Frontiers of Fundamental Physics 14

List of posters

Updated on January 8, 2015

Eric **Baussan** (IPHC) **High Energy Physics**

ESSnuSB Neutrino Oscillation Project

The recent measurements of the last mixing angle performed by the reactor experiment in the neutrino sector enable the search for the CP violation in the leptonic sector. The next generation of neutrino experiments will require new intense neutrino beams and large detector infrastructures.

In this context, a new facility is proposed using the European Spallation Source (ESS), currently under construction in Lund (Sweden), to produced the world's most intense neutrino beam [1] with a megaton Water Cherenkov detector installed 1000 m down in a mine at a distance of about 500 km. This detector will also extent the physics program to proton-decay, atmospheric neutrinos and astrophysics searches [2] .

References

[1] E. Baussan *et al.* [ESSnuSB Collaboration], "A very intense neutrino super beam experiment for leptonic CP violation discovery based on the European spallation source linac" - Nuclear Physics, Section B (2014), pp. 127-149.
[2] L. Agostino *et al.* [MEMPHYS Collaboration], "Study of the performance of a large scale water-Cherenkov detector (MEMPHYS)," JCAP **1301** (2013) 024

Enrico **Calloni** (Università Federico II - Napoli) **Frontiers of Fundamental Physics**

The weighing of layered superconductors transition energy as a possible experimental method to ascertain the Archimedes vacuum force

The main motivations and scheme of a possible experimental way to verify the interaction of vacuum energy with gravitational field are reported [1]. The experiment consists in weighing the transition energy of layered superconductors, to which the Casimir energy is expeced to give a not-negligible contribution [2,3]. The expected signal is compared with the present, or near future, small-forces measurement techniques and to show that it is comparable with expected sensitivities.

References

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Ángel José **Chacón Velasco** (UPTC) **Epistemology and Philosophy**

On semiotics as a sort of "heuristic generator" regarding the construction of epistemological empiric perspectives in philosophy of science

Bogar **Díaz Jiménez** (BUAP) **Quantum Gravity**

Alternative Lagrangian formulations for linearized general relativity

It is well-known that there exists an analogy between Maxwell theory and linearized gravity [1]; on the basis of this analogy it has been possible to extend some results of the former to the latter [2]. On the other hand, Maxwell theory can be written as a BF-type theory [3] and due to the mentioned analogy it is natural to ask if a BF-type action for linearized gravity exists.

We give some action principles of the BF type for linearized gravity: which are based on the Maxwell BF-type action, which on-shell reduces to the well-known Fiertz-Pauli action. Furthermore, we also explore the Hamiltonian analysis of these actions.

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[1] Thirring H 2012. On the formal analogy between the basic electromagnetic equations and Einstein's gravity equations in first approximation, *Gen. Rel. Grav.*, http://link.springer.com article 10.1007 s10714-012-1451-3#, **44** 3225 (republication).
[2] Henneaux M and Teitelboim C 2005, Duality in linearized gravity *Phys. Rev. D* http://prd.aps.org abstract PRD v71 i2 e024018 **71** 02401.
[3] Sundermeyer K 1982 *Constrained Dynamics* Springer.

Semiha **Efe** (Fenbilens) **Mathematical Physics**

Airy Waves in a BEC

We study Airy waves in a Bose-Einstein condensate. We show that Airy wave is self accelerating. We consider the effect of the external harmonic potential on self accelerating Airy waves. We propose possible experimental implementation.

Kevin **Falk** (CPT) **Mathematical Physics**

Spectral triples and Toeplitz operators

We build spectral triples using the theory of Toeplitz operators on Hardy and weighted Bergman spaces over an open smoothly bounded pseudoconvex domain $\Omega \subset \mathbb{C}^n$. A spectral triple involving Toeplitz operators over the Fock space with Gaussian measure is also presented. We describe the involved Dirac operators and their influence on the computation of the dimension of the spectral triples.

Màrius Josep **Fullana i Alfonso** (IMM - UPV) **Frontiers of Fundamental Physics**

Some remarks on time dependent parameters in physical theories

The possibility that the gravitational *constant G* may vary with cosmological time t (or with the cosmological scale factor $a(t)$) has been intensively studied for a long time [1,2,]. The possibility that this also happens with the speed of light c has been taken into account. We present here some important remarks on this subject. These remarks include the condition that, in order to preserve the conservation equations of physics, if G varies c must also vary with time. Then with $G(t)$ and $c(t)$ both varying with time the restriction is $8\pi G/c^4 = \text{constant}$. This applies to the case of a cosmological constant assumed to be a true constant. Otherwise the restriction is $8\pi G/c^2 = \text{constant}$. We also analyze some implications on physical theories.

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Diego **González** (Cinvestav) **Frontiers of Fundamental Physics**

A gauge connection formulation of general relativity

It has been shown in Ref. [1] that general relativity with zero cosmological constant can be described as a "pure spin-connection formulation" using a gauge $SO(3,C)$ connection and a scalar density. The case of nonzero cosmological constant was developed in references [2] and [3]. These formulations, however, are either complicated or not compatible with the case of vanishing cosmological constant. In this talk I report an action principle for general relativity that involves a gauge connection, which works well with or without cosmological constant and that is much simpler.

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Bruno **Gonçalves** (IFSMG) **High Energy Physics**

The exact Foldy-Wouthuysen transformation for a Dirac Theory with the complete set of CPT/LORENTZ Violating terms

Jai-chan **Hwang** (KNU) **Epistemology and Philosophy**

Philosophical Introspection of scientific cosmology

This talk is based on [1]. Scientific cosmology tries to understand the Universe at large with its origin and evolution. Observational and experimental situations in cosmology do not allow us to proceed purely based on the empirical means. We examine in which sense our cosmological assumptions in fact have shaped our current cosmological worldview with consequent inevitable limits. Cosmology, as other branches of science and knowledge, is a construct of human imagination reflecting the popular belief system of the era. The question at issue deserves further philosophic discussions. In Whitehead's words, "philosophy, in one of its functions, is the critic of cosmologies."

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[1] J. Hwang, *Modern Cosmology: Assumptions and Limits*, [arXiv:1206.6297].

Pierre **Mandrin** **Quantum Gravity**

Spin-compatible construction of a consistent quantum gravity model from minimum information

It has been shown in [1] that a quantum gravity formulation exists on the basis of quantum number conservation, the laws of thermodynamics, unspecific interactions, and locally maximizing the ratio of resulting degrees of freedom per imposed degree of freedom of the theory. A generalized form of the First Law of thermodynamics has been imposed on the boundary of space-time volumes, while no explicite microscopic quantum structure was required. From this model, Quantum Field Theory and General Relativity have been recovered as special cases. This talk presents the generalized action in terms of tetrades and shows how the action may be related to the spin of matter fields.

References

[1] P. A. Mandrin, *Existence of a consistent quantum gravity model from minimum microscopic information*, Intern. J. Theor. Phys (2014) DOI 10.1007/s10773-014-2176-8.

Noureddine **Mebarki** (UMC-1) **High Energy Physics**

Gauged and ungauged unparticles signal at the LHC and ILC

Scalar and tensor ungauged unparticles contribution to the polarized diphoton production at the LHC and ILC are studied and the effects of the conformal as well as dimensions scales are discussed. The expressions of the various subprocess helecity amplitudes are also presented. Moreover, the effect of spin 0 and spin 1/2 gauged unparticles on the decay rates of $h \to \gamma\gamma$ and $h \to Z\gamma$ are also shown explicitly.

Noureddine **Mebarki** (UMC-1) **Quantum Gravity**

Loop quantum effects on a viscous dark energy cosmological model

A novel effective cosmological model with bulk viscosity and loop quantum geometry effects is proposed. It is found that the bulk viscosity affects the quintessence scenario leading to the existence of a de Sitter type viscous late time attractor whereas the loop quantum effects influence the phantom case where the big rip singularity is removed.

Marisa **Michelini** (UniUD) **Physics Education**

Conceptual Labs for operative Exploration

In the perspective of the Model of Educational Reconstruction [1], designing new educational path require to gain new information on how students face the specific subject explored. At the PERG of Udine the main steps of the new educational paths were explored with pupils engaged in Conceptual Laboratory of Operative Exploration (CLOE) in informal learning contexts, where using different monitoring tools student spontaneous ideas as well their learning paths were explored and stimulated [2-4]. In CLOE pupils discuss everyday life scenarios, recover their everyday and sensorial knowledge, as well as involve them in the challenges of explorations according to an IBL strategies. The CLOE lab are research based proposals of learning where explore how pupils build formal thinking, reflect on phenomena and construct models, reinterpret common everyday knowledge. The research focus is on the reasoning sequence, the ways in which knowledge is structured, the development of interpretative representations. [5-7] The design characteristic of the CLOE labs are presented exemplifying it in the case of the CLOE on energy.

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Marisa **Michelini** (UniUD) **Physics Education**

IDIFO Teachers Formation on Modern Physics

The main fall in motivation levels with regard to scientific studies in Italy has been collaboratively answered through the national project (Scientific Degree Project—PLS). Master IDIFO is a project in this framework for in-service teacher formation, a project focused on Didactic Innovation in Physics Education and Guidance, carried out by Udine PER Unit in collaboration with 20 Italian universities. It offers educational innovation, science learning laboratories, formative orientation (problem solving) and teacher training on Modern Physics topics for in-service teachers. It implements a model for teacher training, with an aim to develop formal thinking and to relate associated connection between Computer Science-Mathematics and Physics on Modern Physics topics. The activities such as educational and experimental workshops in presence, training teachers at a distance and in presence, conducting exhibitions, designing Inquiry Based Learning materials, activities for the orientation training in physics, informal education through conceptual laboratories (CLOE) and use of ICT to overcome the conceptual nodes in physics, teaching laboratories using problem solving and Prevision-Experiment-Comparison strategies and in-depth analysis of learning processes in educational innovation are achieved.

Brigitte **Rocca** (IAP) **Cosmology**

Primeval Radiogalaxies: The key for AGN-starburst relation

Primeval ($z > 4$) radiogalaxies are privileged targets to understand the tight relation of the supermassive black hole masses with star formation (Ferrarese & Merritt, 2000). At high z, star formation is disentangled from the AGN emission with Herschel observations and the help of our synthesis model Pegase. Moreover the Spitzer satellite revealed an old evolved population (Rocca-Volmerange et al, 2013, MNRAS) . All the ingredients to follow the relation of AGN- star formation on a large time-scale coverage are found in a variety of radiogalaxies as the HeRGE sample (Drouart et al, 2014).

Subir **Sarkar** (UOXF & NBI) **Astroparticle Physics**

Astrophysical explanation for the PAMELA/AMS-02 anomaly

Cosmic rays being Fermi accelerated by a nearby supernova remnant shock wave will create secondaries such as positrons, antiprotons and lighter nuclei, a fraction of which will be (re)accelerated to a harder component that dominates at high energies (1,2). This accounts for the rise in the positron fraction at high energies above the expectation from diffusive propagation in the Galaxy. We use the precision AMS-02 data to predict the expected rise in the antiproton fraction which will test the model (3).

References

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3) P. Mertsch and S. Sarkar, *AMS-02 data confronts acceleration of cosmic ray secondaries in nearby sources*, submitted to Phys.Rev.D, arXiv:1402.0855 [astro-ph.HE].

Vera Georgievna **Sinitsyna** (FIAN RAS) **Astroparticle Physics**

SHALON observations of Active Galactic Nuclei at red shift from z = 0.0179 to z = 1.375

The radio-loud active galactic nuclei having the radio emission arising from a core region rather than from lobes are often referred to as "blazars" and include Flat Spectrum Radio Quasars (FSRQ) and BL Lacertae (BL Lac) objects. We present results of long term observations of FSRQ: among them are known object 3c454.3, high-red shifted quasar 1739+522 (4c+51.37) ($z = 1.375$) and 4c+31.63 ($z = 0.295$), 4c+55.17 ($z = 0.896$) as well as BL Lac type object OJ 287 ($z = 0.306$) which was recently detected by SHALON Cherenkov telescopes [1,2,3]. The observation results are presented with integral spectra, images and spectral energy distributions for each of sources at energies above 800 GeV. A number of variability periods in different wavelengths including VHE γ-rays were found.

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Vera Yurievna **Sinitsyna** (FIAN RAS) **Astroparticle Physics**

EBL measurements through the TeV gamma-ray spectra of Low- and High-red shifted AGN

The detection of TeV gamma-ray sources at high red-shifts namely NGC1275 ($z = 0.0179$), Mkn421 ($z = 0.031$), Mkn501 ($z = 0.034$), Mkn180 ($z = 0.046$), 3c382 ($z = 0.0578$), 4c+31.63 ($z = 0.295$), OJ 287 ($z = 0.306$), 3c454.3 ($z = 0.859$), 4c+55.17 ($z = 0.896$) and 1739+522 ($z = 1.375$) [1,2,3] is the evidence of less average spectral density of Extragalactic Background Light and thus the less star formation rate at early evolution stage, than it is previously believed. Also, the possible explanation of the detected very high energy gamma-emission from the distant AGNi is the re-scattering of primary TeV-photons on the Dark Matter particles, so called WISP - weakly interacting slim particles. The axion-like particles has been considered to be a candidate for such weakly interacting slim particles.

References

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Alberto **Stefanel** (UNIUD) **Physics Education**

Conceptions of secondary students on phenomenology of superconduction

Currently, superconductors at low cost can be used to analyze the typical superconducting phenomena in schools [1-4].

Experimental problem solving on Meissner levitation and breakdown of the resistivity of the superconductors at phase transition for the exploration of the ideal properties of a conductor have been proposed to students of Italian secondary schools, with the use of worksheets tutorials that implement inquiry based learning strategies.[5-6].

The students' initial conceptions about how an ideal conductor dynamically interacts with a magnet in motion, as these conceptions are modified by the phenomenological exploration and how they are structured at the end of the learning path were monitored with pre-test, post-test focused on conceptual issues explored experimentally.

The results evidence that students initially believe that an ideal conductor is a transparent medium to the magnetic field. The exploration of analogical situations of suspension and deceleration of magnets activate in students the recognition of the nature of ideal diamagnet of a superconductor.

References

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Roman **Sverdlov** (IISER) **Frontiers of Fundamental Physics**

Can "infinitesimal" epsilon in path integral propagator actually be finite?

Professor Mikhail Mensky, and, more recently, Adrian Kent, has discussed a possibility of a continuous measurement model involving "restricted path integrals". Instead of computting the probability of "out state" at $t = +\infty$, we are computting a probability of a trajectory $\phi = \phi_{cl}$ taking place over entire space and time. The probability of said trajectory is given by "restricted path integral" around a "corridor" surrounding ϕ_{cl}. The "size" of said corridor is "very large" on quantum scale (thus explaining unbounded path integral) and "very small" on classical scale (thus explaining emergence of "classical" trajectory). Said "corridor" can be replaced by Gaussian "weight" attached to path integral. My own contribution to the above idea involves the realization that said "Gaussian weight" can be interpretted as an "infinitesimal" ϵ parameter used in QFT propagators. Thus, a statement that "ϵ is infinitesimal" is logically equivalent to the statement "classical scale is infinitely large" which, in fact, is a default assumption of quantum physics. On the other hand, since we know that classical scale is finite, we can compute the finite (but very small) value of ϵ and predict deviations to quantum predictions on all scales (although on quantum scales such deviations are very small, and they became large on classical scales). The mathematical derivation of the above phenomenon is given in [1].

References

[1] arXiv:1306.1948

Roman **Sverdlov** (IISER) **Epistemology and Philosophy**

Realistic interpretation of Grassmann variables outside the integral sign

While Grassmann integration is "formally"defined its properties are counter intuitive. Why would integral of an odd function give non-zero value and integral of an even function be zero? Why would the integral of the exponential be proportional to the coefficient in the exponentiation rather than inversely proportional? How can Grassmann integral possibly be real or complex? After all, taking real/complex number to arbitrarily high power would never produce zero, while taking polynomial of products of Grassmmann numbers would (and "integral" should be a limit of such polynomial if it is to be viewed as "limit of the sum"). Of course, none of it is an issue if integral is simply viewed as an operator AS OPPOSED TO limit of the sum. But describing it as limit of the sum seems very problematic. In this talk, we will attempt to do the latter. We consider a space with infinite dimensionality, and in this space we draw a contour with infinitely many turns, each turn having infinitesimal length. We also consider two different kinds of products: dot product and wedge product. In case of both products, the vectors directed along different axes anticommute; but the difference is that if we take a product of unit vector with itself, then the wedge product will return zero and dot product will return 1. Finally, we take Manhatten metric as opposed to Eucledian. When we write down an integral, the product between "infinitesimal" and "finite" part is a dot-product, while the product inside the finite part is a wedge-product (and the product inside infinitesimal part can be either of these two). As long as that is the case, one can design the "turns" on the contour in such a way that integral along that particular contour will, in fact, coincide with expected properties of Grassmann integral. However, that will only be true regarding that particular contour, not any other. In particular, if we are to re-scale this contour, then the integral of $\theta \mathrm{d}\theta$ will no longer be 1 but instead pick up factors coming from rescaling (which answers the question regarding integral of exponential). The description of that integral is provided at [1].

References

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Efrain **Torres-Lomas** (UG) **Frontiers of Fundamental Physics**

Constraining preheating models by PBHs Over-production

Murli Manohar **Verma** (LU) **Cosmology**

The BICEP2 data and the recent cosmic acceleration from a Higgs-like scalar field

This talk proposes that the recently announced BICEP2 value of tensor-to-scalar ratio $r \sim 0.2$ can be explained as containing an extra contribution from the recent acceleration of the universe. In fact, this contribution, being robust, recent and of much longer duration (by a large order of magnitude) may dominate the contribution from the inflationary origin. In a possible scenario, such acceleration arises from the interacting matter (dark or baryonic) and a cosmological constant emerging from a single Higgs-like tachyonic scalar field in the universe. A thermodynamic argument is discussed in favour of an interacting cosmological constant that decays into dark matter.