IWARA2024 - 11th International Workshop on Astronomy and Relativistic Astrophysics

Monday 2 September 2024 - Friday 6 September 2024

Machupicchu Pueblo (Aguas Calientes), Peru

Book of Abstracts

The event is the 11th in a series of meetings gathering scientists working on astroparticle physics, cosmology, gravitation, nuclear physics, and related fields. As in previous years, the IWARA 2024 meeting sessions will consist of invited and contributed talks, poster sessions, and will cover recent developments in the following topics:

• New phenomena and new states of matter in the Universe
• General relativity, gravitation, cosmology
• New directions for general relativity: past, present and future of general relativity
• FRW cosmologies
• Cosmic microwave background radiation
• First Stars, hypernovae, and faint supernovae in the early Universe
• Quantum gravity and quantum cosmology
• Gravity and the unification of fundamental interactions
• Supersymmetry and Inflation
• String theory
• White dwarfs, neutron stars and pulsars
• Black hole physics and astrophysics
• Gamma-ray emission in the Universe
• High energy cosmic rays
• Gravitational waves
• Dark energy and dark matter
• Strange matter and strange stars
• Antimatter in the Universe
• High-energy cosmic neutrinos
• Blazars
• Quantum chromodynamics, nuclear and particle physics and new states of matter in the Universe.
• Heavy ion collisions and the formation of the quark-gluon plasma in heavy ion collisions and in the first instants of the Universe
• Strong magnetic fields in the Universe, strong magnetic fields in compact stars and in galaxies, ultra-strong magnetic fields in neutron star mergers, quark stars and magnetars, strong magnetic fields and the cosmic microwave background
• Laboratories, observatories, telescopes and other experimental and observational facilities that will define the future directions of astrophysics, astronomy, cosmology, nuclear and astroparticle physics as well as the future of physics at the energy frontiers, and topics related to these.

Contents

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f(R)gravity for a FLRW universe in a deformed phase space

Author: Eri Atahualpa Mena Barboza[1]

Co-author: Jesus Antonio Astorga Moreno [2]

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Modify gravity theories have received huge attention in the last decade. In this work, we find the Wheeler-DeWitt (WDW) equation in the Quantum Cosmology (QC) scenario for a Friedmann-Lemaitre-Robertson-Walker (FLRW) model using the deformed phase space in f(R) gravity.

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AGN feeding at Super-Eddington rates and AGN ionised wind feedback from the gravitational - up to the kpc-scale

Author: Thomas Boller[1]

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1. A first look at Narrow-Line Seyfert 1 Galaxies with eROSITA We first present the spectral and timing analysis of Narrow-Line Seyfert 1 Galaxies (NLS1s) with eROSITA based on the SDSS DR12 catalog. The SDSS DR12 spectral analysis is based on a power-law model using XSPEC fit with a Principal Component Analysis (PCA) background model. The photon index distribution is asymmetric with a mean value of about 3, as expected from previous X-ray studies. Interestingly, about 10 percent of the sources are in the super-soft tail with photon indices reaching values between 4 and 10. These sources are of further interest as the source counts run into the X-ray background at values at around 1 keV. We argue that ultra-soft ionized X-ray outflows have been detected eROSITA, supported by subsequent XMM-Newton DDT observations of 4 of the most extreme objects. By analyzing the asymmetry index of the optical emission lines in combination with X-ray eROSITA and XMM-Newton spectral properties, we detect outflows from the innermost few gravitational radii up to the kiloparsec scale. We analyzed intrinsic X-ray variability using standard and Bayesian methods and correlated the variability to the multi-wavelength properties during the individual survey scans as well as between the survey scans.

2. The nature of extreme ultra-soft X-ray variability in 1H0707-495 first detected by eROSITA: One of the most prominent AGNs, the ultra-soft Narrow-Line Seyfert 1 Galaxy 1H0707-495, has been observed with eROSITA as one of the first CalPV observations on October 13, 2019, for about 60.000 seconds. The 2019 spectrum is drastically different from other AGN spectra observed so far, as it is much more variable at low energies up to only 0.8 keV, which has been referred to by Parker et al. (2022) as a new AGN ultra-soft state. The simultaneous XMM-Newton spectra show the same basic shape. We showed that the unusual soft X-ray variability, first detected by eROSITA, is due to an obscuration event and strong suppression of the variance at 1 keV by photoionized emission. An ionized partial coverer and strong relativistic reflection explain the unique X-ray softness. During the eROSITA observations, 1H 0707-495 showed, in addition, a dramatic flux drop by a factor of about 100 in just one day. This variability is primarily in the soft band and is much less extreme in the hard band. Such extremely large-amplitude variability has been observed in the past only in a few AGNs such as IRAS 13224-3809 (Boller et al. 1997), GSN 069 (2019Miniutti et al. 2019), and RX J1301.9+2747 (Giustini et al. 2020). In the combined eROSITA and XMM-Newton observation, 1H 0707-495 was caught in the historically lowest hard-flux state observed so far.

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Strangeness enhancement: possible evidence of Quark Gluon Plasma in pp collisions

Authors: Eleazar Cuautle Flores[1]; MARIANO JESUS EFFIO CUEVA[2]

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[2] *National University of Engineering*

Experimentally, the creation of Quark Gluon Plasma in relativistic heavy ion collisions is well known; its properties are being investigated in different experiments around the world at different energies. However, the results from proton-proton collisions are under debate since there are results with behavior like those observed in heavy ion collisions, for instance, collective phenomena, di-hadron correlations, and many others, but energy loss is not observed yet.

In this work we present an analysis of the enhancement of strangeness production as a function of multiplicity: different kinematic and global observables are studied using EPOS event generator. The results are obtained by simulating the creation of a dense medium, which evolves subsequently; the medium can be described by cascade or hydrodynamic models. Our results are compared to the experimental one, suggesting we can describe the data qualitatively. However, we still need more detail, which could require a better understanding of the models to get better knowledge and predictions of the physical phenomena.

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G166+4.3 SNR viewed through the electromagnetic spectrum

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G166.0+4.3 (VRO 42.05.01) is a mixed-morphology supernova remnant having a different spatial distribution of emission viewed in radio and X-rays. A sharp edge-brightened circular shape of the shell and wing component is visible in radio wavelength. Whereas X-ray emission is dominated by a bright spot in the wing, without any edge-brightened structures. Observed shape of this SNR looking like a shock propagation through the medium of different densities can be a result of the shock encountering the density discontinuity in the interstellar medium which makes favorable condition for the particles acceleration up to very high energy. Thus, the G166+4.3 supernova remnant became a candidate for the investigation of particle acceleration in SNR shocks at high- and very high energies. At TeV energies, the SHALON telescopes discovered extended emission with the main contribution to the very-high-energy γ-ray fluxes given by the regions correlated with the shells visible in the radio energies. But the main contribution to the TeV gamma-ray flux gives the West part of SNR, where the maximum of X-ray emission is located. The origin of the very high energy gamma-ray emission from G166+4.3 SNR is explored. Active galactic nucleus (AGN) phenomenon and its impact on the host galaxy as well as a role of jets, powered by central black hole of AGN, in the feedback of the surroundings on the different scales is the matter of the detailed multiwavelength investigations. Also, the observations of AGNi are used to reveal the processes taking place in the very proximity to the supermassive black holes. To study mechanisms of jet formation, connecting with the AGN activity and their propagation from the very core of active galactic nuclei, the analysis of long-term observations is used. One of the approaches to such studies is to detect the launching of jet components viewed in radio range and then link it with flaring events detected at higher energy ranges. Tracking the jet-initiated variability events through the multiwavelength observations from radio frequencies up high energy gamma-rays allows first to resolve the nucleus structure by the determination of the dynamics of the features of the jet flow in the AGN core region. Whereas the cross-identification of the jet features through the wide energy range and revealing of the time dependence of these jet events evolution allows to locate the regions responsible for the generation of observable features which can lead to exploration of the mechanism of jet launching as well as the origin of emission in the Active Galactic Nucleus. Being the nearby and bright, NGC 1275 is

one of the extensively studying AGNi. This object is very active in the timescales of decades. Multiwavelength long-term observations of NGC 1275 resulted in the detection of different timescale variability from this AGN. For the case of NGC 1275 the cross-correlation of the activity at radio, X-ray and very high energy gamma-rays is investigated. The time dependence of activity of NGC 1275 in the wide energy range was found which allow to localize the sites of the emission generation including one of the very high energies. These multiwavelength long-term studies are highly important for the further advance of the AGN's black hole research and investigations of mechanisms of jet formation.

1

What Dark Matter Halos and the Proton Radius Puzzle May Have in Common

Author: Eugene Oks[1]

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The existence of the HI regions in dark matter halos of a number of galaxies is the observational fact. Each of the eight galaxies analyzed by observers had approximately the same maximum surface brightness temperature throughout its disc, what was explained by the self-absorption in the hydrogen line 21 cm. The opacity or absorption coefficient $\tau\nu$ is controlled by the column density NH of hydrogen atoms and their spin temperature Tspin. The brightness temperature TB is the known function of Tspin, $\tau\nu$, and NH. This allows determining the column density NH from the observed TB and the assumed or estimated Tspin. Coming from cosmic scales to nuclear scales: to the proton radius puzzle. Precise knowledge of such fundamental quantity as the proton charge radius rp is extremely important both for the quantum chromodynamics (for quark-gluon structure) and for atomic physics (for atomic hydrogen spectroscopy). Yet the ambiguity in measuring rp persists for over a dozen of years by now –from the time when in 2010 the muonic hydrogen spectroscopy experiment yielded rp ≈ 0.84 fm in contrast to the form factor experiment by the Mainz group that produced rp ≈ 0.88 fm. Important was that this difference corresponded to about seven standard deviations and therefore was inexplicable. In the intervening dozen of years, more experiments of various kinds were performed in this regard. Nevertheless, the controversy remains, which is why several different types of new experiments are being prepared for measuring rp. In one of our papers, we pointed out the factor that was never taken into account by the corresponding research community. We showed that the allowance for this factor can reconcile the above two values of the proton charge radius. The same factor, being taken into account for dark matter halos, leads to the conclusion that the column density of hydrogen atoms NH could have been overestimated by about 30%.

2

Coarray Fortran Adaptive Mesh Refinement Code for Numerical Modeling of Relativistic Jets

Author: Igor Kulikov[1]

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The Relativistic jets are main sources of radio emission in the Universe. Multiscale flows in jets require of using to adaptive mesh technique. In talk will propose original the Patch-Block-Structured Adaptive-Mesh-Refinement technique for multi-scale modeling of relativistic jets. To use this technique, the numerical method was redesigned in a special way by means Coarray Fortran technology. On problem of jet evolution in interstellar medium, the applicability of the developed approach is shown.

This work was supported by the Russian Science Foundation (project 23-11-00014).

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Spherically Symmetric Objects in Modified Teleparallel Gravity

Author: Silas Guida Vilhena[1]

Co-authors: Mariana Dutra [1]; Pedro Pompeia [1]; Sergio Duarte [2]

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[2] *CBPF*

We investigate compact objects in modified teleparallel gravity with realistic equations of state. We propose a modification of Teleparallel Equivalent to General Relativity, then an appropriate tetrad is applied to the field equations. A specific set of relations showing an equivalency between our gravitational model and the New General Relativity is found. The conservation equation implies that our Tolman-Oppenheimer-Volkoff equations are presented with an efective gravitational coupling constant. Numerical analysis using realistic equations of state is made, and the behavior of mass, radius, and the relation mass-radius as functions of a free parameter of our model is also investigated.

3

The K-essence flow seen from the preferred frame S_V. A scalar field theory with Landau superfluid structure

Author: Rodrigo F. Santos[1]

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We study the hypothesis of deformation of the Lorentz transformations by a universal minimum velocity and we seek to apply this hypothesis to superfluids. Relating the minimum velocity to the idea of a fluid, with superfluid properties, in previous works we related the minimum velocity to the cosmological constant and even to cosmic inflation. Soon we could generate a hypothetical superfluid capable of modeling characteristics of a cosmological fluid with dark energy properties. . The first excited state of this universal superfluid would be a preferred-frame from which all other excited states are observed, so we have a preferred-frame S_V associated with the critical Landau velocity, thus implying that the minimum velocity coincides with the critical Landau velocity, thus the objects observed by the preferred-frame are excited states of the superfluid. This coincidence between the concepts of minimum velocity and Landau's critical velocity makes Landau's critical velocity a type of limit velocity, modifying the usual causal structure of restricted relativity. . Formulating the phenomena in this preferred-frame would have the advantage of providing a simple explanation for astrophysical and cosmological phenomena linked to a causal structure, which emerges from this construction and is very similar to causal structures linked to Gordon geometry and acoustic tackyons.
We build a deformed relativistic Lagrangian, demonstrate its relationship with a K-Essence Lagrangian and calculate the quantities associated with this Lagrangian. We also studied an irrotational fluid and verified the role of enthalpy associated with the minimum velocity structure.

4

Investigating Perturbations in Quantum-Corrected Black Holes

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[2] *Universidade Estadual da Paraíba*

Este estudo investiga perturbações e aspectos-chave de um modelo de buraco negro com correções quânticas dentro do framework da Gravidade Quântica em Loop. Calculamos os modos quasi-normais, revelando uma dependência significativa dos parâmetros da Gravidade Quântica em Loop. Ao mesmo tempo, avaliamos a estabilidade do buraco negro quântico. Nossos resultados sugerem possibilidades intrigantes, incluindo a potencial violação da isospectralidade no contexto dos buracos negros quânticos.

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Cosmological models for f(R,T) - \Lambda(\phi) gravity

Authors: João Rafael Santos[1]; Romário Santos[2]; Simony Santos da Costa[3]

[1] *UFCG and BINGO Telescope*

[2] *UFCG*

[3] *Istituto Nazionale di Fisica Nucleare (INFN)*

The Universe is currently in a phase of accelerated expansion, a fact that was experimentally proven in the late 1990s. Cosmological models involving scalar fields allow the description of this accelerated expansion regime in the Cosmos and present themselves as a promising alternative in the study of the inflationary eras, especially the actual one which is driven by the dark energy. In this work we use the $f(R,T)-\Lambda(\phi)$ gravity to find different cosmological scenarios for our Universe. We also introduce a new path to derive analytic cosmological models which may have a non-trivial mapping between f and T. We show that the analytic cosmological models obtained with this approach are compatible with a good description of the radiation era. In addition, we investigated the inflationary scenario and obtained a good agreement for the scalar spectral index n_s. Concerning the tensor-to-scalar ratio r, we found promising scenarios compatible with current CMB data.

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Reviewing the GR method for estimating black hole parameters of megamaser systems.

Author: Adriana González-Juárez[1]

[1] *Instituto de Física, Benemérita Universidad Autónoma de Puebla*

We review a General Relativistic (GR) method to determine the black hole (BH) parameters: mass-to-distance ratio, position and recessional velocity of 16 active galactic nuclei (AGNs) of Seyfert type, which have an accretion disk with water masers circulating around the BH. This GR method makes use of astrophysical observations: the redshifted and the blueshifted photons emitted from the aforementioned masers and their orbital position on the sky. In order to perform the estimations we implement a Bayesian statistical method to fit the above mentioned observational data. One of the main results of this work consists in analytically expressing the gravitational redshift, allowing us to quantify its magnitude for the photons emitted by the closest masers to the black holes. We computed this quantity for several BHs hosted at the core of AGNs.

6

The cosmological constant, dark matter, and supersymmetry from a fresh perspective

Author: Roland Allen[None]

In this talk, three fundamental problems will be addressed within a unified picture [1-4]. The solution of the cosmological constant problem has two aspects: According to (10.3) of [1], spin 1/2 fermion fields and spin 0 boson fields give zero contribution to the conventional cosmological constant; and (10.8) of [1] (which is completely consistent with the Casimir effect) implies that the same is true for spin 1 gauge fields. In each case classical Einstein gravity is exactly regained for all fields except those in the vacuum (with a cutoff at high energy for quantized gravity). A new interpretation of scalar boson sectors has implications for both dark matter [2,3] and supersymmetry [4]: Calculations and estimates of the relevant cross-sections for a novel dark matter WIMP demonstrate that (i) it may be detectable within the next few years in Xe-based direct-detection experiments, (ii) it may be observable within about 15 years at the high-luminosity LHC, and (iii) it may already have been detected in the gamma rays observed by Fermi-LAT and antiprotons observed by AMS-02. The reinterpretation of scalar boson fields also implies a new phenomenology for sfermions, with reduced cross-sections and modified experimental signatures. There is then a unified picture which may explain why dark matter WIMPs and electroweak-scale sparticles have not yet been detected, but implies that they should still be within reach of near-term experiments.
[1] Roland E. Allen, arXiv:2302.10241 [hep-th].
[2] Reagan Thornberry et al., EPL [European Physics Letters] 134, 49001 (2021), arXiv:2104.11715 [hep-ph], and references therein.
[3] Bailey Tallman et al., Letters in High Energy Physics LHEP-342 (2023), arXiv:2210.15019 [hep-ph].
[4] Roland E. Allen, arXiv:2307.04255 [hep-ph].

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Restoring gauge invariance in non-Abelian second-class theories

Author: Diego Fiorentini[1]

Co-authors: Cleber N. Costa [2]; Everton M. C. Abreu [2]; Jorge Ananias Neto [2]; Paulo R.F. Alves [2]; Victor Vasquez-Otoya [3]

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[2] *Universidade Federal de Juiz de Fora*

[3] *Instituto Federal de Educacao, Ciencia e Tecnologia do Sudeste de Minas Gerais*

In this work, we propose a generalization of the improved gauge unfixing formalism in order to generate gauge symmetries in the non-Abelian valued systems. This generalization displays a proper and formal reformulation of second-class systems within the phase space itself. Then, we present our formalism in a manifestly gauge invariant resolution of the $SU(N)$ massive Yang-Mills and $SU(2)$ Skyrme models, where gauge invariant variables are derived.

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Fermion and Scalar Dark Matter in Standard Model Extensions

Authors: Estela Garcés[1]; Inti Ernesto Chavez Menez[2]; José Halim Montes de Oca Yemha[1]

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[2] *UNAM*

In this study, we investigate Weakly Interacting Massive Particles as candidates for dark matter within an extended Standard Model framework that incorporates both scalar and fermion fields. We calculate the relic density and spin-independent scattering cross-section for these dark matter candidates and compare our results with the values reported by the PLANCK and XENON collaborations. Our results identify the parameter regions that are consistent with the observed constraints for the different dark matter candidates.

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Development of a SiPM-based Water-Cherenkov Detector for Astrophysics

Author: Anderson Fauth[None]

Co-authors: Ana Amelia Machado [1]; Vinicius do Lago Pimentel [2]; Ettore Segreto [1]

[1] *UNICAMP*

[2] *Center of Information Technology Renato Archer*

The Cherenkov effect is widely employed in experiments involving cosmic rays and neutrinos that utilize large sensitive volumes. The water is widely employed as the sensitive medium, with the primary particle to be detected being the muon. In this work, we present the development of a new water-Cherenkov detector that utilizes a photon trapping system and silicon photomultipliers (SiPMs) to record the detector signals, which has been named C-Arapuca. The utilization of SiPMs presents advantages over the traditional photomultiplier tube, PMT, including the utilization of much lower operating voltages and enabling the construction of more compact devices with greater geometric freedom. To study the performance of the C-Arapuca, a tank containing 550 liters of ultra-pure water was utilized. The confinement of Cherenkov photons is achieved through the utilization of a dichroic filter in the optical window and a bar that serves to shift the wavelength and guide the photons to the eight SiPMs coupled to the sides of the bar. The results of the efficiency of muon detection from local cosmic radiation are presented, indicating the feasibility of employing the C-Arapuca in future astroparticle experiments.

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Electron-positron production in electrosphere of compact objects

Author: Gregory Vereshchagin[None]

Co-author: Mikalai Prakapenia

We revisit the mechanism of pair creation in the electrosphere of compact astrophysical objects proposed by Vladimir Usov. Two previously ignored effects: the evaporation of electrons and acceleration of electrons and positrons are discovered. The rate of pair creation strongly depends on electric field strength in the electrosphere. We find that the luminosity in pairs may be as high as 10ˆ52 erg/s.

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Impact of hot and cold dense matter on quasinormal oscillation modes in compact stars

Author: Vivek Baruah Thapa[1]

Co-authors: Adriana R. Raduta [2]; Mikhail V. Beznogov [2]; Pratik Thakur [3]

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[3] *Indian Institute of Technology Jodhpur*

A diverse array of equations of state (EoSs), formulated within the covariant density functional theory of hadronic matter and incorporating density-dependent couplings, is leveraged to scrutinize polar f- and p-oscillations in both cold and hot compact stars. We delve into the correlations between oscillation frequencies of cold purely nucleonic neutron stars (NSs), their global parameters, and properties of nuclear matter (NM) by examining a selection of models, wherein several constraints on the saturation properties of NM, pure neutron matter, and the lower limit of the maximal NS mass were enforced within a Bayesian framework. The impact of finite temperature and the presence of exotic particle degrees of freedom, such as hyperons, Δ-resonances, antikaon condensates, or a transition from hadronic to quark phase, is addressed through a suite of models publicly accessible on Compose. We consider idealized profiles of temperature or entropy per baryon and charge fraction. Our investigations reveal that finite temperature effects lead to a reduction in the oscillation frequencies of nucleonic stars, while the converse trend is observed for stars featuring exotic particle degrees of freedom. When constructing finite temperature EoSs using the Γ-law, errors in estimating oscillation mode frequencies range from approximately 10% to 30%, contingent upon the stellar mass. Throughout our study, we employ the Cowling approximation.

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Green's function approach for late-time tail and echoes in Damour-Solodukhin type wormholes

Author: Wei-Liang Qian[1]

Co-authors: Qiyuan Pan [2]; Hong Guo [1]; Bean Wang [3]; Rui-Hong Yue [4]

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[2] *Hunan Normal University*

[3] *Vanguard University*

[4] *Yangzhou University*

Damour-Solodukhin wormholes are intriguing theoretical constructs that closely mimic many properties of black holes. This study examines two specific aspects of the waveforms emitted from these wormholes: the late-time tails and echoes, which are pivotal in distinguishing them from black holes. Both features manifest in the later stages of quasinormal oscillations and originate from singularities in the Green's function. The late-time tail arises from branch cuts in the Green's function, necessitating a revised understanding of black hole metrics within the Damour-Solodukhin wormhole framework. The echoes, on the other hand, are due to a new set of quasinormal poles that supplement those of black holes, similar to cases where the spacetime metric has a discontinuity. It is concluded that these features are observationally important for identifying wormholes. Additionally, the study suggests a potential interaction between these two phenomena in the late-time evolution of the wormhole.

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State-of-the art of compact object populations

Author: Jorge Horvath[None]

The populations of many types of neutron stars and black holes in the galaxy is discussed, with emphasis in the latest mass determinations and new phenomena detected from some members of

the former group. An attempt to relate these populations to the merging binary systems, studied with a new population synthesis tool BOSSA developed at USP- São Paulo described.

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Physics and Cosmology on a Gravitational Wave Background

Author: Tonatiuh Matos[1]

[1] *Cinvestav*

It is a fact that the universe lives on a Gravitational Wave Background (GWB), which may be in the form of extra energy, which is not contained in Einstein's field equations. In previous work, a new model called Compton Mass Dark Energy (CMaDE) was developed to explain the current accelerated expansion of the universe where a GWB was incorporated by extending Einstein's equations to
$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \frac{2\pi^2}{\lambda^2}g_{\mu\nu} = \kappa^2 T_{\mu\nu}$,
where λ is the Compton wavelength of the graviton. In the present talk we show that the geodesics in a GWB satisfy the Klein Gordon equation and then we show that
the CMaDE model agrees very well with the observations of the cosmic chronometers, Baryon Acoustic Oscillations and Pantheon Super Novae type Ia, reproducing the observational data with a $\Delta\chi^2 = 3.26$ in favor of the current model compared to the ΛCDM. The values favored by these observations are $\Omega_m = 0.31 \pm 0.02$, $H_0 = 68 \pm 0.02$ Km/s/Mpc, $\Omega_k = 0.001 \pm 0.011$. Using these same values we also find excellent consistency of this model with the Cosmic Microwave Background and the Power Spectrum of Matter, provided that $H_0 = 68.3$ Km/s/Mpc. We conclude that this model is an excellent alternative to explain the accelerated expansion of the universe without incorporating the cosmological constant or adding extra matter.

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Cosmological models in $f(R,T) - \Lambda(\phi)$ gravity

Author: JOAO Santos[1]

Co-authors: Romario Santos ; Simony Costa

[1] *UFCG and BINGO Telescope*

The Universe is currently in a phase of accelerated expansion, a fact that was experimentally proven in the late 1990s. Cosmological models involving scalar fields allow the description of this accelerated expansion regime in the Cosmos and present themselves as a promising alternative in the study of the inflationary eras, specially the actual one which is driven by the dark energy. In this work we use the $f(R,T) - \Lambda(\phi)$ gravity to find complete cosmological scenarios for our Universe. We show that the analytic cosmological parameters are compatible with a good description of several eras that the Universe passes through. We also introduce a new path to find analytic cosmological models which may have a non-trivial mapping between f and T.

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Dynamical and static properties for quark stars within a holographic description

Author: Michael Santos[1]

Co-authors: Cesar Henrique Lenzi [1]; Roldao Da Rocha [2]; Wayne De Paula [1]

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[2] *Universidade Federal do ABC*

The recent NICER observational data for the pulsars PSR J0030+0451 \[1\] and PSR J0740 + 6620 \[2\] impose new constrains in the mass-radius diagram of the corresponding compact star. Here, we investigate the possibility of such astrophysical object being a quark star. In particular, the quark matter is described by a holographic model with N_c D3 branes and N_f D7 probe branes, where N_c and N_f are the number of colors and flavors respectively \[3\]. For this top-down model, we determine the quark matter equation of state (EOS) and solve the Tolman-Oppenheimer-Volkoff (TOV) equations, obtaining the mass-radius diagram for a range of model parameters. In addition, we investigate dynamical astrophysical properties. For this end, we calculate the deformability parameter of a binary quark star system. The outcome is compared against the data of the GW170817 event detected by the LIGO-Virgo collaboration \[4\]. We present the range of parameters for which the model satisfies the LIGO-Virgo or the NICER astrophysical constraints. In particular, we show that it is not possible to satisfy simultaneously the LIGO-Virgo and the NICER constraints while considering quark stars composed of flavor-independent quark matter within the D3/D7 holographic model \[5\].

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Galactic Chemical Evolution with short-lived radioactive isotopes

Author: Benjamin Wehmeyer[1]

Co-authors: Andrés Yagüe López ; Benoit Côté ; Maria K. Pető [2]; Chiaki Kobayashi [3]; Maria Lugaro [2]

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Studying the galactic chemical evolution with short lived radioisotopes (SLRs) has a significant advantage over using stable elements: Due to their radioactive decay, SLRs carry additional timing information on astrophysical nucleosynthesis sites.

We can use meteoritic abundance data in conjunction with a chemical evolution model to constrain the physical conditions in the last rapid neutron capture process event that polluted the early Solar system prior to its formation 1.

Further, with the help of detections of live SLRs of cosmic origin in the deep sea crust 2, we can use these data in a 3-dimensional chemical evolution code to explain why different classes of radioisotopes should often arrive conjointly on Earth, even if they were produced in different sites (e.g., neutron star mergers, core-collapse/thermonuclear supernovae) 3.

Finally, we included radioisotope production into a cosmological zoom-in simulation to create a map of Al-26 decay gamma-rays indicating areas of ongoing star formation in the Galaxy, consistent with the observations by the SPI/INTEGRAL instrument 4.

We provide predictions for future gamma-ray detection instruments.

References:
1 Côté et al., 2021 Science 371, 945
2 Wallner et al., 2021 Science 372, 742W
3 Wehmeyer et al., 2023 ApJ 944, 121
4 Kretschmer et al., 2013 A&A 559, A9

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The effect of the gravity of a black hole on the acceleration of energetic cosmic particles

Author: Arash Majidian[None]

Co-author: Mehdi Jafari Matehkolaee

Quantum mechanical particles will be affected by the gravitational field of black holes and the curvature of space. In general, by writing the structure of the desired Hilbert space near a black hole, the physical and quantum mechanical behavior of a fundamental particle can be investigated. For example, we will indicate the wave packet motion of a particle and its modified standard quantum equation in the gravitational field of a black hole.

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A Theoretical Investigation Of Cosmic Rays Flux

Author: Arash Majidian[None]

Co-author: Mehdi Jafari Matehkolaee

In this study, we investigate the differential flux of cosmic rays. Initially, we demonstrate the applicability of Liouville's theorem to cosmic rays, establishing the conservation of intensity in phase space. In the following using the liquid drop model from nuclear physics, we derive the relationship for the differential flux and determine the spectral index in terms of energy, following a power law. We have indicated that the spectral index values are 2.7 and 3.1 for Bosonic and Fermionic distributions, respectively, both of which align with experimental observations.

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Black hole parameters and estimation of the Hubble constant from observations: a GR approach

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We extract the Hubble law by the frequency shift considerations of test particles revolving a Kerr black hole in asymptotically de Sitter spacetime. To this end, we consider massive geodesic particles circularly orbiting a Kerr-de Sitter black hole that emit redshifted photons towards a distant observer which is moving away from the emitter–black hole system. We further obtain an expression for the redshift in terms of spacetime parameters such as mass, rotation parameter and the cosmological constant. Then, we express the frequency shift of photons in terms of the Hubble constant with the help of some reasonable physically motivated approximations. Finally, some exact formulas for the Schwarzschild black hole mass and the Hubble constant in terms of the observational redshift of massive bodies circularly orbiting the black hole are extracted. Our results pave the way to develop a new independent general relativistic approach to estimating the late-time Hubble constant in terms of observable astrophysical quantities.

22

Time Delay Interferometry in space-based gravitational wave detection

Author: Pan-Pan Wang[None]

Co-author: Cheng Gang Shao [1]

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The space-based gravitational wave detector will open a new window in the frequency range of 0.1 mHz to 1 Hz, which cannot be covered by ground-based gravitational wave detectors. This is of great significance for studying the formation and evolution of the universe. However, detecting gravitational wave signals in space is a significant challenge. One of the main obstacles is the high level of laser frequency noise and clock noise, which can be several orders of magnitude higher than typical gravitational wave signals. These noise sources can greatly interfere with the detection of gravitational waves. To address this, our group has been conducting theoretical research on the Time Delay Interferometry (TDI) technique. TDI is a powerful method for suppressing the effects of laser frequency noise and clock noise on gravitational wave detection in data post-processing. In this talk, we focus on various aspects of TDI. This includes exploring both algebraic and geometric methods for constructing TDI combinations, developing algorithm for suppressing clock noise, and calculating sensitivity functions to optimize the performance of the detector.

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Particle acceleration in solar flares from radio and hard X-ray spectra

Author: Adriana Valio[1]

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For a deeper understanding of the physical processes at play in solar
flares, it is necessary to analyse the flare emissions at multiple wavelengths. This multi-frequency approach enables the characterisation of energetic electrons accelerated from tens of keV and up to several hundreds of MeV. This study reports on the observation of nine solar flares, in which the spectral parameters were determined for the cm/mm and X-ray bands, as well as the delay between flux peaks at different wavelengths. The radio spectrum was fitted using gyro-synchrotron emission whereas the hard X-rays fit considered a model of thermal plus non-thermal emission of accelerated electrons. The results show that the spectral indices of the energy distribution of non-thermal electrons emitting in millimeter and hard X-rays do not agree, with the millimeter spectral index being approximately 2 times harder than that of hard X-rays. These findings are consistent with previous research and suggest the existence of a break in the energy spectrum of accelerated electrons.

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The influence of QCD at weak scattering in electron-(proton/positron) collider, using dipole formalism to describe hadron production from boson-(proton/boson).

Author: Gabriel Zardo Becker[1]

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Recently, the FPF LHC neutrino detector recorded its first measurements, opening new possibilities for studying weak interactions. In this work, we explore related observable, such as the proton structure function (F_2) from weak interactions, and the cross section of $W^+W^- \to X$ and $\gamma W^- \to X$, which could be significant for future colliders. We employ QCD dynamics equations, dipole formalism, and light cone wave functions of $W^\pm \to q\bar{q}'$ to calculate the exclusive hadron production with heavy quarks in the final state. These processes offer intriguing opportunities for studying the evolution of QCD and its relationship with neutrino physics in a new energy regime that has never been explored before.

In the high-energy regime, using light cone coordinates, it is possible to calculate the probability of boson (γ, $W^\pm$, and Z^0) fluctuating into a quark-antiquark pair, which in turn can be approached through the dipole formalism. In this work, we present important observable that will be essential to study the background contributions of future electron-positron accelerators, such as contributions from interactions between two boson in ultraperipheral collisions measured at the LHC.

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Quasi-normal mode of dyonic hairy black hole and its interplay with phase transitions

Author: Supragyan Priyadarshinee[None]

We explore the dynamics of the massless scalar field in the context of hairy black holes within the Einstein–Maxwell-scalar gravity system. Utilizing both the series solution and shooting methods, we numerically compute the corresponding quasinormal modes (QNMs) across various black hole parameters. Notably, the values obtained from these two methods exhibit robust agreement. The consistently negative imaginary part of the QNM underscores the stability of the massless scalar field in the backdrop of the black hole. Our investigation reveals that both the decay and oscillatory modes of the scalar field perturbation exhibit a linear increase with the horizon radius, particularly notable for large black holes. We conduct a comprehensive analysis of QNMs across diverse black hole parameters, encompassing the electric charge, magnetic charge, horizon radius, and the hairy parameter. Moreover, we extend our scrutiny to the QNM behavior near the small/large black hole phase transition. Intriguingly, we discern distinct characteristics in the nature of QNMs between the large and small black hole phases, indicating the potential of QNMs as a probing tool for black hole phase transitions.

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Signatures of black holes through eclipses: the case of Mrk 501 and Sag A*

Authors: Gustavo Magallanes-Guijon[1]; Milton Jair Santibanez-Armenta[1]; Sergio Mendoza[None]

[1] *Instituto de Astronomia, Universidad Nacional Autonoma de Mexico*

This is an abstract

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The matter Lagrangian of a non-perfect fluid

Authors: Sarahí Silva García[1]; Sergio Mendoza[1]

[1] *Universidad Nacional Autónoma de México*

The Lagrangian of matter is a crucial component in the action of relativistic gravity theories with matter couplings, such as general relativity. Particularly in alternative gravity theories featuring non-minimal curvature-matter couplings, the matter Lagrangian explicitly figures in the field equations. Consequently, its precise value is necessary to fully compute these field equations. In this study, we demonstrate that the plus or minus sign of the total energy density, comprising the internal energy density and the rest energy density, is an appropriate value for the matter Lagrangian of a non-perfect fluid. The sign is contingent on the metric signature and the definition of the matter action, and its value remains independent of the gravitational model, selected thermodynamic variables, equation of state, or thermodynamic fluxes.

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Modeling massive quark stars with repulsive vector couplings

Author: Fabio Köpp[1]

Co-authors: CESAR AUGUSTO Zen Vasconcellos [2]; Dimiter Hadjimichef [3]; Jorge Horvath [4]

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We describe in this work a stellar phase composed of up, down and strange quarks, based on the repulsive vector interaction enhanced MIT bag model (vMIT), a crucial component to describe stable and massive hybrid NS configurations with quark matter cores, in agreement with the recent observations of pulsars with two solar masses. The motivation for this study, based on known theoretical approaches, is to review some of its foundations. Among these, the level of stability of a compact star stands out, in addition to its correlation with the density of quark matter and the value of the bag constant, as well as its impact on stellar rigidity. Through appropriate parameterizations of the vector meson coupling constant, we reevaluate the proposition formulated by Witten, Farhi and Jaffe, which suggests that strange quark matter may actually be more stable than conventional matter. Following the same line of reasoning, we reevaluate the Bodmer-Witten stability assumption for strange stars. To this end, through appropriate choices of coupling constants and mass of the vector meson ratios, alternative stability limits of strange matter were established with structural implications for compact stars. The results presented indicate that the appropriate choices of coupling constants, stellar density, as well as bag constants, modulated by stability conditions are in accordance with observational expectations for massive stars, and may even exceed in some cases 2.0 solar masses.

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Modeling the mass of color-flavor locked strange quark stars

Author: Fabio Köpp[1]

Co-authors: CESAR AUGUSTO Zen Vasconcellos [2]; Dimiter Hadjimichef [3]; Jorge Horvath

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In the search for the true ground state of dense matter at sufficiently large densities and low temperatures, in the following we model the mass of color-flavor locked strange quark stars. We address then feasibility conditions for the realization of the phase diagram of dense nuclear matter, as a function of the baryonic chemical potential, μ_B , and the temperature T (plane $\mu_B - T$), in the quark stars regime $T \sim 0$, $\mu_B \sim M_n$, where M_n represents the mass of the nucleon. Given observational and theoretical uncertainties in the determination of the phase diagram of superdense matter, in our study we focus our attention on consistent parameterizations of the quark matter density ρ, the superconducting band gap Δ and the strange quark mass m_s in order to matche observational mass predictions. Our results are in accordance with observational expectations for massive compact stars, and may even exceed in some cases 2.0 solar masses.

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The effects of minimal length on the Kerr metric and the Hawking temperature

Authors: L. Maghlaoui[1]; Peter O. Hess[1]

[1] *UNAM*

We first resume the main properties of the pseudo-complex General Relativity (pcGR). Then the Hawking temperature is determined within pcGR for a black hole, with varying the intensity of the dark energy around the central mass. In particular we investigate the effects of a minimal length, which is a consequence of pcGR. Three cases are studied: i) The pc-Schwarzschild case with zero minimal length; ii) The pc-Kerr case with zero minimal length; and finaly iii) the pc-Kerr-case with a minimal length. We show that Hawking radiation can also be emited in a curved space (the gravitational Schwinger effect), not necessarily at the surface of a star. When an event horizon is present, the theory predicts the occurrence of negative temperature, which generate negative pressure, stabilizing the star in this manner. We also show that the effects of a minimal length are only noticeable for very small black hole masses, showing that their formation is inhibited.

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Inka Astronomy at Machu Picchu

Author: Steven Gullberg[1]

[1] *University of Oklahoma*

Machu Piqchu has been variously described as a citadel, a lost city, a royal estate, and a sacred center. Machu Piqchu was likely recognized by the Inkas as a place of power because of its many granite outcrops and caves and the cardinality of mountains such as Veronica, Machu Piqchu, Wayna Piqchu, Pumasillo, and the snow peak of Salcantay. Machu Piqchu is a multi-faceted complex that exhibits carved rocks, light and shadow effects, solsticial orientations, an equinoctial orientation, a zenith alignment, an anti-zenith orientation, a Pleiades orientation, stairs, seats, niches, a water source, fountains, basins, caves, altars, platforms, double-jambed doorways, animal replica stones, horizon replica stones, structures, and terraces. Astronomy within and surrounding Machu Piqchu will be discussed at the sites of The Mortars, Intimachay, Temple of the Condor, The Torreon, Wayna Piqchu, The Gran Caverna, the Sacred Plaza, the River Iniwatana, the Llactapata Sun Temple, and the Dark Constellations of the Milky Way.

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Inka Cosmovision: The Astronomical Legacy of an Andean Empire

Author: Steven Gullberg[1]

[1] *University of Oklahoma*

The Inkas worshipped the Sun, and their emperor was thought to be the son of the Sun. They conquered most of the Andes and their former empire is replete with examples of their astronomy. They used solar positions on the horizon for calendrical purposes and managed their crops and religious festivals in this manner. Many examples remain of their intentional light and shadow effects that demonstrate their sophisticated understanding of the Sun's movement and of solar horizon events. Evidence of their astronomy can only be fully understood in its cultural context, and Inka Cosmovision is explored through the cosmic worldview of the Inkas from the perspective of oral traditions passed from one generation to the next among the Quechua, the
Inkas'living descendants.

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Phase Structure of Holographic Superconductors with Spontaneous Scalarization

Author: Hong Guo[1]

Co-authors: Bean Wang [2]; Wei-Liang Qian [1]

[1] *University of Sao Paulo*

[2] *Vanguard University*

Holographic superconductor phase transition and spontaneous scalarization are triggered by the instability of the underlying vacuum black hole spacetime. Although both hairy black hole solutions are closely associated with the tachyonic instability of the scalar degree of freedom, they are understood to be driven by distinct causes. It is, therefore, interesting to explore the interplay between the two phenomena in the context of a scenario where both mechanisms are present. To this end, we investigate the Einstein-scalar-Gauss-Bonnet theory in asymptotically anti-de Sitter spacetime with the presence of a Maxwell field. Even though different origins for the tachyonic mass behave independently and can be recognized by the distinctive natures of their effective potentials, it is shown that near the transition curve, the holographic superconductor and spontaneous scalarization are found to be largely indistinguishable. This raises the question of whether the hairy black holes triggered by different mechanisms are smoothly joined by a phase transition or whether these are actually identical solutions. To assess the transition more closely, we evaluate the phase diagram in terms of temperature and chemical potential and discover a smooth but first-order transition between the two hairy solutions by explicitly evaluating Gibbs free energy and its derivatives. In particular, one can elaborate a thermodynamic process through which a superconducting black hole transits into a scalarized one by raising or decreasing the temperature. Exhausting the underlying phase space, we analyze the properties and the interplay between the two hairy solutions.

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Discrimination on electron/positron TB II beam identification analysis

Author: Carlos Solano[1]

Co-authors: Edgar Chavarria [2]; Isadora Barbosa [3]

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[3] *UTFPR*

In High Energy Physics it is essential the study of the particles that make up everything (at least the known baryonic universe). Carrying out a study of these particles is necessary devices (detectors). These devices interact with particles through known physical processes and then, through a data acquisition system, one can proceed for further analysis. In the MINER⊠A experiment, the cross-section measurements are generally done. As a previous step, they used a mini test detector called Test Beam II (TB II) to see the response of new materials (objectives and scintillators) to different energy bands. In this work, the response of the Beam II test detector to electron and positron beams are studied. The response of this detector is studied for energies in the range of 2 to 8 ⊠⊠⊠. A data/MC comparison is also performed to see discrepancies with the model used, as well as in the analysis of the behavior of electron and positron beams under different parameters (electromagnetic cascade opening angle, electromagnetic cascade starting module and energy absorbed by the calorimeter). Our method has allowed the differentiation of electron and positron beams, unequivocally for the energies in the range 2-6⊠⊠⊠ and, to a lesser extent, in the range 6-8 ⊠⊠⊠. This is genius result given that previous experiments did not obtain results that could differentiate well electron beams relative to positron beams in these beam energy ranges

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Stellar Physics and General Relativity

Author: Shuichi Yokoyama[1]

[1] *Ritsumeikan University*

As seen in most textbooks of astrophysics, most astronomical bodies such as main sequence stars have been investigated only by Newtonian gravity. This is presumably based on a belief that Newtonian physics could be sufficient to extract important physics of most astronomical bodies except compact stars, and that General Relativity would be too precise to be suitable.

In this talk, I will explain that this belief is not correct any more and General Relativity plays an important role in extracting new physics of luminous stars like the Sun.

I will explain it based on my recent work arXiv:2306.16647, in which I have investigated the relativistic extension of the classic stellar structure equations and proposed a closed set of differential equations as the basic relativistic structure equations for a hydrostatic equilibrium system with spherical symmetry.

The following characteristic results will be explained as much as possible within given time:

(i) The proposed structure equations are consistent with the expected local thermodynamic relation.

(ii) The exact forms of the relativistic Poisson equation and steady-state heat conduction equation were derived.

(iii) They were solved exactly or non-perturbatively in the Newton constant for a system consisting of ideal gas of particles with their number conserved, and thermal observables were exactly determined to exhibit the power law behavior.

(iv) This power law behavior is expected also inside the Sun, which is in tension with results in textbooks.

(v) The conventional argument using the Newtonian approximation in coronal region is invalid.

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Modeling the mass of strange quark stars within the scope of PQCD

Author: Fabio Köpp[1]

Co-authors: CESAR AUGUSTO Zen Vasconcellos [2]; Dimiter Hadjimichef [3]; Jorge Horvath [4]

[1] *UFSC*

[2] *UFRGS/ICRANet*

[3] *UFRGS*

[4] *IAG/USP*

In the present work we address the equation of state for strange quark stars considering a model of high-density perturbative QCD (PQCD). In the second order regime of the strong coupling constant, the results depend sensitively on the choice of the renormalization mass scale that corresponds in turn to a first-order chiral transition. The results indicate quark stars with maximum masses higher than $2.0M_{\odot}$ and radii equivalent to ordinary neutron stars.

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Multiwavelength activity of NGC 1275 nucleus

Author: Vera G. Sinitsyna[1]

Co-authors: Sergey Borisov [1]; Vera Y. Sinitsyna [1]

[1] *P.N. Lebedev Physical Institute, Russian Academy of Science*

Active galactic nucleus (AGN) phenomenon and a role of jets, powered by central black hole of AGN, in the feedback of the surroundings on the different scales is the matter of the detailed multiwavelength investigations. The long-term observations of AGNi are used to reveal the processes taking place in the very proximity to the supermassive black holes. One of the approaches to such studies is to detect the launching of jet components viewed in radio range and then link it with flaring events detected at higher energy ranges. Tracking the jet-initiated variability events through the multiwavelength observations as well as its cross-identification from radio frequencies up high energy gamma-rays allows to locate the regions responsible for the generation of observable features which can lead to exploration of the mechanism of jet launching and the origin of emission in the Active Galactic Nucleus. Being the nearby and bright, NGC 1275 is one of the extensively studying AGNi. This object is very active in the timescales of decades. Multiwavelength long-term observations of NGC 1275 resulted in the detection of different timescale variability from this AGN. For the case of NGC 1275 the cross-correlation of the activity at radio, X-ray and very high energy gamma-rays is investigated. The time dependence of activity of NGC 1275 in the wide energy range was found which allow to localize the sites of the emission generation including one of the very high energies. These multiwavelength long-term studies are highly important for the further advance of the AGN's black hole research and investigations of mechanisms of jet formation.

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Mechanisms of high energy emission from Mkn 180 BL Lacertae object

Authors: Vera G. Sinitsyna,[1]; Vera Y. Sinitsyna[1]

[1] *P.N. Lebedev Physical Institute, Russian Academy of Science*

Mkn 180 is the BL Lac object with spectrum has been measured through radio and X-ray band to high energy gamma-rays. This object is considered as a potential candidate for the source of high-energy leptonic and\or hadronic cosmic-ray acceleration. Also, it has been proposed to be a GeV – TeV gamma-ray source. The very high energy gamma-rays from Mkn 180 were detected due to the trigger switched on by an optical burst. Mrk 180 was monitored in the optical wave band and in high and very high energy gamma-rays for a long period and its light curve was obtained. The spectral energy distribution of Mkn 180 blazar was obtained in the wide energy range as well. The spectral energy distributions of blazars consist of two broad peaks. The first, lower frequency peak occurring between radio and soft X-ray energies is due to the synchrotron emissions of relativistic electrons population. Leptonic and hadronic emission mechanisms are considered to describe the second, higher frequency spectrum part between X-ray and VHE γ -ray energies. The Inverse Compton emissions of the same electrons (synchrotron self-Compton model) or combined with an external Compton mechanism originating from the broad-line region, or the accretion disk are considered in the leptonic scenario. Also, the high energy spectrum part is supposed to be generated due to the processes of photohadronic or hadronuclear interactions of cosmic rays with radiation or matter in the AGN's jet emission region. The multiwavelength observations of Mkn 180 including the GeV – TeV energy data can help to clarify the dominant mechanism of generation of high-energy γ -ray emission in this object.

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Very high energy observations of Low-Mass X-ray binary 4U 2129+47

Authors: Vera G. Sinitsyna[1]; Vera Y. Sinitsyna[1]

[1] *P.N. Lebedev Physical Institute, Russian Academy of Science*

4U2129+47 is classified as a Low-Mass X-ray Binary containing a neutron star. It is actively studied in the optical and X-ray. It was found that exhibit both outburst and quiescent states. The spectroscopic investigations of optical counterpart of neutron star in this binary system shown that the 4U 2129+47 is a hierarchical triple system. X-ray observations shown the evidence for a spatially extended Accretion Disk Corona. This type of object is considered as a possible sources of high energy emission generated due to the interaction between the wind of the neutron star pulsar and accretion disk. Observations of 4U 2129+47 system with SHALON telescope were performed at the period 1999 to 2011 yy. Weak gamma-ray emission from this object was detected with significance of 10⍰. An integral flux above > 0.8 GeV of was measured. The modulation of detected gamma-ray emission with the orbital period of 5.24 hours is found. The hard spectrum with photon index of -.2 has been determined. Detected modulation of TeV gamma-ray flux with orbit together with the hard tail of soft X-rays detected with Chandra can be evidence of active accretion and also may point to the generation of emission through the interaction of the wind and accretion stream.

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Bounds on CPT violation parameters using observatory neutrinos data

Author: Isadora Barbosa[1]

Co-author: Carlos Javier Solano Salinas

[1] *UTFPR*

This work introduces the exploration of sidereal coordinates in the context of LIV, opening doors to new possibilities, including sensitivity studies and simulations.
Our research resulted in creating a comprehensive repository of LIV parameters, which stands as a valuable resource for future research.

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The Accelerating Universe in a Noncommutative Analytically Continued Foliated Quantum Gravity

Author: Benno Bodmann[1]

Co-authors: CESAR AUGUSTO Zen Vasconcellos [2]; Dimiter Hadjimichef [1]; Fridolin Weber [3]; Geovane Naysinger [1]; José Antonio de Freitas Pacheco [4]; Marcelo Netz-Marzola [5]; Peter Hess [6]

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[5] *FIAS*

[6] *UNAM*

Based on an analytically continued Riemannian foliated quantum gravity super-Hamiltonian, known as Branch Cut Quantum Gravity (BCQG) we propose a novel approach to investigating the effects of noncommutative geometry on a minisuperspace of variables, influencing the acceleration behavior of the universe's wave function and the cosmic scale factor. Noncommutativity is introduced through a deformation of the conventional Poisson algebra, enhanced with a symplectic metric. The resulting symplectic manifold provides a natural setting that enables an isomorphism between canonically conjugate dual vector spaces, spanning the BCQG cosmic scale factor and its complementary quantum counterpart. Using this formulation, we describe the dynamic evolution of the universe's wave function, the cosmic scale factor, and its complementary quantum image. Our results strongly suggest that the noncommutative algebra induces late-time accelerated growth of the wave function, the universe's scale factor, and its complementary quantum counterpart, offering a new perspective on explaining the accelerating cosmic expansion rate and the inflationary period. In contrast to the inflationary model, where inflation requires a remarkably fine-tuned set of initial conditions in a patch of the universe, analytically continued non-commutative foliated quantum gravity captures short and long scales, driving the evolutionary dynamics of the universe through a reconfiguration of the primordial cosmic content of matter and energy. This reconfiguration is encapsulated into a quantum field potential, which leads to the generation of relic gravitational waves, a topic for future investigation. Graphical representations and contour plots indicate a characteristic torsion (or twist) deformation of spacetime geometry. This result introduces new speculative elements
regarding the reconfiguration of matter and energy as a driver of spacetime torsion deformation, generating relic gravitational waves and serving as an alternative topological mechanism for the universe's acceleration. However, these assumptions require further investigation.

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Primordial Black Holes: Abundances and Constraints

Author: Ravi Sheth[1]

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I will describe recent work showing how to estimate the abundance of black holes which formed over an extended period of time, with a wide spectrum of masses, during radiation domination.

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SPECIAL RELATIVITY IN NON-INERTIAL REFERENCE SYSTEMS

Author: Angel Oswaldo Montes Palma[1]

[1] *Universidad Nacional de Ingeniería*

In this work, space-time will be studied taking into account a geometric structure of affine space, which can be identified with $\mathbb{R}^4$ space. The focus will be on the development of non-inertial reference systems, also called observers, and the description of the effects that can be physically measured by them. Therefore, in addition to discussing concepts such as world line, the concepts of simultaneity and local frame will be introduced. A relativistic approach to kinematics will also be taken, focusing on the measurements made by observers.

The study of non-inertial reference systems has been divided into two separate cases. On the one hand, uniformly accelerated observers have been defined, with which the trajectory of photons as seen by these observers has been calculated, and the phenomenon of redshift has been studied. Then, uniformly rotating and co-rotating observers have been defined to determine the synchronization processes that can be carried out by the latter.

The results showed, on the one hand, that the physical properties of photons, such as their rectilinear world line and the conservation of their energy, do not hold for a uniformly accelerated observer. On the other hand, it was found that a synchronization process is possible for co-rotating observers at a local level, but not at a global level.

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Evolution of State Density during Cosmic Inflation in the Framework of Open Quantum Systems

Author: Johor David Peñalba Quispitupa[1]

[1] *Universidad Nacional de Ingeniería*

The evolution of the scalar fluctuations via the Wigner formalism shows that the Wigner function is "squeezed". This result leads us to interpret the inflationary dynamics within the framework of open quantum systems, using the Lindblad master equation to model the interaction of quantum perturbations with their environment. This approach provides a deep understanding of the transition from quantum coherence to classicality, with significant implications for cosmology and quantum physics in future applications.

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Implementation and development of a computational routine for the evolution of multiple coupled inflationary fields.

Author: STEFANO RAFAEL GONZALES GUERRERO[None]

Given the previous work "Classicalization of the initial conditions in the inflationary universe", where the matter present in the universe was modeled by means of a scalar field known as inflaton, the transition of quantum fluctuations (within the context of inflation, it is known that temperature and polarization inhomogeneities of the CMB are driven by scalar and tensor fluctuations) to classical observables was observed. This result was achieved by means of simulations of the field for different modes, for which use was made of the decomposition of the field into amplitude and phase. However, since a more realistic model of this fact corresponds to studying inflation with multiple sources, the question arises: Is it possible to generalize the result to multiple fields? While it is feasible, it would be necessary to introduce a mechanism by which the multiple fields can be separated into fast and slow evolving components, in order to improve the computational efficiency and

accuracy of such simulation. In this project, the separation for multiple fields is proposed and the consistency of the separation model is evaluated.

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Non commutative cosomology

Author: ERI ATAHUALPA MENA BARBOZA[1]

[1] *Centro Universitario de la CIénega, Universidad de Guadalajara*

we develop and apply the WKB-type approximation to several examples
of noncommutative quantum cosmology, obtaining the time evolution of the noncommutative universe. This is accomplished by starting from a noncommutative quantum formulation of cosmology, where the noncommutativity is introduced by a deformation on the minisuperspace variables. This procedure gives a straightforward algorithm to
incorporate noncommutativity into cosmology and inflation.

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Beyond Einstein: A Glimpse into Semiclassical Gravity

Authors: Benito Alberto Juárez Aubry[1]; MILTON CRISTIAN MAMANI LEQQUE[2]

[1] *Unversity of York*

[2] *National University of the Altiplano Puno*

This work explores the effects of quantum matter on classical spacetime through the theory of semiclassical gravity. Renormalization in curved spaces using Hadamard states is employed to calculate the energy momentum tensor. Solutions in ultrastatic and globally hyperbolic spacetimes are presented, highlighting the complexity of fourth-order semiclassical equations and the conditions required for their formulation. Additionally, applications in cosmology and black hole evaporation are discussed, emphasizing the importance of studying specific cases to advance this theory.

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Strangeness enhancement: possible evidence of Quark Gluon Plasma in pp collisions

Authors: Eleazar Cuautle Flores[1]; MARIANO JESUS EFFIO CUEVA[2]

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[2] *UNI*

Experimentally, the creation of Quark Gluon Plasma in relativistic heavy ion collisions is well known; its properties are being investigated in different experiments around the world at different energies. However, the results from proton-proton collisions are under debate since there are results with behavior like those observed in heavy ion collisions, for instance, collective phenomena, di-hadron correlations, and many others, but energy loss is not observed yet.bIn this work we present an analysis of the enhancement of strangeness production as a function of multiplicity: different kinematic and global observables are studied using EPOS event generator. The results are obtained by simulating the creation of a dense medium, which evolves subsequently; the medium can be described

by cascade or hydrodynamic models. Our results are compared to the experimental one, suggesting we can describe the data qualitatively. However, we still need more detail, which could require a better understanding of the models to get better knowledge and predictions of the physical phenomena.

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Multi-strangeness hadron production and their evolution in the proton proton collision

Authors: Eleazar Cuautle Flores[1]; Jose Francisco Bautista Leon[2]

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The latest results from proton-proton collisions, reported from experiments at CERN, have provided evidence of collective phenomena similar to those observed in relativistic heavy ion collisions. The enhancement of strangeness as a function of multiplicity in proton-proton collisions is considered a crucial result, as it supports the potential creation of mini Quark-Gluon Plasma. In the present work, we report the evolution with the energy of different kinematic variables related to strangeness hadrons. The analysis is done using an EPOS event generator, with cascade and hydrodynamical models to follow the evolution of the medium created in the collisions. We emphasize the importance of measuring and identifying multi-strange hadrons. Finally, the results are compared to experimental data to get preliminary predictions.