Titles and Abstracts

Poster Presentations

Sebastián Bahamonde (University of Tartu)

1) Title: "Is really General Relativity the correct starting point for quantum gravity? "

In this poster I will introduce the Trinity of gravity. The first theory is General Relativity (GR) whose connection is torsionless and contains curvature, and the metric satisfies the compatibility condition. The second one is the Teleparallel equivalent of GR (TEGR) which is also constructed from a metric which satisfies the metric compatibility condition but the connection is curvatureless and contains torsion. The last theory is Coincident GR (CGR) which has zero curvature and torsion but the metric does not satisfy the metric compatibility condition. These three theories give the same classical Einstein field equations, but both their physical interpretation and quantum descriptions are different. I will argue that all the efforts to construct a viable quantum gravity theory has been done by considering GR as the starting point, but in principle, one can start with either TEGR or CGG and then study their possible quantum theories. Some interesting possible advantages for studying these two alternatives gravitational theories in the context of quantum gravity will be also pointed out.

2) Title: "Reviving Horndeski gravity using Teleparallel gravity"

General Relativity (GR) is based on a manifold with curvature and zero torsion and on the contrary, Teleparallel gravity (TG) is a theory which assumes a non-zero torsion with zero curvature. It turns out that it is possible to write down a theory in Teleparallel gravity that is equivalent to GR in terms of the field equations. Even though these theories are equivalent in field equations, their modifications are different. Horndeski gravity which is based from GR was highly constraint from the recent gravitational waves observations due to $|c_g/c - 1| < 10^{-15}$. We constructed an analogue version of Horndenki gravity which is based in Teleparallel gravity and showed that in this context, it is possible to construct a theory satisfying $c_T = c_g/c = 1$ without eliminating the coupling functions $G_5(\phi , X)$ and $G_4(\phi , X)$ that were highly constraint in standard Horndeski theory. Hence, in the Teleparallel approach, one is able to restore these terms creating an interesting way to revive
Horndeski gravity.

Jinzhao Wang (ETH, Zurich)

1) Title: "On the geometry of small causal diamonds"

The geometry of small causal diamonds in the absence of matter is considered, based on three distinct constructions that are common in the literature, namely the geodesic ball, Alexandrov interval and lightcone cut. The causal diamond geometry is studied perturbatively using Riemann normal coordinate expansion up to the leading order in both vacuum and non-vacuum. We provide a collection of results including the area of the codimension-two edge, the maximal hypersurface volume and their isoperimetric ratio for each construction. In particular, by solving the evolution equations of the optical quantities on the lightcone, we find that intriguingly only the lightcone cut construction yields an area deficit proportional to the Bel-Robinson superenergy density W in four dimensional spacetime, but such a direct connection fails to hold in any other dimension. We also compute the volume of the Alexandrov interval causal diamond in vacuum, which we believe is important but missing from the literature. Our work systematically studies various causal diamonds under the same setting, and extends the earlier works on the causal diamond geometry by Gibbons and Solodukhin, Jacobson, Senovilla and Speranza and many others. Some potential applications of our results in mathematical general relativity and quantum gravity are discussed.

2) Title: “On the Hawking-Hayward mass in arbitrary dimensions”

The quasilocal mass is a crucial but yet fully understood notion in gravity. In General Relativity, many proposals for a good definition of quasilocal mass have been given over the past half-century. However, most of the proposals do not have sound generalisations beyond four spacetime dimensions. We study here the natural generalisation of the Hawking-Hayward mass to arbitrary dimen- sions, which uniquely inherits some nice properties of the original definition in four dimensions. In the small sphere limit, however, the Hawking-Hayward mass fails to be proportional to the Bel- Robinson superenergy in dimensions other than four. Given the uniqueness of both generalisations of the Hawking-Hayward mass and the Bel-Robinson superenergy to higher dimensions, our result points at the inconsistency of the local behaviors of quasilocal mass in higher dimensions. Potential solutions await the proper generalisations of other quasilocal mass definitions, and ultimately the understanding of its quantum origin.

Salvatore Baldino, Roberto Vega Alvarez, and Maximilian Schwick (IST, University of Lisbon)

Title: "Towards Nonperturbative Solutions of 2D gravity and supergravity"

In the settings of 2D quantum gravity and quantum supergravity, the Painlevé I and Painlevé II equations play prominent roles in obtaining the corresponding partition functions. Solutions to these Painlevé equations are subject to non-trivial, non-linear Stokes phenomena, where some of the Stokes data can be related to ZZ-brane amplitudes. It is expected that the complete Stokes data can be further related to FZZT-brane amplitudes (and in fact to the full semi-classical content of these theories). However, currently, there is no analytical procedure that produces the complete Stokes data for those equations.

We have developed a numerical method to compute Stokes data in a general setting. This method is based on the transseries representation in [1]. By imposing smoothness of the Borel resummed transseries at the Stokes lines, systems of equations involving polynomial combinations of Stokes data can be written, whose coefficients can be computed through numerical Borel resummations of asymptotic series within the transseries.

We obtained a systematic way to extract values for the Stokes data, alongside numerical results of this analysis, within the setting of the Painlevé I and Painlevé II equations, confirming the partial results obtained through other methods in [2] and [3], and presenting a plethora of new data. We present an interpretation of this data as building blocks that allow us to write a globally defined partition function for the models. We have conjectured relations between the Stokes data to reduce the amount of independent data, and tested them using the numerical results. These results, that will be presented in the poster, will appear in [4].

[1] Inês Aniceto, Gökçe Başar, Ricardo Schiappa. "A Primer on Resurgent Transseries and Their Asymptotics." Physics Reports (2019). arXiv preprint arXiv:1802.10441
[2] Inês Aniceto, Ricardo Schiappa, Marcel Vonk. "The Resurgence of Instantons in String Theory." Commun. Num. Theor. Phys. 6 (2012) 339-496. arXiv preprint arXiv:1106.5922
[3] Ricardo Schiappa, Ricardo Vaz. "The Resurgence of Instantons: Multi-Cut Stokes Phases and the Painlevé II Equation." Commun. Math. Phys. 330 (2014) 655-721. arXiv preprint arXiv:1302.5138
[4] Salvatore Baldino, Ricardo Schiappa, Maximilian Schwick, Roberto Vega, (2019) to appear.

Alessio Baldazzi (SISSA, Trieste)

Title: "Wicked metrics vs path integral in Lorentzian spacetimes"

There are various ways of defining the Wick rotation in a gravitational context.
In order to preserve the manifold structure, it would be preferable to view it as an analytic continuation of the metric, instead of the coordinates. We focus on one very general definition and show that it is not always compatible with the additional requirements of preserving the field equations and the symmetries at global level.
Then we consider another approach based not on the deformation of the time or the metric, but of the integration contour of the fields. In particular we discuss the calculation of one-loop effective actions in Lorentzian spacetimes, based on a very simple application of the method of steepest descent to the integral over the field. We show that for static spacetimes this procedure agrees with the analytic continuation of Euclidean calculations. When applied to quantum gravity on static backgrounds, our procedure is equivalent to analytically continuing time and the integral over the conformal factor.

Shoichiro Miyashita (Waseda University)

Title: "DOS of GR"

In quantum gravity, gravity would thermalize, in the sense that some observables defined on the spacetime boundary reach equilibrium. The information of such gravitational thermal states could be obtained statistical mechanically. The partition functions of gravity are formally defined by certain kinds of Euclidean path integral of General Relativity(GR). However, since there are known to be the divergent problem in Euclidean path integral of GR, its integration contour must be genuinely complex which generally picks up complex saddle-point geometry. In this work, we seek the suitable integration contour for the microcanonical partition function or Density of States(DOS) of a quantum spacetime with R × S^2 boundary by using minisuperspace approximation. Although we found that there always exists only one saddle point for any given boundary data, it does not always dominate the possible integration contours. One of the obtained DOS shows exponential of Bekenstein-Hawking entropy for a certain energy range where it is dominated by the saddle point. However, for sufficiently high energy, where the saddle point no longer dominates, the DOS approaches a positive constant. This presentation is based on arXiv:1906.11838.

Haruka Mori (Kitasato University)

Title: "Space-time foliations, doubled aspects of Vaisman algebroid and gauge symmetry in double field theory"

Double Field Theory (DFT) is a gravity theory that respects T-duality in string theory. The geometry behind DFT exhibits non-trivial mathematical structures. The metric algebroid proposed by Vaisman (the Vaisman algebroid) governs the gauge symmetry algebra generated by the C-bracket in DFT. Based on a geometric realization of doubled space-time as a para-Hermitian manifold, we examine exterior algebras and a para-Dolbeault cohomology on DFT and discuss the structure of the Drinfel'd double for the DFT gauge symmetry. We find that Lagrangian subbundles (L,\tilde{L}) defined over space-time foliations in a para-Hermitian manifold play Dirac-like structures in the Vaisman algebroid. We also find that an algebraic origin of the strong constraint in DFT is traced back to the compatibility condition needed for (L,\tilde{L}) be a Lie bialgebroid.
We further comment on groupoid structures appearing in the doubled space-time.

Arkaprava Mukherjee (Indian Institute of Science Education and Research, Kolkata)

Title: "Quantum out-of-equilibrium cosmology and Bound on Quantum Chaos for GUE"

The one to one correspondence between the conduction phenomena in electrical wires with impurity and the scattering events responsible for particle production during stochastic inflation and reheating implemented under a closed quantum mechanical system in early universe cosmology leads to derivation of quantum corrected version of the Fokker–Planck equation without dissipation and its fourth order corrected analytical solution for the probability distribution profile responsible for studying the dynamical features of the particle creation events . Quantum corrected Fokker–Planck equation describe the particle creation phenomena for Dirac delta scatterer.

The measure of the stochastic non-linearity (randomness or chaos) arising in the stochastic inflation and reheating epoch of the universe(Lyapunov Exponent) has been studied . Quantum chaos in a closed system have a more strong measure, Spectral Form Factor which has been calculated from principles of RMT with GUE. SFF from the computation of two point Out of Time Order Correlation function (OTOC) has been shown to have a bound on $-1/N\,(1 - 1/\pi) \leq \mathrm{SFF} \leq 0$ and $0 \leq \mathrm{SFF} \leq 1/\pi N$, valid for thermal systems with large and small number of degrees of freedom respectively. Also early and late behavior of SFF(quantum chaos) to check the validity and applicability of our derived bound has been discussed.

Reference:-
1."Quantum out-of-equilibrium cosmology"-Eur. Phys. J. C (2019) 79:320, S. Choudhury, A. Mukherjee, P. Chauhan, S. Bhattacherjee
2."Quantum randomness in the sky"-arXiv:1812.04107 [physics.gen-ph], S. Choudhury, A. Mukherjee
3. "A bound on quantum chaos from Random Matrix Theory with Gaussian Unitary Ensemble"-https://doi.org/10.1007/JHEP05(2019)149, S. Choudhury, A. Mukherjee

Kenta Shiozawa (Kitasato University)

Title: "Worldsheet Instanton Corrections to Five-branes and Waves in Double Field Theory"

We make a comprehensive study on the string winding corrections to supergravity solutions in double field theory (DFT). We find five-brane and wave solutions of diverse codimensions in which the winding coordinates are naturally included. We discuss a physical interpretation of the winding coordinate dependence. The analysis based on the geometric structures behind the solutions leads to an interpretation of the winding dependence as string worldsheet instanton corrections. We also give a brief discussion on the origins of these winding corrections in gauged linear sigma model (GLSM). We propose a GLSM that provides a string sigma model whose target spaces are a defect NS5-brane, a Kaluza-Klein vortex and an exotic 5^2_2-brane. This presentation is based on JHEP07(2018)001 and JHEP12(2018)095.

Carlos Mauricio Nieto Guerrero (SISSA, Trieste)

Title: "Ultraviolet completion and predictivity from a minimal parameterization of Beyond-Standard-Model physics"

I will discuss the effect of quantum gravity contributions on the running of gauge and Yukawa couplings in the Standard Model. Using a simple but general parametrization for these corrections, I explore different Ultraviolet behaviors of the system of couplings. One of my main goals is to understand the pattern observed in the masses of the quark sector, as well as the CKM mixing angles.

Kazumasa Okabayashi (Osaka City University)

Title: “Maximal Efficiency of Collisional Penrose Process with Spinning Particle II Collision with a particle in ISCO”

We analyze the collisional Penrose process between a particle in its ISCO around an extreme Kerr black hole and a particle impinging from infinity in both spinless and spinning case. We evaluate the maximal efficiency, η_{max} = (extracted energy)/(input energy), for the elastic collision, the inverse Compton scattering, which are considered as natural process. When spin is taken into account, we obtain $\eta_{max} \approx 8.442$ in the elastic collision, which is the largest value compared with the other case. On the other hand, when we consider the spinless collision, $\eta_{max} \approx 4.041$ is obtained in the inverse Compton scattering, which is the largest value. When spin is taken into account, we find from tables that the efficiency becomes much larger. In this sense, spin plays an important role in the collisional processes, and should not be ignored.

Vasilis Kiosses (Aristotle University of Thessaloniki)
Title: “Gravity as black body radiation and black hole themodynamis”
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Gravitation as blackbody radiation and black hole thermodynamics

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Abstract

In this presentation, we provide a heuristic way to consider gravity as blackbody radiation. Our formulation involves two basic elements. A quantum spacetime, described by the quantum excitations of a new kind of fields, named as accelerated fields, which live in momentum space. And a massive object defined as a collection of spacetime quanta in thermodynamic equilibrium. This object behaves as a blackbody, emitting quantum lengths and time intervals, at temperature inversely proportional to its mass. Having established a correspondence between quantum and Rindler spacetime (PLB 781, 611, 2018), equivalence principle allows us to identify gravity with the massive object's blackbody radiation, since the last affects the corresponding geometry of spacetime. At Planck scale, our argument directly leads to the Hawking temperature of a black hole (up to a constant) demonstrating that a black hole can actually reach thermal equilibrium if spacetime comes in discrete units.

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