BWAM25: SEENET-MTP Workshop and Assessment Meeting

July 7-8, 2025, Bucharest, Romania

ABSTRACTS

Ciprian ACATRINEI (Department of Theoretical Physics, IFIN-HH)

Fuzzy Fields

Abstract: Aspects related to fields defined over noncommutative spaces will be reviewed. Special attention will be devoted to conceptual questions like the interplay between noncommutativity and nonlocality, dimensional reduction and discretization of space.

Stefan CARSTEA (Department of Theoretical Physics, IFIN-HH)

Discrete dynamical systems: how to construct invariants and symmetries?

Abstract: We review the role of singularities in the global analysis of integrability for 2D discrete dynamical systems. Using desingularization procedure we show how to linearize the systems on the Picard lattice and how to construct invariants and symmetries. We discuss also the role of singularities in the study of tropical dynamical systems (cellular automata)

Marija Dimitrijevic CIRIC (University of Belgrade)

Advances in the braided BV quantization of noncommutative field theories

In this talk we will review the newly developed method for quantization of noncommutative (NC) field theories, the braided BV quantization. We will discuss results for the NC QFT on the Moyal space and then we will generalize these to a spacetime with non-constant noncommutativity, the lambda-Minkowski spacetime. We will show that, in the case of scalar field theory, the NC contribution enters in a specific way and we will discuss the obtained results in some detail.

Atish DABHOLKAR (CERN)

Quantum Entanglement and Gravity

I discuss the fascinating connections between quantum entanglement on one hand and gravity and spacetime geometry on the other. I outline the motivations from black hole physics and holography for expecting finite quantum entanglement entropy in quantum gravity and then describe recent results in defining such a notion in perturbative string theory by a stringy analog of the replica method using ZN orbifolds constructed for any odd positive integer N. The entropy so defined naturally includes a classical piece and is manifestly UV finite but has potential tachyonic IR divergences. I show that the specific structure of the tachyonic spectrum allows for a re-summation and analytic continuation to the physical region $0 < N \leq 1$ where the IR divergences are absent and the resulting entropy is finite to one-loop order.

Borislav GAJIC (Mathematical Institute SANU, Serbia)

Bridging Statistics with Geometry and Mechanics

Abstract. We emphasize the importance of bridges between statistics, mechanics, and geometry. We develop and employ links between pencils of quadrics, moments of inertia, and linear and

orthogonal regressions. For a given system of points in R^k representing a sample of a full rank, we construct a pencil of confocal quadrics which appears to be a useful geometric tool to study the data. Some of the obtained results can be seen as generalizations of classical results of Pearson on orthogonal regression. Applications include statistics of errors-in-variables models (EIV) and restricted regressions, both ordinary and orthogonal ones. For the latter, a new formula for test statistic is derived, using the Jacobi elliptic coordinates associated to the pencil of confocal quadrics. The developed methods and results are illustrated in natural statistics examples. The talk is based on a joint work with Vladimir Dragović and the following papers:

[1] V. Dragović and B. Gajić, (2023) Points with rotational ellipsoids of inertia, envelopes of hyperplanes which equally fit the system of points in R^k, and ellipsoidal billiards, Physica D: Nonlinear Phenomena, 15 p. Volume 451, 133776.
[2] V. Dragović and B. Gajić, (2025) Orthogonal and Linear Regressions and Pencils of Confocal Quadrics, Statistical Science, Vol. 40, No. 2

Dragoljub DIMITRIJEVIC (Faculty of Sciences and Mathematics, University of Nis)

A Two-Field Model for Cosmological Inflation

Abstract: We study cosmological inflation with two real scalar fields. We start from one scalar field with the DBI-type Lagrangian, which is of non-canonical form This scalar field can be related to a perfect fluid which describes (dominant) matter in the Universe at a time of interest. We then extend the model introducing auxiliary real scalar field. The second field does not carry any dynamics, i.e. the equation of motion (at the background level) for the first field will not change. Finally, we promote the second field to be dynamical, adding its kinetic term. This model, with now two dynamical fields is used to study cosmological inflation. We discuss scalar cosmological perturbation and estimate the scalar spectral index for the two-field model.

References:

[1]. Dimitrijevic, M. Dimitrijevic, G. Djordjevic, and M. Milosevic, AIP Conference Proceedings 2071, 020008 (2019).
[2]. Langlois and S. Renaux-Petel, JCAP 0804, 017 (2008).
[3]. M. Peterson and M. Tegmark, Physical Review D, 83(2):023522 (2011).

Vladimir DRAGOVIC (The University of Texas at Dallas / MI SANU Belgrade)

Integrable Magnetic Flows on Spheres and Nonholonomic Mechanics

Abstract: We introduce and study the Chaplygin systems with gyroscopic forces. We put a special emphasis on the important subclass of such systems with magnetic forces. In a reduction, we construct Hamiltonian magnetic systems on spheres S n. We prove the integrability of the latter systems for n = 2, 3, 4, and 5. We conjecture the integrability of those systems for all n. This is based on joint work with Borislav Gajic and Bozidar Jovanovic and the following papers:

[1] Dragović, V., Gajić, B., Jovanović, B., Demchenko’s nonholonomic case of a gyroscopic ballrolling without sliding over a sphere after his 1923 Belgrade doctoral thesis, Theor. Appl. Mech. (2020).

[2] Dragović, V., Gajić, B., Jovanović, B., Gyroscopic Chaplygin systems and integrable magnetic flows on spheres, J. Nonlinear Sci. (2023) [3] Dragović V., Gajić, B., Jovanović, B., Integrability of homogeneous exact magnetic flows on spheres, arXiv: 2504.20515, Regular and Chaotic Dynamics, (2025).

Vladimir S. GERDJIKOV
(Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,
Institute for Advanced Physical Studies, New Bulgarian University)

Sine-Gordon equation: solitons, applications, integrability

Abstract: The sine-Gordon equation

$$\frac{\partial^2\phi}{\partial x\partial t} = \sin(\phi(x,t)),$$

has been discovered by Bäcklund in 1872 trying to describe surfaces with constant negative curvature in differential geometry. Bäcklund proposed also a method for its solution, now known as the Bäcklund transformations. In 1970'ies the interest to this equation was revived due to the discovery of its applications in nonlinear optics, superconductivity and other physical areas. We will also outline another method of its solution based on the inverse scattering method. It will allow one to understand that sine-Gordon equation is infinite dimensional completely integrable Hamiltonian system, see [1].

References:

[1] V. S. Gerdjikov, G. Vilasi, A. B. Yanovski. Integrable Hamiltonian Hierarchies. Spectral and Geometric Methods Lecture Notes in Physics 748, Springer Verlag, Berlin, Heidelberg, New York (2008). ISBN: 978-3-540-77054-1.

Aurelian ISAR (Department of Theoretical Physics, IFIN-HH)

Quantum entanglement of two bosonic modes in de Sitter space

Abstract: In recent years, extensive studies on quantum correlations in various scenarios, such as non-inertial frames, curved spacetime, and an expanding universe have been performed [1–6]. In the framework of the theory of open systems based on completely positive quantum dynamical semigroups, we investigate the time evolution of Gaussian quantum entanglement of two bosonic modes associated with a scalar quantum field in de Sitter space and in interaction with a thermal reservoir. We show that quantum entanglement strongly depends on the squeezing of the bimodal state, the parameters characterizing the thermal environment, the curvature parameter of de Sitter space, and the mass parameter. The thermal environment and the curvature have a destructive influence on the entanglement, whose survival time depends on the competition between the contrary effects provided by the squeezing of the bimodal state, the curvature, and the thermal bath. The entanglement is minimized for values 1/2 and 3/2 of the mass parameter, corresponding to the conformally coupled scalar field, respectively minimally coupled massless field [7].

References:

[1] P.M. Alsing, I. Fuentes-Schuller, R.B. Mann, T.E. Tessier, Phys. Rev. A 74, 032326 (2006).
[2] D.E. Bruschi, A. Dragan, I. Fuentes, J. Louko, Phys. Rev. D 86, 025026 (2012).
[3] G. Adesso, S. Raga, D. Girolami, Class. Quantum Grav. 29, 224002 (2012).
[4] B. Richter, Y. Omar Phys. Rev. A 92, 022334 (2015).
[5] S.M. Wu, H.S. Zeng, Quantum Inf. Process. 18, 305 (2019).
[6] M. Calamanciuc, A. Isar, Results Phys. 55, 107167 (2023).
[7] M. Calamanciuc, A. Isar, submitted for publication.

Raul JIMENEZ (ICREA & Univ. of. Barcelona)

Cosmology without models

Abstract: All we are doing in the LCDM model is to fit a model to observations. While successful, fitting is very different from understanding. In this talk I will show how one can avoid fitting models o cosmology data and actually test theories.

Adrian TANASA (Bordeaux University & IFIN-HH)

A generalization of matrix models, from random geometries to the holographic Sachdev-Ye-Kitaev model

Abstract: Matrix models are well known for providing, among other, a quantum field theoretical (QFT) description of random surfaces, further proven to be related to 2D quantum gravity. A natural generalization to dimensions 3 and higher is given by tensor models, which, seen as QFTs, give a theory of random volumes and hyper-volumes. On the other hand, Witten showed that these tensor models are also linked in an unexpected and non-trivial way to the holographic Sachdev-Ye-Kitaev model (which is a celebrated toy-model for the AdS/CFT correspondence). In this talk, I will present an overview of various results on tensor models from a QFT perspective (large N limit, double scaling limit, renormalization group flows and so on).

Todor POPOV (INRNE, BAS & American Univerity in Bulgaria)

Dynamical (super)symmetry in Landau levels and H-atoms

Abstract: We use the connection between the 2D harmonic oscillator and the Landau problem to recover the spectrum generating group Sp(4, R) of the common Hilbert space. On quantum leveli the Newton-Hooke duality between the Newton potential −1/r and the harmonic oscillator potential r2 yields the 2D hydrogen atom spectrum together with its hidden conformal SO(2, 3)-symmetry. However we show that the Landau levels enjoy bigger dynamical supersummetry OSp(1|4). The 4D oscillator enjoys conformal group symmetry SU (2, 2). We push further the analogy considering the Haldane spherical model of an electron on a sphere and as a reduction of the 4D harmonic oscillator. Gerhard Mack and Ivan Todorov in their seminal work on U (2, 2) ladder representations classified massless conformal group representations. Applying the Newton-Hooke duality via Hopf mapping leads to the quantum 3D MIC-Kepler model. The zero magnetic charge sector is the hydrogen atom while the minimal non-zero magnetic charge sector yields the dyogen atom, i.e., dyon-dyon system. The results reported were obtained with the use of Jordan algebra tools which will be explained in the next talk.

Ioannis RIZOS (University of Ioannina)

On the Quest for the Standard Model Among String Theory Vacua

Abstract: We investigate a broad class of four-dimensional heterotic string compactifications with spontaneously broken supersymmetry, realized via the Scherk–Schwarz mechanism. Employing a combined approach based on free-fermionic and orbifold constructions, we identify vacua exhibiting phenomenologically appealing features, including three chiral generations and Standard Model–breaking Higgs fields. We further examine the constraints imposed by the absence of physical tachyons and the suppression of the one-loop cosmological constant.

Tsvetan VETSOV (Sofia University)

Optimal control theory of black holes in energy and entropy thermodynamic representations

Abstract: We apply geometric control theory to model finite-time transformations in the thermodynamic phase space of black holes. This approach allows us to determine minimally dissipative pathways—those that minimize energy or entropy costs - connecting equilibrium and non-equilibrium states. Key to this analysis are the thermodynamic metric and its associated thermodynamic length, which dictate the likelihood of such transitions, whether spontaneous or

externally driven. Our results reveal how intrinsic geometric structures can be harnessed to optimize black hole evolution during processes like evaporation and accretion.

George ZOUPANOS (National Technical University of Athens)

Unification of Conformal and Fuzzy Gravities with Internal Interactions

Abstract: Based on the observation that the dimension of the tangent space is not necessarily equal to the dimension of the corresponding curved manifold and on the known fact that gravitational theories can be formulated in a gauge theoretic way, we discuss how to describe all known interactions in a unified manner. This is achieved by enlarging the tangent group of the four-dimensional manifold to SO(2,18), which permits the inclusion of both gauge groups, the one that describes gravity as a gauge theory as well as the SO(10) GUT. The gravity theories to be discussed are the Conformal and Fuzzy gravities.