algorithm is the event position reconstruction in the detector. Here, we present updated results on the application of a fully-connected neural network for quality improvement. We also describe the structure of the neural network, its changes from the previous version, and a comparison with existing event position reconstruction algorithms.

Oscillations of sub-GeV neutrinos in matter.

Ara Ioannisyan

YerPhI

We uncover several physical properties of oscillations of sub-GeV atmospheric (anti)neutrinos inside the Earth. In that energy range, the oscillations are very fast, far beyond the resolution of modern neutrino detectors. After averaging over fast oscillations, in the "averaged" oscillation probabilities the CP violation odd term does not wash out. The "averaged" oscillation probabilities contain the constant term and the oscillated term, dependance on the azimuthal angle of neutrino motion. The last one, for some combinations of neutrino mixing angles, depends only on odd term of the CP violation. We discuss a possibility to extract CP violation phase from sub-GeV athmosperic neutrinos at HyperKamiokande.

Generalized Wigner operators and massless relativistic fields

Alexey Isaev

JINR & MSU

We introduce and study the generalized Bargmann-Wigner operators. By definition, such operators transforms Wigner wave functions, which form the space of an induced irreducible representation of the four-dimensional Poincaré group, into local relativistic fields. In massive case, these fields automatically satisfy Dirack-Pauli-Fierz equations. The case of the massless irreps (infinite spin irreps and integer helicity irreps) of the Poincaré group is considered in detail.

Model of inflation without singularity

Rinat Kagirov

INR

The study explored the possibility of constructing cosmological models of Inflation without initial singularity. The main focus was on the model of a closed Universe, which has a constant radius in the asymptotic past and undergoes Inflation in the future, leading to a Universe dominated by a massless scalar field ('kination'). This evolution is an analog of the Genesis model with an inflationary exit but in a closed Universe. The key feature of the examined model is the absence of the Null Energy Condition (NEC), allowing the use of the simplest quadratic subclass of the Horndeski theory. This subclass essentially represents a scalar field with an unusual kinetic term and General Relativity. By employing the Horndeski theory framework for a closed Universe, it was demonstrated that the model remains stable at all times, meaning there are no ghosts or gradient instabilities. Furthermore, the spectrum of scalar perturbations was numerically determined, which is crucial as it corresponds to observable data.

New Physics at NICA

Dmitrii Kalashnikov
INR

We investigate NICA perspectives in searches for light new physics particles, up to few 100 MeV. We consider models with pseudoscalar axionlike particles and dark photons with couplings to photons and leptons. At NICA energies NP particles decay inside the detector volume but can travel macroscopic distances. This can be used as a signal with secondary vertex. Aim of this work is to illustrate capabilities of the NICA experiment after it's modification with ITS. Which provides a tool to distinguish primary and secondary verities.

Status of UV divergences in maximally supersymmetric theories

Renata Kallosh
Stanford U

Maximally supersymmetric Yang-Mills quantum field theories in $d > 4$ are UV divergent but UV finite in $d = 4$. Maximally supersymmetric gravitational field theories in $d > 4$ are UV divergent. In $d = 4$ there are supergravities with "enhanced" cancellations of UV infinities. These cases support a possibility that maximal supergravity in $d = 4$ might be perturbatively UV finite if there are no anomalies. Future loop computations will either discover these anomalies or support UV finiteness.

Non-renormalizable interactions:

Dmitry Kazakov
BLTP JINR

I will present a novel view on non-renormalizable interactions and suggest how one can proceed to get unambiguous predictions for the S-matrix elements and for effective potential. Some particular examples including gauge and scalar field theories will be considered.

Recent results and prospects of the NA62 experiment at CERN

Sergei Kholodenko
INFN-Pisa

The NA62 experiment at CERN collected the world's largest dataset of charged kaon decays in 2016-2018, leading to the first measurement of the branching ratio of the ultra-rare $K^+ \to \pi^+ u\bar{u}$ decay, based on 20 candidates. Rare kaon decays are among the most sensitive probes of both heavy and light new physics beyond the Standard Model description thanks to high precision of the Standard Model predictions, availability of very large datasets, and the relatively simple decay topologies. The NA62 experiment at CERN is a multi-purpose high-intensity kaon decay experiment, and carries out a broad rare-decay and hidden-sector physics programme. In this talk, recent NA62 results on searches for violation of lepton flavour and lepton number in kaon decays, and searches for production of hidden-sector mediators in kaon decays, are presented. Future prospects of these searches are discussed. Searches for visible decays of exotic mediators from data taken in "beam-dump" mode with the NA62 experiment are also reported. The NA62 experiment can be run as a "beam-dump experiment" by removing the kaon production target and moving the upstream collimators into a "closed" position. More than 10^{17} protons on target have been collected in this way during a week-long data-taking campaign by the NA62 experiment. We report on new results from analysis of this data, with a particular emphasis on Dark Photon and Axion-like particle Models. The future availability of high-intensity kaon beams at the CERN SPS North Area gives rise to unique possibilities for sensitive tests of the Standard Model in the kaon sector. An overview of the physics goals, detector requirements, and project status for HIKE, the next generation of kaon physics experiments at CERN, will be also presented.

Current status and prospects of NA64 experiment

Dmitry Kirpichnikov
INR

We discuss a current status and prospect limits on a light dark matter models from the NA64 electron fixed-target experiment at CERN SPS. We also discuss prospects of NA64 to exclude light dark matter with muon beam setup.

Neutrino production in blazar radio cores

Polina Kivokurtseva
MSU & INR

Models of the origin of astrophysical neutrinos with energies from TeVs to PeVs are strongly constrained by multimessenger observations and population studies. Recent results point to statistically significant associations between these neutrinos and active galactic nuclei (AGN) selected by their radio flux observed with very-long-baseline interferometry (VLBI). This suggests that the neutrinos are produced in central parsecs of blazars, AGN with relativistic jets pointing to the observer. However, conventional AGN models tend to explain only the highest-energy part of the neutrino flux observationally associated with blazars. Here we discuss in detail how the neutrinos can be produced in the part of an AGN giving the dominant contribution to the VLBI radio flux, the radio core located close to the jet base. Physical conditions there differ both from the immediate environment of the central black hole and from the plasma blobs moving along the jet. Required neutrino fluxes, considerably smaller than those of photons, can be produced in interactions of relativistic protons, accelerated closer to the black hole, with radiation in the core.

Nonequillibrium Gaussian QFT and its analytic properties

Nikita Kolganov
MIPT & ITMP MSU & LPI

We consider most general Gaussian nonequillibrium QFT with arbitrary Gaussian density matrix and examine analytic properties of its in-in correlation functions. We found conditions, under which these correlation functions can be obtained by analytic continuation of Matsubara correlation functions in appropriatio Euclidean QFT. Also we found preferred basis of mode functions, which admits corpuscular interpretation at all stages of evolution, and can be obtained as analytic continuation of Bloch functions of underlying Euclidean QFT. We demonstrate obtained results on instructive examples such as scalar field in Friedmann Universe, and discuss its relation to well-known results such as Universe in Hartle-Hawking state.

HNL see-saw: lower mixing limit and pseudodegenerate state

Igor Krasnov
INR

Heavy Neutral Leptons are popular hypothetical particles, first introduced as a way to explain neutrino oscillations, and since then extensively studied in relation to many other aspects of physics beyond the Standard Model. They also serve as viable targets for direct experimental searches, being effectively described only by HNL mass and mixing with each neutrino flavor. Motivated by this, we study the lower theoretical boundary for mixing with a specified flavor in two and three HNL cases. We find the connection of this limit with the effective neutrino mass appearing in neutrinoless double beta decay (and similar expressions for mixing with muon and tau neutrino). In two HNL case, there is a rather strict relation between mixing of different HNL with the same neutrino flavor. We find that existing exclusion regions and their expected expansions in the near future are all described by a certain limit. We call that limit pseudodegenerate and find its relation to the symmetrical limit, already studied in the literature. We also study pseudodegenerate limit and conditions under which it is achieved in three HNL case. (Based on arXiv:2307.01190)

Dark photon emission in elastic proton bremsstrahlung

Ekaterina Kriukova
INR & MSU

We explore hypothetical vector particles, dark photons γ', which mix with the Standard Model photons and thus mediate interactions with charged particles into the hidden sector. We study the elastic proton bremsstrahlung of dark photons with masses 0.4–1.8 GeV, relevant for direct searches with proton accelerators. A key feature of our calculation is that it explicitly considers the non-zero momentum transfer between protons in the process $pp \to pp\gamma'$. We compare the obtained differential and full bremsstrahlung cross sections with the results of other authors. Our calculation agrees well (up to 3–9% corrections) with the Weizsacker-Williams approximation that confirms its applicability for proton beams. Then we refine predictions for the dark photon production with proton beams of energy 30 GeV, 70 GeV, 120 GeV and 400 GeV relevant for past, present and future experiments considered in literature.

Recent results and prospects of LBL accelerator experiments

Yury Kudenko
INR

The recent progress and perspectives in a search for CP violation, determination of the neutrino mass ordering, and measurements of oscillation parameters in current long baseline accelerator experiments T2K and NovA will be reported. The results of combined accelerator neutrino data from T2K and atmospheric neutrino data from Super-Kamiokande will be presented. The status, expected sensitivities, and plans of future LBL experiments DUNE and Hyper-Kamiokande will be also outlined.

Towards new tests of cosmic-ray correlations with BL Lac type objects

Maria Kudenko
INR

Ultra-high energy cosmic rays (UHECR) can be produced in active galaxies, and directional correlations between them were studied extensively. One puzzling result was the correlations of arrival directions of UHECR and a particular class of active galactic nuclei, BL Lacertae type objects, discovered in 2004 with the HiRes stereo data set [1,2]. If confirmed, this result would definitely mean new physics or very unconventional astrophysics because it implies neutral particles travelling for cosmological distances. However, the HiRes resolution remains unsurpassed, and the hypothesis has not yet been tested with independent data. The original correlations [1] used the catalog [3] which is not complete by any criteria. Even though statistical methods of analysis were selected to minimize the associated uncertainties, random biases still could have affected the result. That's why it is needed to repeat this analysis with the use of a complete sample of sources. This report is dedicated to the methods used in construction of such a complete and isotropic set of BL Lacs adopted for future tests of the enigmatic correlations with the new data of the Telescope Array experiment. [1] – D. S. Gorbunov, P. G. Tinyakov, I. I. Tkachev, S. V. Troitsky, arXiv:astro-ph/0406654v1 [2] – HiRes Collaboration 2005 [3] – M. P. V´eron-Cetty and P. V´eron, ESO scientific report (2000); M. P. V´eron-Cetty and P. V´eron, Astron. Astrophys. 374 (2001) 92.

Asymptotic freedom in (3+1)-dimensional projectable Horava gravity

Alexander Kurov
LPI

We investigate renormalization group flow of projectable Horava model in 3+1 dimensions generated by marginal operators. We show that there is a flow that runs into an asymptotically free fixed point in the ultraviolet (UV) regime, while in the infrared (IR) regime the flow runs towards the region with general relativistic form of the kinetic term.

A new bound on UHECR source number density from detection of the highest energy cosmic rays

Mikhail Kuznetsov
INR

The presence of the highest energy events in the tail of the UHECR spectrum implies that their sources are close enough to us. This in turn leads to a lower bound on the UHECR source number density. In this contribution we show how this bound might depend on the UHECR injection scenario. We apply our analysis to the highest energy events reported by the Telescope Array experiment and derive the strongest bound on the UHECR source number density.

New Euclidean axion wormholes.

George Lavrelashvili
TSU

As was discovered some time ago by Giddings and Strominger, an axion can support a wormhole geometry in the presence of a massless dilaton, as long as the dilaton coupling remains below a critical value. We find that when the dilaton becomes massive, the set of solutions is vastly increased: not only do solutions exist above the critical value of the coupling, but new branches of solutions with several minima in the geometry also appear. All of these generalised Giddings-Strominger-like solutions possess the property that, when analytically continued from Euclidean to Minkowski signature, they lead to a contracting baby universe. We show that in addition there exist families of solutions which, upon analytic continuation, lead to expanding baby universes. A curious property of axion-dilaton wormhole families is that their Euclidean action often decreases when the solutions acquire additional oscillations in the fields. When we replace the dilaton by an ordinary scalar field with a double well potential, we find analogous wormhole families leading to expanding baby universes. This time the Euclidean action has the expected behaviour of increasing with the number of oscillations in the fields, although it also contains a puzzling aspect in that some solutions possess a negative action.

Solar mass black holes from neutron stars and bosonic dark matter

Dmitry Levkov
INR & ITMP MSU

Stellar evolution cannot produce black holes lighter than 2.5 solar masses. A popular scenario of their formation involves transmutation of neutron stars - by accumulation of dark matter triggering gravitational collapse in their centers. We show that this scenario can be realized in the models of bosonic dark matter despite apparently contradicting requirements on the interactions of dark matter particles: on the one hand, the interactions should be strong enough for capturing dark matter inside the neutron stars, on the other, they induce self-interactions that impede collapse. Observing that these conflicting conditions are imposed at different scales, we demonstrate that models with efficient accumulation of dark matter can be deformed at large fields to make unavoidable its subsequent collapse into a black hole. Workable examples include weakly coupled models with bended infinite valleys.

Q-balls and LIGO/VIRGO gravitational wave signals

Alexander Libanov
MSU & INR

LIGO/VIRGO are gravitational wave interferometers that detect gravitational wave signals and determine the masses of interacting objects with a fairly high accuracy. There are several unusual signals such as GW190814, GW190814, GW200105 and GW200115. The masses of objects that have emitted these gravitational wave signals violate the neutron star equation of state or fall into the black hole mass gap. In this paper, as a solution to this problem, it is proposed to consider the Friedberg-Lee-Searlin model of Q-balls of dark matter. It is proposed to estimate the parameters of the Lagrangian, to consider a model for the formation of cosmological Q-balls during a first-order phase transition in the early Universe and a model for their interaction, during which the cosmological Q-ball acquires the necessary mass.

Cosmological α-attractors, CMB, and PBH

Andrei Linde
Stanford U

I will describe α-attractors, a broad class of inflationary developed during the last 10 years. Single-field α-attractors have universal predictions $n_s = 1 - 2/N$ and $r = 12\alpha/N^2$ providing a good match to all presently available CMB-based cosmological data for $\alpha \leq 5$. The universal structure of predictions $n_s = 1 - 2/N$ and $r = 12\alpha/N^2$ is preserved for α-attractor versions of hybrid inflation, but in these two-field models the number of e-foldings N should be replaced by its effective value $N^* > N$, depending on certain details of these models. This flexibility may be helpful because some attempts to avoid the conflict between the CMB and supernova data require greater values of n_s. Hybrid attractors may also produce high peaks in the spectrum of perturbations, leading to copious productions of primordial black holes and generation of a stochastic background of gravitational waves.

Measurement of pion formfactor by CMD-3 and its implications to hadronic contribution to muon (g-2)

Ivan Logashenko
BINP

We present the new measurement of the cross section of e^+e^- annihilation to pion pair, performed with CMD-3 detector at VEPP-2000 collider at Budker Institute of Nuclear Physics in Novosibirsk. The measurement is based on the world largest data sample, collected in the center of mass energy range from 0.32 to 1.2 GeV. We discuss the key features of analysis, the comparison of CMD-3 results to previous measurements and the implication of the new measurement to the calculation of the hadronic contribution to muon $(g - 2)$.

Observational constrained F(R, G) gravity cosmological model and the dynamical system analysis

Santosh Lohakare
BITS-Pilani

This study analysed the geometrical and dynamical parameters of the F(R, G) gravity cosmological model constrained through the cosmological data sets. The functional form of F(R, G) involves the square Ricci scalar and the higher power of the Gauss-Bonnet invariant. Based on the best-fit value of free parameters, we obtain the present value of geometrical parameters as well as the late-time behavior of the Universe. In all the data sets, the early deceleration and late time acceleration behavior of the Universe have been observed. We employ a dynamical system analysis to explore the phase space of the model and examine its stability through the behavior of the critical points. We also discuss the asymptotic behavior of the

critical points of the system. We obtain the value of the density parameter for matter-dominated and dark energy almost the same using the dynamical system analysis and the cosmological data sets.

Particles production in the early Universe

Yann Mambrini
IJCLab, U Paris-Saclay, CNRS

I will present recent works concerning the production of particles in the earliest stage of the Universe, between the preheating phase and the reheating time. I will insist on the subtleties of backreactions from scattering of the inflaton and apply it to the mechanism to the dark matter production in minimal extensions of the Standard Model, especially gravitational production.

On the contribution of cosmic-ray interactions in the Galactic halo to the observed neutrino flux

Nickolay Martynenko
MSU & INR

Cosmic rays interacting with the Milky Way circumgalactic gas produce high-energy neutrinos and photons observable at the Earth. This must contribute to the (10...1000) TeV band Ice Cube neutrino spectrum. However, previous studies reported very different estimates of this contribution, so it was unclear whether it is essential. Here we readdress the calculation of this circumgalactic neutrino flux under various assumptions. We find this contribution to be subleading provided gamma-ray constraints are satisfied.

Monodromy oscillons: an effective analytic description

Vasily Maslov
INR

Oscillons are localized long-lived field configurations that exist in many scalar theories and can affect a wide range of cosmological phenomena. They are known to achieve extreme longevity when the scalar potential is close to quadratic, specifically, in the monodromy model. The latter gained traction in some inflationary scenarios as well as a dark matter candidate. In addition to that, monodromy oscillons have large spatial sizes, and their fields can be extremely strong, making them essentially nonperturbative. In this talk we will present an effective and precise description of monodromy oscillons. Namely, a consistent expansion in the anharmonicity of the potential at arbitrary strong fields will be constructed and made accurate by introducing a field-dependent "running mass." At every order, the resulting effective theory has a continuous global symmetry, thus closely approximating oscillons as a family of nontopological solitons. Time permitting, a generalization of this approach to large-sized oscillons in a generic scalar model will be outlined.

Cold Matter at Very High Baryon Density

Larry McLerran
INT U of Washington

I discuss the properties of strongly interacting matter at densities above that of nuclear matter, including inferences from observations concerning neutron stars. Such matter undergoes a rapid transition to matter with a very hard equation of state, and the physical origin of this is explained.

Little review of matrix models

Andrey Mironov
LPI

I will present a brief review of modern status of matrix models and discuss their main features: integrability, superintegrability, W-representations.

Global stability in Horndeski theory and beyond

Sergey Mironov
INR & ITMP MSU

I plan to make a review of joint work with Valery Rubakov. I mostly focus on stability in early universe cosmology. I formulate the no-go theorem in Horndeski theory and describe different possibilities to circumvent it. I show examples of healthy stable solutions in different scalar-tensor theories.

Position space approach to banana Feynman diagrams

Victor Mishnyakov
LPI & MIPT

The answers for Feynman diagrams satisfy various kinds of differential equations – which is not a surprise, because they are defined as Gaussian correlators, possessing a vast variety of Ward identities and superintegrability properties. We study these equations in the simplest example of banana diagrams. They contain any number of loops, but can be efficiently handled in position rather than momentum representation, where loop integrals do not show up. We derive equations for the case of scalar fields, explain their origins and drastic simplification at coincident masses. To further simplify the story we do not consider coincident points, i.e. ignore delta-function contributions and ultraviolet divergences for the most part. The equations in this case reduce to homogeneous and have as many solutions as there are different Green functions – 2^{n+1} for n loops, what reduces to just n+1 for coincident masses, i.e. for a single field. We comment on the recovery of the delta-functions directly from the homogeneous equations and also compare our result with momentum space formulas known in the literature.

Using Photometric SNe for doing cosmology in the LSST

Ayan Mitra

IUCAA & Nazarbayev U

We perform a rigorous cosmology analysis on simulated type Ia supernovae (SN Ia) and evaluate the improvement from including photometric host-galaxy redshifts compared to using only the "zspec" subset with spectroscopic redshifts from the host or SN. We use the Deep Drilling Fields ($\sim 50deg^2$) from the Photometric LSST Astronomical Time-Series Classification Challenge (PLaSTiCC), in combination with a low-z sample based on Data Challenge2 (DC2). The analysis includes light curve fitting to standardize the SN brightness, a high-statistics simulation to obtain a bias-corrected Hubble diagram, a statistical+systematics covariance matrix including calibration and photo-z uncertainties, and cosmology fitting with a prior from the cosmic microwave background. Compared to using the zspec subset, including events with SN+host photo-z results in i) more precise distances for $z > 0.5$, ii) a Hubble diagram that extends 0.3 further in redshift, and iii) a 50 % increase in the Dark Energy Task Force figure of merit (FoM) based on the w0-wa CDM model. Analyzing 25 simulated data samples, the average bias on w0 and wa is consistent with zero. The host photo-z systematic of 0.01 reduces FoM by only 2 % because i) most $z < 0.5$ events are in the zspec subset, ii) the combined SN+host photo-z has X 2 smaller bias, and iii) the anti-correlation between fitted redshift and color self corrects distance errors. To prepare for analysing real data, the next SNIa-cosmology analysis with photo-z's should include non SN-Ia contamination and host galaxy mis-associations.

On democratic formulation of field theory and electric-magnetic duality.

Karapet Mkrtchyan

ICL

I will review our recent progress on first-order (democratic) formulations of the classical theory of (chiral) p-forms. In particular, for electric-magnetic duality symmetric theories this duality can be made a manifest symmetry of the Lorentz-covariant theory.

Cold Dark Matter in the SE6SSM

Roman Nevzorov
LPI

In the E6 inspired extension of the minimal supersymmetric (SUSY) standard model (MSSM) with an extra $U(1)_N$ gauge symmetry under which right-handed neutrinos have zero charge, a single discrete $\tilde{Z}_2^H$ symmetry permits suppressing rapid proton decay and non-diagonal flavour transitions. To ensure anomaly cancellation this SUSY model (SE6SSM) involves additional exotic matter beyond the MSSM. If matter parity and $\tilde{Z}_2^H$ symmetry are preserved the SE6SSM contains two dark matter candidates. Here we consider the scenario in which the cold dark matter is composed of the lightest neutral exotic fermion and gravitino with mass $m_{3/2} < 1$ GeV. We argue that in this case the dark matter-nucleon scattering cross section can be considerably smaller than the present experimental limits.

Effective potential in Friedberg-Lee-Sirlin model

Emin Nugaev
INR

The Friedberg-Lee-Sirlin (FLS) model is a well-known renormalizable scalar fields theory that provides existence of non-topological solitons. Since this model was proposed, numerous works have been dedicated to studying of classical configurations and their applicability to various physical problems in cosmology, quantum chromodynamics, etc. In this paper, we study how Q-balls in EFT reenacts non-topological solitons in full FLS theory. We obtained analytical description in the simplified model and compare results with numerical calculations and perturbation theory. Moreover, we obtained new results for the condensation of bosons on domain walls. The latter analysis based on the application of EFT methods for significantly inhomogeneous configurations.

Cosmic Rays, Magnetic Fields, and Galactic Interstellar Emission from Radio to Gamma Rays

Elena Orlando
U of Trieste

Observations of the Galactic diffuse emission from radio to gamma rays trace cosmic rays and magnetic fields. However, uncertainties still puzzle our understanding. Our method combines in a consistent way the various multi-frequency observations of the interstellar emission, latest cosmic-ray direct measurements, large-scale magnetic field models, and cosmic-ray propagation modeling in the Galaxy. We describe our program on modeling such an emission and our latest results on cosmic rays and magnetic fields. This large effort has also fundamental impacts on accessing important cosmological and astrophysical discoveries in radio, microwaves, and gamma rays.

Bose stars

Alexander Panin
INR

Light bosonic (axion-like) particles are among the most popular candidates for the dark matter of the Universe. Due to low velocities and large occupation numbers such dark matter is able to form Bose stars - gravitationally bound "drops" of Bose-Einstein condensate. I will present a brief overview of the formation of Bose stars and discuss their potentially observable astrophysical consequences.

Photon Polarization Operator in External Electromagnetic Field with Account of Virtual-Fermion AMM

Alexander Parkhomenko
YarSU

Non-diagonal two-point vector-tensor and tensor-tensor correlator of fermionic currents are calculated in a constant homogeneous magnetic field background. The crossed-field limit of these correlators is presented. The tensor current is a fermionic part of the Pauli Lagrangian density describing the electromagnetic interaction of fermions through their anomalous magnetic moment (AMM). Under assumption that this interaction enters the effective QED Lagrangian, the contribution induced by AMM to the photon polarization operator is calculated and discussed.

Stability of symmetric teleparallel scalar-tensor cosmologies with alternative connections

Laxmipriya Pati
U of Tartu

In symmetric teleparallel geometry the curvature and torsion tensors are assumed to vanish identically, while the dynamics of gravity is encoded by nonmetricity. Here the spatially homogeneous and isotropic connections that can accompany flat Friedmann-Lemaître-Robertson-Walker metric come in three sets. As the trivial set has received much attention, we focus on the two alternative sets which introduce an extra degree of freedom into the equations. Working in the context of symmetric teleparallel scalar-tensor gravity with generic nonminimal coupling and potential, we show that the extra free function in the connection can not play the role of dark matter nor dark energy, but it drastically alters the scalar field behavior. We determine the restrictions on the model functions which permit the standard cosmological scenario of successive radiation, dust matter, and scalar potential domination eras to be stable. However, the alternative connections also introduce a rather general possibility of the system meeting a singularity in finite time.

GENERATING COSMOLOGICAL PERTURBATIONS AT HORNDESKI BOUNCE

Pavel Petrov

INR

We construct a concrete model of Horndeski bounce with strong gravity in the past. Within this model we show that the correct spectra of cosmological perturbations may be generated at early contracting epoch, with mild fine-tuning ensuring that the scalar spectral tilt ns and tensor-to-scalar ratio r are consistent with observations. The smallness of r is governed by the smallness of the scalar sound speed. Arbitrarily small values of r are forbidden in our setup because of the strong coupling in the past. Nevertheless, we show that it is possible to generate perturbations in a controllable way, i.e. in the regime where the background evolution and perturbations are legitimately described within classical field theory and weakly coupled quantum theory.

Mass composition of 1-100 PeV cosmic rays with KASCADE and machine learning

Nikita Petrov

BINP

We present a new result of the mass composition analysis for cosmic rays of 1-100 PeV primary energy using archival data from the KASCADE experiment. The data provided by the KASCADE Cosmic Ray Data Center (KCDC) were collected from 1998 to 2013 and are competitive with those from modern experiments. Our analysis is based on modern machine learning techniques, including random forest, convolutional and self-attention neural networks trained with KCDC Monte-Carlo. The accuracy of mass composition reconstruction in our analysis is improved compared to the standard KASCADE analysis. We also use modern hadronic interaction models QGSJetII-04, EPOS-LHC and Sybill2.3c instead of the pre-LHC model QGSJetII-02 used in the standard KASCADE analysis, that affects the results significantly. We reconstruct the energy spectra for five individual groups of primary nuclei (protons, helium, carbon, silicon and iron) and compare the results with original KASCADE, modern experiments and models.

Leptogenesis via absorption by primordial black holes

Nikolay Pozdnyakov
NSU

Recently a new baryogenesis mechanism proceeding via different particle and antiparticle capture rates by primordial black holes was suggested. Such a difference could appear due to interference between tree and one-loop scattering diagrams. The baryon number could be conserved at the interaction level. In present work the analogous leptogenesis mechanism is considered instead. The lepton asymmetry can be transferred to baryonic matter through the electroweak processes that break both baryonic and leptonic numbers conservation but conserve B-L.

Constraints on the extragalactic magnetic field from gamma-ray observations of GRB 221009A

Grigory Rubtsov
INR

One may study the extragalactic magnetic field (EGMF) by measuring the delayed cascade gamma-ray emission from distant transient sources. Primary very high energy (VHE) gamma-rays from these sources interact with extragalactic background light photons, leading to the creation of secondary electrons and positrons. These secondary particles in turn produce cascade gamma-rays within the range energy of space gamma-ray telescopes such as Fermi-LAT. The gamma-ray burst GRB 221009A was an exceptionally bright transient event that provided an excellent opportunity to study the propagation of gamma-rays through intergalactic space. VHE gamma-ray spectrum of the burst have been measured by both Fermi LAT space telescope and LHAASO observatory. Using publicly-available Fermi-LAT data, we obtain upper limits on the spectrum of delayed emission from GRB 221009A during the time window of 30 days after the burst. We compare the latter with model delayed emission spectra calculated for various EGMF strengths B. We arrive at the lower limit on the strength of EGMF at the level of $B > 10^{-18}$ G. For some models of the VHE spectrum of GRB 221009A, stronger constraint $B > 10^{-17}$ G may be achieved.

Effective mass of the graviton in de Sitter space

Damir Sadekov
MIPT

With the use of the non-stationary Keldysh-Schwinger diagram technique, we find the one-loop effective action for the graviton that interacts with the scalar field on the background of de Sitter space and investigate the effective mass of the graviton. We will show and discuss the reason why the mass should be zero in de Sitter space-time for the most symmetrical Bunch-Davies quantum state of the matter, while there can be non-zero value in anti de-Sitter space.

Light-shining-through-wall cavity setups for probing ALPs.

Dmitry Salnikov

INR & MSU

The talk discusses the aspects of axion-like-particles (ALPs) searches with Light-Shining-through-Wall (LSW) experimental setups consisted of two radio-frequency cavities. The efficiency of four setups which involve the cavity pump modes and external magnetic fields are compared. Additionally, the sensitivity dependence is considered both on the relative position of two cylindrical cavities and on their radius-to-length ratio.

Resonant generation of electromagnetic modes in nonlinear electrodynamics: Quantum perturbative approach

Petr Satunin

INR

We study resonant generation of higher-order harmonics in a closed cavity in Euler-Heisenberg electrodynamics from the point of view of pure quantum field theory. We consider quantum states of the electromagnetic field in a rectangular cavity with conducting boundary conditions, and calculate the cross-section for the merging of three quanta of cavity modes into a single one ($3 \to 1$ process) as well as the scattering of two cavity mode quanta ($2 \to 2$ process). We show that the amplitude of the merging process vanishes for a cavity with an arbitrary aspect ratio, and provide an explanation based on plane wave decomposition for cavity modes. Contrary, the scattering amplitude is nonzero for specific cavity aspect ratio. This $2 \to 2$ scattering is a crucial elementary process for the generation of a quantum of a high-order harmonics with frequency $2\omega_1 - \omega_2$ in an interaction of two coherent states of cavity modes with frequencies ω_1 and ω_2. For this process we calculate the mean number of quanta in the final state in a model with dissipation, which supports the previous result of resonant higher-order harmonics generation in an effective field theory approach.

Positivity bounds on effective field theories with spontaneously broken Lorentz invariance.

Leonardo Senatore

ETH Zurich

We derive positivity bounds on EFT coefficients in theories where boosts are spontaneously broken. We employ the analytic properties of the retarded Green's function of conserved currents (or of the stress-energy tensor) and assume the theory becomes conformal in the UV. The method is general and applicable to both cosmology and condensed matter systems. As a concrete example, we look at the EFT of conformal superfluids which describes the universal low-energy dynamics of CFT's at large chemical potential and we derive inequalities on the coefficients of the operators, in three dimensions, at NLO and NNLO.

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

Anatolii Serebrov

NRC KI - PNPI

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 ($\Delta m_{14}^2 = 7.3eV^2$ and $sin^2 2\theta_{14} = 0.36$) 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 $N_\nu = 3 - 0.04 < \xi_e < 0.04$, and for $N_\nu = 4$ $0.02 < \xi_e < 0.10$. The possibility of the appearance of lepton asymmetry due to CP violation during oscillations into sterile neutrinos is discussed.

Electroweak baryogenesis: 38 years later

Geraldine Servant
DESY

TBA

Sterile Neutrino Dark Matter, Matter-Antimatter Separation, and the QCD Phase Transition

Mikhail Shaposhnikov
EPFL

TBA

Shower formation constraints on cubic Lorentz Invariance Violation parameters in quantum electrodynamics

Andrey Sharofeev
INR & MSU

In this work, we calculate the decay cross-section of a high-energy photon into an electron-positron pair in the Coulomb field of a nucleus (the Bethe-Heitler process) within a model featuring cubic violations of Lorentz invariance induced by the effective field theory of Myers-Pospelov. This process is of crucial importance for the development of atmospheric showers initiated by high-energy photons. The obtained cross-section of the process modifies the suppression coefficient of atmospheric shower formation, which depends on the energy of the initial photon. Employing the statistical method of maximum likelihood estimation, we establish constraints on the parameters of Lorentz invariance violation for sub-PeV sources using data from the LHAASO experiment.

First order phase transitions within holographic approach in application to baryon asymmetry problem

Andrey Shavrin

SPbU

The common way to investigate the quantum field theory is perturbative approach, which scope of applicability is restricted. In particular, non-perturbative effects appearing in nonequilibrium dynamics and soliton solutions cannot be considered in this framework. One of the possible ways to explore a quantum field theory in this regime is AdS/CFT correspondence, a certain duality between the strongly coupled (i.e. with large coupling constant) conformal filed theory and the weakly coupled gravitational theory in Anti-de Sitter spacetime. The interest in nonequilibrium dynamic is due to the requirement of the first order phase transitions presence in particle physics model according to Sakharov conditions. We consider electroweak baryogengesis scenario within bottom-up holographic Composed Higgs model. A first order phase transition has been found in certain temperature range.

Thermal false vacuum decay around black holes

Andrey Shkerin

U of Minnesota

In flat space and at finite temperature, there are two regimes of false vacuum decay in quantum field theory. At low temperature, the decay proceeds through thermally-assisted tunneling described by periodic Euclidean solutions — bounces — with non-trivial time dependence. On the other hand, at high temperature the bounces are time-independent and describe thermal jumps of the field over the potential barrier. We argue that only solutions of the second type are relevant for false vacuum decay catalyzed by a black hole in equilibrium with thermal bath. The argument applies to a wide class of spherical black holes, including d-dimensional AdS/dS-Schwarzschild black holes and Reissner–Nordstr¨om black holes sufficiently far from criticality. It does not rely on the thin-wall approximation and applies to multi-field scalar theories.

Stable solutions in Horndeski theory

Arina Shtennikova
INR

Horndeski theories are the most general scalar-tensor theories of gravitation, having second-order equations of motion and thus avoiding the Ostrogradsky instability. In addition, it was found that in this theory the null energy conditions (NEC) are not related to the stability of cosmological solutions. This fact allows one to construct healthy NEC-violating genesis and bounce solutions, as well as new models of dark energy and inflation with interesting phenomenology. However, the construction of non-singular cosmological solutions is prevented by the so-called no-go theorem. In our talk we present a classification of solutions that avoid the no-go theorem.

Analytical solution of the Sommerfeld-Page equation

Zurab Silagadze
BINP

The Sommerfeld-Page equation describes the non-relativistic dynamics of a classical electron modeled by a sphere of finite size with a uniform surface charge density. The Sommerfeld-Page equation is a delay differential equation, and almost no exact results on solutions of this equation was known. However, the progress has been made, especially in the last few years, and recently an analytical solution was found for an almost identical delay differential equation, which arose in the context of mathematical modeling of Covid-19 epidemics. Inspired by this research, we offer a exposition of how one can find an analytical solution of the Sommerfeld-Page equation.

General constraints on sources of high-energy cosmic rays from the interaction losses

Simon Sotirov
MSU

Sources of high-energy cosmic rays are presently unknown, but can be constrained in various ways. Some of these constraints can be graphically presented on the so-called Hillas diagram. Previous versions of this diagram determined the range of geometrical sizes and magnetic fields of potential astrophysical accelerators, taking into account geometrical criteria and radiation losses. In this work, we update the Hillas diagram for protons, taking into account the losses associated with the p-gamma and photopair interactions, relating the allowed regions to the source electromagnetic luminosity. The strongest constraints are obtained for bright compact sources such as the central regions of active galactic nuclei.

Superconformal indices and special functions

Vyacheslav Spiridonov
JINR & NRU HSE

Superconformal indices of 4d N=1 supersymmetric field theories, introduced in 2006, are expressed in terms of the elliptic hypergeometric integrals, discovered in 2000. I will give a brief description of this link between quantum field theory and special functions of hypergeometric type and outline some of its forthcoming developments.

The diversity of Gamma-Ray Bursts: from precursor to afterglow

Boris Stern
INR

The brightest gamma-ray burst GRB 231009A has revived an interest in the phenomenon of GRBs which still remains a puzzle in many respects. The reports of "forbidden" multi-TeV photons which invoke a wealth of theoretical papers, as it seems, are not confirmed nevertheless the record breaking event remains very interesting and can clarify some issues. Particularly, the event demonstrated an interesting interplay between the precursor, the prompt emission and the afterglow. The time variability of GRBs and their emission spectra which are reviewed in the talk imply that we observe a very complicated and diverse phenomenon involving many different mechanisms such as multiple jets, radiation dominated internal shocks, reconnecting MHD turbulence and e+e- pair loading of external medium.

MODELING GRAVITATIONAL WAVE EMISSION IN THE POST-INFLATIONARY UNIVERSE

Gleb Suzdalov
MSU & INR

The paper learn the growth of inhomogeneities of the inflaton field at the post-inflationary stage of evolution of the Universe in realistic inflationary models and studies the dynamics of inhomogeneities at the nonlinear stage of evolution. At the beginning of this stage, the inflaton field can be considered almost homogeneous, and the law of expansion of the Universe coincides with the law of expansion at the dust-like stage. Over time, inhomogeneities develop in the inflaton field due to Jeans (gravitational) instability. If the stage of post-inflationary heating is long enough, these inhomogeneities can lead to the appearance of the first gravitationally bound structures. For the study, a numerical code was written to simulate the development of inhomogeneities at the post-inflationary stage of the evolution of the Universe. In the future, it is planned to calculate the spectrum of gravitational waves formed during the nonlinear evolution of structures

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Some aspects of Tsallis Holographic dark energy

Alexander Tepliakov
IKBFU

Various cosmological models of the Universe filled with the holographic dark energy of Tsallis are considered. The event horizon L_e is chosen as a characteristic scale, and the energy density is assumed to be proportional to $simL_e^{2\gamma-4}$, where γ is the nonadditivity parameter. The cosmological evolution of such a Universe on the Randall-Sandrum brane is investigated, and a constraint on the tension on the brane is determined from observational data. Further, the model of holographic dark energy is analyzed in the presence of interaction between dark energy and matter, special attention is paid to the possibility of fantomization and elimination of future singularities. Finally, we consider the dynamics of the Universe with holographic dark energy against the background of modified Nozhiri-Odintsov gravity.

Tkachenko mode and noncommutative field theory

Dam Thanh Son
Chicago U

A superfluid rotates by creating a lattice of quantized vortices. The Tkachenko mode is an elastic wave propagating on the vortex lattice with two unusual properties: quadratic dispersion relation and absence of longitudinal polarization. We show how the Tkachenko mode can be described by a noncommutative field theory, in which it is a Nambu-Goldstone boson. Using this theory we derive the decay rate of the Tkachenko mode.

Low-scale leptogenesis via neutrino oscillations

Inar Timiryasov
NBI, U of Copenhagen

The type-I seesaw extension of the Standard Model explains the origin of neutrino masses in an elegant and minimalistic way. This extension introduces new massive particles – heavy neutral leptons. These particles are in the spotlight of many experimental searches. With masses in the experimentally accessible range, heavy neutral leptons could generate the observed baryon asymmetry of the universe via the mechanism suggested by Akhmedov, Rubakov, and Smirnov. In this talk, I will discuss various implications of this model.

Constraints on promordial black holes from observation of stars

Petr Tinyakov
ULB

We will discuss constraints on the abundance of primordial black holes of masses around 10^20 g that may result from their cature by main sequence stars in dwarf galaxies, with subsequent destruction of the infected stars. We show that capture of PBH at the stage of star formation is efficient and may significantly affect the star population in some of the observed dwarf galaxies – those having higher dark matter density and lower velocity dispersion. We identify Triangulum II as one of the best candidates which may exclude 100% of dark matter composed of PBH with masses around 10^20 g.

Unitarity bounds on effective field theories

Anna Tokareva
HIAS

TBA

Effective potentials in inflationary cosmology

Denis Tolkachev
JINR

In my talk I am going to consider such questions as construction of quantum effective potentials and application to study inflationary cosmology with slow roll. We derived the generalised renormalization group equation for the effective potential in the leading logarithmic approximation and applied it to evaluate the potentials of $Tanh^2$ and $Tanh^4$-models, which are often used in modern models of slow roll inflation. We found that while the one-loop correction strongly affects the potential, breaking its original symmetry, the contribution of the other loops smooths the behaviour of the potential. However, unlike the φ^4 (Coleman and Weinberg)-case, we found that the effective potentials preserve spontaneous symmetry breaking when summing all the leading corrections. We calculate the spectral indices n_s and r for the effective potentials of both models and found that they consistent with the observational data for a wide range of parameters of the models.

General radially moving references frames in the black hole background

Alexey Toporensky
SAI MSU

We consider general radially moving frames realized in the background of nonextremal black holes having causal structure similar to that of the Schwarzschild metric. In doing so, we generalize the Lemaître approach, constructing free-falling frames which are built from the reference particles with an arbitrary specific energy e_0 including $e_0 < 0$ and a special case $e_0 = 0$. The general formula of 3-velocity of a freely falling particle with the specific energy e with respect to a frame with e_0 is presented. Using our radially moving frames, we consider also nonradial motion of test particles including the regions near the horizon and singularity. We also point out the properties of the Lemaître time at horizons depending on the frame and sign of particle energy.

High-energy photons from distant sources, particle physics and cosmology

Sergey Troitsky
INR

I will discuss implications of observations of high-energy gamma rays from distant astrophysical sources, including GRB 221009A, for new models in particle physics and cosmology.

AdS/CFT, Wilson loops and M2-branes

Arkady Tseytlin
ICL & ITMP MSU

Recently there was a lot of progress in using exact results based on method of localization in supersymmetric gauge theories for precise tests of AdS/CFT correspondence. We will review some of this work related to matching exact strong-coupling results in supersymmetric 3d Chern-Simons-matter (ABJM) model to quantum string and supermembrane computations in dual superstring theory and M-theory.

A minimal SM/LCDM cosmology

Neil Turok
U of Edinburgh & PI

Recent observations seem to favour a highly economical description of the cosmos on both small and large scales. With this motivation, we have been developing a simpler and more predictive theoretical framework. Our search has so far uncovered 1) the simplest-yet explanation for the cosmic dark matter, soon to be tested by galaxy surveys, 2) a thermodynamic explanation for the large scale geometry of the cosmos, based on the concept of gravitational entropy advanced by Hawking and others, 3) a new account of the big bang singularity as a “mirror” enforcing CPT symmetry and realising Penrose’s “Weyl curvature hypothesis,” and 4) a new mechanism for cancelling the divergent vacuum energy and trace anomalies in the Standard Model (SM) which explains the primordial density variations quantitatively, in terms of measured SM parameters. It also explains why there are 3 generations of elementary particles, including RH neutrinos. I’ll outline the challenges it faces and the opportunities it presents, ranging from the Higgs boson to quantum gravity, as well as prospective observational tests.

Instanton Calculus, Spectral Flow and Beta Functions

Arkady Vainshtein
U of Minnesota

TBA

Stability of nonsingular Cosmologies in Galileons with Torsion

Juan Mauricio Valencia Villegas
ITMP MSU

This talk outlines our recent studies in Galileons (Horndeski theory) on a spacetime with torsion and the implications for the stability of the graviton and the scalar mode. The main point is a critical modification of a well known NO-GO theorem that holds for nonsingular cosmological solutions in the torsionless theory (up to some special cases). These advances are restricted to up to quartic Galileons. We discuss prospects for its extension.

Recent progress in higher-spin theory

Mikhail Vasiliev
LPI

I will discuss recent progress in higher-spin gauge theory with the emphasize on the issue of locality.

Wormholes in scalar-tensor theories

Victoria Volkova
INR

The talk gives a brief overview of recent advances in wormholes studies within Horndeski theories and their extensions. The main emphasis is put on ensuring stability of a wormhole solution at a linear level of perturbations. We discuss prospects of constructing a completely stable wormhole solution.

Heat kernel expansions for higher order and nonminimal operators

Wladyslaw Wachowski
LPI

The standard Schwinger-DeWitt proper time method is limited only to Laplace type (i.e. second order minimal) operators. In order to apply it also to higher order and nonminimal operators, which are important in gauge field and modified gravity theories, indirect reduction methods were used. We have developed new methods based on generalized heat kernel expansions and systematic use of the so-called "generalized exponential functions (GEF)". They made it possible to understand deeper the structure of expansions and the source of the previous difficulties - the presence of a decreasing series of terms with negative powers in proper time, whose coefficients vanish in the coincidence limit. On the other hand, they give us a computational gain, which is important for extremely laborious calculations of effective action.

Gravitational Waves from Chain Inflation

Martin Winkler
UT Austin

Chain inflation is an alternative to slow-roll inflation in which the inflaton tunnels along a series of consecutive minima in its potential. I will perform a comprehensive calculation of the gravitational wave spectrum from chain inflation. I will show that chain inflation produces a very characteristic double-peak spectrum: a faint higher-frequency peak associated with the gravitational radiation emitted during inflation, and a strong lower-frequency peak associated with the graceful exit from chain inflation. There exist exciting prospects to test the gravitational wave signal from chain inflation at the aLIGO-aVIRGO-KAGRA network, at LISA and/or at pulsar timing array experiments. A particularly intriguing possibility is that chain inflation produced the stochastic gravitational wave background recently detected by NANOGrav. I will also show that the gravitational wave signal from chain inflation is accompanied by running/ higher running of the scalar spectral index to be tested at future CMB experiments. (based on collaboration with K. Freese, A. Litsa)

Impact of Higgsplosion on relic density of dark matter

Masato Yamanaka
Hosei U

We revisit the relic density of Higgs portal dark matter (DM) with taking into account the Higgsplosion effect. We minimally extend the standard model by introducing a fermionic DM, and derive the Boltzmann equation with the DM annihilation channel of high-multiplicity final state. It is shown that the balance of Higgsplosion and Higgspersion effects derives a window function, and the final state multiplicity of DM annihilation is uniquely fixed as a function of Higgs self-coupling. Numerical calculation of the Boltzmann equation demonstrates the enhancement of effective reaction rate at the freeze out regime compared with well-studied DM scenario which annihilates into Higgs-pair.

What is the correct definition of entropy for general relativistic field theory?

Shuichi Yokoyama
Ritsumeikan U

Entropy is the most innovative concept in thermodynamics. However, it seems that a unified definition of entropy for general field theory has not been established and entropy has been computed defined in each context. Recently, the author and collaborators have proposed a unified method to construct entropy current and entropy density as a conserved current and a conserved charge density, respectively, for a general field theory defined on general curved spacetime with covariantly conserved energy momentum tensor even without any global symmetry. An important consequence of the proposal is that the entropy computed by the proposed method for a couple of classic gravitational systems satisfies both the local Euler's relation and the first law of thermodynamics non-perturbatively with respect to the Newton constant. Other important aspects will be also reported within allowed time.

N=2 higher spin theories and harmonic superspace

Nikita Zaigraev
MIPT & JINR

We report on a recent progress in constructing off-shell N = 2,4D supersymmetric and superconformal higher-spin theory in terms of unconstrained harmonic analytic gauge superfields. All theories are built in a harmonic superspace that allows to work effectively with N=2 supersymmetric theories. In particular, the harmonic superspace elegantly allows us to construct higher-spin cubic interactions with the matter hypermultiplets. Also, within the framework of this approach, various N=2 hypermultiplet supercurrents are built in a beautiful way.

New general relativity tests

Alexander Zakharov
JINR & NRC KI - ITEP

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. Similarly we constrain a tidal charge for the black hole at the Galactic Center based on shadow reconstruction done by EHT in 2022. We discuss opportunities to use shadows to test alternative theories of gravity and alternative theories for galactic centers. We use also observational data for trajectories of bright stars near the Galactic Center to test gravity theories and theoretical models for the Galactic Center.

Lepton flavor phenomenology of dark photon

Alexey Zhevlakov
JINR

We study possible impact of dark photons on lepton flavor phenomenology. We derive the constraints on non-diagonal dark photon couplings with leptons by analyzing corresponding contributions to lepton anomalous magnetic moments, rare lepton decays and the prospects of fixed-target experiments aiming for search for light dark matter based on missing energy/momentum techniques.
