Paolo Aschieri (University of Turin, Italy)

Nonassociative differential geometry and gravity with non-geometric fluxes

Nonassociative geometries arise in closed string theory and field theory when considering T-duality transformations in the presence of background fluxes. In particular, in the presence of a constant locally non-geometric closed string flux, phase space becomes nonassociative and noncommutative. We develop a corresponding differential geometry and gravity theory. We obtain explicit expressions for the torsion, curvature, Ricci tensor and Levi-Civita connection in nonassociative Riemannian geometry on phase space, and write down Einstein field equations. These lead to flux dependent Einstein field equations on spacetime.

Manuel Asorey (Universidad de Zaragoza, Spain)

Unitarity problems in higher derivative field theories and Quantum Gravity

We analyze the unitarity 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.

Wolfgang Bietenholz (National Autonomous University of Mexico, Mexico)

Spontaneous symmetry breaking in a non-commutative plane:
Non-locality as a loophole in the Mermin-Wagner Theoreom

Biswajit Chakraborty (S. N. Bose National Centre for Basic Sciences, Kolkata, India)

A Hilbert-Schmidt operatorial approach to study quantum mechanics and geometry of Non-commutative spaces

Hilbert-Schmidt operatorial formulation provides a natural setting to address the questions arising in Noncommutative Quantum mechanics and also can be adapted for the Connes formulation to study the metric aspects of such spaces. We discuss few examples, like Quantum Mechanics in Noncommutative spacetime (of Moyal type) and geometry of Moyal space and fuzzy sphere and finally to examine a system, where noncommutativity can be shown to be a source of dissipation.

Dariusz Chruscinski (University of Physics, Toruń, Poland)

Entanglement witnesses from mutually unbiased bases

I provide a class of entanglement witnesses constructed in terms of Mutually Unbiased Bases (MUBs) which play essential role in quantum information. This construction reproduces many well-known examples like the celebrated reduction map and Choi map together with its generalizations. In particular it gives rise to indecomposable and optimal entanglement witnesses.

F. M. Ciaglia (INFN, sezione di Napoli; Università Federico II, Italy)

Information,monotone metrics from relative entropies

Within geometrical formulation of quantum mechanics,it is possible to use relative entropies as "quantum divergences", i.e., "potential functions" which generate quantum metrics possessing the property of not increasing the distance between states under the action of quantum stochastic maps.

Bruno Carneiro da Cunha (Federal University of Pernambuco, Recife, Brazil)

Conformal Blocks, Riemann-Hilbert problems and Black Hole normal modes

Riemann-Hilbert (RH) problems has had many applications to condensed matter physics and classical complex analysis. Recently, I have taken part, along with collaborators, in a program to apply RH techniques to black hole scattering and the study of normal modes. We will review the cases for generic Kerr-de Sitter black holes in AdS5, whose scattering problem can be solved in terms of Painlevé VI transcendents, and usual Kerr-Newman black holes in 4 dimensions, which are associated to Painlevé V. We relate these problems with Liouville field theory boundary conditions and the puzzling relation between semiclassical and c=1 conformal blocks.

Elisa Ercolessi (University of Bologna, Italy)

How hidden topology changes quantum field theories

The idea that the topology of space-time can influence physics is well known and accepted. However interesting physical effects may emerge thanks to topological properties of more unusual spaces, such as the space of physical constants or momentum space. We will review some of these cases in quantum many body and field theories, discussing also the role of spontaneously broken hidden symmetries.

Paolo Facchi (University of Bari, Italy)

Boundaries without boundaries

Starting with a quantum particle on a closed manifold without boundary, we consider the process of generating boundaries by modding out by a group action with fixed points, and we study the emergent quantum dynamics on the quotient manifold. As an illustrative example, we consider a free nonrelativistic quantum particle on the circle and generate the interval via parity reduction. A free particle with Neumann and Dirichlet boundary conditions on the interval is obtained, and, by changing the metric near the boundary, Robin boundary conditions can also be accommodated. We also indicate a possible method of generating non-local boundary conditions. Then, we explore an alternative generation mechanism which makes use of a folding procedure and is applicable to a generic Hamiltonian through the emergence of an ancillary spin degree of freedom.

T. R. Govindarajan (Institute of Mathematical Sciences, Chennai, India)

New look at Asymptotic symmetries, Infrared Divergence in QED

Gauge theories exhibit asymptotic symmetries and also have infrared divergence associated problems. We study these questions from new perspectives, namely that of edge physics and boundary conditions. This studied using massive regulator. Implications will be explored.

Alberto Ibort (Universidad Carlos III de Madrid, Spain)

Groupoids, categories and Quantum Mechanics

Groupoids are known to play an instrumental role in the construction of Schwinger's algebra of selective measurements. The road to the construction of a picture of Quantum Mechanics inspired in Schwingers algebra and resting on elementary categorical notions and groupoids will be explored in the talk.

Pankaj Jain (Indian Institute of Technology, Kanpur, India)

Large Scale Anisotropy in the Universe

There currently exist several observations which indicate a potential violation of the cosmological principle. One such observation is hemispherical anisotropy in the CMB temperature. I will discuss how it might be related to space-time non-commutativity.

Chethan Krishnan (Indian Institute of Science, Bangalore, India)

Contextuality, Locality and Free Will

I will discuss some aspects of the Conway-Kochen "Free Will" Theorem. The material is largely (but hopefully not entirely) review of known stuff.

Seçkin Kürkçüoğlu (Middle East Technical University, Turkey)

Quantum Hall Effect on Odd-Dimensional Spheres

Higher dimensional generalizations of quantum Hall effect (QHE), which share several similar features of the 2-D QHE, have been a continually appearing theme in contemporary theoretical physics in the past decade or so. Initially, these investigations were motivated by ideas emerging form quantum field theories as well as string physics. Recent research also indicates that QHE on spheres may also be used to model A-class and A-III class topological insulators in higher dimensions. In this talk, after providing a short review of the main aspects of the problem, we will consider the Landau problem for charged particles on all odd-dimensional spheres in the background of certain suitable gauge field configurations. We will determine the energy spectrum and wave functions of the relevant Landau and Dirac-Landau Hamiltonians and discuss some elementary properties of the LLLs. We also plan to remark upon several emerging geometrical features of the problem, which appear to be of physical interest.

Giovanni Landi (Università di Trieste, Italy)

The quantum Yang–Baxter equation and noncommutative Euclidean spaces

We present natural families of coordinate algebras of noncommutative Euclidean spaces and noncommutative products of Euclidean spaces. These coordinate algebras are quadratic ones associated with an R-matrix which is involutive and satisfies the quantum Yang–Baxter equation. As a consequence they enjoy a list of nice properties, being regular of finite global dimension. Notably, we have spherical manifolds, and noncommutative quaternionic planes as well as noncommutative quaternionic tori. On these there is an action of the classical "quaternionic torus" $SU(2) \times SU(2)$ in parallel with the action of the torus $U(1) \times U(1)$ on a "complex noncommutative torus".

Fedele Lizzi (Università di Napoli Federico II, Italy)

Noncommutative Geometry, the spectral action and the standard model

I will review some aspect of the approach to the standard model based on the spectral point of view which is at the heart of nocomutative geometry. I will mostly concentrate on symmetries and discuss how this model might also have phenomenological validity.

Luca Lusanna (University of Naples Federico II, Italy)

Non-Inertial Frames in Minkowski and in Einstein Spacetimes

In both Minkowski spacetime and in globally hyperbolic, asymptotically flat Einstein spacetimes without supertranslations it is possible to define global non-inertial frames with radar 4-coordinates by means of the 3+1 splitting mehod. In both cases there are realizations of the Poincaré algebra (the asymptotic ADM one in general relativity), which is needed for particle physics. In Minkowski spacetime it is now possible to formulate relativistic mechanics of particles and relativistic bound states with a consistent elimination of relative times and a consistent definition of relativistic center of mass in inertial frames and then to extend the results to the non-inertial ones. In Einstein spacetimes, by using Dirac-Bergmann theory of constraints, it is possible to find a canonical basis for ADM tetrad gravity allowing the identification of the gauge variables with the understanding of their inertial meaning (relativistic metrology) and to show that one of them (the York time) may explain dark matter as a relativistic inertial effect.

G. Marmo (INFN, sezione di Napoli; Università Federico II, Italy)

Hilbert Manifold of Quantum States,Observables and Evolution

The probabilistic interpretation of Quantum Mechanics requires that states are represented by rays or rank-one projectors,they do not form a complex vector space any more.They are points of a complex projective space associated with a complex separable Hilbert space,they constitute a Hilbert manifold.This change of perspective requires a reformulation of observables and of the C*-algebra of which they are the real elements. We shall consider these geometrical structures mostly with the help of the most simple and nontrivial example : the q-bit.

William J. Meggs (Brody School of Medicine at East Carolina University)

Biological Homing: Hypothesis for a Quantum Motive Force in Biology

In biological systems, complex molecules interact with specificity and rapidity. The hypothesis is advanced that there are complementary sites on the surfaces of pairs of biological molecules with an enhanced attraction due to quantum mechanics. The postulate is advanced that a biological homing effect arises from the quantumm mechanical probability the complementary pairs of molecules will join, and that this phenomenon is the force that drives geology and gives rise to the existence of life. To illustrate the approach, a simplified calculation is given for the interaction cross-section between two molecules, each with N surface charges that have an identical spatial distribution but with paired charges having opposite signs. The resulting cross-section is enhanced by a factor of N2 over the coulomb scattering cross-section for a single pair of charges. We hypothesize that the existence of life is a direct and inevitable consequence of he principles discussed.

Parameswaran Nair (City College of New York, USA)

Coherent States, Thermofield Dynamics and Gravity

Thermofield dynamics is presented in terms of a path-integral using coherent states, equivalently, using a coadjoint orbit action. A field theoretic formulation in terms of fields on a manifold $M \times \tilde{M}$ where the two components have opposite orientation is also presented. We propose formulating gravitational dynamics for noncommutative geometry using thermofield dynamics, doubling the Hilbert space modeling the noncommutative space. We consider 2+1 dimensions in some detail and show that the commutative limit leads to the Einstein-Hilbert action as the difference of two Chern-Simons actions. Matter dynamics and the role of coherent states on Virasoro orbits will be touched upon.

Pramod Padmanabhan (IBS Center for Theoretical Physics of the Universe, South Korea)

Using Supersymmetry to create Many Body Localized Phases

Equilibration in closed quantum systems is a long standing issue which has recently regained interest. The notion of typicality ensures that quantum states we use to measure expectation values match with the thermal values, and this lead to the *Eigenstate Thermalization Hypothesis* (ETH). However there are quantum systems where this fails, a standard example being integrable models hosting non-thermal states. By introducing disorder in such systems the transport properties can be altered, a feature seen in Anderson Localization. If we bring this transport to zero we are essentially dealing with a system with *Local Integrals of Motion* (LIOMs) which brings us to the idea of *Many Body Localized* (MBL) states. We will show how $0+1$ dimensional SUSY algebras can be used to create many body systems with LIOMs and compute the *out-of-time ordered correlators* (OTOCs) to confirm the existence of MBL states in such systems.

Juan Manuel Pérez-Pardo (Charles III University of Madrid, Spain)

Edge States on Quantum Systems

Quantum field theories can be used to construct effective modells to describe condensed matter systems. One of the main differences between condensed matter systems and fundamental particle physics is that, in the former, the materials where the effective field theory lives are of finite size and have boundaries. This difference is crucial and brings extra features like the appearance of edge states. I will show that the appearance of edge states is related with the type of boundary conditions describing the effective model and the difficulties that might arise when one considers different boundary conditions. For doing that I will consider two different situations, scalar theories and fermionic theories. Surprisingly, in the latter case, there is a threshold size for the sample below which the edge states disappear.

Aleksandr Pinzul (University of Brasília, Brazil)

Dimensional deception: Fuzzy torus vs Horava-Lifshitz

Using the notion of the scaling dimension we discuss the dimensional aspect of the observed geometry of quantum spaces (fuzzy torus) and the spaces with some preferred structure (Horava-Lifshitz).

Peter Prešnajder (Comenius University Bratislava, Slovakia)

Quantum systems in relativistic fuzzy space

We define quantum systems in relativistic fuzzy space. Such systems contain three fundamental constants (Planck constant, speed of light and fundamental length). The gravitational constant can be expressed in terms of those constants. We shall therefore investigate potential contacts with gravity.

Sarada G. Rajeev (University of Rochester, USA)

Curvature in Hamiltonian Mechanics

Riemannian geometry is a particular case of hamiltonian mechanics: the geodesic equation is Hamilton's equation on the cotangent space with the square of momentum as the hamiltonian. Curvature measures the infinitesimal deviation of geodesics from each other. There is no notion of curvature in symplectic geometry (Darboux), even given a hamiltonian (Birkhoff). Given a symplectic manifold, a hamiltonian and a Lagrangian submanifold, the second variation of the action (Hamilton's principal function) makes sense. I will show that this can be used to define a curvature, which measures the deviation of trajectories from each other. An explicit formula involving fourth derivatives of the hamiltonian in terms of canonical co-ordinates is derived. The harmonic oscillator is the analogue of a sphere in Riemannian geometry: the lowest dimensional case with constant positive curvature. There is a notion of distance, which is symmetric if the hamiltonian is time-reversal symmetric (e.g., no magnetic field). The Boltzmann measure gives a notion of volume. Analogues for Ricci tensor and scalar are constructed. Einstein-Maxwell-Dilaton gravity is shown to be a particular case of a Ricci-flat Hamiltonian geometry.

Andrés F. Reyes Lega (University of Los Andes, Bogota, Colombia)

The Shale-Stinespring theorem and topological phases of matter

Ground states of quadratic Hamiltonians for fermionic systems can be characterized in terms of orthogonal complex structures. An explicit connection between such structures and the topological Z_2 invariant is established in the context of the Shale-Stinespring theorem. This in turn allows to uncover the topological origin of the (thermal) phase transition in the classical 2D Ising model.

Donald Salisbury (Austin College, Texas, USA)

Full four-dimensional diffeomorphism invariants and their role in quantum theories of gravity

It is in principle possible to express the spatial and temporal coordinates, given any vacuum solutions of the classical Einstein equations, in terms of Weyl curvature scalars. It follows that all solutions expressed in terms of these scalars are invariant under the action of the full diffeomorphism-induced phase space transformation group. Thus there is a sense in which every admissible set of coordinate conditions yields physically distinguishable classical evolution. I will investigate some possible implications of this observation for several current approaches to quantum gravity, including the Wheeler-DeWitt equation, loop quantum gravitational spin foam models, causal set approaches, noncommutative geometry, and vacuum entanglement entropy.

Balachandran Sathiapalan (Institute of Mathematical Sciences, Chennai, India)

A Holographic form for Wilson's RG

An attempt is made to make precise the connection between Wilson's RG and "Holographic RG" by writing Wilson's RG in a holographic form. A functional formulation is given for the exact RG evolution of a scalar field in d (flat) dimensions. It is shown that a change of variables maps the action to that for a scalar field in AdS_{d+1}. This provides a holographic form for Wilson's RG that can be called "Holographic RG". This mapping can only be done for a specific form of the cutoff function in the Exact Renormalization Group formalism. The notion of scale and conformal invariance in the presence of a *finite* UV cutoff is emphasized. The discussion is primarily about the two-point function and the Gaussian fixed point. Some remarks are made about nontrivial fixed points.

Vikram Soni (University of California, Santa Barbara, USA)

IS THERE A THEORY WHICH HAS TRULY ELEMENTARY PARTICLE AT ALL SCALES?

In the vast zoo of known particles it is difficult to find a particle that is elementary at all scales.For example, it is established that the neutron and the proton are composed of quarks which are seen at high energy accelarators. The electron in Quantum Electrodynamics (QED) has certainly been thought of as a point like elementary particle without substructure. However, at high energies the QED effective coupling increases till it encounters a Landau singulaity and the theory itself is ill defined. Similarly, whereas quarks are found to be elementary point particles (partons) in the asymptotically free regime at high energy in Quantum Chromodynamics, they cease to be realisable free particles at low energy. So, we ask the question if we can have bonafide quantum theory that has an elementary particle at all scales?

We consider a theory that is an extension of QCD, wherein quarks and are coupled to gluons. QCD is extended by coupling the quarks to a colour singlet chiral multiplet of (σ, π) of scalar (psuedoscalar) fields. This theory has a phase governed by a ultra violet (high energy) fixed point where all couplings are AF (asymptotically free). This implies that the scalars are elementary at high energies (UV). And, as they are colour singlets,they are not confined at low energy (IR). We thus have a renormalisable quantum theory in which the (pseudoscalar)scalar particles are elementary at all scales.

Rafael Sorkin (Perimeter Institute for Theoretical Physics, Canada)

Why should (and why can) the path integral serve as the basis for quantum theory?

Allen Stern (University of Alabama, USA)

Non-commutative AdS_2/CFT_1 duality

We show how to construct correlators for the CFT1 which is dual to noncommutative AdS2 (ncAdS2). We do it explicitly for the example of scalar fields on Euclidean ncAdS2. ncAdS2 is the quantization of AdS2 that preserves all the isometries. It is described in terms of the unitary irreducible representations, more specifically discrete series representations, of so(2,1). We write down symmetric differential representations for the discrete series and then map them to functions on the Moyal-Weyl plane. The Moyal-Weyl plane has a large distance limit which can be identified with the boundary of ncAdS2. Killing vectors are constructed on ncAdS2 and reduce to the AdS2 Killing vectors near the boundary. We, therefore, conclude that ncAdS2 is asymptotically AdS2, and so the AdS/CFT correspondence should apply. For the example of scalar fields on Euclidean ncAdS2, the two-point function for the boundary theory is computed to leading order in the noncommutativity parameter. The result is remarkably simple and agrees with that of the commutative scalar field theory, up to a rescaling.

Paulo Teotônio-Sobrinho (University of Sao Paulo, Brazil)

Higher Gauge Theories and Topological Order: quantum physics meets topology

Quantum double models are good examples of quantum systems with topological order. They are lattice gauge theories with a finite gauge group. The lattice is described by a finite simplicial complex X whereas gauge configurations are maps from the set of 1-simplices into the gauge group. Examples where a 2-group plays the role of the usual gauge group lead to interesting models and new topological phases. In this talk, we are going to present a model with topological order that generalizes some of the ideas above. In our construction, the lattice is replaced by a chain complex C of finitely generated free abelian groups and the gauge group is replaced by a chain complex G of finite abelian groups. From this initial data, we construct a Hilbert space H and a frustration free Hamiltonian. Topological order is manifest when we describe the ground state space $\mathcal{H}_0 \subset \mathcal{H}$ in terms of a cohomology with coefficients in a finite chain complex. This cohomology, denoted by $H^0(C, G)$, was first introduced by Ronald Brown in 1964. He proved that H^0 is isomorphic to a product of usual cohomology groups. This result allows us to compute the ground state degeneracy and to find a convenient set of quantum numbers that label the states of $\mathcal{H}_0$. Abelian examples of 1-gauge and 2-gauge theories are recovered as special cases.

Sachin Vaidya (Indian Institute of Science, India)

The Low-Energy Spectrum of QCD from Gauge Matrix Model

We discuss a matrix model for QCD first proposed by Balachandran, Queiroz and Vaidya. The low-lying spectrum of this model is in surprisingly good agreement with the lattice predictions of glueball masses. When coupled to fermions, the model can be used to investigate the phase structure of QCD-like theories.

Dimitra Karabali (Lehman College, CUNY, New York, USA)

The geometry of quantum Hall effect: An effective action for all dimensions

Fabio Deelan Cunden (University College Dublin, Ireland)

Free fermions and the classical compact groups

There is a close connection between the ground state of non-interacting free fermions in a box with classical (absorbing, reflecting, and periodic) boundary conditions and the eigenvalue statistics of the classical compact groups. The associated determinantal point processes can be extended in two natural directions: i) we consider the full family of admissible quantum boundary conditions (i.e., self-adjoint extensions) for the Laplacian on a bounded interval, and the corresponding projection correlation kernels; ii) we construct the grand canonical extensions at finite temperature of the projection kernels, interpolating from Poisson to random matrix eigenvalue statistics. The scaling limits in the bulk and at the edges are studied in a unified framework, and the question of universality is addressed. Whether the finite temperature determinantal processes correspond to the eigenvalue statistics of some matrix models is, a priori, not obvious. We complete the picture by constructing a finite temperature extension of the Haar measure on the classical compact groups. The eigenvalue statistics of the resulting grand canonical matrix models (of random size) corresponds exactly to the grand canonical measure of non-interacting free fermions with classical boundary conditions.

Badis Ydri (Annaba University, Algeria)
Multitrace Matrix Models