Non-Perturbative Gauge Theories & Gravity

(7^{th} – 12^{th} January, 2008)

List of Abstracts

A. Agarwal (CUNY)	**Aspects of Strongly coupled Yang-Mills Theory in 2+1 dimensions** Yang-Mills theories in three dimensions, while sharing many of the features of their four dimensional counterparts, can be analyzed non-perturbatively using some recently developed techniques due to Karabali, Kim and Nair. This talk will focus on some recent results related to the physics of confinement in 2+1 dimensional QCD.
S. Chatterjee, (SNBNCBS)	**Parallel transport on path space and gauge theory** In this presentation I will discuss how a path space bundle can be constructed from a principal bundle and a special kind of connection on this path space can be used to parallel transport a curve. The possible problems arising from a single holonomy group and techniques to avoid those problems will be discussed. A flatness condition required for a well defined surface holonomy will be derived. Horizontal and vertical compositions of surface holonomies and their equivalence will be shown. The gauge transformation of this holonomy will naturally give us the individual gauge transformations of path and surface holonomies.
N. K. Dadhich (IUCAA)	**Classical motivation for higher dimension for gravity**
A. Ghosh (SINP)	
K. S. Gupta (SINP)	**Non Commutative Gravity & Black Holes** Space-time noncommutativity is expected to be relevant for describing physics at the Planck scale. It has recently been shown that the diffeomorphism invariance is compatible with space-time noncommutativity, which indicates that the notion of gravity and black holes can be described within the noncommutative setup. In this talk we shall discuss the noncommutative deformations of the BTZ black hole. We shall show that such a deformation, which is consistent with the symmetries of the system, leads to a completely new picture of the black hole. In particular, our procedure leads to quantization of time. The possible relevance of such analysis to the notion of noncommutative holography would also be discussed.

E. Harikumar (University of Hyderabad)	**Topological configurations of Yang-Mills theory** We show that the topological configurations of SO(3) gauge fields can be completely characterised in terms of certain gauge invariant vector fields. Using this procedure, configurations of monopoles and vortices having one-half winding number have been obtained. We also sketch a systematic way to include the topological configurations in perturbation theory.
S. de Haro (King's College, London)	**Instantons and Chern-Simons Terms in AdS4/CFT3. Gravity on the Brane?** AdS/CFT is a weak/strong coupling duality between gravity and gauge theories. The dual to a four-dimensional gravity theory is a three-dimensional CFT. This CFT describes the IR limit of interacting membranes, but not much is known about its fundamental formulation. I will use instantons and Chern-Simons terms in four-dimensional AdS to explore this CFT, including its stability and duality properties. From the consistency of general Robin boundary conditions for gravity I will argue that in a certain limit the CFT may be coupled to gravity.
S. D. Joglekar (IIT Kanpur)	**A Yukawa model, bound states and causality** We consider a Yukawa model in 1+1 dimensions. We show that in a certain limit of its parameters, the model, to all orders, reduces to a non-local effective field theory of a scalar field. We study the bound states in the Yukawa model and show that the model can be interpreted as an effective field theory of a scalar bound state of fermion-antifermion pair. We study effects of non-locality and causality violation in such a model. This work is an attempt to study the possibility that a composite model may exhibit effects of non-locality and of causality violation.
A. Khare (IOP Bhubaneswar)	**Discrete $\lambda \phi^4$ field theory** We study a rather general discrete $\lambda \phi^4$ field theory with cubic nonlinearity and discuss various issues related with discretization. For example, while the model violates both Lorentz and translational invariance, we obtain a wide class of exact static as well as moving, translationally invariant soliton solutions. Several solutions with unlimited propagation velocity are also obtained. Stability of several of these solutions is also examined. Further, we also obtain several special models satisfying different conservation laws. Finally, two-point maps are derived from which the static three-point problem can be derived.
T. Levy (CNRS and ENS)	**Schur-Weyl duality, two-dimensional Yang-Mills fields and random ramified coverings**. The Schur-Weyl duality is a dictionary between unitary and symmetric quantities. In the language of two-dimensional Yang-Mills theory, it allows one to relate unitary gauge fields and ramified coverings. In this talk, we will

	describe briefly the Schur-Weyl duality and explain how it allows one to compute the heat kernel on the unitary group in terms of the most natural random walk on the symmetric group. This result can be formulated, in the spirit of the work of D. Gross and W. Taylor, as an equality between the partition functions of the Yang-Mills theory on one hand and of a natural model of random ramified coverings on the other hand. This result is also well adapted to the study of the "large N limit" of the heat kernel on the unitary group. We will in particular describe this limit in the framework of free probability, thus recovering results of P. Biane, F. Xu and A. Sengupta.
R. Maartens (University of Portsmouth)	**Dark Energy And Dark Gravity** Observations from the late 1990s provide increasingly strong evidence that the Universe is not just expanding, but is in fact accelerating. This revolutionary advance in cosmological observations confronts cosmological theory with a tremendous challenge. Explanations of the acceleration within the framework of general relativity are plagued by difficulties. Speculative ideas from string theory may hold some promise, but it is fair to say that no convincing model has yet been proposed. An alternative to dark energy is that gravity itself may behave differently from general relativity on the largest scales, in such a way as to produce acceleration. I will review the observational evidence and the various theoretical models.
P. Majumdar (SINP)	**Holography, CFT and black hole entropy** The talk begins with a critique of event horizons and proposes {\it Isolated} horizons as an alternative for spacetimes with portions inaccessible to external observers. The boundary conditions describing such horizons are shown to single out Chern Simons theories as appropriate for description of the horizon states for this class of spacetimes which includes black holes. Using the link of CS theories with WZW models the entropy of generic, isolated, macroscopic 4 dimensional black holes is obtained ab initio within a Loop Quantum Gravity scenario. The holographic aspect is further developed for non-isolated radiant black holes and thermal stability criteria derived without recourse to any assumption about the classical geometry.
M. Mathur (SNBNCBS)	**Loop Approach to Lattice Gauge Theories** We solve the Gauss law and the corresponding Mandelstam constraints exactly in the loop Hilbert space by using the prepotential formulation of (d+1) dimensional SU(2) lattice gauge theory. The resulting loop dynamics without any redundant loop degrees of freedom is shown to be governed by real and symmetric Wigner 3nj coefficients of the second kind (e.g., n=6, 10 for d = 2, 3 respectively). The corresponding "3nj ribbon diagrams" representing loop dynamics are constructed. These prepotential techniques can be trivially extended to include matter fields leading to a description in terms of loops and strings.

P. Mitra (SINP)	**Deconstruction of Strong CP and its Gravitational analogue** The phase of a complex mass term of a quark does not violate CP in QCD or even in a gravitational background. The QCD vacuum angle can be set equal to zero naturally. There is no need for axions.
S. Naik (HRI)	**Geometry & self-dual supergravity** We give a covariant and off-shell formulation of N=8 self-dual supergravity in super twistor space and a possible formulation of a closed superstring field theory.
V. P. Nair (CUNY)	**Yang-Mills in 2+1 dimensions: Basics and Update** Yang-Mills theories in 2+1 (or 3) dimensions are interesting as nontrivial gauge theories in their own right and as effective theories of QCd at high temperatures. By a suitable parametrization of fields and techniques from 2-dimensional CFT, a Hamiltonian approach has been developed which has led to interetsing results on the vacuum wave function, string tension, mass gap, etc. I shall review the basics of this approach, emphasizing symmetries and robustness of results, and also provide a short update on its status. **Twistor strings: Old and New** I will give an introduction to twistor strings, starting from the field theory calculations. Then I shall talk about graviton amplitudes and how they suggest new twistor strings which describe variants of supergravity. I shall also present some calculations on graviton scattering amplitudes in the new twistor string theories.
P. Orland (CUNY)	**Near-Integrability of 2+1-Dimensional and 3+1-Dimensional Gauge Theories** In the last few years, 2+1-Dimensional Yang-Mills theories have been studied analytically at weak coupling by perturbing around 1+1-Dimensional integrable quantum field theories. String tensions and mass spectra can be computed directly. The inherent anisotropy of these Yang-Mills theories is now intepreted as a consequence of the eikonal approximation. A generalization to 3+1-Dimensional QCD is immediate, and appears closely related to the proposals of McLerran and Venugopalan and of Verlinde and Verlinde. Confinement of color is thereby solved for the case of diffractive scattering.

M. B. Paranjape (Université de Montréal, Canada and Sogang University, Korea)	**Euclidean Path Integrals, Perturbation Theory and Complex Actions** We study the Euclidean path integral when the Euclidean action contains imaginary terms. This happens in the presence of t-odd, CP violating terms. The critical points of the action are generically attained at complex values of the field configurations. We show by an explicit calculation that the perturbation theory defined by perturbing about the critical points of only the real part of the action does not give the correct perturbative result. In fact the correct perturbation theory is obtained via analytic continuation of the contour of path integration to pass through the complex critical points of the action via the path of steepest descent.
A.D. Patel (CHEP, IISc, Bangalore)	**Large-N QCD at Strong Transverse Gauge Coupling** QCD is analysed with two light-front continuum dimensions and two transverse lattice dimensions. In the limit of large number of colours and strong transverse gauge coupling, dynamical contributions of light-front and transverse directions factorise, and the theory can be analytically solved in a closed form. Exact functional integration over the gauge field produces an effective action for the bilinear field, which can be extremised in different hadronic sectors. For the mesons, an integral equation is obtained, which generalises the 't Hooft equation by including spin degrees of freedom. Spectral properties of mesons are extracted from this equation, while light-front wavefunctions and form factors can be obtained by numerical solution. For baryons, an integral equation describing the valence quark density is obtained, which again requires numerical solution. These results should be a good starting point to model QCD observables that only weakly depend on transverse directions, e.g. deep inelastic scattering structure functions.
J. Pullin (LSU)	**Loop quantum gravity of spherically symmetric space-times** We apply the techniques of loop quantum gravity to the spherically symmetric vacuum midi-superspaces. We show treatments for the exterior and the interior and show progress towards a complete treatment of the space-time. We also discuss a new approach to the dynamics of the theory called "uniform discretization" and its future applicability when treating more complex space-times.
M. Sivakumar (University of Hyderabad)	**Spin-2 triality**

V. V. Sreedhar (CMI, Chennai)	**Topological Investigations Into Discrete Gauge Theories** We explore some intriguing connections between classical topology and quantum entanglement by studying a class of three-dimensional discrete gauge theories. This is accomplished through duality transformations which allow us to map these theories, in a suitable approximation, to topological field theories of the Chern-Simons type with a finite gauge group. In this limit, connections are established between von Neumann entropy and topological invariants of three-manifolds obtained from finite group cohomology -- the so-called, Dijkgraaf-Witten invariants.
M. Varadarajan (RRI)	**Quantum Gravity and the Information Loss Problem** I will discuss how an underlying theory of quantum gravity may illuminate the Black Hole Information Loss Problem. I will review the standard picture of black hole evaporation and the ensuing Information Loss Problem. Next, I will describe an alternate picture of black hole evaporation proposed by Ashtekar and Bojowald which rests on their expectation that the black hole singularity is resolved by quantum gravity. Due to the inavailability of a complete theory of quantum gravity, their proposal is extremely qualitative. In order to confront their ideas in a precise setting, I will decribe some recent work with Ashtekar and Taveras on a toy model of black holes which yields new insights of a robust nature, into the Information Loss Problem.
Vikram Vyas (St. Stephen's College, Delhi)	**Spin-String Interaction in QCD Strings** I analyse the problem of introducing the spin of the quark and the antiquark in effective QCD strings from the point of view of the Wilson loop for a spin-half particle, or the Super Wilson loop. A string representation of the Super Wilson loop is obtained starting from an effective string representation of a Wilson Loop. The action obtained in this manner is invariant under a worldline supersymmetry and has a boundary term which contains the spin-string interaction. For rectangular loops the spin-string interaction vanishes. If an allowance is made for the finite thickness of the flux tube that is being modelled by a string then we obtain a spin-spin interaction which falls as the fifth power of the distance. Such a term was previously suggested by Kogut and Parisi in the context of a flux-tube model of confinement.