Abstracts of the participants of the 25th International Workshop "What comes beyond the standard models?" July 4-10 2022

http://bsm.fmf.uni-lj.si/bled2022bsm/presentations.html

R. Bernabei: Recent results and empowered DAMA/LIBRA-phase2 perspectives

Abstract: The DAMA/LIBRA-phase2 experimental apparatus (about 250 kg of highly radiopure NaI(Tl)) operates at the INFN National Laboratory of Gran Sasso. Recent results will be presented in this talk as well as the empowered configuration of the apparatus currently in data taking with the aim of studying events at energies below the software threshold of 1 keV. Emphasis will be given to the impact of this improvement.

T.E.Bikbaev: Modelling of dark atom interaction with nuclei

Abstract: Dark atom interaction with nuclei is the crucial long-standing problem of the composite dark matter solution for the puzzles of direct dark matter searches. This solution assumes existence of stable -2n charged particles bound by Coulomb interaction with n nuclei of primordial helium forming nuclear interacting Bohr-like OHe (n=1) or Thomson-like XHe (n¿1) dark atoms. The puzzles of direct DM searches are then explained by the annual modulation of low-energy binding of dark atom with nuclei in the DAMA/NaI and DAMA/LIBRA detectors, which cannot be detected in direct WIMP searches for recoil nuclei or electrons from WIMP interaction with the matter in other detectors. The continuous approach to the realistic description dark atom interaction with nuclei by the quantum mechanical accomplishment of the numercial study of classical three body problem both for OHe and XHe is now accompanied by the development of methods to solve the Schroedinger equation for the considered problem. The progress in our studies is reported.

L. Bonora: Elusive anomalies

Abstract: Usually, in order to compute an anomaly (be it chiral or trace) with a perturbative method, the lowest significant order is sufficient. With the help of gauge or diffeomorphism invariance it uniquely identifies the anomaly. This note is meant to signal a particular (somewhat pathological) case in which the lowest perturbative order is not enough to unambiguously identify a trace anomaly. This may shed light on some recent contradictory results.

S. Brodsky: Maximally precise tests of the Standard Model: Elimination of perturbative QCD renormalization scale and scheme ambiguities

Abstract: The Principle of Maximum Conformality (PMC) systematically and rigorously eliminates order-by-order the renormalization scale and scheme ambiguities of perturbative QCD predictions, a topic central and crucial for testing the Standard Model to high precision. The QCD running coupling $\alpha_s(q^2)$ is defined to sum all β terms (vacuum polarization contributions) of a pQCD series. When applying the PMC, all β terms are identified and used to set the renormalization scale of $\alpha_s(q^2)$, as required by renormalization group invariance. The resulting series pQCD matches the corresponding conformal

theory, thus eliminating the non-convergent N-factorial renormalon growth of pQCD. Relations between observables using the PMC are independent of the choice of renormalization scheme. The PMC is the analytic generalization to non-Abelian theory of Gell Mann-Low scale-setting used in QED, The PMC thus satisfies the requirement that one must use the same scale-setting procedure in all sectors of a Grand Unified Theory. I will also review many successful PMC scale-fixed predictions.

A. Chaudhuri: Electroweak phase transition and entropy release in Z_2 symmetric extension of the Standard Model

Abstract: In this work we consider the simple Z2 symmetric extension to the Standard Model (SM) and proceed to study the nature of electroweak phase transition (EWPT) in the early universe. We show that the nature of the phase transition changes from a smooth crossover in the SM to a strong first order with this addition of the real scalar. Furthermore, we show the entropy release in this scenario is higher than that of the SM. This can lead to a strong dilution of frozen out dark matter particles and baryon asymmetry, if something existed before the onset of the phase transition.

S. R. Chowdhury, M. Khlopov: The impact of mass transfer in the formation of compact binary merging

Abstract: The binary black hole coalescences GW150914 and GW151226 observed by the LIGO started the gravitational wave (GW) astronomy era. It enabled us to investigate gravity in the strong-field regime. In order to resemble the observations, accurate theoretical models are required to compare the results. There are still significant uncertainties about the stability of mass transfer and common envelope evolution in formation models involving isolated binary stars. Large binary population simulations have been used to anticipate the sources for GW. Populations can be produced on timescales of days using a binary population synthesis tool that balances physical modelling and simulation speed. With the help of COSMIC, we simulate the galactic population of compact binaries and their GW signals. Based on the metallicity, the final fate of the population has been estimated.

E. Dmitrieff: On construction of artificial empty space

Abstract: We consider principles of four-dimensional tessellation model of physical vacuum, and suggest a concept of experimental hardware equipment intended to reproduce some of its properties.

1. The basic structure for our model is the 4D space-filling by 26-cell 'satori' polytopes. It can be produced from the tesseract grid by solid-shifting all its nodes in four orthogonal directions on half-edge length along the crystallographic axes. Each node is considered either Even or Odd. This Parity data is inherited from the original tesseract lattice.

2. Postulating the changeable Charge of node, and its initial equality to the original Parity, one bit for each node, we can consider the grid as a kind of memory storing the data locally in nodes and having the node-based syntactical freedom.

3. While the Parity of nodes is fixed by their position in the lattice, the Charge bits can be exchanged, producing a pair of anti-structural defects recognizable as opposite-charged particle and anti-particle with opposite Parity. It reflects the known natural Charge-Parity (CP) symmetry between left-handed particles and right-handed antiparticles, and

vice versa.

4. The Charge of node can be deferred from the known particle charges statistics; it must be 16 of the electron charge. Then, the single defect would carry ± 13 e , corresponding to down quarks/anti-quarks, the double defect is an up quark with ± 23 e, the triple defect is a charged lepton with$\pm$ e. The estimated scale (domain radius) based on Higgs expectation value is about $10 - 21$ m.

5. The data in grid is stored both in nodes and edges. The edges are more conservative than nodes. The modification (rewriting) of edges is associated with processes of Universe formation, such as big bang, inflation, bariogenesis, and vacuum phase transitions. In the modern Universe (maybe excepting black holes) they are constants, so the geometrical structure is fixed. It determines the emergent space dimension count, its symmetry, and the rules of node data exchanges. However, the orientation of edge changes according to change in node data.

6. The node data it is represented by Charge bits. It is more volatile than edges. It describes individual particles and their behavior. The node data is supposed to be 1 bit per node. Or, say the node is one bit.

7. The rolling or folding of grid together with Charge-Parity concept can explain why the observable space is isotropic while both periodic and quasi-periodic grids, that are supposed to be the background structure of space, are not. In case of folding, there are two mirror-reflected layers in projection, so pairs of CP-symmetric nodes can effectively

cancel each other in projection. The Charge (in absence of defects) is exactly 0 everywhere, so nodes are not observable, and the projected space appears isotropic and empty.

8. However, all nodes still exist in the rolled space and they can participate in time clock movement and cellular-automaton-like evolution. Defects cause de-compensations of charges, that are observable as charged or not charged particles.

9. The 4D tesseract grid has the equal lengths of its main diagonal and of its translation unit along its edges. Also, the both ends of the main diagonal have the same parity. So, this grid can be rolled in two ways with the same radius. This property is inherited by 26-cell space-filling because it is produced from the tesseract grid. It is possible that there exists some third way of compactification that combines both ways.

10. The cellular automaton's cell may be equipped with simple hardware circuit that performs the evaluating rule for all cells simultaneously. Doing so asynchronously has advanced effects that cannot be achieved by using Turing machine with dedicated CPU that runs simple program rule for all the cells in turn.

11. The simple circuit approach allows to get rid of computational resources limitations and of lowering performance on big arrays. In asynchronous regime some interesting effects of mutual concurrency may appear, that are suppressed in synchronous computations.

12. The proper time seems to be connected to the branching rate of walk paths. Zero proper time for light-speed movement is presumably caused by no forks on 5D helical paths having the maximal possible pitch. In the 26-cell filling, there are no straight (geodesic) paths, but there are forks with small angles that are also joins in reverse direction. So each path is a combination of joins and forks with some rate. It is always positive. Thus, the proper time is non-negative and not reversible. Defects, propagating by paths, cannot be tachyons.

13. The 4th (rolled) coordinate is not a time. But the T symmetry is connected to reflection in this direction, not with the proper time (that is a positive count). The

movement along it in both directions is as free as in other three dimensions. But since it is compactified, both results have just minor differences that are observable as rare cases of CP symmetry violations.

14. The compactification (rolling, folding) of the 4th dimension makes the modeling simpler. Instead of 4D, it allows using 3D silicon/copper hardware arrays for effective modeling of some aspects of its behavior. Its geometrical structure is fixed by the array construction. So this hardware model would not be able to reproduce the gravity, black holes and other special cases without additional tricks.

P. Frampton: I Additional baryons and mesons

Abstract: In a particle theory model whose most readily discovered new particle is the $\approx 1TeV$ bilepton resonance in same-sign leptons, currently being sought at CERN's LHC, there exist three quarks D, S, T which will be bound by QCD into baryons and mesons. We consider the decays of these additional baryons and mesons whose detailed experimental study will be beyond the reach of the 14 TeV CERN collider and accessible only at an O(100 TeV) collider.

II Is there additional dark matter?

Abstract: Assuming that the entropy of the contents of the universe saturates the holographic bound, we extend the P BH idea for dark matter within galaxies and clusters of galaxies by populating the universe with extremely massive P BHs having masses extending up to values close to the mass of the universe. The Great Attractor is one possible example of such additional dark matter.

A. Hernandez-Galeana: Fermion masses and mixing within a gauged SU(3) family symmetry model

Abstract: Recently some experiments have reported possible deviations from the standard model predictions, such as; lepton flavor universality violation in rare B decays, the results of the g - 2 experiment of the muon at Fermilab, and the violation of unitarity in the quark mixing matrix, VCKM. Attempting to find new physics that provides possible solutions to these anomalies, we address the problem of generating the quark and lepton masses and mixing, including neutrinos, in the con- text of a gauged SU(3) family symmetry model. This BSM introduces new particles: scalars, gauge bosons, right handed neutrinos, and a set of SU(2)L weak singlets vector-like fermions U,D,E,N, with N a neutral lepton. We provide updated numerical results and report the non-unitary, (VCKM)4×4 and (UPMNS)4×8, quark and lepton mixing matrices.

M. Ildes: I Analytic Solutions of Scalar Field Cosmology, Mathematical Structures for Early Inflation and Late Time Accelerated Expansion Abstract: We study the most general cosmological model with real scalar eld which is mini- mally coupled to gravity. Our calculations are based on Friedmann-Lemaitre-Robertson-Walker (FLRW) background metric. Field equations consist of three dierential equations.

II Analytic Solutions of Brans-Dicke Cosmology: Early Inflation and Late Time Accelerated Expansion Abstract: We investigate the most general exact solutions of Brans-

Dicke cosmology by choosing the scale factor "a" as the new independent variable. It is shown that a set of three eld equations can be reduced to a constraint equation and a rst order linear dierential equation.

Comparison of our results with recent observations of type Ia supernovae indicates that eighty-nine percent of present universe may consist of domain walls while rest is matter.

S. Kabana: Thermal production of Sexaquarks in Heavy Ion Collisions

Abstract: Sexaquarks are a hypothetical low mass, small radius uuddss dibaryon which has been proposed recently and especially as a candidate for Dark Matter. The low mass region below 2 GeV escapes upper limits set from experiments which have searched for the unstable, higher mass H-dibaryon and did not find it. Depending on its mass, such state may be absolutely stable or almost stable with decay rate of the order of the lifetime of the Universe therefore making it a possible Dark Matter candidate . Even though not everyone agrees its possible cosmological implications as DM candidate cannot be excluded and it has been recently searched in the BaBar experiment.

The assumption of a light Sexaquark has been shown to be consistent with observations of neutron stars and the Bose Einstein Condensate of light Sexaquarks has been discussed as a mechanism that could induce quark deconfindement in the core of neutron stars.

S production in heavy ion collisions is expected to be much more favorable than in the only experimental search to date, $Y \rightarrow S\Lambda \rightarrow \lambda \rightarrow$, which is severely suppressed by requiring a low multiplicity exclusive final state. By contrast, parton coalescence and/or thermal production give much larger rates in heavy ion collisions.

We use a model which has very successfully described hadron and nuclei production in nucleus-nucleus collisions at the LHC, in order to estimate the thermal production rate of Sexaquarks with characteristics such as discussed previously rendering them DM candidates.

We show new results on the variation of the Sexaquark production rates with mass, radius and temperature and chemical potentials assumed and their ratio to hadrons and nuclei and discuss the consequences.

A.O.Kirichenko: Propagation of antinuclei in galactic magnetic field

Abstract: We model the propagation of antihelium particles in the magnetic fields of the Galaxy from a supposed source of antimatter in the Galactic halo in the form of a globular antistellar cluster. The well-known JF12 model (R. Jansson, G. R. Farrar, 2012) with the addition of an irregular component (A. Beck, A. Strong, 2016) was taken as a magnetic field model. The cutoff energy for the penetration of particles into the disk in the total magnetic field of the Galaxy (of the order of 1000 GeV) is estimated. Particles of low energies (less than 100 GeV) are largely suppressed when they try to penetrate the disk region. The observed suppression is similar to the effect of solar modulation, which occurs when cosmic rays penetrate into the heliosphere. Taking into account expected decreasing power law suppression at the high energies in the source convergence of this cut off with the power law energy dependence favors the energy range which is optimal for search for antihelium component of cosmic rays at the AMS02 experiment

M. Khlopov: Cosmological reflection of the BSM physics

Abstract: The modern cosmology is based on the BSM physics, involved in the mechanisms of inflation, baryosynthesis and the physical nature of dark matter. To specify the parameters of BSM models methods of multimessenger cosmology are developed with special emphasis on the important role of exotic deviations from the now Standard cosmological paradigm, like macroscopic antimatter in baryon asymmetrical Universe, primordial black holes, structures and inhomegeneities in the dark matter distribution as well as Warmer than Cold dark atom scenario of composite dark matter. Positive evidence for such deviations would strongly restrict possible classes of BSM models and provide determination of BSM parameters with "astronomical accuracy".

M. Y. Khlopov, O.M. Lecian I Primordial Antimatter and Dark Matter celestial objects

Abstract: The structure and evolution of Primordial Antimatter domains and Dark matter objects are analysed. Relativistic low- density antimatter domains are described. The Relativistic FRW perfect-fluid solution is found for the characterization of i) ultra-high density antimatter domains, ii) high-density antimatter domains, and iii) dense antimatter domains. The possible sub-domains structures is analyzed. The structures evolved to the time of galaxy formation are outlined. Comparison is given with other primordial celestial objects. T he features of antistars are outlined. In the case of WIMP dark matter clumps, the mechanisms of their survival to the present time are discussed. The cosmological features of neutrino clumping due to fifth force are examined.

A.V.Kravtsova: Interaction of antinuclei with galactic interstellar gas

Abstract: Models of strongly inhomogeneous baryosynthesis in the baryon-asymmetric Universe admit the existence of macroscopic domains of antimatter, which could evolve as a globular cluster of antistars in the halo of our Galaxy. Assuming the symmetry of evolution of the globular cluster of stars and antistars on the basis of symmetry of matter and antimatter properties, such an object could be the source of anthelium nuclei in galactic cosmic rays. This allows us to the prediction of the expected fraction from the fluxes of cosmic antinuclei propagation in the magnetic field of the Galaxy, taking into account the inelastic interaction with interstellar matter, in which destruction of antiHe-4 can result in creation of anti-He3. Assuming that interstellar gas predominantly contains different components of hydrogen we formulate the problem of cosmic ray enrichment by anti-He3, which will be important for interpretation of the coming AMS02 data.

A. Kleppe: Flavours, families, handedness

Abstract: Some thoughts about chirality and weak interactions.

F. Lev: I The concept of particle-antiparticle in particle theory

Abstract: The title of this conference is: "What comes beyond standard models?". Standard models are based on standard Poincare invariant quantum theory (SQT). Here irreducible representations (IRs) of the Poincare algebra are such that in each IR, the energies are either ≥ 0 or ≤ 0. In the first case, IRs are associated with particles and in the second case with antiparticles, while particles for which all additive quantum numbers (electric charge, baryon and lepton quantum numbers) equal zero are called neutral.

However, SQT is a special degenerate case of finite quantum theory (FQT) in the formal limit p ! 1 where p is a characteristic of a ring in FQT. In FQT, one IR of the symmetry algebra describes a particle and its antiparticle simultaneously, and there are no conservation laws of additive quantum numbers. One IR in FQT splits into two standard IRs with positive and negative energies in the formal limit p ! 1. The construction of FQT is one of the most fundamental (if not the most fundamental) problems of particle theory.

II Discussion of cosmological acceleration and dark energy

Abstract: Following our publications, we argue that the phenomenon of cosmological acceleration has a natural explanation as a consequence of quantum de Sitter symmetry in semiclassical approximation. The explanation does not involve dark energy and other exotic concepts.

N.S. Mankoč Borštnik: Understanding nature with the spin-charge-family theory

Abstract: In a long series of papers I have been developing, together with collaborators, the model named the *spin-charge-family* theory, with fermions the internal space of which is described with the odd products of the Clifford algebra objects in $d = (13 + 1)$, what makes the corresponding creation and annihilation operators anticommuting second quantized objects. The model is able to explain all the assumptions of the standard model, with the appearance of families included, offering explanation for also other observed phenomena, as there are the dark matter and the matter/antimatter asymmetry in the universe, making several predictions. In my talk I present new way of the second quantized not only fermion fields but also boson fields: The second quantization of both kinds of fields origins in the description of the internal space of fields with the "basis vectors" which are the superposition of odd (when describing fermions) or even (when describing bosons) products of the Clifford algebra operators γ^a's. The tensor products of the "basis vectors" with the basis in ordinary space form the creation operators which manifest the anticommutativity of fermions or commutativity of bosons, explaining the second quantization postulates of Dirac for both kinds of fields. The Clifford even creation operators are discussed in details for the case that $d = (5+1)$, showing up that they have all the properties of the gauge fields of the corresponding fermion fields, offering a new understanding of the fermion and boson fields.

R N. Mohapatra: A unified theory of neutrino mass, dark matter, baryogenesis and strong CP

Abstract: We discuss the Affleck-Dine mechanism for leptogenesis which involves the cosmological evolution of a complex lepton number carrying scalar field that can also implements inflation. We show how explicit lepton number breaking terms involving this field needed to implement this scenario combined with fermionic WIMP dark matter, can generate neutrino mass at the one loop level, thus providing a unified, interconnected framework for solving four of the major puzzles of the standard model i.e. inflation, baryogenesis, dark matter and neutrino mass. We discuss how an extension of this model can solve the strong CP problem as well.

V.V. Monakhov: Modules over Clifford algebras as a basis for the theory of second quantization of spinors

Abstract: In 1913, Elie Cartan discovered spinors as two-valued irreducible complex representations of simple Lie groups. Pauli in 1940 proved the connection between spin and statistics. Since then, the concepts of "spinor" and "fermion" have been considered identical. Lounesto and a number of other authors developed the theory of spinors as elements of left ideals of Clifford algebras. Such spinors are called algebraic. The development of the theory of second quantization proceeded along a parallel branch and practically did not intersect with the algebraic theory of spinors. Fermion field quantization based on canonical anticommutation relations (CAR) was introduced by Jordan and Wigner in 1928. The fundamentals of the relativistic quantum theory of spinor fields, using the second quantization method, were formulated by Schwinger in 1951-1953. The theory of second quantization was mathematically substantiated on the basis of the theory of CAR algebras in the works of Gårding, Wightman, Araki, Berezin. In both approaches, an important role was played by the spinor vacuum as a state in which there are no spinors. However, in the theory of algebraic spinors it turned out that the identity of the Clifford algebra can be decomposed into a sum of spaces of algebraic spinors. Therefore, if we consider the space of spinors as an element of the Clifford algebra, then the spinor vacuum is the sum of the spinor components. Another problem arose in the theory of CAR Modules over Clifford algebras as a basis for the theory of second quantization of spinors.

H. B. Nielsen: I Dusty dark matter pearls developed

Abstract: We develop our earlier model for dark matter being bubbles of a new type of vacuum filled with say diamond to make these pearls now dirtified by cosmic dust, which in trun has got hardened due to influence from the pearl proper on the electron orbits. We still consider very strongly the mysterious line of X-ray of photon energy 3.5 keV, and seek to resolve the seeming inconsistencies or mysteries of the intensities measured from the Persues Cluster. Our point is that the emission from the outskirts of this galactic cluster of this 3.5 keV line comes by excitation of the bubbles by the surrounding intergalactic medium rather than by collision of dark matter pearls as is supposed to be the usual mechanism for making the 3.5 keV radiation.

II A new view on Cosmology, with Non-translational invariant Hamiltonian

Abstract: It is irritating that one due to the ambiguities or difficulties of making a Hamiltonian in general relativity cannot have a good intuition fro using a hamiltonian description of the whole universe. The idea is to choose coordinates so as to make the time development be given as one of the Killinng transformations for one of the symmetries of a (chosen) caricature of the cosmological model universe development, e.g. an anti-DeSitter space, which has a good inflation.

P. Salucci: A Nietzschean paradigm for the dark matter phenomenon

Abstract: Well known scaling laws among the structural properties of the dark and the luminous matter in disc systems are too complex to be arisen by two inert components that just share the same gravitational field. This brings us to critically focus on the 30-year-old paradigm, that, resting on a priori knowledge of the nature of Dark Matter (DM), has led us to a restricted number of scenarios, especially favoring the collisionless

Λ Cold Dark Matter one. Motivated by such observational evidence, we propose to resolve the dark matter mystery by following a new Paradigm: the nature of DM must be guessed/derived by deeply analyzing the properties of the dark and luminous mass distribution at galactic scales as complex and unexpected they can be. The immediate application of this paradigm leads us to propose the existence of a direct interaction between Dark and Standard Model particles, which has finely shaped the inner regions of galaxies.

D.Sopin: Primordial asymmetry of new sequential superheavy quarks and leptons

Abstract: New stable family with the Standard model electroweak (EW) charges should take part in sphaleron transitions in the early Universe before the phase transition with the EW symmetry breaking. It puts balance between the excess of new quarks and leptons and baryon asymmetry. We consider the asymmetry of superheavy new generation particles (new quarks U, D and new leptons E, N) balanced with the baryon excess. At temperatures above the electroweak phase transition it can be found with the use of system of equations for the chemical potentials and Boltzmann kinetic equation.

Guy F. de Teramond Emergence of confinement and the proton mass scale: The holographic QCD perspective

Abstract: A basic understanding of fundamental features of hadron physics from first principles QCD has remained elusive. These include the mechanism of color confinement, the origin of the hadron mass scale, chiral symmetry breaking and the pattern of hadronic excitations. In this talk I will discuss how emerging QCD properties would appear in an effective computational framework of hadron structure based on a semiclassical approximation to light-front QCD and its holographic embedding in AdS space. Additional constraints from a superconformal algebraic structure introduce a mass scale and fix the effective confinement potential for mesons, baryons and tetraquarks, while keeping the pion massless. This new approach to hadron physics leads to relativistic wave equations similar in their simplicity to the Schrödinger equation in atomic physics.

K. Zioutas: Planetary relationship as the new signature from the dark Universe

Abstract: The discovery of dunkle Materie (DM) by ZWICKY came from unexpected cosmological observations. Similarly, the last 160 years a number of unexpected energetic observations could be the manifestation of the dark Universe. We refer to this class of particle candidates as "invisible" to distinguish them from the already excluded parameter phase space of WIMPs and axions. In this work we stress a simple feature as the common signature of such observations within the solar system. Namely, the widely discussed dark sector constituents with velocity of 1‰ c (c=velocity of light). As pointed out since 20 years, streams of constituents with such velocities can be gravitationally focused or deflected by any solar system body to others. The aforementioned energetic observations include the unpredictable flaring Sun, its irradiance, its size variation, its elemental composition, etc, but also terrestrial phenomena including the dynamic atmosphere and other highly crossdisciplinary observations like the not randomly appearing Earthquakes. All observations follow otherwise unexpected planetary relationships. More results may come out until this conference following more out-of-the-box thinking including exo-solar planetary systems. To conclude, a planetary relationship is a key signature pointing on its

own at exo-solar origin. In this conference we will focus on Earthquakes. The only viable explanation is thanks to planetary gravitational focusing of streaming invisible matter, which is tentatively identified with constituents from the dark Universe, interacting with large cross section with ordinary matter. Implications in (ongoing) DM experiments will be discussed. The mostly inspiring particle constituents fitting-in a number of observations are AntiQuarkNuggets, magnetic monopoles and dark photons. Though, more emerging candidates like the pearls (see talk by Holger Nilsen) are encouraged to investigate whether they fit-in, and, how to identify their possible involvement.