

Annual Meeting QGSKY - Quantum Universe



Report of Contributions

Contribution ID: 1

Type: **not specified**

Decoding a black hole metric from the interferometric pattern of relativistic images

Thursday, 5 October 2023 15:00 (20 minutes)

Gravitational Lensing is the effect for which light rays are deflected by a gravitational field. In presence of a black hole acting as a lens, photons can wind several times around it before fleeing towards the observer. This creates two infinite sequences of images of a given source with decreasing magnitude, asymptotically approaching the border of a zone that will remain obscure called shadow. The features of these images are reflected by a characteristic staircase structure in the complex visibility function. Recalling the formalism of the strong deflection limit, we derive analytical formulae for the height, the width, and the periodicities of the steps in the visibility function that can be inverted to determine the metric coefficients, distance and size of the source starting from the images pattern. With respect to diffuse emission by the whole accretion flow, this ideal framework provides clean insight and model-independent information on the metric. Moreover, these formulae can track the changes induced by orbital motion of the source or alternative metrics and ultimately test General Relativity.

Presenter: ARATORE, Fabio (Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 14-16

Contribution ID: 2

Type: **not specified**

The Different Faces of Cosmography

Friday, 6 October 2023 09:40 (20 minutes)

Recently, the cosmographic approach has gained considerable interest as a model-independent technique that can describe the recent expansion of the universe. In fact, given only the observational assumptions of the cosmological principle, it makes it possible to study such an evolution without assuming a specific cosmological model. In this talk I will show some of the most promising lines of research in current cosmography, both in its use in astrophysics and strategies for using it in a cosmological context.

Presenter: BENETTI, Micol (Istituto Nazionale di Fisica Nucleare)

Session Classification: Friday 9:20 - 11:00

Contribution ID: 4

Type: **not specified**

Non-local gravity effects in galaxy cluster lensing

Thursday, 5 October 2023 14:40 (20 minutes)

Extended theories of gravity have been extensively investigated during the last thirty years, aiming at fixing the infrared and ultraviolet shortcomings of General Relativity and the associated Λ CDM cosmological model. Recently, non-local theories of gravity have drawn increasing attention due to their potential to ameliorate both the UV and IR behaviour of the gravitational interaction. Integral Kernel theories of Gravity indeed provide a viable mechanism to explain the late time cosmic acceleration as to avoid the introduction of any form of unknown dark energy. Moreover, these models represent a natural bridge towards quantum gravity. I will discuss a scalar-tensor equivalent of General Relativity corrected with non-local terms that have been selected via Noether symmetries. The main cosmological properties of the non-local model will be reviewed, and our detailed analysis of its features at galaxy cluster scales will be presented. We provide constraints on the non-local length scales and the Navarro–Frenk–White parameters through the comparison between the non-local theoretical predictions for the gravitational lensing, and the observations from the CLASH program.

Presenter: BOUCHÈ, Filippo (Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 14-16

Contribution ID: 5

Type: **not specified**

QGSKY - Highlights on Catania Unit research work

Friday, 6 October 2023 11:40 (20 minutes)

QGSKY - Highlights on Catania Unit research work

Presenter: BRANCHINA, Vincenzo (University of Catania)

Session Classification: Friday 11:40 - 13:20

Contribution ID: 6

Type: **not specified**

The Gravitational Energy-Momentum Pseudo-Tensor in Higher Order Theories of Gravity

Friday, 6 October 2023 10:20 (20 minutes)

We discuss the generalization of gravitational energy-momentum pseudo-tensor to Extended Theories of Gravity, in particular to higher-order theories in curvature invariants. This result is achieved by imposing that the local variation of gravitational action of any order vanishes under rigid translations. We also prove that this tensor, in general, is not covariant but only affine, that is, it is a pseudo-tensor. The pseudo-tensor is calculated in the weak-field limit up to a first non-vanishing term of order h^2 , where h is the metric perturbation. The average value of the pseudo-tensor, over a suitable spacetime domain, is obtained. Finally, we calculate the emitted power, per unit solid angle, carried by a gravitational wave in a direction x for a fixed wave number k under a suitable gauge.

Presenter: CAPOZZIELLO, Salvatore (Università di Napoli "Federico II")

Session Classification: Friday 9:20 - 11:00

Contribution ID: 7

Type: **not specified**

NON-LINEAR ELECTRODYNAMICS IN BLANDFORD-ZNAJEK ENERGY EXTRACTION

Friday, 6 October 2023 12:40 (20 minutes)

Non-linear electrodynamics (NLED) is a generalization of Maxwell's electrodynamics for strong fields. It could have significant implications for the study of black holes and cosmology and have been extensively studied in the literature, extending from quantum to cosmological contexts. Recently, its application to black holes, inflation and dark energy has caught on, being able to provide an accelerated Universe and address some current theoretical inconsistencies, such as the Big Bang singularity. In this work, we report two new ways to investigate these non-linear theories. First, we have analyzed the Blandford-Znajek mechanism in light of this promising theoretical context, providing the general form of the extracted power up to second order in the black hole spin parameter a . We have found that, depending on the NLED model, the emitted power can be extremely increased or decreased, and that the magnetic field lines around the black hole seems to become vertical quickly. Considering only separated solutions, we have found that no monopole solutions exist and this could have interesting astrophysical consequences (not considered here).

Presenter: CARLEO, Amodio (Istituto Nazionale di Fisica Nucleare)

Session Classification: Friday 11:40 - 13:20

Contribution ID: 8

Type: **not specified**

Naturalness. Higgs mass, cosmological constant and Physical Tuning

Friday, 6 October 2023 12:00 (20 minutes)

Due to unsuppressed quantum fluctuations, the Higgs boson mass and the cosmological constant turn out to be extremely sensitive to the UV modes of the underlying high energy theory, and this usually demands an “unnatural” and “formal” fine-tuning. We show that when the Wilsonian EFT paradigm is properly implemented in the theory, a “physical tuning” scenario naturally emerges. This is clearly illustrated, for instance, by the multiplicative renormalization of the Higgs boson mass. In the usual perturbative framework, the latter is realized only after the “formal” cancellation of quadratic divergences is operated with the help of some renormalization technique (no matter if you see them explicitly, or you hide them as it is, for instance, the case in dimensional regularization). In the EFT (physical) framework it emerges as an IR property of the full Wilsonian running, and naturally gives rise to the IR (measured) value of the mass. The cosmological constant naturalness problem can be studied in a similar way, the tiny measured value emerging in the IR as a result of the RG Wilsonian flow.

Presenter: CONTINO, Filippo

Session Classification: Friday 11:40 - 13:20

Contribution ID: 9

Type: **not specified**

Conformal Backreaction in the Early Universe and Effective Actions

Thursday, 5 October 2023 17:20 (20 minutes)

I discuss recent developments in the analysis of the conformal backreaction exerted by conformal matter on the external classical gravitational metric. The approach relies on a reconstruction of the effective action exploiting conformal symmetry in momentum space.

Presenter: CORIANO', Claudio (LE)

Session Classification: Thursday 16:40-18:00

Contribution ID: 10

Type: **not specified**

The Hubble constant tension: The Classical Cepheid point of view

Friday, 6 October 2023 10:00 (20 minutes)

One of the most debated issues in astrophysics is the discrepancy, which ranges between 4 to 6 sigma, between the locally estimated value of the Hubble constant using the SNeIa distance scale calibrated with Classical Cepheids and the cosmological value derived from Cosmic Microwave Background Radiation (CMBR). This problem is commonly referred to as the Hubble constant tension and represents a significant challenge for both cosmologists and astrophysics experts. From the perspective of the local universe, several systematic effects in the calibration of the extragalactic distance scale based on Classical Cepheids may contribute to this tension. Using an updated and extended set of nonlinear convective Classical Cepheid pulsation models, we are theoretically investigating these systematic effects when combined with the most recent Gaia results to gain a deeper understanding of the potential impact of variations in the physical and chemical parameters of these standard candles on the estimated value of the Hubble constant.

Presenter: DE SOMMA, Giulia (Istituto Nazionale di Fisica Nucleare)

Session Classification: Friday 9:20 - 11:00

Contribution ID: 11

Type: **not specified**

Bianchi type-I cosmological dynamics in $f(Q)$ gravity: a covariant approach

Thursday, 5 October 2023 17:00 (20 minutes)

Making use of the 1 + 3 covariant formalism, we show explicitly the effect that nonmetricity has on the dynamics of the universe. Then, using the Dynamical System Approach, we analyze the evolution of Bianchi type-I cosmologies within the framework of $f(Q)$ gravity. We consider several models of function $f(Q)$, each of them manifesting isotropic eras of the universe, whether transitional or not. In one case, in addition to the qualitative analysis provided by the dynamical system method, we also obtain analytical solutions in terms of the average length scale l .

Presenter: ESPOSITO, Fabrizio (Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 16:40-18:00

Contribution ID: 12

Type: **not specified**

Dirac Hydrodynamics

Thursday, 5 October 2023 15:40 (20 minutes)

We present the relativistic version with spin of quantum mechanics written in terms of hydrodynamic variables: in this way the Dirac theory is converted into a form that does not involve the selection of any representation nor the choice of any frame. Such a re-formulation is necessary to visualize concepts of quantum mechanics, and it is also important for No-Go theorems where a choice of frame could reduce their validity.

Presenter: FABBRI, Luca (University of Genova and Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 14-16

Contribution ID: 13

Type: **not specified**

Parity-odd Anomalies and CFT correlators in momentum-space

Thursday, 5 October 2023 17:40 (20 minutes)

Conformal symmetry imposes strong constraints on correlation functions. Indeed, the general structure of 2 and 3-point functions is completely fixed up to a few constants by such symmetry. These results are usually obtained in position space in contrast with general QFT where Feynman diagrams are typically computed in momentum space. I will discuss how conformal symmetry completely determines correlators that are specifically affected by parity-odd anomalies in momentum-space. One of the main reasons for studying CFTs in momentum space is to see the effects of anomalies more directly. I will focus in particular on the role of the chiral, gravitational and conformal anomalies. This study has applications ranging from condensed matter theory to holography and cosmology.

Presenter: LIONETTI, Stefano (Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 16:40-18:00

Contribution ID: 14

Type: **not specified**

Modified dispersion relations, generalized Bell nonlocality, quantum gravitational decoherence: windows to Planck-scale physics

Thursday, 5 October 2023 15:20 (20 minutes)

We show how in phenomenological approaches to quantum gravity associated with fundamental length or energy scales, the propagation of particles is associated with dispersion relations characterized by additional terms or non-linearities. Deviations from ordinary dispersion relations provide essential signatures of Planck-scale physics and induce quantum gravitational effects, as modified Hamiltonian interactions that can be probed at accessible energy scales. For the specific case of electrons in external magnetic fields, we show that one such effect amounts to a modification of the anomalous magnetic moment of the electron, that can be measured and can thus constrain possible quantum gravitational effects. If time allows, we will discuss the implications of minimal length on Bell nonlocality, the structure of the spin operator and the relation between internal and spacetime degrees of freedom.

Presenter: Dr PETRUZZIELLO, Luciano (Università degli Studi di Salerno & Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 14-16

Contribution ID: 15

Type: **not specified**

Adiabatic States in non-Smooth spacetimes

Thursday, 5 October 2023 16:40 (20 minutes)

The analysis of quantum states in non-smooth spacetimes has two main motivations. First, there are several models of physical phenomena that require spacetime metrics with finite regularity. These include models of gravitational collapse, astrophysical objects and general relativistic fluids. Second, the well-posedness of Einstein's equations, viewed as a system of hyperbolic PDE requires spaces with finite regularity. Ground states are a well-known class of Hadamard states in smooth spacetimes. In this talk, I will present our proof that the ground state of the Klein–Gordon field in a non-smooth ultra static spacetime is an adiabatic state characterised by a Sobolev Wavefront set condition that depends on the regularity of the metric

Presenter: SANCHEZ SANCHEZ, Yafet (University of Genova and Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 16:40-18:00

Contribution ID: 16

Type: **not specified**

Flavour oscillation and torsion in Quantum Field Theory

Thursday, 5 October 2023 14:20 (20 minutes)

We study the quantum field theory of neutrino mixing in the presence of spacetime torsion. We derive new oscillation formulae for the constant torsion background, displaying the spin dependence of the oscillation probability

Presenter: SERAO, Raoul (Istituto Nazionale di Fisica Nucleare)

Session Classification: Thursday 14-16

Contribution ID: 17

Type: **not specified**

Gravitational memory of Casimir effect

Friday, 6 October 2023 09:20 (20 minutes)

We investigate the influence of a time-varying spacetime background on the vacuum polarization of a massless quantum field confined to a Casimir cavity. The background is modelled as an anisotropic Bianchi-I spacetime, in which small time-dependent perturbations around the flat spacetime are vanishing in the far past and future. The spacetime admits asymptotic Minkowskian regions, thus allowing for an unambiguous definition of the in- and out-field vacua. Following Schwinger's proper-time approach, we evaluate the vacuum polarization inside the Casimir cavity. We show the presence of a small shift in the field vacuum energy, once the perturbation is over. The time-dependent background has distorted the field modes, causing a permanent change in the zero-point energy of the field confined to the Casimir apparatus. As an example, we briefly consider the case of a weak gravitational wave background, which can be locally identified with the previously employed Bianchi-I spacetime model. The present effect appears as a sort of gravitational memory of the Casimir effect

Presenter: SORGE, Francesco (Istituto Nazionale di Fisica Nucleare)

Session Classification: Friday 9:20 - 11:00

Contribution ID: **18**

Type: **not specified**

Opening: Introduction to QGSKY

Thursday, 5 October 2023 14:00 (20 minutes)

Presenter: CAPOZZIELLO, Salvatore (Università di Napoli "Federico II")

Session Classification: Thursday 14-16

Contribution ID: **19**

Type: **not specified**

Final remarks

Friday, 6 October 2023 13:00 (20 minutes)

Presenter: CAPOZZIELLO, Salvatore (Università di Napoli "Federico II")

Session Classification: Friday 11:40 - 13:20

Contribution ID: 20

Type: **not specified**

Does the cosmological constant really indicate the existence of a dark dimension?

Friday, 6 October 2023 12:20 (20 minutes)

When the Higgs effective potential $V_{eff}(\phi)$ and/or the vacuum energy ρ are derived from higher dimensional theories with compact extra dimensions and non-trivial boundary conditions (as in the case of the Scherk-Schwarz SUSY breaking mechanism), the usual calculations lead to the conclusion that these quantities are UV-insensitive. Based on the finite result for ρ and on the measured value of the cosmological constant, it has been recently proposed that we might live in a universe with a single compact extra dimension (dark dimension), whose mesoscopic size is of order μm . Since this proposal has been advanced, a lot of work has been dedicated to studying several phenomenological consequences related to the existence of this fifth (compact) dimension. We show that a source of strong UV-sensitivity for ρ , intimately connected to the non-trivial topology of the spacetime, is missed by the usual calculation and renders the dark dimension proposal untenable, at least the way it has been originally formulated.

Presenter: PERNACE, Arcangelo (Istituto Nazionale di Fisica Nucleare)

Session Classification: Friday 11:40 - 13:20

Contribution ID: 22

Type: **not specified**

Tomography of the Universe: a new way to investigate the properties of the universe and their origin

Friday, 6 October 2023 10:40 (20 minutes)

In this talk, I give a definition for the phenomenological tomogram of the universe. I introduce the theoretical classical and quantum tomograms. I show how we could investigate the primordial quantum state of the universe from the possible deviations of the phenomenological tomogram from the classical tomogram.

Presenter: STORNAIOLO, Cosimo (Istituto Nazionale di Fisica Nucleare)

Session Classification: Friday 9:20 - 11:00