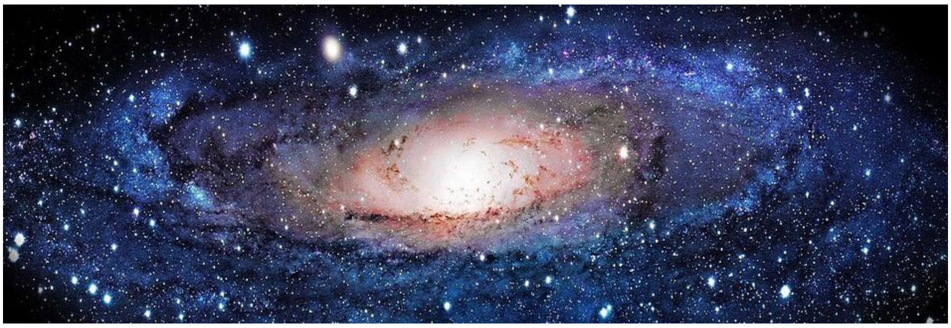
Workshop on Astro-particles and Gravity

Tuesday 20 September 2022 - Thursday 22 September 2022

Cairo University



Book of Abstracts

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An isotropic solution in mimetic-like gravity coupled with Lagrange multiplier

Author: Gamal Nashed[1]

[1] *The British University in Egypt*

Corresponding Author: nashed@bue.edu.eg

We derive for the first time an isotropic stellar model in the frame of mimetic gravity coupled with a Lagrange multiplier. The physics of this model is checked using different procedures. We show that the physical results are consistent with the true stellar model.

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The Bianchi-V spacetime with viscous matter and evolving gravitational and cosmological 'constants'

Author: Amare Abebe[1]

[1] *North-West University*

Corresponding Author: amareabebe.gidelew@nwu.ac.za

In this presentation, we discuss the cosmological solutions of the Bianchi type−V spacetime filled with bulk viscous fluid and evolving cosmological Λ and Newtonian G parameters. We show that the model describes a universe that starts off with a negative cosmological term, dominated by non-relativistic matter and decelerated, that eventually becomes dark energy- dominated and hence expanding with acceleration, in concordance with current observations. Ongoing work in this direction will also be briefly discussed.

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Gauss Bonnet Gravity: Singularity Analysis

Author: Adel Awad[1]

[1] *Ain Shams University*

Corresponding Author: awad.adel@gmail.com

Can higher curvature terms in the gravitational action affect the nature of initial-time singularities as well as black hole singularities? Are these singularities traversable? Are these spacetimes extendible? Using Gauss-Bonnet gravity as an example of higher curvature gravity, we try to answer these questions through studying cosmological singularities as well as black hole singularities and the possibility of extending their time like or null geodesics beyond the singular points. We show that in the case of cosmological singularities, the spacetimes are traversable and one can extend the spacetime in such a way to have a geodesically complete manifold. For the case of black hole solutions we show that this extension is not possible for the usual Desert-Boulware black hole in Gauss-Bonnet theory.

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Fuzzy Dark (matter) Imprints in Galaxies Quantum effects on galactic scales…

Author: Amr El-Zant[1]

[1] *Centre for Theoretical Physics, The British University in Egypt*

Corresponding Author: aaeznyt@yahoo.com

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Connecting the modified hybrid inflation to the electroweak vacuum stability

Author: Merna Ibrahim[1]

[1] *Ain Shams University*

Corresponding Author: merna.ibrahim37@gmail.com

We study the connection of the Hybrid Inflation to the Electro-weak Vacuum Stability conditions. We show how the issue of the standard model electroweak Higgs vacuum stability can be treated via its interaction with singlet scalar field(s), which also participate in modifying the hybrid inflation model. The so-called hybrid Higgs-inflaton model leads to a positive correction for the Higgs quartic coupling which is shown to have a very significant effect in stabilizing the vacuum up to the Planck scale. We consider a hybrid inflation model which can typically be implemented with the inflaton field rolling towards the origin. It gives a spectral index ns < 1, in contrast to the conventional 2-field hybrid inflation, for super-Placnkian values of the field and a small tensor-scalar ratio r, as desired. It can be seen that the new proposed physics parameters, which connect both frameworks, are pretty sufficient to give very good inflationary observables which are in high consistency with Planck and Bicep 2021 results.

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Black holes in Teleparallel gravity

Author: Christian Pfeifer[1]

[1] *University of Bremen, Germany*

Corresponding Author: christian.pfeifer@zarm.uni-bremen.de

In this talk I will give a brief introduction to teleparallel gravity and discuss ordinary and scalarised black hole solutions in f(T)-gravity. The later being the teleparallel analogue of f(R)-gravity. It turns out that the theory posses interesting generalisations of Schwarzschild geometry as solutions as well as scalarized black holes. A particular focus will be Born-Infeld f(T)-gravity, since in this theory a non-perturbative genralisation of Schwarzschild geometry has been found.

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Opening

Corresponding Author: a.moursy@cu.edu.eg

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Confronting the Chaplygin gas with data: background and perturbed cosmic dynamics

Author: Heba Abdulrahman[1]

[1] *North-West University, South Africa*

Corresponding Author: hebasami.abdulrahman@gmail.com

In this work, we undertake a unified study of background dynamics and cosmological perturbations in the presence of the Chaplygin gas. This is done by first constraining the background cosmological parameters of different Chaplygin gas models with SNIa data, and then feeding these observationally constrained parameters in the analysis of cosmological perturbations. Based on the statistical criteria we followed, none of the models has a substantial observational support but we show that the so-called 'original'and 'generalized'Chaplygin gas models have some observational support and less observational support, respectively, whereas the 'modified'and 'modified generalized'Chaplygin gas models miss out on the less observational support category but cannot be ruled out. The so-called 'generalized cosmic Chaplygin gas'model, on the other hand, falls under the no observational support category of the statistical criterion and can be ruled out. We follow the $1 + 3$ covariant formalism of perturbation theory and derive the evolution equations of the fluctuations in the matter density contrast of the matter-Chaplygin gas system for the models with some or less statistical support. The solutions to these coupled systems of equations are then computed in both short-wavelength and long-wavelength modes.

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N-body Simulations of Interacting Dark Energy with Non-Gaussian Initial Conditions

Author: Mahmoud Hashim[1]

[1] *CTP, BUE*

Corresponding Author: mahmoud@aims.ac.za

We perform for the first time N-body simulations of interacting dark energy assuming non-Gaussian initial conditions, with the aim of investigating possible degeneracies of these two theoretically independent phenomena in different observational probes. We focus on the large-scale matter distribution, as well as on the statistical and structural properties of collapsed haloes and cosmic voids. On very large scales, we show that it is possible to choose the interaction and non-Gaussian parameters such that their effects on the halo power spectrum cancel, and the power spectrum is indistinguishable from a Λ cold dark matter (|ΛCDM|) model. On small scales, measurements of the non-linear

matter power spectrum, halo-matter bias, halo and subhalo mass function, and cosmic void number function validate the degeneracy determined on large scales. However, the internal structural properties of haloes and cosmic voids, namely halo concentration–mass relation and void density profile, are very different from those measured in the |ΛCDM| model, thereby breaking the degeneracy. In practice, the values of f_NL required to cancel the effect of interaction are already ruled by observations. Our results show in principle that the combination of large- and small-scale probes is needed to constrain interacting dark energy and primordial non-Gaussianity separately.

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A new perspective on some current mysteries, including dark matter, dark energy, and black hole entropy

Author: Roland Allen[1]

[1] *Texas A&M University, US*

Corresponding Author: allen@tamu.edu

The many long-standing and still unresolved problems in fundamental physics suggest that a completely new perspective is needed. A new picture [1,2] leads to an action for quantum fields that contains the Standard Model embedded in a more complete theory, with SO(10) grand unification, supersymmetry (at some energy scale), and an extended Higgs sector. This last feature predicts a novel dark matter WIMP, with a mass of about 70 GeV and no interactions except second-order gauge couplings to W and Z bosons [3,4]. This particle should be observable within the next several years in dark matter direct-detection experiments (XENONnT, LZ, and PandaX), and in 12-15 years at the high-luminosity LHC, and it may already have been detected in the gamma rays observed by Fermi-LAT and antiprotons observed by AMS-02. In addition to the preceding quantitative predictions, the present theory has implications for other fundamental issues, such as the cosmological constant problem and the origin of black hole entropy.

[1] Roland E. Allen, "Predictions of a fundamental statistical picture", arXiv:1101.0586 [hep-th].
[2] Roland E. Allen, "From the origin of spacetime coordinates and quantum fields to quantitative predictions for near-term experiments", under review.
[3] Reagan Thornberry, Maxwell Throm, Gabriel Frohaug, John Killough, Dylan Blend, Michael Erickson, Brian Sun, Brett Bays, and Roland E. Allen. "Experimental signatures of a new dark matter WIMP", EPL (Europhysics Letters) 134, 49001 (2021), arXiv:2104.11715 [hep-ph].
[4] Caden LaFontaine, Bailey Tallman, Spencer Ellis, Trevor Croteau, Brandon Torres, Sabrina Hernandez, Diego Cristancho Guerrero, Jessica Jaksik, Drue Lubanski, and Roland E. Allen, "A Dark Matter WIMP That Can Be Detected and Definitively Identified with Currently Planned Experiments", Universe 7, 270 (2021), arXiv:2107.14390 [hep-ph].

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Cosmic Tensions and Cracks in the Standard Model of Cosmology

Author: Waleed El Hanafy[1]

[1] *Centre for Theoretical Physics, The British University in Egypt*

Corresponding Author: elhanafy.w@gmail.com

The standard Λ Cold Dark Matter cosmological model amazingly fits a wide range of astrophysical and astronomical data. However, the increase of the experimental sensitivity emerges some cracks in the standard scenario due tensions between different independent cosmological datasets. The Planck mission estimation of Hubble constant H0 is at 4-6σ tension with its measured value by SH0ES and

H0LiCOW collaborations. Also, the tension between Planck data and weak lensing measurements and redshift surveys about the value of the matter energy density Ωm, and the amplitude or rate of growth of structure (σ8, fσ8) becomes significant. New physics could be in action to resolve these cosmic tensions. We give an outline of the different approaches to solve these tensions with some interesting models.

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3 Ways of Probing High Scale Leptogenesis via Gravitational Waves: Primordial Back Holes, Phase transitions and Domain Walls

Author: Anish Ghoshal[1]

[1] *University of Warsaw, Poland*

Corresponding Author: anishghoshal1@gmail.com

Leptogenesis usually involves high scales and it is hard to test in laboratories, Here we will discuss probing high scale and intermediate scale leptogenesis via primordial sources of Gravitational Waves from inflationary tensor perturbations, thermal phase transitions and domain walls.

First we will show Hawking evaporation of primordial black holes (PBHs) can facilitate the generation of matter-antimatter asymmetry via baryogengesis directly or via leptogenesis. We propose a novel test of this scenario by detecting its characteristic doubly peaked gravitational wave (GW) spectrum in future GW observatories. Here the first order adiabatic perturbation from inflation and from the isocurvature perturbations due to PBH distribution, source tensor perturbations in second-order and lead to two peaks in the induced GW backgrounded this would provide a smoking gun signal of non-thermal baryogenesis from evaporating PBHs, which is otherwise impossible to test in laboratory experiments due to the very high energy scales involved or the feeble interaction of the dark sector with the visible sector.

Second we will show leptogenesis in B−L symmetry breaking scenario associated with a strong first-order phase transition that gives rise to detectable gravitational waves (GWs) via bubble collision. And the possible future GW experiments can effectively probe leptogenesis over a wide range of the B−L symmetry-breaking scale.

Third, we propose a novel way of probing high-scale Dirac leptogenesis, a viable alternative to the canonical leptogenesis scenario where the total lepton number is conserved, keeping light standard model neutrinos purely Dirac. This leads to GW signals from collapsing domain walls. We find that most of the near-future GW observatories will be able to probe Dirac leptogenesis scales all the way up to.

Based on the following Refs:
JHEP 07 (2022) 130
https://arxiv.org/abs/2206.07032
Phys.Rev.D 106 (2022) 1, 015007

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Imprints of Mini Primordial Black Holes in Cosmological Data

Author: Lucien Heurtier[1]

[1] *IPPP, Durham, England*

Corresponding Author: lucien.heurtier@durham.ac.uk

I will present recent developments regarding the effect of the primordial black hole evaporation on the cosmological evolution of the Universe, the relic density of dark matter, and the abundance of dark radiation measurable in the CMB spectrum. As we will see, extended distributions of primordial black holes evaporating in the early Universe may leave traces that will be measurable by various cosmological observatories or dark particle searches.

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Discussions

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On conformal geometry and new conformal invariants in absolute parallelism geometry

Author: Ebtsam H. Taha[1]

[1] *Department of Mathematics, Faculty of science, Cairo University*

Corresponding Author: ebtsam.h.taha@hotmail.com

I will give a quick look to conformal transformation in different frameworks, namely, in the context of Riemannian geometry, Finsler geometry and absolute parallelism geometry. After that, I will move to absolute parallelism geometry and investigate conformal changes in this geometry. Then, some new conformal invariants in terms of the Weitzenbock connection and the Levi-Civita connection of an absolute parallelism space are given.

This talk is based on some references such as:
1- N. L. Youssef, A. Soleiman, and Ebtsam H. Taha, new conformal invariants in absolute parallelism geometry , Int. J. Geom. Methods Mod. Phys. (2018) 1850012.
2- M. A. Javaloyes and B. L. Soares, Anisotropic conformal invariance of lightlike geodesics in pseudo-Finsler manifolds, Class. Quantum Grav. 38 (2021) 025002.
3- N. Voicu, Conformal maps between pseudo-Finsler spaces, Int. J. Geom. Methods Mod. Phys. (2018) 15 1850003.

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On some problems of modifying gravity

Author: Alexey Golovnev[1]

[1] *Centre for Theoretical Physics, The British University in Egypt*

Corresponding Author: alexey.golovnev@bue.edu.eg

I will briefly review the troubles one might get in the process of modifying gravity, with examples from mimetic gravity and f(T) teleparallel gravity.

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A Langrangian generalisation of the notion of a stationary Lorentzian metric

Author: Erasmo Caponio[1]

[1] *Politecnico di Bari (Italy)*

Corresponding Author: erasmo.caponio@poliba.it

I will consider a class of Lagrangians on a finite dimensional manifold which are invariant by the action of a continuous group of local diffeomorphisms and that capture some of the features of a Lorentzian metric admitting a timelike Killing vector field. This class includes known examples of stationary Lorentz-Finsler metrics and since they admit a locally injective Legendre transform they might be of some interest for modified dispersion relations.

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Hamilton's equations for the teleparallel equivalent of general relativity

Author: Maria Jose Guzman[1]

[1] *University of Tartu, Estonia*

Corresponding Author: maria.j.guzman.m@gmail.com

We compute Hamilton's equations for the teleparallel equivalent of general relativity (TEGR), which is a reformulation of general relativity based on a curvatureless, metric compatible, and torsionful connection. For this, we consider the Hamiltonian for TEGR expressed in the vector, antisymmetric, symmetric and trace-free, and trace decomposition of the phase space variables. We compare our results with Hamilton's equations of general relativity, and stress its importance for the formulation of the Cauchy problem in modifications based on this theory, as f(T) gravity, and its applicability in numerical relativity.

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Neutrinos in Astrophysics

Author: Mary Bishai[1]

[1] *Brookhaven National Laboratory (US)*

Corresponding Author: mbishai@bnl.gov

Neutrinos are the most abundant of the known elementary particles in our Universe and carry unique information on astrophysical properties: Big Bang nucleosynthesis, the metallicity of the sun, the dynamics of Supernova explosions, ultra high energy neutrinos from active galactic nuclei…to name a few. I will present a brief summary of the role of neutrinos as astrophysical probes, what astrophysics and cosmology can tell us about neutrinos and give some brief updates of the latest results from astrophysical neutrino experiments and planned future experiments.

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Closing