9th Workshop
On
Quantization, Dualities And Integrable Systems

9QDIS

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TITLES AND ABSTRACTS
INVITED TALK:

**Thermodynamics and Dissipation in the Quark-Gluon Plasma from Holography**

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I will review the recent developments on how to apply the AdS/CFT correspondence in more realistic field theories. The example that I will consider is the $SU(N)$ gauge theory in the large N limit. This theory shares common salient features with QCD, as such it serves as a good approximation to study the quark-gluon plasma that is being produced at the RHIC and the LHC experiments. I will review how to derive the thermodynamics of the QGP from the dual gravitational system. Finally, I will describe how to study the transport phenomena in the QGP by holographic methods.

Keywords: AdS/CFT, gauge theories, black-holes, thermodynamics

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**Supersymmetry in the Space-time of Higher-dimensional Rotating Black Holes**

Hagi Ahmedov
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General higher-dimensional rotating black hole spacetimes of any dimensions admit the Killing and Killing-Yano tensors, which generate the hidden symmetries just as in four-dimensional Kerr spacetime. We study these properties of the black holes using the formalism of supersymmetric mechanics of pseudoclassical spinning point particles. We present two nontrivial supercharges, corresponding to the Killing-Yano and conformal Killing-Yano tensors of the second rank. We demonstrate that an unusual extended Poisson-Dirac algebra of these supercharges results in two independent Killing tensors in spacetime dimensions $D \geq 6$, giving explicit examples for the Myers-Perry black holes in $D = 6$ dimensions.
Decoupling and Reduction in Chern-Simons Modified Gravity

Alikram N. Aliev
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In this talk, I will discuss a decoupling theorem in CS modified gravity, proving that for four-dimensional spacetimes with a hypersurface orthogonal Killing vector and for a Chern-Simons (CS) background scalar field being constant along the Killing vector, the source-free equations of CS modified gravity decouple into their Einstein and Cotton constituents. Thus, the model supports only general relativity solutions. I will also discuss the model, when the embedding vector (the gradient of the CS scalar field) is parallel to the hypersurface orthogonal Killing vector of constant length. I will show that in this case CS modified gravity reduces to topologically massive gravity in three dimensions.

The talk is based on a recent joint work with H. Ahmedov, arXiv:1003.3148 [hep-th]

Chern-Simons S-Brane Solutions in M-theory

Sadık Değer
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We construct an intersecting S-brane solution of 11-dimensional supergravity for which the contribution of the Chern-Simons term to the field equations is non-zero. After studying some of its properties, we consider three different compactifications (each with 3 separate subcases) of this system to 4-dimensions. Two of these give accelerating cosmologies, however their expansion factors are of order unity. We also find two static versions of this configuration and its dimensional reduction to type IIA theory.
Charged Relativistic Fluids and Born-Infeld Electrodynamics
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The electromagnetic fields in Maxwell’s theory satisfy linear equations in the classical vacuum. This is modified in classical non-linear electrodynamic theories. To date there has been little experimental evidence that any of these modified theories are tenable. However with the advent of high-intensity lasers and powerful laboratory magnetic fields this situation may be changing. We argue that an approach involving the self-consistent relativistic motion of a smooth fluid-like distribution of matter (composed of a large number of charged or neutral particles) in an electromagnetic field offers a viable theoretical framework in which to explore the experimental consequences of non-linear electrodynamics. We construct such a model based on the theory of Born and Infeld and suggest that a simple laboratory experiment involving the propagation of light in a static magnetic field could be used to place bounds on the fundamental coupling in that theory. Such a framework has many applications including a new description of the motion of particles in modern accelerators and plasmas as well as phenomena in astrophysical contexts such as in the environment of magnetars, quasars and gamma-ray bursts.


Spin Hall Effect in Non-commutative Coordinates
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A semiclassical constrained hamiltonian system which was established to study dynamical systems of matrix valued non–abelian gauge fields is employed to formulate spin Hall effect in noncommuting coordinates at the first order in the constant noncommutativity parameter \( \theta \). The method is
illustrated by studying the Hall effect on the noncommutative plane in a
gauge independent fashion. Then, we applied it to the Drude model type
and the Hall effect type formulations of spin Hall effect to obtain spin Hall
conductivity in noncommuting coordinates. It is shown that by adjusting
the noncommutativity parameter \( \theta \) different formulations yielding spin Hall
conductivity are accomplished. Hence, the noncommutative theory can be
envisaged as an effective theory which unifies different approaches.

Point Interactions in 2- and 3-Dimensional
Riemannian Manifolds

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Here, an alternative and more general construction to our previous work [Burak Altunkaynak, Fatih Erman, O. Teoman Turgut, JMP 47, 8, 2006] will be presented, that is, a non-perturbative renormalization of the bound state problem for finitely many Dirac delta interactions on two and three dimensional Riemannian manifolds is given with the help of heat kernel. We formulate the problem in terms of a finite dimensional matrix, called the principal or characteristic matrix \( \Phi \). After we get the finite formulation of the problem, the lower bound of the ground state energy is found for compact and Cartan-Hadamard manifolds. Then, the change in the bound state energy in the tunneling regime is calculated by perturbation theory. Non-degeneracy and uniqueness of the ground state is proven by Perron-Frobenious theorem. Moreover, the pointwise bounds on the wave function is given and all these results are consistent with the one given in standard quantum mechanics. Renormalization procedure does not lead to any radical change in these cases. Finally, renormalization group equations are derived and \( \beta \) function is exactly calculated.
On the Uniqueness of the Grossman-Kephart-Stasheff Instanton: Solution of the Bianchi Identities for the Connection 1-form

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The Grossman-Kephart Stasheff (GKS) solution[1] is an SO(8) connection on the 8-sphere whose curvature 2-form $F$ is self-dual in the sense that $F \wedge F$ is Hodge dual. In a previous work[2], it has been proved that the maximality of the second Pontrjagin number implies that the form of $F$ has to be as in GKS. Recently, we proved[3] that if the base manifold is conformally flat, then the maximality of the second Pontrjagin class not only determines the connection on the bundle, but it also forces the base manifold to be a sphere. In this talk we give the computation of the bundle connection from the Bianchi identities.

This is joint work with Ayşe Hümayra Bilge, Tekin Dereli, Şahin Koçak.


Topological Architectures for Hybrid Quantum Processors

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We investigate the hybrid quantum processors that form interfaces between quantum optical and solid state systems in quantum information and computation tasks. In our analysis, quantum interconnect superconducting solid
state qubits and atomic ensembles are the main building blocks to construct protocols for quantum communication and computation. In this scenario processing of reversible information transfer between superconducting quantum logic gates and stored information in atomic ensembles is used for the construction of the quantum devices for long distance quantum communication. Charged nitrogen-vacancy centers in diamond with its large decoherence time even in room temperatures will be used in circuits consisting superconducting qubits. To use anyonic states in long distance communication, we will look for the protocols for implementing Kitaev lattice model in superconducting circuits. These topologically protected states and encoding schemes give rise to new applications in quantum information processing with hybrid systems containing anyons.

### Canonical Structure of Higher Derivative Gravity in 3D: The Flat Space

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We give an explicitly gauge invariant canonical analysis of linearized quadratic gravity theories in three dimensions for flat backgrounds. We also study the effects of gravitational Chern-Simons term, and include the sources, compute the weak field limit as well as scattering between spinning massive particles.  

This talk is based on I. Gullu, T. C. Sisman, B. Tekin, “Canonical Structure of Higher Derivative Gravity in 3D”, arXiv:1002.3778v2 [hep-th]
Killing Vector Fields in Three Dimensions: A Method to Solve Massive Gravity Field Equations

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Killing vector fields in three dimensions play important role in the construction of the related spacetime geometry. In this work we show that when a three dimensional geometry admits a Killing vector field then the Ricci tensor of the geometry is determined in terms of the Killing vector field and its scalars. In this way we can generate all products and covariant derivatives at any order of the ricci tensor. Using this property we give ways of solving the field equations of Massive Gravity Theories introduced recently. In particular when the scalars of the Killing vector field (timelike, spacelike and null cases) are constants then all three dimensional symmetric tensors of the geometry, the ricci and einstein tensors, their covariant derivatives at all orders, their products of all orders are completely determined by the Killing vector field and the metric. Hence the corresponding three dimensional metrics are strong candidates of solving all higher derivative gravitational field equations in three dimensions.

A Theorem to Generate Einstein-Non-Linear Maxwell Fields

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We present a theorem in d-dimensional static, spherically symmetric spacetime in generic Lovelock gravity coupled with a non-linear electrodynamic source to generate solutions. The theorem states that irrespective of the order of the Lovelock gravity and non-linear Maxwell (NLM) Lagrangian, for the pure electric field case the NLM equations are satisfied by virtue of the Einstein-Lovelock equations. Applications of the theorem, specifically to the study of black hole solutions in Chern-Simons (CS) theory is given. Radiating black hole version of the theorem has also been considered, which generalizes the Bonnor-Vaidya (BV) metric to the Lovelock gravity with a NLM field as a radiating source.
Approximate Solutions of Maxwell-Bloch Equations
and Possible Lotka-Volterra Type Behavior

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Dynamical properties of laser models based on the Maxwell-Bloch system
given below are studied.

\[
\begin{align*}
\dot{E} &= -kE + gP \\
\dot{P} &= -\gamma_\perp P + gE\Delta \\
\dot{\Delta} &= -\gamma_\parallel (\Delta - \Delta_0) - 4gPE
\end{align*}
\]

It is demonstrated that the system has a rich structure as a function of
its parameters. An operating point exhibiting Lorenz-like chaos has been
found. The parameters correspond to far infrared lasers. A parameter study
starting from this point reveals several types of instability. Bifurcation mech-
anisms that characterize the possible transition to chaos from this operating
point, and in particular, several instances of Hopf bifurcation have been iden-
tified. Hopf bifurcation has also been traced using a normal form analysis,
by imposing the appropriate requirement for the eigenvalues of the linearized
system at equilibrium.

Special solutions of the system one of which reduces to the Lotka-Volterra
system under simplifying assumptions are derived. Reasons for the absence
of oscillating solutions in the modified systems are studied. All of them lead
to stable behavior, characteristic of Type I and II lasers. The oscillatory be-
havior that is left over from the chaotic region turns out to be a \( g \) dominated
regime. Omitting the \( g \) dominating terms lead to exponentially decaying
stable solutions.

Keywords: Maxwell-Bloch Equations, Lotka-Volterra Equations, Oscillatory
Solutions, Bifurcations, Chaos

This is a joint work by Avadis Hacınlıyan, İlknur Kuşbeyzi and Özgür Aybar.
We consider the complex model

$$-\psi''(x) = E \rho(x) \psi(x), \quad x \in \left[-\frac{L}{2}, 0\right) \cup \left(0, \frac{L}{2}\right],$$

(1)

$$\psi(0^-) = \psi(0^+), \quad \psi'(0^-) = e^{2i\theta} \psi'(0^+),$$

(2)

$$\psi\left(-\frac{L}{2}\right) = \psi\left(\frac{L}{2}\right) = 0,$$

(3)

depending on two real parameters $\theta$ and $\delta$ in $[0, \pi/2)$, where $E$ is a spectral parameter ("energy"), $L$ is a fixed positive real number, and

$$\rho(x) = \begin{cases} 
e^{2i\delta} & \text{for } x \in \left[-\frac{L}{2}, 0\right), \\ e^{-2i\delta} & \text{for } x \in \left(0, \frac{L}{2}\right). \end{cases}$$

Problem (1)–(3) is PT-symmetric and it is Hermitian with respect to the usual inner product of space $L^2(-L/2, L/2)$ if and only if $\theta = \delta = 0$. Suppose that $\theta$ and $\delta$ are not both zero so that problem (1)–(3) is non-Hermitian. It turns out that the eigenvalues of (1)–(3) are all real if and only if $\delta = \theta$. We investigate in this case the metric operator which relates non-Hermitian problem (1)–(3) to a Hermitian one. The case $\delta = 2\theta$ in which only a finite number of the eigenvalues are real was earlier investigated by A. Mostafazadeh (2005).
We consider the particle creation process associated with a quantum field $\chi$ in a time-dependent, homogeneous and isotropic, classical background. It is shown that the field square $\chi^2$, the energy density and the pressure of the created particles have large fluctuations comparable to their vacuum expectation values. Possible effects of these fluctuations on the reheating process after inflation are discussed. After determining the correlation length of the fluctuations in two different models, corresponding to the decay in the parametric resonance regime and in the perturbation theory, it is found that these fluctuations should be taken into account in the final thermalization process, in the back-reaction effects and when the formation of primordial black holes is considered. In both models, by comparing quantum and thermal fluctuations with each other it is observed that very quick thermalization after the complete inflaton decay is not always possible even when the interaction rates are large. On the other hand, when the back-reaction effects are included during the preheating stage, the coherence of the inflaton oscillations is shown to be lost because of the fluctuations in $\chi^2$. Finally, we note that a large fluctuation in the energy density may cause a black hole to form and we determine the fraction of total energy density that goes into such primordial black holes in the model of preheating we consider.

We extend the Majumdar-Papapetrou (MP) solution of the Einstein-Maxwell (EM) equations which is implied generally for static electric charge in non-rotating metrics to encompass equally well magnetic charges. In the absence
of Higgs and non-Abelian gauge fields, 'dyonic' is to be understood in this simpler sense. Cosmologically this may have far-reaching consequences, to the extent that existence of multi-magnetic monopole black holes may become a reality in our universe. Infalling charged particle geodesics may reveal, through particular integrals, their inner secrets which are screened from our observation.

**Deformations of M-Theory Backgrounds With Field Theory Duals**

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We construct new M-theory solutions starting from those that contain 5 U(1) isometries. We do this by reducing along one of the 5-torus directions, then T-dualizing via the action of an O(4,4) matrix and lifting back to 11-dimensions. The particular T-duality transformation is a sequence of O(2,2) transformations embedded in O(4,4), where the action of each O(2,2) gives a Lunin-Maldacena deformation in 10-dimensions. We will start by a brief review of the Lunin-Maldacena deformation, followed by its generalization to M-theory backgrounds. Then we apply the results to certain M-theory backgrounds, with field theory duals.

This talk is based on the paper Class. Quant. Grav. 26 (2009) 245015, with Nihat Sadık Değer.

**Information Loss and Entropy Conservation of Linear Dilaton Black Holes in Quantum Corrected Hawking Radiation**

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It has been shown recently that information is lost in the Hawking radiation of the linear dilaton black holes in various theories when applying the tunneling formulism without considering quantum gravity effects. In this talk,
we show how one can recalculate the emission probability by taking into account of the log-area correction to the Bekenstein-Hawking entropy and the statistical correlation between quanta emitted. The crucial role of the black hole remnant on the entropy conservation is highlighted. The entropy conservation in the higher dimensional linear dilaton black holes is also discussed. In summary, we show in detail that the information can also leak out from the linear dilaton black holes together with preserving unitarity in quantum mechanics.

New Massive Gravity and Chiral Gravity in de-Sitter Space

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We study the canonical structure of New Massive Gravity and Chiral Gravity in de-Sitter backgrounds. Our construction reveals the physical degrees of freedom in an explicitly gauge invariant way.

This talk is based on I. Gullu, T. C. Sisman, B. Tekin, “Canonical Structure of Higher Derivative Gravity in 3D”, arXiv:1002.3778v2 [hep-th], and on an unpublished work by the same authors.

Born-Infeld Extension of New Massive Gravity

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We present a three-dimensional gravitational Born-Infeld theory which reduces to the recently found New Massive Gravity (NMG) at the quadratic level in the small curvature expansion and at the cubic order reproduces the deformation of NMG obtained from AdS/CFT. Our action provides a remarkable extension of NMG to all orders in the curvature, and might define a consistent quantum gravity.