ESTATE QUANTISTICA 2018

Dedicated to

Júlio Fabris -- Richard Kerner -- Winfried Zimdahl

on the occasion of their birthdays

Grand Hotel de Rose, Scalea Italy ***11-15 June 2018***

Program

Monday, June 11

9:15 – 10:00	*Tribute to J. Fabris, R. Kerner, and W. Zimdahl*	
10:00 – 11:00	**J. W. van Holten**	*The gravitational field of a light wave*
Coffee break		
11:30 – 12:30	**A. Cattaneo**	*Geometrical construction of reduced phase spaces*
Lunch		
16:30 – 17:30	**J.-P. Gazeau**	*Orientations in the plane as quantum states*
17:30 – 18:30	**V. Abramov**	*Ternary Lie algebras, superalgebras and applications*
18:30 – 19:00	**O. Liivapuu**	*Ternary algebras with combined $\mathbb{Z}_2$ and $\mathbb{Z}_3$ grading*

Tuesday, June 12

9:00 – 10:00	**K. Gawedzki**	*Heat waves in Conformal Field Theory*
10:00 – 11:00	**M. Picco**	*Dynamics in phase transitions and percolation*
Coffee break		
11:30 – 12:30	**A. Mann**	*On criteria for separability of density matrices*
Lunch		
16:00 – 17:00	**J. Martin**	*Quantum Mechanics in the Sky*
17:00 – 18:00	**O. Piattella**	*Stability of neutron stars in R^2 gravity*
18:00 – 18:30	**F. Sbisá**	*Degravitation of the Cosmological Constant and the Cascading DGP model*
18:30 – 19:00	**B. L. Giacchini**	*Classical features of polynomial higher-derivative gravity models*

Wednesday, June 13

9:00 – 10:00	**I. Shapiro**	*Anomaly and induced effective action of gravity*
10:00 – 11:00	**M. Asorey**	*Positivity problems in higher derivative field theories and Quantum Gravity*
Coffee break		
11:30 – 12:30	**J. Lukierski**	*Quantum Gravity and Noncommutative Space-times*
Lunch		
16:00 – 17:00	**P. Martinetti**	*Bosons in noncommutative geometry: beyond the Standard Model*
17:00 – 18:00	**F. D'Andrea**	*Obstructions to twist quantization of symplectic manifolds*
18:00 – 19:00	**A. Pinzul**	*Dimensional deception: From Horava-Lischitz to noncommutative torus*

Thursday, June 14

9:00 – 10:00	**P. Peter**	*Using trajectories in quantum cosmology*
10:00 – 11:00	**N. Pinto-Neto**	*The de Broglie-Bohm quantum cosmology with dark energy*
Coffee break		
11:30 – 12:30	**D. Wands**	*Cosmic inflation, quantum diffusion and primordial black holes*
Lunch		
16:30 – 17:30	**A. Borowiec**	*Quantum Mechanics with noncommuting position operators?*
17:30 – 18:30	**G. Pogosyan**	*Classical and Quantum Zernike System*
18:30 – 19:00	**J. Asorey**	*Cosmology with wide field photometric surveys and gravitational lensing of type Ia Supernovae*

Friday, June 15

9:00 – 10:00	**R. Kerner**	*The Quantum Physical Origin of the Lorentz transformations*
10:00 – 11:00	**W. Zimdahl**	*Matter growth in imperfect fluid cosmology*
Coffee break		
11:30 – 12:30	**J. Fabris**	*Viscous Cosmology*
Lunch and closing		

Abstracts

Victor Abramov
University of Tartu

Ternary Lie algebras, superalgebras and applications

Abstract: Given a matrix Lie algebra one can construct the ternary Lie algebra by means of the trace of a matrix. In the present talk we show that this approach can be extended to matrix 3-Lie superalgebras $\mathfrak{gl}(m, n)$ if instead of the trace of a matrix we make use of the super trace of a matrix. It is proved that a graded triple commutator of two matrices constructed with the help of the graded commutator and the super trace satisfies the super ternary Filippov-Jacobi identity. In two particular cases of $\mathfrak{gl}(1, 2)$ and $\mathfrak{gl}(2, 2)$ we show that the Pauli and Dirac matrices generate the matrix 3-Lie superalgebras, and we find the non-trivial graded triple commutators of these algebras. We propose a Clifford algebra approach to ternary Lie superalgebras induced by Lie superalgebras. We also discuss an application of matrix 3-Lie superalgebras in BRST-formalism. We propose an extension of n-ary Nambu-Poisson bracket to superspace. We define the n-ary bracket of n even degree smooth functions defined on the superspace $\mathbb{R}^{n|m}$ by means of the superdeterminant. This n-ary bracket depends on a choice of m odd degree smooth functions, which determine the invertible transformation of Grassmann coordinates in the superspace $\mathbb{R}^{n|m}$. We prove in the case of the superspaces $\mathbb{R}^{n|1}$ and $\mathbb{R}^{n|2}$ that our n-ary bracket, defined with the help of superdeterminant, satisfies the conditions for n-ary Nambu-Poisson bracket, i.e. it is totally skew-symmetric and it satisfies the Leibniz rule and the Filippov-Jacobi identity (fundamental identity). We study the structure of n-ary bracket defined with the help of superdeterminant in the case of superspace $\mathbb{R}^{n|2}$ and show that it is the sum of usual n-ary Nambu-Poisson bracket and the new n-ary bracket, which we call χ-bracket, where χ is the product of two odd degree smooth functions.

Jacobo Asorey
Korea Astronomy and Space Science Institute

Cosmology with wide field photometric surveys and gravitational lensing of type Ia Supernovae

Abstract: One of the main unsolved problems in cosmology is to understand the nature of dark energy, the driving force of the accelerated expansion of the Universe. Some probes such as type Ia Supernovae (SN or baryonic acoustic oscillations probe the dynamics of the expansion of the Universe while other such as gravitational lensing probe the growth of structures in cosmic scales. But the effect of lensing on type Ia SN can allow us extract cosmological information on the growth of structure. I will discuss some details of this and recent cosmological results using the Dark Energy Survey first year of data.

Manuel Asorey
Universidad de Zaragoza

Positivity problems in higher derivative field theories and Quantum Gravity

Abstract: We analyze the unitarity and positivity properties of higher derivative quantum field theories which are free of ghosts and ultraviolet singularities. We point out that in spite of the absence of ghosts most of these theories are not unitary. This result confirms the difficulties of finding a consistent quantum field theory of quantum gravity.

Andrzej Borowiec
Uniwersytet Wrocławski

Quantum Mechanics with noncommuting position operators?

Abstract: Canonical commutation relations between position and momentum operators play central role in Quantum Mechanics. Their algebra can be enlarged by adding external symmetry generators in order to form extended quantum covariant phase space. Its deformations in the category of Hopf algebroids are main subject of the talk. Therefore, they are discussed with some details: Drinfeld twist techniques are shown to be very effective for these purposes. Particularly, two methods of twist quantization will be compared. Finally, some examples will be presented in an explicit form.

Alberto S. Cattaneo
Universität Zürich

Geometrical construction of reduced phase spaces

Abstract: The reduced phase space of a field theory is the space of its possible initial conditions endowed with a natural symplectic structure. An alternative to Dirac's method, relying on natural geometric aspects of variational problems, was introduced by Kijowski and Tulczijev. This method also has the advantage of having a natural generalization in the BV context. In this talk, I will explain the method and describe some examples, focusing in particular on the tetradic version of general relativity in four dimensions.

Francesco D'Andrea
Università di Napoli Federico II

Obstructions to twist quantization of symplectic manifolds

Abstract: Drinfel'd twists are powerful functorial tools to simultaneously deform bialgebras together with all of their modules and module algebras. A star product obtained by a twist will be called a *twist* star product. While it is well known that every Poisson manifold admits a deformation quantization, it is not clear when a manifold admits a deformation quantization coming from a Drinfel'd twist. In this talk I will explain how Morita equivalence can be used to prove a no-go theorem for the existence of twist star products: more precisely, I will argue that equivariant line bundles with non-trivial Chern class and twist star products cannot both coexist on the same symplectic manifold. This implies, for example, that there is no star product on the symplectic projective space $\mathbb{C}\mathrm{P}^{n-1}$ induced by a twist based on $U(\mathfrak{gl}_n(\mathbb{C}))[[h]]$ or any sub-bialgebra, for any $n \geq 2$. (From a joint work with Thomas Weber.)

Júlio C. Fabris
Universidade Federal do Espírito Santo

Viscous Cosmology

Abstract: It is analyzed the effects of both bulk and shear viscosities on the perturbations, relevant for structure formation in late time cosmology. It is shown that shear viscosity can be as effective as the bulk viscosity on suppressing the growth of perturbations and delaying the nonlinear regime. The possible degeneracy of the results with respect to the modified gravity framework is discussed. A dissipation term of geometric origin is also presented at background and perturbative level.

Krzysztof Gawedzki
École normale supérieure de Lyon

Heat waves in Conformal Field Theory

Abstract: I shall discuss a class of nonequilibrium states in CFT in one space dimension and how heat transport in such states connects to the representation theory of the group of circle diffeomorphisms.

Jean-Pierre Gazeau
APC, Université Paris Diderot

Orientations in the plane as quantum states

Abstract: I will introduce and discuss some of the most basic fundamental concepts of quantum physics by using orientations or angles in the plane. Associating these quantum orientations with linear polarisations of light in the plane normal to its propagation constitutes the most appealing physical example of the presented formalism. The pure states form the unit circle (actually a half of it) and the mixed states form the unit disk (actually a half of it). Rotations in the plane rule time evolution through Majorana-like equations involving only real quantities for closed and open systems. Since the tensor product of two planes, their direct sum, and their cartesian product, are isomorphic (2 is the unique solution to $x^x = x \times x = x + x$), and they are also isomorphic to $\mathbb{C}^2$, and to the quaternion field $\mathbb{H}$ (as a vector space), I will describe an interesting relation between entanglement of real states, one-half spin cat states, and unit-norm quaternions which form the group $\mathrm{SU}(2)$. Finally, I will present an example of quantum measurement with pointer states lying also in the Euclidean plane.

Breno L. Giacchini
Centro Brasileiro de Pesquisas Físicas

Classical features of polynomial higher-derivative gravity models

Abstract: Local gravitational theories with more than four derivatives have remarkable quantum properties. Namely, they are super-renormalizable and may be unitary in the Lee-Wick sense, if the massive poles of the propagator are complex. It is important, therefore, to explore also the IR limit of these theories and identify possible observable signatures of the higher derivatives. In this talk we present recent results in this direction. Specifically, we discuss the effect that those higher-order terms can have one the Newtonian potential and related singularities. Also, we discuss the viability of a gravitational seesaw-like mechanism, which could be a mean of avoiding the Planck suppression of the higher derivatives' effects.

Jan-Willem van Holten
Nikhef, Amsterdam and Leiden University

The gravitational field of a light wave

Abstract: According to the classical Einstein-Maxwell theory a light-wave traveling in empty space-time is accompanied by a gravitational field. For ideal planar waves of infinite extent a complete solution exists for linearly and circularly polarized light. The physical implication is that all particles, even electrically neutral ones, will be scattered by the light wave. I present results for the scattering of particles in a classical and semi-classical analysis.

Richard Kerner
Sorbonne Université

The Quantum Physical Origin of the Lorentz transformations

Abstract: Our aim is to derive the symmetries of the space-time, i.e. the Lorentz transformations, from the *discrete* symmetries of the interactions between the most fundamental constituents of matter, in particular quarks and leptons,
We show how the discrete symmetries Z_2 and Z_3 combined with the superposition principle result in the $SL(2, \mathbf{C})$-symmetry.
The role of Pauli's exclusion principle in the derivation of the $SL(2, \mathbf{C})$ symmetry is put forward as the source of the macroscopically observed Lorentz symmetry. Then Pauli's principle is generalized for the case of the Z_3 grading replacing the usual Z_2 grading, leading to ternary commutation relations for quantum operator algebras. In the case of lowest dimension, with two generators only, it is shown how the cubic combinations Z_3-graded elements behave like Lorentz spinors, and the binary product of elements of this algebra with an element of the conjugate algebra behave like Lorentz vectors.

Olga Liivapuu
Estonian University of Life Sciences

Ternary algebras with combined $\mathbb{Z}_2$ and $\mathbb{Z}_3$ grading

Abstract: We investigate the possibility of combining the usual Grassmann algebras with their ternary $\mathbb{Z}_3$-graded counterparts, thus creating a more general algebra with quadratic and cubic constitutive relations coexisting together.
We recall the classification of ternary and cubic algebras according to the symmetry properties of ternary products under the action of the S_3 permutation group. Instead of only two kinds of binary algebras, symmetric or antisymmetric, here we get *four* different generalizations of each of those cases.

Jerzy Lukierski
Uniwersytet Wrocławski

Quantum Gravity and Noncommutative Space-times

Abstract: After short discussion of the historical development of fundamental interactions theories I shall discuss the main conceptual problem with formulation of quantum gravity(QG): the dynamical nature of space-time. I shall recall(Doplicher et all) the extension of Heisenberg uncertainty relations to the space-time sector, describing measurements accuracy limitations of space-time distances at ultra-short distances. Considering noncommutativity of quantum space-time as basic feature of the QG framework, I shall describe briefly three popular models of quantum space-times: Snyder, kappa-Minkowski and Θ-deformed. The future quantum Riemannian geometry will be advocated as the way to obtain algebraic geometrization of QG. Finally we shall provide some comments on the measurability of QG effects.

Ady Mann
Technion - Israel Institute of Technology

On criteria for separability of density matrices

Abstract: Some sufficient criteria for separability of density matrices will be presented, with explicit exhibition of separability in some cases.

Jérôme Martin
Institut d'Astrophysique de Paris

Quantum Mechanics in the Sky

Abstract: According to the theory of cosmic inflation, the structures in our universe (galaxies, clusters of galaxies ...) and the Cosmic Microwave Background (CMB) anisotropies are of quantum mechanical origin. Moreover, at the end of inflation, these fluctuations were supposed to be placed in a very peculiar quantum state, namely a two-mode squeezed state, which is a highly non-classical state. In this talk, I will discuss how astrophysical measurements could reveal the quantum origin of these inflationary cosmological perturbations.

Pierre Martinetti
Università di Genova

Bosons in noncommutative geometry: beyond the Standard Model

Abstract: In 1989, Dubois-Violette Kerner and Madore showed how to obtain classical bosons, including the Higgs, in noncommutative geometry. We shall present some recent developments of this idea, based on Connes theory of twisted spectral triples. Besides the Higgs, one gets additional fields that may be relevant for physics "beyond the Standard Model."

Patrick Peter
Institut d'Astrophysique de Paris

Using trajectories in quantum cosmology

Abstract: In a Wheeler-De Witt version for quantum cosmology, the scale factor of the universe cannot be given any particular meaning except in a trajectory approach. Independently of any interpretative framework, I'll discuss the usefulness of this formulation, in particular when it comes to obtaining numerical solutions.

Oliver Fabio Piattella
Universidade Federal do Espírito Santo

Stability of neutron stars in R^2 gravity

Abstract: We study the stability of spherical symmetric configurations of matter described by a Sly equation of state in the context of $f(R) = R + \alpha R^2$ gravity.

Marco Picco
LPTHE, Sorbonne Université

Dynamics in phase transitions and percolation

Abstract: Symmetry breaking phase transitions plays a very important role in many fields of physics: in condensed matter at low temperature, in high energy physics, in cosmology or astrophysics, etc. After recalling some general results, I will present some recent progress on a very simple case corresponding to quenches in the bidimensionnal Ising model. I will show that the coarsening mechanism can produce some macroscopic states associated to the percolation and will describe some consequences.

Nelson Pinto-Neto
Centro Brasileiro de Pesquisas Físicas

The de Broglie-Bohm quantum cosmology with dark energy

Abstract: We investigate cosmological scenarios containing one canonical scalar field with an exponential potential in the context of bouncing models, where the bounce happens due to quantum cosmological effects. The only possible bouncing solutions in this scenario must have one and only one dark energy phase, either occurring in the contracting era or in the expanding era. Naturally, the more convenient solution is the one where the dark energy phase happens in the expanding era, in order to be a possible explanation for the current accelerated expansion indicated by cosmological observations. In this case, one has the picture of a universe undergoing a classical dust contraction, realizing a bounce, and then launched to a dark energy era, after passing through radiation and dust dominated phases. We calculate the spectral indexes and amplitudes of scalar and tensor perturbations numerically. As the background model is necessarily dust dominated in the far past, the usual adiabatic vacuum initial conditions can be easily imposed in this era. Hence, this is a cosmological model where the presence of dark energy behavior in the universe does not turn problematic the usual vacuum initial conditions prescription for cosmological perturbation in bouncing models. The background parameters can be adjusted, without fine tunings, to yield the observed amplitude for scalar perturbations, and also for the ratio between tensor and scalar amplitudes, $r = T/S \lesssim 0.1$. The amplification of scalar perturbations over tensor perturbations takes place only around the bounce, due to quantum effects, and it would not occur if General Relativity has remained valid throughout this phase.

Aleksandr Pinzul
Universidade de Brasília

Dimensional deception: From Horava-Lischitz to noncommutative torus

Abstract: Using the notion of the scaling dimension based on some natural generalization of Weyl formula, we discuss the dimensional aspects of the observed geometry of quantum spaces (fuzzy torus) and the spaces with some preferred structure (Horava-Lifshitz). We also comment on how the same generalization can be used to study the quantum (non-commutative) corrections to area of some fuzzy geometries.

George S. Pogosyan
ICAS, Yerevan State University

Classical and Quantum Zernike System

Abstract We present the work what we call the Zernike system. It stems from a differential equation proposed by Frits Zernike in 1934 to describe wavefronts at circular optical pupils through a basis of polynomial solutions on the unit disk and free boundary conditions. This system entails a classical model and a quantum model. The classical model leads to closed elliptic orbits while the quantum model yields bases of polynomial wavefunctions that separate in a manifold of coordinate systems, where only the polar one is orthogonal. Special functions that appear in the solutions and interbasis expansions include the Legendre, Gegenbauer, Jacobi, Heun, Hahn and Racah polynomials, as well as special Clebsch-Gordan and $6j$ coefficients. The underlying symmetry is a cubic Higgs superintegrable algebra.
The work was done in collaboration with N. Atakishiev, K.B. Wolf and A. Yakhno.

Fulvio Sbisá
Universidade Federal do Espírito Santo

Degravitation of the Cosmological Constant and the Cascading DGP model

Abstract: A interesting shift in the approach to the cosmological constant problem is reformulate the problem as "why vacuum energy gravitates so little?", instead of "why vacuum energy is so small?". The possible existence of extra dimensions and branes, of fundamental importance in string theory, permits to build models where the effect of a huge vacuum energy is felt mostly in the extra dimensions, while its effect on our four-dimensional universe is suppressed. In this talk, we present a fairly recent braneworld model, the Cascading DGP model, and discuss its properties regarding the degravitation of the Cosmological Constant.

Ilya L. Shapiro
Universidade Federal de Juiz de Fora

Anomaly and induced effective action of gravity

Abstract: The effective action of gravity is supposed to contains the main information about quantum corrections to gravity. However, in many cases it can not be calculated exactly. A remarkable and important exception is the effective action of vacuum for massless and conformal-invariant matter fields. In this case the effective action can be easily derived by integrating trace anomaly. The integration constant is an unknown conformal functional of the background metric, but for zero-order cosmology this functional is irrelevant and the solution becomes exact. Until recently the integrated anomaly was known only in dimensions $d = 2$ and $d = 4$, but recently we achieved the explicit result for $d = 6$, which confirms the universal functional structure of the effective action. The most important applications in $d = 4$ include systematic classification of vacuum states in the vicinity of the black hole and the Starobinsky model of inflation. The effective action of gravity is supposed to contains the main information about quantum corrections to gravity. However, in many cases it can not be calculated exactly. A remarkable and important exception is the effective action of vacuum for massless and conformal-invariant matter fields. In this case the effective action can be easily derived by integrating trace anomaly. The integration constant is an unknown conformal functional of the background metric, but for zero-order cosmology this functional is irrelevant and the solution becomes exact. Until recently the integrated anomaly was known only in dimensions $d = 2$ and $d = 4$, but recently we achieved the explicit result for $d = 6$, which confirms the universal functional structure of the effective action. The most important applications in $d = 4$ include systematic classification of vacuum states in the vicinity of the black hole and the Starobinsky model of inflation. It is remarkable that one can write down the general form of the anomaly-induced action in an arbitrary even dimension, if assuming the correctness of two conjectures about the conformal features of topological and surface terms.

David Wands
University of Portsmouth

Cosmic inflation, quantum diffusion and primordial black holes

Abstract: Cosmological inflation gives us a window onto the very early universe. In particular quantum fluctuations during inflation can give rise to the large-scale structure of our universe today. I will discuss the stochastic approach to inflation which incorporates the effect of quantum fluctuations into the dynamics of the coarse-grained fields above the characteristic Hubble scale during inflation. In some regimes this stochastic diffusion of the fields can become comparable to the classical drift leading to large density perturbations and even the formation of primordial black holes after inflation.

Winfried Zimdahl
Universidade Federal do Espírito Santo

Matter growth in imperfect fluid cosmology

Abstract: The cosmic medium is modeled as an imperfect fluid in Einstein's GR. The imperfect fluid structure allows us to include anisotropic stresses and energy fluxes which are considered as potential signatures for deviations from the cosmological standard model. As an example we consider the dynamics of a scalar-tensor extension of the ΛCDM model, the $e_\Phi\Lambda$CDM model. We quantify the possible impact of effective dark-energy perturbations and constrain the magnitude of anisotropic stresses with the help of redshift-space distortion (RSD) data for the matter growth function.