Abstracts
of the participants of the 27th International Workshop "What comes beyond the standard models?" July 8-17 2024

(presented in alphabetical order of participants' surnames)

1 Ignatios Antoniadis

Title: **Landscape, swampland and extra dimensions**

Abstract: I will argue on the possibility that the smallness of some physical parameters signals a universe at a large distance corner in the string landscape of vacua. Such parameters can be the scales of dark energy and supersymmetry breaking, which should then be tied to a large 'dark' dimension at the micron scale. I will discuss the theoretical framework and some of its main physical implications.

2 R. Bernabei

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Title: **Status of the DAMA project**

Abstract: In 1990 the DAMA project was proposed as a pioneer in the field of Dark Matter (DM) direct investigation proposing the realization of large mass set-ups (with highly radiopure NaI(TI) and liquid Xenon) mainly by exploiting the model-independent signature (originally suggested in the middle of the '80). In particular, the DAMA/NaI experiment (= 100 kg of highly radiopure NaI(TI) in a multi-ton multi-component shield) has been a pioneer experiment running deep underground in the Gran Sasso National Laboratory (LNGS) of INFN until 2002. It has been investigated as first the DM signature with suitable exposed mass, sensitivity and control of the running parameters. In July 2002 after several years of new developments, carried out during the running of DAMA/NaI, and its dismounting the installation of the new DAMA/LIBRA experimental set-up (about 250 kg of highly radiopure NaI(TI) in multi-ton multi-component shield) started. The experimental site as well as many components of the installation were implemented. All the procedures performed during the dismounting of DAMA/NaI and the installation of the DAMA/LIBRA detectors were carried out in high purity (HP) Nitrogen atmosphere; the detectors are also continuously maintained in such an atmosphere in all the operations since then. A significant upgrade of that configuration has been performed at the end of 2010. replacing all the PMTs with

new ones that have higher quantum efficiency, i.e. lowering the software energy threshold of the experiment. After a period of commissioning, this DAMA/LIBRA-phase2 began data collection. Many model-independent results and related corollary analyses have been published. More recently, after studies and tests to further lower the software energy threshold, below 1 keV, a new upgrade has been performed. The final solution has been to equip the PMTs with new low-background voltage dividers with pre-amps on the same board and to use Transient Digitizers with higher vertical resolution (14 bits). This new configuration, we named DAMA/LIBRA-phase2-empowered, is in measurements and data collection is planned to continue until December 2024.

For completeness, it should be reminded that DAMA has been and is working as an observatory for rare processes by developing other kinds of low radioactive scintillators and using them deep underground at LNGS. Several low background setups are operative and many different kinds of measurements have been and are carried out.

In conclusion, the long-standing model-independent annual modulation effect measured by DAMA deep nderground at Gran Sasso Laboratory with different experimental configurations in 2.86 ton x yr exposure so far, will be discussed as well as aspects of the presently running DAMA/LIBRA-phase2-empowered with an even lower software energy threshold. Comparison with other experimental activities and the new data taking will be outlined. Finally a mention to some of the other searches carried out will be just mentioned.

3 Timur E. Bikbaev

Title: Quantum-mechanical numerical model of interaction between "dark atom" and nucleus

Abstract: The hypothesis of composite XHe "dark atoms" may provide a solution to the long-standing problem of direct searches for dark matter particles. The main problem of the XHe "dark atom" is its ability to interact strongly with the nucleus of substance, arising from the unshielded nuclear attraction between the helium nucleus and the nucleus of matter. It is assumed that in order to prevent the destruction of the bound structure of "dark atom", the effective potential of interaction between XHe and the nucleus of substance must have dipole Coulomb barrier that prevents the fusion of dark matter atom particles with the nucleus of substance. It is also assumed that the effective potential of interaction between X-helium and the nucleus of matter will have a shallow potential well in front of the dipole Coulomb barrier, which characterizes the bound state of the "dark atom" with the nucleus of substance. The problem in describing the interaction between "dark atom" and substance nucleus is the three-body problem, for which an exact analytical solution is not available. Consequently, to assess the physical meaning of the proposed scenario, it is essential to develop a numerical approach. This approach must adequately account for the complex dynamics and non-trivial nature inherent in this the three-body problem,

thereby enabling the validation of the proposed scenario. Our approach involves consistently developing an accurate quantum mechanical description of this three-body system, comprising bound "dark atom" and the external nucleus of substance. We incorporate the necessary effects and interactions to enhance the precision of the results, which helps to elucidate the most significant aspects of the proposed "dark atom" scenario. As a result, our approach led to the development of numerical quantum mechanical model to describe the interaction between XHe and the nucleus of substance, allowing us to reconstruct the effective interaction potential in the XHe-nucleus system.

4 Stan Brodsky

SLAC National Accelerator Laboratory, Stanford University

Title: **New Perspectives for Hadron Spectroscopy and Dynamics and the QCD Running Coupling from Color-Confining Holographic Light-Front QCD**

Abstract: A fundamental question in hadron and nuclear physics is how the mass scale for hadrons emerges from QCD, even in the limit of zero quark mass. I will discuss a novel approach to the origin of the QCD mass scale and color confinement based on "light-front holography", a formalism which relates the bound-state amplitudes in the fifth dimension of AdS space to the boost-invariant light-front wavefunctions describing the structure of hadrons in physical space-time. The result is a set of Poincarè-invariant bound-state wave equations which incorporate quark confinement and predict many observed spectroscopic and dynamical features of hadron physics, such as linear Regge trajectories with identical slopes in both the radial quantum number and the internal orbital angular momentum. Generalizing this procedure using superconformal algebra leads to a unified Regge spectroscopy of meson, baryon, and tetraquarks, including remarkable supersymmetric relations between the masses of mesons and baryons. The pion bound-state, although composite, is massless for zero quark mass. One also can predict nonperturbative hadronic observables such as structure functions, transverse momentum distributions, and the distribution amplitudes defined from the hadronic light-front wavefunctions. The analytic behavior of the QCD coupling controlling quark and gluon interactions at large and small distances is also determined. The result is an effective coupling defined at all momenta with a transition mass scale which sets the interface between perturbative and nonperturbative hadron dynamics. One also obtains a relation between the perturbative QCD mass scale and hadron masses.

5 Andrzej J. Buras

Title: **Hunting New Particles with Rare Kaon and B Meson Decays**

Abstract: Rare Kaon and B meson decays are among main players in the indirect search for new particles. To this end Standard Model (SM) predictions for their branching ratios must be as accurate as possible. Unfortunately the present tension in the values of the CKM element V_{cb} from exclusive and inclusive tree-level decays introduce significant uncertainties in these predictions. Another problem is the danger of the infection of the CKM parameters by new physics obtained from global fits not allowing thereby genuine SM predictions for the decays in question. Finally, non-perturbative QCD uncertainties lower the precision in a number of branching ratio. I will present a recent strategy which avoids all these problems and allows to make precise predictions for many SM branching ratios. The implications for this strategy for Z' models will be briefly discussed. Next new ideas for disentangling new physics in $K \to \pi\nu\bar{\nu}$ and $B \to K(K^*)\nu\bar{\nu}$ decays will be presented. Finally the present status of the $\Delta I = 1/2$ rule and of the ratio ε'/ε in the SM will be summarized.

6 Sourav Roy Chowdhury

Department of Physics, Vidyasagar College.
Research Institute of Physics, Southern Federal University, 344090 Rostov on Don, Russia.

Title: **Effects of metallicity on Compact binary coalescences**

Abstract: Gravitational wave sources in the millihertz to hertz frequency range are expected to exhibit notable eccentricity. Compact object binaries with significant eccentricity emit gravitational waves, particularly in dynamic scenarios where environmental disturbances cause a binary with a large initial orbital separation to undergo a close pericenter passage, leading to an inspiral phase. We model the galactic population of compact binaries using the "Binary Population Synthesis" method with COSMIC and GW signals. The ultimate fate of the population has been predicted based on metallicity. The formation characteristics of the final mass are strongly influenced by the initial mass and the metallicity at a system-defined critical point. Recent analyses of stellar evolution have shown that metallicity significantly impacts the properties of compact object. We investigate how the metallicity of a compact object affects the characteristics of a galactic binary merger.

7 Elia Dmitrieff

Title: **A curious example of dimensionality reduction in the E_8 lattice**

Abstract: In this work, the relationship between the vertices of a three-dimensional Fibonacci icosagrid quasicrystal and the E_8 root lattice was investigated for application in a physically realistic cellular automaton. Under the influence of the Elser-Sloan matrix, the original infinite lattice splits into three orthogonal spaces - a three-dimensional fractal quasicrystal, a two-dimensional square lattice and a three-dimensional space containing a finite three-dimensional polyhedron that specifies the degree of detail. It turns out that in this system various versions of multiverses with different realizations of time can be modeled, which are specified by paths through the nodes of a square lattice. Due to the fractal nature of the projection, a 'natural' non-strict reduction of dimension arises, associated with the degree of detail of the model. Our estimates of the size of the polyhedron, corresponding to the detailing of the quasicrystal down to 10^{-15} m, give values of the order of 10^{-40} m. Thus, the polyhedron is almost a point, that is, three of the eight dimensions are almost completely reduced.

8 Elia Dmitrieff

Title: Techniques that allow the implementation of a 4D borderless lattice model in the form of a 3D hardware device

Abstract: We propose a practical way to construct a computing environment in the form of a cellular automaton on a four-dimensional lattice. Specific folding allows us to obtain a logical seamless and borderless 4D network as a 3D hardware device. We believe that the use of such a framework, together with a special reversible computational rule, will make it possible to realistically simulate the behavior of fundamental particles.

9 Elia Dmitrieff

Title: Variables with non-zero entropy

Abstract: We consider examples of variable mathematical quantities that have uncertainty, that is, characterized by non-zero entropy. These include solutions to eigenvalue problems and other algebraic and logical equations.

According to established practice, before substituting such quantities into expressions, they are usually implicitly specified, that is, a particular value is selected from a certain set.

However, in physical applications such implicit specification can lead to explicit consequences that are quite observable. This is due to the fact that the entropy of a variable decreases when choosing one value or another, which means that we should expect the appearance of fundamentally observable effects of redistribution or release of energy according to the Landauer principle.

We believe that mathematical modeling using variables with non-zero entropy should explicitly take into account the operations that occur with decreasing entropy. In particular, for closed systems it is necessary to show which parts of them have become less defined, and for open systems it is necessary to take into account the channels through which excess entropy is released into the external environment.

In experiments with entangled particles, we expect heat release on polarization analyzers of the order of 10 mEV per photon, resulting from a decrease in the spin entropy of the photon pair.

Theories that operate on hidden variables with non-zero entropy can apparently bypass the prohibition imposed by the Bell's theorem and be both local and compatible with quantum mechanics.

10 Daniele Fargion

Title: **A new UHECR Astronomy?**

Abstract: Understanding Ultra High Energy Cosmic Rays and their smeared maps is a key goal in modern astro-physics.

We found that the lightest nuclei at tens EeV, may explain the AUGER dipole and their few hot spot clustering. Their source are mainly galaxy in nearest Local Universe as the Local Sheet.

The most energetic UHECR might be very heavy nuclei originated in our own galaxy, or very far signals by exotic neutrino signals.

11 Albino Hernández-Galeana

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Title: **Fermion masses, mixing and FCNC's within a gauged SU(3) family symmetry**

Abstract: Within a gauged SU(3) family symmetry model, we address the problem of mass generation for ordinary fermions, including neutrinos in a 3+5 scenario.

In this framework right handed neutrinos are needed in order to cancel anomalies. We also introduce a set of $SU(2)_L$ weak singlet vector-like fermions U,D,E,N, with N a neutral lepton. These vector-like fermions allows the implementation of See-saw mechanisms at tree level to generate the masses of the top and bottom quarks and the tau lepton. Light fermions obtain masses from loop corrections mediated by the massive SU(3) gauge bosons.

We show the parameter space region for the simultaneous solutions of quark and lepton masses and the FCNC's suppression, trying to keep as low as possible the SU(3) gauge boson masses.

12 Dmitri Kalashnikov

based on work by D.Kalashnikov, K.Belotsky

Title: Prospects for calculating the structure formation of self-interacting dark matter

Abstract: The Standard Cosmological Model (ΛCDM) demonstrates robust agreement with observations of large-scale structure of the Universe. However, the model shows significant differences when dealing with observations of individual galaxies. To address these discrepancies, various extensions of ΛCDM are being explored, one of which is self-interacting dark matter (SIDM).

We employ a model featuring self-interacting dark matter characterized by a dark Coulomb-like interaction mediated by a dark photon ("y"), dark electrons (e_y) and dark protons (p_y). Our analysis focuses on the three-body recombination process to estimate the concentration of relict neutral dark atoms. Through our calculations, we determine the concentration of relict neutral recombined dark atoms numerically and analytically.

The findings of this study contribute to a deeper understanding of the dynamics and observational studies of dark matter. The study demonstrates that three-body recombination process presents a mechanism for fast formation of dark bound states in the early Universe.

13 S.V. Ketov

Tokyo Metropolitan University and Kavli IPMU, Japan

Title: Cosmological inflation and High-scale SUSY as the Origin of Dark Matter

Abstract: The Starobinsky model of inflation is argued to be the best inflationary model at present, both from the theoretical and observational points of view. We propose various extensions of the Starobinsky model with and without supersymmetry, in order to accommodate the primordial black hole production during inflation. Implications of those models for supersymmetry breaking, dark matter and the minimal supersymmetric standard model are outlined.

14 Artem Kharakhashyan

Research Institute of Physics, Southern Federal University, Russia

Title: Elusive influence of invisible mass on ionospheric observations

Abstract: In recent years, the number of publications devoted to the study of the influence of Dark Matter and the effects of gravitational lensing in the Solar System has increased significantly. Observational evidence indicates the existence of possible focusing effects of Dark Matter in the vicinity of the Earth, which affects the results of measurements of parameters characterizing the state of the ionosphere and stratosphere. Such data can shed light on many processes in the Solar System, since they accumulated over relatively long periods of time under known conditions and the volume of this data will only increase. Over the years of research, a number of unexplained anomalies in the behavior of these parameters have been observed, the sources of which have not been identified. In most recent publications, the effects that Dark Matter can have on the ionosphere are associated with the influence of Dark Photons and Axion-like particles, due resonant conversion into electromagnetic waves in the magnetic field in ionized plasma, and due coupling.

In this work, we use the galactic reference frame and consider a set of ionospheric parameters and solar wind parameters measured on the Earth's surface or near the Earth, and construct gradients of changes in these parameters at different times and in different directions in order to determine possible inhomogeneities in the behavior of these parameters due to distribution of hidden mass in the Solar System in spacetime. It is shown that for the selected parameters, the gradients calculated since 1986 have clearly defined directions that are not determined by the Sun at certain time intervals, and the directional vectors are consistent between the parameters.

15 Maxim Khlopov

Title: Open questions of BSM Cosmology

Abstract: BSM physics, on which the now standard inflationary cosmology with baryosynthesis and dark matter/energy is based, inevitably leads to cosmological scenarios beyond this standard model, involving specific model dependent choice of models and parameters of BSM physics. Such model dependent cosmologiocal predictions may be already found confirmations in the positive results of direct dark matter searches by DAMA/NaI and DAMA/LIBRA experiments, interpretation of the results of Gravitational Wave experiments in terms of Primordial Black Hole merging, observation of Stochastic Gravitational Wave background by Pulsar Timing Arrays, and searches for cosmic antihelium in the AMS02 experiment. We discuss the open questions in studies of these signatures of BSM cosmology.

16 Astri Kleppe

Title: **A minimal mass matrix with a democratic texture**

Abstract: In 1981, Yoshio Koide noticed that the square root values of the charged lepton masses satisfy the relation

$$Q = \frac{m_e + m_\mu + m_\tau}{(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau})^2} \approx \frac{2}{3} \tag{1}$$

From the Koide relation, combined with the philosophy that the mass matrices are initially democratic, we derive a mass matrix with a democratic texture.

17 Maxim Krasnov

based on work by M. A. Krasnov, M. Yu. Khlopov, O. Trivedi, Yu. N. Eroshenko

Title: **Strong primordial inhomogeneities induced by axion-like field**

Abstract: We consider axion-like scalar field as a potential source of primordial inhomogeneities in the early Universe. Domain walls are well known source of primordial black holes and, when domain walls are dominant within the horizon, of wormholes. In order to study the evolution of space-time dominated by a domain wall, we solve field equations numerically assuming spherical symmetry.

18 N.S. Mankoč Borštnik

Department of Physics, University of Ljubljana
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Title: **Can the "basis vectors", describing the internal spaces of fermion and boson fields with the Clifford odd (for fermion) and Clifford even (for boson) objects, explain interactions among fields, with gravitons included?**

Abstract: The Clifford odd and even "basis vectors", describing the internal spaces of fermion and boson fields, respectively, offer in even-dimensional spaces, like in d=(13+1), the description of quarks and leptons and antiquarks and antileptons appearing in families, as well as of all the corresponding gauge fields: photons, weak bosons, gluons, Higgs's scalars

and the gravitons, which not only explain all the assumptions of the standard model, and makes several predictions, but also explains the existence of the graviton gauge fields.

Analysing the properties of fermion and boson fields concerning how they manifest in d=(3+1), assuming space in d=(3+1) flat, while all the fields have non-zero momenta only in d=(3+1), this talk illustrates that scattering of fermion and boson fields, with gravitons included, represented by the Feynman diagrams, are determined by the algebraic products of the corresponding "basis vectors" of fields, contributing to scattering. There are two kinds of boson gauge fields appearing in this theory, both contribute when describing scattering.

19 N.S. Mankoč Borštnik[1], H.B. Nielsen[2]

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Title: **Can the "basis vectors", describing the internal space of point fermion and boson fields with the Clifford odd (for fermions) and Clifford even (for bosons) objects, be meaningfully extended to strings?**

Abstract: The string theorists promise a mathematically consistent way for explaining so far observed fermion and boson second quantized fields, with gravity included, by offering the renormalizability of the theory by extending the point fermions and bosons into strings and by offering the supersymmetry among fermions and bosons. In a long series of works one of the authors in collaboration with another author and other collaborators, has found the phenomenological success with the model named the spin-charge-family theory with the properties: The creation and annihilation operators for fermion and boson fields are described as tensor products of the Clifford odd (for fermions) and the Clifford even (for bosons) "basis vectors" and basis in ordinary space, explaining the second quantization postulates. The theory offers the explanation for the observed properties of fermion and bosons and for several cosmological observations. Since the number of creation and annihilation operators for fermions and bosons is in this theory the same, manifesting correspondingly a kind of supersymmetry, the authors start to study in this contribution the properties of the creation and annihilation operators if extending the point fermions and bosons into strings, expecting that this theory offers in the low energy limit a new understanding for the string theory.

20 N.S. Mankoč Borštnik

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Title: **Clifford odd and even objects in even and odd dimensional spaces describing internal spaces of fermion and boson fields**

Abstract: In a long series of works, it has been demonstrated that the spin-charge-family theory, assuming a simple starting action in even dimensional spaces with d=(13 +1), with massless fermions interacting with gravity only, offers the explanation for all in the standard model assumed properties of the second quantized fermion and boson fields, offering as well several predictions and explanations for several of the observed phenomena. The description of the internal spaces of fermion and boson fields by the Clifford odd and even objects, respectively, justifies the choice of the simple starting action of the spin-charge-family theory. The main topic of the presentation is the analyse of the properties of the internal spaces of the fermion and boson fields in odd dimensional spaces, $d = (2n + 1)$, described again by the Clifford odd and even objects, respectively. It namely turns out that the properties of fermion and boson fields differ essentially from their properties in even dimensional spaces, resembling the ghosts needed when looking for final solutions with Feynman diagrams.

21 N.S. Mankoč Borštnik

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Title: **Do the internal spaces of the second quantized fermion and boson fields in even and odd-dimensional spaces offer the understanding of the birth and evolution of our universe?**

Abstract: The spin-charge-family theory assumes that the internal spaces of fermion and boson second quantized fields are described (determined) with the Clifford "basis vectors", The Clifford odd "basis vectors" appear in $2^{\frac{d}{2}-1}$ families, each family having $2^{\frac{d}{2}-1}$ members. Their Hermitian conjugated partners have $2^{\frac{d}{2}-1}$ $2^{\frac{d}{2}-1}$ members. The Clifford even "basis vectors" appearing in two orthogonal groups, each group having $2^{\frac{d}{2}-1}$ $2^{\frac{d}{2}-1}$ members, have their Hermitian conjugated partners within the same group. These Clifford even "basis vectors" describe the internal spaces of all second quantized vector and scalar boson fields, with graviton included. However, knowing all the Clifford odd "basis vectors", we also know all the Clifford even "basis vectors" of both groups. The dynamics of the universe are determined by the non zero momenta in ordinary space-time. To what extent do internal spaces of fermion and boson second quantized fields determine properties of our universe?

22 Euich Miztani

JEIN Institute for Fundamental Science (JIFS)

Title: Special Relativity and Its SO(3) in Euclidean Space — Time-Independent Special Theory of Relativity

Abstract: In the process of Albert Einstein establishing the theory of special relativity, the principle of relativity is completely based on geometrical description. On the other hand, the electromagnetic theory is purely algebraic and complicated. Minkowski's work extended it for the 4-dimensional space-time which is purely algebraic as well.

However, we are able to understand Einstein's idea more simply and phenomenally. Such a description of special relativity will facilitate researches in spintropics to consider the relativistic effect. Besides, it leads to an unknown special orthogonal group in real space, unlike the Lorentz group SL(2, C). In this talk, we discuss so-to-speak the 'complete' geometric special relativity and its new Lie group in real space.

23 Ranjini Mondol

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Title: Dipole Cosmology: A Direction for our Universe

Abstract: We will look into the scope of a paradigm shift by introducing a "Dipole Cosmology" ansatz, which retains the homogeneity assumptions but relaxes the assumptions on isotropy. Increasingly numerous (but still tentative) observations suggest that we are observers embedded in a "bulk flow". Dipole Cosmology refers to the ansatz that explores the most symmetric generalization of FLRW models that can incorporate global flows. Einstein equations in our "dipole cosmology" are still ordinary differential equations – but instead of the two Friedmann equations, now we have four. The two new functions can be viewed as an anisotropic scale factor that breaks the isotropy group from SO(3) to U(1) and a "tilt" that captures the cosmic flow velocity. A key observation is that the cosmic flow (tilt) can grow even while the anisotropy (shear) dies down. We also demonstrated how multiple fluid components with independent flows can be realized in this setup. This is the necessary step to promote "tilted" Bianchi cosmologies to a viable framework for cosmological model building involving fluid mixtures (as in FLRW). We introduced a dipole ΛCDM model, which has radiation and matter with independent flows, with a positive cosmological constant. A remarkable feature of models containing radiation (including dipole ΛCDM) is that the relative flow between radiation and matter can increase at late times, which can contribute to interesting phenomenology e.g., the CMB dipole. Interestingly, the cosmography at the

background level shows that acceleration is possible even in the absence of a cosmological constant for the Dipole Universe.

24 Boris Murygin

based on work by Murygin B.S.[1,2], Stasenko V.D.[1,2], Eroshenko Yu.N.[2]
[1]National Research Nuclear University "MEPhI", Moscow, Russia
[2]Institute for Nuclear Research RAS, Moscow, Russia

Title: Baryon halos around supermassive primordial black holes

Abstract: According to some theoretical models, primordial black holes (PBHs) with masses of more than 10^8 solar masses could be born in the universe, and their possible observational manifestations have been investigated in a number of works. Dense dark matter and baryon halos could form around such PBHs even at the pre-galactic stage (in the Dark Ages cosmological epoch). In this work, the distribution and physical state of the gas in the halo are calculated taking into account the transfer of X-ray radiation from the central accreting region. This made it possible to find the ionization radius, outside of which there are regions of neutral hydrogen absorbing in the 21 cm line. The existence of such annular absorption regions was predicted in the work of S.I. Grachev et al. in 2021. Their detection at high redshifts may provide evidence of the existence of supermassive PBHs.

25 Boris Murygin

based on work by Murygin B.S., Nikulin V.V., Kirillov A.A.,
National Research Nuclear University "MEPhI", Moscow, Russia

Title: Formation of soliton foam in the early Universe

Abstract: The formation of composite solitons in the early Universe is considered. It is shown that under realistic initial conditions arising at the inflationary stage, the evolution of the field leads to the formation of a ¡¡soliton foam¿¿ consisting of closed domain walls, domain walls limited by strings and scalar field radiation. As a result of the ¡¡soliton foam¿¿ evolution, a large number of scalar field particles are emitted, that can be interpreted as WIMPs constituting a fraction of dark matter of the Universe.

26 Holger Bech Nilsen

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Title: **Approximate SU(5), Several Fundamental Scales, Fine Structure Constants**

Abstract: We fit the three fine structure constants of the Standard Model with three, in first approximation theoretically estimable parameters,

1) a "unified scale", turning out not equal to the Planck scale and thus only estimable by a very speculative story,

2) a "number of layers" being a priori the number of families, and

3) a unified coupling related to a critical coupling on a lattice.

So formally we postdict the three fine structure constants! In the philosophy of our model there is a physically lattice theory with link variables taking values in a (or in the various) "small" representations of the Standard Model Group. We argue for that these representations function in first approximation as were the theory a genuine SU(5) theory. Next we take into account fluctuation of the gauge fields in the lattice and obtain a correction to the a priori SU(5) approximation, because of course the link fluctuations not corresponding any Standard model Lie algebra, but only to the SU(5), do not exist. The model is a development of our old anti-grand-unification model having as its genuine gauge group, close to fundamental scale, a cross product of the standard model group $S(U(3) \times U(2))$ with itself, there being one Cartesian product factor for each family. In these old works we included the hypothesis of "multiple point criticality principle" which here effectively means the coupling constants be critical on the lattice. Counted relative to the Higgs scale we suggest the in our sense "unified scale" (where the deviations between the inverse fine structure constants deviate by quantum fluctuations being only from standard model groups, not SU(5)) makes up the 2/3th power of the Planck scale relative to the Higgs scale, or better the top quark mass scale.

27 Holger Bech Nielsen

(being discussed with Keiichi Nagao and Astri Kleppe)

Title: **Random Dynamics, Deriving ? Quantum Mechanics**

Abstract: We formulate a very general framework for a theory in terms of a probability functional giving the probability density for any thinkable time developments (paths) and derive under some assumptions about the functional an approximate determinism - but only approximate, thus allowing like quantum mechanics a system to be in several places at once. By adding some oscillating system we obtain quantum mechanics with effectively the mysterious use of complex numbers, of which we suggest, one should be able to get rid of.

28 Holger Bech Nielsen and Colin D. Froggatt

Title: Dark matter Model, the 3.5 keV Line

Abstract: In our dark matter model, on which we have long worked, we look at how the line 3.5 keV X-ray radiation come about. Most of it comes from collisions of dark matter with dark matter and Cline and Frye has fitted it like that. But in three cases we must instead take it that it comes from dark matter colliding with ordinary matter. We seek a fit of dark matter as atomic size but macroscopic objects in the sense of containing very many nuclei and electrons.

29 Tetsuo Shinduo

Title: Flavor physics in SU(5) grand unified theory with scalar fields in the 45 representation

Abstract: We study a realistic SU(5) grand unified model, where a 45 representation of scalar fields is added to the Georgi-Glashow model in order to realize the gauge coupling unification and the masses and mixing of quarks and leptons. The gauge coupling unification together with constraints from proton decay leads to extra scalars at the significantly lower scale than the scale of the grand unification. We assume that an SU(2) triplet component of the 45 scalar has a TeV-scale mass, and we study its contributions to flavor physics. We provide predictions for lepton-flavor violation and lepton-flavor-universality violation induced by the extra scalar, and find that current and future experiments have a chance to find a footprint of our SU(5) model. This talk is based on the paper, 10.1103/PhysRevD.108.095012.

30 Ekaterina Shlepkina

based on work by
E.Shlepkina, B.Muchkinova, K.Belotsky

Title: On the effect of gravitational microlensing of stars on primordial black hole clusters

Abstract: The report is devoted to the study of possibilities to search for gravitational lensing effects from primordial black hole clusters. It is assumed that such clusters could constitute the entire dark matter. It is possible to detect PBH clusters in the dark halo of the Galaxy through the gravitational microlensing on stars of nearby galaxies, for example, on the stars of the Large Magellanic Cloud. Such a cluster, depending on its parameters and internal

structure, can manifest itself differently in the microlensing effect. A primordial black hole cluster, unlike single PBH, can behave like one single gravitational lens, and also individual gravitational lenses in the cluster can cause the appearance of a unique signal in the form of multiple peaks in the light curve of the background star. In this work, we classify possible manifestations of the cluster structure of a primordial black hole in the microlensing effect and evaluates the following characteristics: the optical depth for two cases (single and cluster primordial black hole structures), the number of stars that experienced the microlensing on the cluster, the time period between microlensing events for the same two cases, an estimate probability of multiple events on a primordial black hole cluster. An additional analysis of events based on the MACHO experiment data was also carried out, taking into account the hypothesis of microlensing on the cluster. The analysis identified three additional candidate microlensing events.

31 Danila Sopin

based on work by V.Beylin, M.Khlopov and D.Sopin

Title: **Problems of dark atom cosmology**

Abstract: The dark atoms XHe are the composite Thomson like atomic dark matter candidates. We address two cosmological problems of this model. The excess of new superheavy particles with even negative charge X^{-2n} over the corresponding antiparticles is balanced by sphaleron transitions with baryon asymmetry and the mass range of X particles should be specified at which this excess can provide dominance of dark atoms in the dark matter density. The other problem is possible capture of light nuclei by dark atoms, which can lead to formation of anomalous isotopes. The possibility of formation of multi dark atom systems at the nucleosynthesis stage is also studied. We approach these open questions of dark atom cosmology in the present work.

32 Viktor Stasenko

Title: **Mergers of primordial black holes**

Abstracts: The report considers the formation and mergers of binary primordial black holes (PBHs). Particular attention is paid to the effects of PBH clustering and their influence on the destruction and formation of new pairs of black holes. Constraints on the fraction of PBHs in the composition of dark matter are discussed in the context of observations of black hole mergers by the LIGO-Virgo-KAGRA collaboration. It is also shown that future gravitational wave detectors will be able to test the hypothesis of the existence of primordial black holes by observing mergers at high redshifts.

33 Kostya Stepanyantz

Title: **Exact expressions for the renormalization constants in the MS-like schemes**

Abstract: For the MS-like renormalization prescriptions we present some expressions for the renormalization constants exact in all orders using the version of the dimensional technique in which the dimensionful parameter Λ differs from the renormalization scale μ. These expressions encode the equations relating the coefficients at higher ε-poles, powers of $\ln\Lambda/\mu$, and mixed terms $\varepsilon^{-q}\ln\Lambda/\mu$ to the coefficients of the renormalization group functions (i.e. of the β-function and the anomalous dimension). In the particular case $\Lambda = \mu$ they give the explicit solutions of the 't Hooft pole equations. For the general case we discuss the relations between the coefficients of ε-poles and logarithms and some features of the renormalization constant structure. The general results obtained from the renormalization group equations are verified by some multiloop calculations.

34 Oem Trivedi

International Centre for Space and Cosmology, Ahmedabad University, India

Title: **Holography and Late-Time Cosmology: From Dark Energy to the "Big Vanish"**

Abstract: Holography has proven to be one of the most fascinating ideas in contemporary quantum gravitational theories, being a cornerstone of many advancements in string theory and beyond. Its implications on cosmology, like other ideas inspired from quantum gravity, have been vividly studied in recent years. This has led to several constructions of holographic dark energy, which display an interesting approach towards dealing with late-time acceleration of the universe. I shall discuss various constructs of holographic dark energy, then discuss various intricate issues with such approaches pertaining to thermodynamics, stability and energy conditions. I shall then discuss the nature of rips and other cosmological singularities in this approach. Finally, I shall then discuss a new end to the universe which has been recently found in the paradigms of holographic dark energy, which is the "Big Vanish".