IWARA2022 - 10th International Workshop on Astronomy and Relativistic Astrophysics

Monday, 5 September 2022 - Friday, 9 September 2022

IWARA

From Quarks to Cosmos

Book of Abstracts

The event is the 9th in a series of meetings gathering scientists working on astroparticle physics, cosmology, gravitation, nuclear physics, and related fields. As in previous years, the IWARA2020 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.

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Heritage, Indigenous Peoples and Astronomy

Authors: Javier Mejuto[1]; Steven Gullberg[2]

[1] *Universidad Nacional Autónoma de Honduras*

[2] *University of Oklahoma*

The use and appropriation of common spaces, public spaces, and indigenous lands have become frequent and normalized, unfortunately this is also true for Astronomy, Astrophysics and Space Sciences. In this work, the indigenous concerns and social movements regarding sacred lands and astronomical facilities that have been built upon them will be presented. The joint initiative IAU/RAS/AAS Working Group on Culturally Sensitive Sites will also be presented along with its main objectives, and first activities. The first efforts will be two-fold: first, to make astronomers better aware of such sensitivities and how they may best be addressed, and next how much empathy can better bond science and culture.

The aim of this work is to open astronomical science to broader perspectives, the role of native societies in preserving humanity's astronomical heritage, and indeed how astronomy can play a decisive role as an open discipline in the development of science and inclusivity worldwide. Research, education and outreach in Astronomy and Astrophysics must play a role in that. We all live under one sky.

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The Archaeoastronomy of Tikal, Guatemala: A Reanalysis

Authors: Christopher Layser[1]; Steven Gullberg[1]

[1] *University of Oklahoma*

The great Maya city of Tikal was a major center of political, economic, and religious influence from its earliest pre-classic foundations to its classic period heights– through its fall and reestablishment, until its eventual abandonment. Like many other polities of the ancient Maya, Tikal's city-planning and architectural organization was designed to incorporate the beliefs and principles of the Maya cosmos. It's earliest ceremonial plaza, the Mundo Perdido, is one of the oldest pre-Classic E-Groups of the Petén; the astronomy of E-Groups is a topic which has been debated by archaeologists and archaeoastronomers alike over the past century. New measurements of Mundo Perdido will be analyzed within the framework of recent E-Group theories posited by Ivan Ŝprajc (2021). In 1988 Aveni and Hartung discussed the archaeoastronomy and dynastic history at Tikal. Breakthroughs in the decipherment of the Maya glyphs over the intervening decades has greatly increased our understanding of Tikal's dynastic history while interpretations in the field of archaeoastronomy have become more rigorous. In this light, the resurvey and reanalysis of several Tikal's great temples is warranted. Lastly, it will be demonstrated that the unique twin-pyramid complexes of Tikal not only exemplify many of Ashmore's (1991) principal components of the Classic Maya cosmological template, but also present grand three-dimensional models of the Sun's movement through the cosmos– constructed in celebration of calendrical period endings.

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Can Quantum Mechanics explain the Dark Universe?

Author: Tonatiuh Matos[None]

Two of the most impressive open questions in science are, without a doubt, the discovery of the nature of Dark Matter and Dark Energy, the so-called Dark Universe. Scientists have worked to solve these questions for many years, decades. Quantum Mechanics (QM) was established to understand the microworld, atoms, molecules, etc. Since 1998 we have carried out a systematic study of the Scalar Field Dark Matter model, also called Ultralight Dark Matter model where Dark Matter satisfies the Schrödinger-Poisson equations. In this talk we are going to speak about how QM can give an alternative explanation to the problem of the Dark Universe, assuming that Dark Matter halos behave like atoms and dark energy could be a consequence of the most elemental precepts of QM.

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Search for dark photons in heavy-ion collisions

Authors: Elena Bratkovskaya[None]; Ida Schmidt[1]; Malgorzata Gumberidze[2]; Romain Holzmann[2]

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The vector U-bosons, or so called 'dark photons', are one of the possible candidates for the dark matter (DM) mediators. They are supposed to interact with the standard matter via a 'vector portal' due to the $U(1) - U(1)'$ symmetry group mixing which might make them visible in particle and heavy-ion experiments. While there is no confirmed observation of dark photons, the detailed analysis of different experimental data allows to estimate the upper limit for the kinetic mixing parameter ϵ^2 depending on the mass M_U of U-bosons which is also unknown.

In Ref. [1] we have introduced a procedure to define theoretical constraints on the upper limit of $\epsilon^2(M_U)$ from heavy-ion (as well as $p + p$ and $p + A$) dilepton data. Our analysis is based on the microscopic Parton-Hadron-String Dynamics (PHSD) transport approach which reproduces well the measured dilepton spectra in $p+p$, $p+A$ and $A+A$ collisions. Additionally to the different dilepton channels originating from interactions and decays of ordinary (Standard Model) matter particles (mesons and baryons), we incorporate in the microscopic transport approach - for the first time - the decay of hypothetical U-bosons to dileptons, $U \to e^+e^-$, where the U-bosons themselves are produced by the Dalitz decay of pions $\pi^0 \to \gamma U$, η-mesons $\eta \to \gamma U$ and Delta resonances $\Delta \to NU$.

Using the fact that dark photons are not observed in dilepton experiments so far one can require that their contribution can not exceed some limit which would make them visible in experimental data. By varying the parameter $\epsilon^2(M_U)$ in the model calculations, one can obtain upper constraints on $\epsilon^2(M_U)$ based on pure theoretical results for dilepton spectra under the constraint that the 'surplus' of the DM contribution doesn't overshine the SM contributions (which is equivalent to the measured dilepton spectra) with any requested accuracy. We confront our results with the analysis from the HADES Collaboration [1] at SIS18 energies where the dark photons are not observed as well as with the world data collection.

This analysis can help to estimate the requested accuracy for future experimental searches of 'light' dark photons by dilepton experiments. We note that this procedure can be extended for the search of dark photons of any masses when the corresponding production and decay channels are implemented in the transport approach.

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The role of a standard family of Supernovae in the creation of the BdHNI , BDHNII and BDHNIII Grbs

Author: Remo Ruffini[1]

[1] *ICRANet*

In this contribution we present the most recent results about the role of a standard family of Supernovae in the creation of the BdHNI , BDHNII and BDHNIII Grbs. Some important conclusions and open questions are addressed.

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Where we are with the Dark Energy Spectroscopic Instrument ?

Author: Mariana Vargas Magana[None]

The Dark Energy Spectroscopic Instrument is a fourth generation dark energy experiment which will revolutionate the cosmological constraints that we can extract from the large scale structure of the universe. DESI started to take data in 2020, and now it just finished the September this first year of data. In this talk, I will summarize the survey, present the status of the experiment and give some highlights of the analysis being performed right now with the data collected, the simulations and the preparation of the analysis.

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A (axial)vector meson extended quark-meson model to describe quark matter in the core of neutron star

Authors: György Wolf[1]; J. Schaffner-Bielich[2]; J. Takatsy[2]; P. Kovacs[2]

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The existence of quark matter inside the cores of heavy neutron stars is a possibility which can be probed with modern astrophysical observations. We use an (axial)vector meson extended quark-meson model to describe quark matter in the core of neutron stars. We discover that an additional parameter constraint is necessary in the quark model to ensure chiral restoration at high densities. Since they significantly increase the radii of hybrid stars, large sigma meson masses are excluded –consistently with our purely particle physics-based parametrization. The vector coupling can be constrained by mass limits since the maximum mass of hybrid stars is only weakly dependent on the phase transition. We performed a full Bayesian analysis using multiple astrophysical constraints: GW170817, NICER measurements and mass constraints. The results for the quark model parameters are consistent with our simple M–R relation-based investigation, but in addition, we found that observations are best accommodated by a stiff intermediate region with a center at ~4 n0.

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Neutron star collisions and the gravitational collapse

Author: Matthias Hanauske[None]

With the first detection of gravitational waves from a binary system of neutron stars GW170817, a new window was opened to study the properties of relativistic fluids at and above the nuclear-saturation density. Reaching densities a few times that of nuclear matter and temperatures up to 100 MeV, such mergers also represent potential sites for a phase transition from confined hadronic matter to deconfined quark matter. A hypermassive hybrid star is a metastable remnant of a binary neutron star merger, and in contrast to its purely hadronic counterpart (hypermassive neutron star), it contains deconfined strange quark matter in its inner region. During the last phase, the hypermassive hybrid star collapses into a black hole and the quark matter in the inner region gets macroscopically confined by the formation of the event horizons of the resulting rotating black hole.

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Quark Deconfinement in Neutron Stars and Their Mergers

Authors: Andreas Bauswein[1]; David Blaschke[None]; Oleksii Ivanytskyi[2]; Tobias Fischer[2]

[1] *GSI Darmstadt*

[2] *University of Wroclaw*

We outline the role that an early deconfinement phase transition from normal nuclear matter to a color superconducting quark-gluon plasma phase plays for the phenomenology of supernova explosions and binary neutron star mergers. To this end we develop a density functional approach to the equation of state (EoS) of quark matter with confinement and color superconductivity [1] and construct the transition to the EoS of the hadronic matter phase from vanishing to moderately high temperatures that will become accessible also in future terrestrial experiments with heavy-ion collisions. For the first time a phase transition construction is developed that allows for multiple critical points in the QCD phase diagram, including the possibility of a "crossover all over"[2].
We study the connection of such hybrid EoS with the mass-radius relation of cold compact stars, including the intriguing possibility of additional families, as a consequence of the presence of an early and strong phase transition. Special emphasis is devoted to the simultaneous fulfillment of the new constraint from the NICER mass and radius measurement on PSR J0740+6620 and the tidal deformability constraint from the binary neutron star merger event GW170817 which require the EoS to be soft at about twice saturation density and to stiffen at higher densities. Such a pattern is provided by an early and strong deconfinement transition [1]. We discuss whether the deconfinement signals remain intact which have recently been found in dynamical astrophysical scenarios, such as binary compact star mergers including the subsequent emission of gravitational waves [3] and supernova explosions of massive supergiant stars where neutrinos and gravitational waves play the role of messengers [4,5].
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The cosmological constant in Loop Quantum Cosmology revisited

Authors: Hugo A. Morales-Técotl[1]; Omar Gallegos[2]; Tonatiuh Matos[2]

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The current acceleration of our Universe leads to the question of a possible origin of a cosmological constant. Within loop quantum cosmology a recent proposal yields an effective model including a behavior corresponding to it which origin lies in the relative weight of two pieces entering the Hamiltonian constraint, Euclidian and Lorentzian. Matching with the observations essentially fixes such relative weight. However, this analysis does not take into account the selfadjoint character of the Hamiltonian constraint. In this work, we take a first step in this direction. Previous, selfadjointness results developed for the purely Euclidian term are here extended to incorporate it with the Lorentzian one. The ensuing effective dynamics is studied together with its possible consistency with observations.

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Effect of the Metallicity of the Intergalactic Medium in the Lyman-α Forest Correlation Function

Author: Andrea Muñoz-Gutiérrez[None]

Co-author: Axel De la Macorra [1]

[1] *Instituto de Física, UNAM*

The Lyman-α (Lyα) forest allows to constraint cosmological parameters at z>1.8 using the technique of standard rulers determined by Baryon Acoustic Oscillations (BAO). This makes it an important tracer for the study of the Universe at high redshift. For this work several synthetic datasets have been generated to understand the astrophysical effects and contaminants that contribute to the shape of the Lyα flux correlation function ξLyα, and to be able to reproduce the correlation function measured with data spectra from different galaxy surveys (eBOSS and DESI). Among these phenomena the presence of metals in the Intergalactic Medium (IGM) translate into an important bias in the ξLyα with respect to the ξLyα calculated considering an only Hydrogen in the IGM. In this work we study the influence of the metallicity in ξLyα, simulating the presence of four Si transitions in synthetic spectra developed in preparation for DESI and compared with the data obtained in the DR14 of eBOSS. These results were used for the analysis of eBOSS DR16 and are currently being used for the analysis of the first data release of DESI.

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The curvature energy-momentum tensor in extended theories of gravity with curvature-matter couplings

Authors: Sarahi Silva[1]; Sergio Mendoza[1]

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

It is shown how in general terms one can construct a curvature energy-momentum tensor in extended theories of gravity with particular attention to gravitational theories with curvature-matter couplings for ideal fluids. In passing by, it will also be shown a unique way to define the matter Lagrangian for the case of ideal fluids.

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Constraints in the TeV halo population of M31

Author: Alexis Andrés[1]

Co-authors: María Magdalena González [1]; Tomás Capistrán [1]

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TeV halos are a new class of extended gamma-ray objects recently discovered around middle-aged pulsars. Although it is still unclear if TeV halos are characteristics of all pulsars, their population in the Milky Way galaxy has been studied. In this work, we study the TeV halo population in the Andromeda galaxy (M31), the closest largest spiral galaxy to the Milky Way. Concretely, we assume M31 is a Milky Way-like galaxy and compute the contribution of TeV halos to the gamma-ray emission of M31. We acknowledge the support from PAPIIT IG101320.

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Mildly relativistic cokscrew jets as rotated spirals

Authors: Alejandro Raga[None]; Jorge Canto[1]

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It has been noted before that the observed spiral structure of free-streaming, precessing jets appears to be increasingly "rotated" (i.e., with an apparent increase/decrease of the angle between the precession axis and the plane of the sky) as v/c increases. We derive the value of the rotation angle, and show that this "rotated spiral" description is appropriate for jets with v/c<0.8. We find that in order to obtain the correct predicted image, the half-opening angle of the spiral also has to be modified as a function of v/c.

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A reconstruction scheme for f(T) gravity and information theory based model validation

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Co-author: Surajit Chattopadhyay [2]

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[2] *Department of Mathematics, Amity University, Kolkata*

Here, We will be reporting a study on Generalized Chaplygin Gas(GCG) in bulk viscosity framework. We have reconstructed f(T) gravity considering that the background fluid, is evolving as GCG interacting with pressureless dark matter in a viscous scenario. Stability of reconstructed f(T) has been analyzed against small purterbations. The model has been finally validated against observational data through Shannon entropy maximization and Gaussian Mixture Model.

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New tools for better characterizing astroparticle physics sites and detectors for the Latin American Giant Observatory

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The Latin American Giant Observatory (LAGO) is an extended astroparticle observatory, consisting of a synchronised network of water Cherenkov detectors operating in Latin America and covering a wide range of altitudes above sea level and geomagnetic rigidity cut-offs[1]. LAGO is operated by the LAGO Collaboration, a highly collaborative organization with 100 members from more than 30 Iberoamerican institutions. LAGO research objectives are focused on studying of high-energy astrophysical and space weather and climate phenomena, by indirectly measuring the temporal evolution of the flux of galactic cosmic rays from ground level[2].
The interaction of such cosmic rays with the atmosphere produces a large number of secondary particles via radiative and decay processes. These true cascades of particles, collectively known as Extensive Air Showers, could reach up to 10^{11} particles at the instant of their maximum development.
To accomplish these tasks we have developed several computational tools[3]; that take advantage of the increasing computational capabilities available at high-performance computing facilities and in cloud-based computing environments, such as the European Open Scientific Cloud (EOSC)[4]. With these tools, we can calculate the expected particle flux at any place in the World, including real-time atmospheric and geomagnetic effects, reproducing the expected signals in different types of detectors. We can also calculate the impact in the expected flux due to the occurrence of transient astrophysical phenomena, such as those related to Solar Activity[5] or the high energy component of Gamma-Ray Bursts[6].
In this contribution, we will show how this very complex sequence of simulations is helping us to characterize new sites for our Observatory and to design new and improved astroparticle detectors for the LAGO detection network.

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Air Showers Simulations to Produce Technological Results

Authors: Mauricio Suárez-Durán[1]; Christian Sarmiento Cano[None]; Antonio J. Rubio-Montero[2]; Alvaro Taboada[3]; Raúl Pagán-Muñoz[2]; Rolando Calderón Ardila[None]; Luis Alberto Nuñez Villavicencio[None]; Ivan Sidelnik[4]; Hernán Asorey[None]; Rafael Mayo-García[2]

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[3] *ITeDA, CNEA*

[4] *CONICET (Consejo Nacional de Investigaciones Científícas y Técnicas) - Centro Atómico Bariloche - Argentina*

Atmospheric radiation is mainly produced during the interaction of high energy cosmic rays with the atmosphere. After the first interaction of these primary cosmic rays, a series of radiative and decay processes generate a collective process known as Extensive Air Shower (EAS), with up to 10 secondary particles per primary per GeV at the altitude of the maximum development, and continue evolving up to reach the ground level.

Bearing this in mind, calculating the atmospheric radiation background is a very complex and demanding task. This computation is originated from the integration of all the secondary particles produced by the complete and modulated flux of cosmic rays that impinge on the atmosphere. For doing this we developed ARTI [1], a computational framework that takes advantage of the state-of-the-art radiation propagation and interaction codes, such as CORSIKA [2] and Geant4 [3], to trustworthily estimate the expected flux of radiation at any place in the World under real-time evolving

atmospheric and geomagnetic conditions [4]. We are also capable to include the impacts produced during the sudden occurrence of transient astrophysical phenomena. As these calculations require a vast amount of computational resources, several approaches were adopted, such as the recent development of OneDataSim [5], a virtualized application to run ARTI on high-performance computing and cloud-based environments.

In this work, we show some of the implications and technological applications of our research, including results related to the precise calculation of the expected muon flux at underground laboratories, the mining prospecting and volcanoes risk assessment in muography, some new applications for precision agriculture and personal safe ward, and even how we are able to predict the occurrence of silent and non-silent errors at the new exascale supercomputers centres.

In addition, some results will be shown for the future ANDES underground laboratory. Thus, regarding the study of high energetic secondary particles at the tens of TeV scale for this lab background calculations and the expected flux of muons for muography geophysical applications, the expected flux over an integration time of 1 year at different altitudes of the ANDES mountain profile will be presented.

In all those cases, the accuracy and statistical significance of previous results have been extended by using these new resources.

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Acknowledgments
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Review of Latest Advances on Dark Matter

Author: Eugene Oks[1]

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The review will cover the latest advances in understanding dark matter. At the beginning it will follow my review on dark matter published in 2021 in the Elsevier journal "New Astronomy Reviews" (v. 93, 101632) and my review published in 2021 by Nova Science Publishers as a chapter in the book "Advances in Dark Matter Research". Then the current review will cover the newest results published after the above two reviews had been printed.

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On the maximum mass of differentially rotating neutron stars and strange quark stars

Author: Dorota Rosinska[None]

An understanding of differentially rotating relativistic stars is key to many areas of astrophysics, in particular to the emission of gravitational waves. A newly born, proto-neutron star or a compact remnant of neutron stars binary merger are expected to rotate differentially and to be important sources of gravitational radiation. A highly accurate and stable, relativistic, multidomain spectral code is used to explore the whole solution space for broad ranges of the degree of differential rotation. Staying within an astrophysically motivated range of rotation profiles, we investigate the characteristics of neutron stars with maximal mass for all types of families of differentially rotating neutron stars and different equations of state.
We find various types of configurations, which were not considered in previous work, mainly due to numerical limitations. The maximum allowed mass for the new types of configurations and moderate degree of differential rotation can be even 2-4 times higher then the maximum mass of non-rotating neutron stars with the same equation of state. Differential rotation can temporarily stabilize a hypermassive neutron star against gravitational collapse. This result may have important consequences for the gravitational wave signal expected from coalescing neutron star binaries or from some supernova events.

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Constraints on the EoS of strongly interacting matter and on particle properties from relativistic heavy ion collisions

Author: Joerg Aichelin[1]

[1] *SUBATECH*

The calculation of neutron star properties as well as the interpretation of the gravitational wave results for neutron star collisions requires the knowledge of the equation of state of strongly interacting matter.
Relativistic heavy ion collisions have collected over the last years a number of results which are sensitive on the nuclear equation of state and the properties of elementary particles if they are brought in a strongly interaction environment. State of the art transport theories like PHSD or PHQMD have been used to extract this equation of state information contained in the experimental results. We report on what we know presently about the equation of state up to densities of about 3 times normal baryon densities and temperatures up to around 100 MeV.

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Strange stars confronting with the observations: non-Newtonian gravity effects, or existence of a dark-matter core inside the stars

Author: Shu-Hua Yang[1]

Co-authors: Chun-Mei Pi [2]; Xiao-Ping Zheng [3]; Fridolin Weber [4]

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We find that the existence of strange stars is ruled out by the dimensionless tidal deformability of a 1.4 M_sun star of GW170817 and the mass of PSR J0740+6620 , both for the standard MIT bag model and for the density dependent quark mass model. However, if non-Newtonian gravity effects are considered, strange stars can exist for certain ranges of the values of the non-Newtonian gravity parameter. An alternative explanation to the observations is to suppose that strange stars in GW170817 have a dark-matter core.

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Dark Matter Searches Through Multi-Messenger Observations of Compact Stars

Author: David Edwin Alvarez Castillo[1]

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The purpose of this talk is discuss the possibility of detection of dark matter through multiple observations of compact stars and related phenomena. Recent scientific and technological developments have allowed for a better study of the nature of these astrophysical objects, in particular of the equation of state (EoS). As we advance on the quest for clarification of the neutron star internal content, we will be able to reveal or discard the existence of dark matter in the corresponding stellar environments. In one hand, new channels of multi-messenger observations like gravitational radiation from merger events of binary systems of compact stars or radio and X-ray signals from isolated pulsars have revealed their most basic structural properties like mass, radius, compactness, cooling rates and compressibility of their matter. In the other hand, nuclear measurement and experiments have narrowed the EoS uncertainty in the lowest to intermediate density range. Importantly, there exist several types of violent, transient energetic emissions associated not only with the strong magnetic fields and extreme gravity in the proximity of these objects but with explosive, evolutionary stages often triggered by mass accretion from companion stars. Therefore, we expect that the presence of dark matter will leave an imprint in the many kinds of detected signals from compact stars.

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Coherent quantum states in resonant-mass gravitational wave detectors

Authors: Carlos Frajuca[1]; Douglas Alves da Silva[2]; Fabio da Silva Bortoli[1]; Lucas Bonifacio Selbach[2]; Nadja Simao Magalhaes[3]

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[2] *FURG*

[3] *UNIFESP*

Quantum coherent states is a new features in quantum mechanics. Resonant-mass gravitational waves detectors didn´t succeed in detecting gravitational waves probably because of the operational frequency range chosen when the design of such detectors. But such detectors can be important in the future. This work describe the importance of quantum coherent states when the a resonant-mass gravitational detects a energy from the gravitational wave very very close to the quantum limit. At this point quantum coherent states of vibration and quantum non-demolition measurements becomes essential.

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Simulating the Early Universe

Author: David Garrison[1]

[1] *University of Houston-Clear Lake*

The Numerical Cosmology Group at UHCL has been working for several years to develop the most accurate simulations of the Early Universe possible in order to answer several basic questions such as when did the first magnetic fields develop? In addition, our numerical code can be used to test

several fundamental theories in physics. In this presentation, I plan to talk about how we developed this simulation software and what we have already learned from using it. The primary focus of this talk will be Magnetogenesis or the creation of the first magnetic fields in the universe.

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Deflection of ultrarelativistic massive particles in Schwarzschild space-time

Authors: Milton Jair Santibáñez Armenta[None]; Sergio Mendoza[None]

Gravitational fields curve space-time about them, modifying massive and non-massive particle trayectories. In this work the delfection angle we study the deflection angle generated by the change in the trayecoties affected by the gravitational field of a Schwarzschild space-time. We present an exact analytic formula for small angles and a useful relation for numerical computations. Different applications, in particular to ultrarelativistic neutrinos are presented.

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Expected exclusion limits to TeV dark matter from the Perseus Cluster with CTA

Author: Sergio Hernández-Cadena[None]

Co-author: Jose Ruben Alfaro Molina [1]

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Clusters of galaxies are the largest gravitationally-bound structures in the Universe. They are composed of galaxies and gas (~15% of the total mass), and dark matter (DM; ~85%). If the DM is composed of Weakly Interacting Massive Particles (WIMPs), galaxy clusters represent the best targets to search for gamma-ray signals induced by the decay of WIMPs with masses at the TeV scale. Due to its sensitivity and energy range of operation (from a few tens of GeV up to tens of TeV), the Cherenkov Telescope Array (CTA) Observatory has a unique opportunity to test the decay of WIMPs with masses close to the unitarity limit, complementing the searches for DM from other gamma-ray observatories as well as direct and collider experiments. One of the most promising clusters in terms of expected DM annihilation/decay fluxes is Perseus. In the first years of operation the CTA Observatory is planning to search for both DM and cosmic-ray induced gamma-ray emissions in this cluster. In this talk, preliminary limits to the annihilation cross-section and decay lifetime of WIMPs with masses between 50 GeV and 100 TeV using simulated observations of Perseus with CTA will be presented.

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Statistical and computational methods for the inference of a binary black hole in Mrk 501

Authors: Gustavo Magallanes-Guijón[None]; Milton Jair Santibáñez Armenta[None]; Sergio Mendoza[None]

In this work, a multifrequency analysis (radio, optical, x-rays, and gamma rays) of the blazar Mrk 501 is presented. We analyze the light curves of this extragalactic object with different computational algorithms (analysis of variance, discrete Fourier transform, periodograms, wavelets transform, among others). With the help of numerical simulations and light curve fitting using elliptic

Jacobi functions, we infer the presence of an eclipsing binary companion with periodicity ~228d.

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Relativistic Scenario for a Binary BH system in Blazars

Authors: Bryan Larios[None]; Bryant Morazan[None]; Héctor Pérez[1]; Jose Rodrigo Sacahui Reyes[None]; Miguel Toralla[None]; Roger Raudales[2]

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Blazars are a type of Active Galactic Nucley (AGN) which jet points towards the observer. Their emission is variable in different time scales and at different wavelenghts. Some objets presents periodicity in their emission, like the blazar PG 1553+113. In this work we study a scenario to explain blazar periodicities with timescales of few years. The scenario is built on a binary supermassive black hole (SMBH) system where one of the two SMBH carries a jet. Furthermore, we are considering that the two SMBH have angular momentum and that one of them (central) is described by a Kerr black hole metric. We found estimations for the masses of the sources and the distance that separates the two SMBH.

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Simulated performance of a 55 compact IACTs array at high altitude

Authors: Rubén Alfaro[1]; Jan Audehm[2]; Thomas Bretz[2]; Oscar Chaparro-Amaro[3]; Giang Do[2]; M.M. González[4]; Francisco González[4]; Arturo Iriarte[4]; Jesús Martínez-Castro[3]; Miguel Martínez-Felipe[3]; Frank Maslowsky[2]; Yunior Pérez[4]; Florian Rehbein[2]; Merlin Schaufel[2]; Ibrahim Torres[5]; José Serna-Franco[1]

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In modern astrophysics, the innovation of new instruments for the detection of high-energy particles is very relevant for the next generation of gamma-ray observatories such as SWGO (Southern Wide-Field Gamma-Ray Observatory). The HAWCS's Eye telescope is a prototype of a proposed compact wide-field-of-view Imaging Air-Cherenkov Telescope (IACT). It is designed as a SiPM-based 61-pixel telescope featuring a sealed Fresnel optic, and a versatile DAQ. In the following work, the characterization of a simulated array of 55 HAWC's Eye telescopes at 4,100 m a.s.l. is shown, considering single and stereoscopic observations with a different number of telescopes and configurations. This project was realized with the support of DGAPA PAPIIT IG101320. The authors thankfully acknowledge the computer resources, technical expertise, and support provided by the Laboratorio Nacional de Supercómputo del Sureste de México, CONACYT member of the network of national laboratories.

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Searches of ALPs : Galactic Sources

Author: Alvaro Pratts[1]

Co-authors: José Andrés García-González [2]; Rubén Alfaro [1]; Sergio Hernández-Cadena ; for the HAWC Collaboration .

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Even though dark matter constitutes approximately 27% of the Universe, it has been impossible to understand its nature and composition. Historically, the most favored candidate has been the WIMPs (Weakly Interacting Massive Particles), with the Supersymmetric neutralino being the most known candidate. However, it has not been observed any supersymmetric particle. Thus other candidates for dark matter have begun to emerge with more force and renewed interest. One of these is the *Axion like particle*(ALP), a hypothetical light particle (in the range of $\sim \mu$ eVs) arising within theories beyond the standard model (BSM) as an extension of the Axion concept of QCD. The effect of the conversion of ALPs to photons should be observed in the spectrum of highly energetic astronomical gamma-ray sources. In the particular case of galactic sources, the total effect of this coupling is expected as attenuation of their spectrum at energies above several tens of TeVs. Thus, observatories like HAWC have a golden opportunity to explore the properties of ALPs in the range of masses of μeV. This work presents the calculation of the possible effect of the photon-ALP conversion observed as attenuation of the spectrum of eHWC J1908+063 —a high-energy source detected by the HAWC observatory. Limits on two fundamental parameters of this candidate, mass and coupling constant, are established.

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Determination of chaotic behaviour in time series generated by charged particle motion around magnetized Schwarzschild black holes

Author: Radim Pánis[1]

Co-authors: Martin Kološ [1]; Zdeněk Stuchlík [1]

[1] *Institute of Physics, Silesian University in Opava*

We study behaviour of ionized region of a Keplerian disk orbiting a Schwarzschild black hole immersed in an asymptotically uniform magnetic field. In dependence on the magnetic parameter $\boldsymbol{B}$, and inclination angle $\boldsymbol{\theta}$ of the disk plane with respect to the magnetic field direction, the charged particles of the ionized disk can enter three regimes: a) regular oscillatory motion, b) destruction due to capture by the magnetized black hole, c) chaotic regime of the motion. In order to study transition between the regular and chaotic type of the charged particle motion, we generate time series of the solution of equations of motion under various conditions, and study them by non-linear (box counting, correlation dimension, Lyapunov exponent, recurrence analysis, machine learning) methods of chaos determination. We demonstrate that the machine learning method appears to be the most efficient in determining the chaotic region of the $\boldsymbol{\theta}$–$\boldsymbol{r}$ space. We show that the chaotic character of the ionized particle motion increases with the inclination angle. For the inclination angles $\boldsymbol{\theta}$~$\boldsymbol{0}$ whole the ionized internal part of the Keplerian disk is captured by the black hole.

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Astrophysics in Central América and the Caribbean

Author: Jose Rodrigo Sacahui Reyes[1]

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The Central American and the Caribbean region has low scientific development indicators. Montero-Camacho et al. 2021 highlights four main factors for these: 1. Absences of Ph.D. programs; 2. Lack of postdoctoral opportunities; 3. Low to none economic incentives and 4. Poor infrastructure. Most of the production in the last 20 years comes from Puerto Rico, the country that hosted the Arecibo International Radio Telescope, followed by Cuba and Costa Rica. The numbers are in contrast with the scientific production of neighboring countries such as México, where UNAM employs more lecturers/researchers in astronomy than all Central American institutions.These numbers are unlikely to change in the close future due to problems in science funding and the diminish of the Gross Domestic Product in recent years. To tackle this problem several efforts are being done. With time programs like summer schools, mentorships, research internships can change the current situation.In this talk I present the recent, ongoing and future work of a group of Central Americans/Caribbeans, and persons related to the region, working for the development of the Astronomical Sciences in the region.

15

The Plasma Window as a Vacuum-atmosphere Interface for Measurements of Stellar Neutron-induced Reaction Cross Sections

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Neutrons play a dominant role in the stellar nucleosynthesis of heavy elements. We review a scheme for the experimental determinations of neutron-induced reaction cross sections using a high-intensity neutron source based on the 18O(p,n)18F reaction with an 18O-water target at SARAF's upcoming Phase II. The quasi-Maxwellian neutron spectrum with effective thermal energy kT ≈ 5 keV, characteristic of the target (p,n) yield at proton energy Ep ≈ 2.6 MeV close to its neutron threshold, is well suited for laboratory measurements of MACS of neutron-capture reactions, based on activation of targets of astrophysical interest along the s-process path. 18O-water's vapour pressure requires a separation in between the accelerator vacuum and the target chamber. The high-intensity proton beam (in the mA range) of SARAF is incompatible with a solid window in the beam's path. Our suggested solution is the use of a Plasma Window, which is a device that utilizes ionized gas as an interface between vacuum and atmosphere, and is useful for a plethora of applications in science, engineering and medicine. The high power dissipation (few kW) at the target is expected to result in one of the most intense sources of neutrons available at stellar-like energies. Preliminary results concerning proton beam energy loss and heat deposition profiles for target characteristics and design, a new full-scale 3-dimensional computer-aided design model of the Plasma Window (as well as its operation principles) and the planned experimental scheme, will be reviewed.

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Filling the gap between neutron star and black hole masses

Authors: A. A. Bernardo[1]; Jorge Horvath[2]; L. de Sá[1]; L.S. Rocha[3]; P.H.R.S. Moraes[4]; R.R. Assis Bachega[1]

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The lack of objects between 2 and 5 $M_\odot$ enter code here in the joint mass distribution of compact objects has been termed "mass gap" and attributed to the characteristics of the supernova mechanism at their birth. However, recent observations show that a number of candidates reported to lie inside the "gap" may fill it, and the paucity may be the result of small number statistics. We quantify in this work the individual candidates and evaluate the joint probability of a mass gap, working in a frequentist and Bayesian approach. Our results show that a mass gap is not present, to a very high confidence level. It remains to be seen if a relative paucity of objects ensues and how this population can be related to the formation processes, which may include neutron star mergers, collapse of a neutron star to a black hole and others.

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Evaporation Black Holes in the Early Universe and the Hubble Tension

Author: Tsvi Piran[1]

[1] *The Hebrew University*

TBA

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Black holes in the Early Universe

Author: Felix Mirabel[1]

[1] *IAFE*

The existence of supermassive black holes (SMBHs) of ~ 109 solar masses in quasars at z ~ 7.5, when the Universe was ~700 Myr old, is an intriguing puzzle because their originremains unconstraint. It have been proposed that those SMBHs result from rapidly growing BH seeds of stellar and/or intermediate masses BHs at redshifts z ~30. However, there is no consensus on whether such extreme rapid mass growth of BHs may be sustainable during the 600 hundred million years since the Bi Bang. Direct detections in the near and mid-infrared of galaxies and massive BHs at z = 7 to 16 with the JWST, and indirect detections of radio loud BH signals in the redshifted 21cm line of HI at z~20 with radio arrays as SKA, may constrain the ultimate origin of the SMBHs observed up to z ~7.5. In this talk I will discuss these issues along the lines of a review of open access published in New Astronomy Reviews 94, 101642 (2022).

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Identity for scalar-valued functions of tensors and its applications in classical field theories and gravity

Author: Jürgen Struckmeier[1]

[1] *GSI*

We present a theorem on scalar-valued functions of tensors, where "scalar"refers to absolute scalars as well as relative scalars of weight w. The theorem thereby generalizes an identity referred to earlier by Rosenfeld in his publication "On the energy-momentum tensor"and provides a (1,1)-tensor identity which can be regarded as the tensor analogue of the identity following from Euler's theorem on homogeneous functions. The remarkably simple identity is independent of any internal symmetries of the constituent tensors, providing a powerful tool for deriving relations between field-theoretical expressions and physical quantities. We apply the identity especially for analyzing the relation of metric and canonical energy-momentum tensors of matter and gravity. The identity allows to formulate an equivalent representation of a generalized Einstein field equation for arbitrary model Lagrangian of vacuum space-time dynamics —including torsion and non-metricity.

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On the cosmological constant in the De Donder-Weyl Hamiltonian formulation of gauge gravity

Author: David Vasak[1]

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A modification of the Einstein-Hilbert theory, the Covariant Canonical Gauge Gravity (CCGG), leads to a cosmological constant that represents the energy of the space-time continuum when deformed from its (A)dS ground state to a flat geometry . CCGG is based on the canonical transformation theory in the De Donder-Weyl (DW) Hamiltonian formulation. That framework "deforms"the Einstein-Hilbert Lagrangian of the free gravitational field by a quadratic Riemann-Cartan concomitant. The theory predicts a total energy-momentum of the system of space-time and matter to vanish, in line with the conjecture of a "Zero-Energy-Universe" going back to Lorentz (1916) and Levi-Civita (1917). Consequently a flat geometry can only exist in presence of matter where the vacuum energy of matter is balanced by the vacuum energy of space-time. The observed cosmological constant is then just a a residual energy imbalance emerging from deviations from a flat geometry, torsion of space-time, and quantum gravity corrections. The constants of nature, Newton's G and Einstein's \Lambda, are mapped onto the coupling constants of CCGG.

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Development of an analytical model for TeV Halos

Author: Fernanda Carreon[1]

Co-authors: Alexis Andrés [2]; Daniel Avila-Rojas [3]; María Magdalena González [2]; Tomás Capistrán [2]

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TeV Halos are regions of extended emission around pulsars, produced due to inverse-Compton scattering of photons by particles accelerated inside and diffused away from the pulsar wind nebulae. TeV Halos, discovered in 2017 by the HAWC Collaboration, represent a possible detection tool for "silent"pulsars, those whose radiation jets are never oriented towards Earth. In addition, TeV Halos are very energetic cosmic accelerators and represent an uncharacterized population of gamma-ray sources that contribute to the galactic and extragalactic diffuse gamma-ray background. Finally, given their high-energy emission, these halos are potential probes for the search for Dark Matter. Thus, improvement of techniques to search for Halos is very important. In this work, we present a simulation of the gamma-ray emission of Geminga and Monogem side-by-side with the observations by HAWC. We use a simplified model for the emission based on pulsar characteristics. This project was supported by DGAPA PAPIIT IG101320.

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Exploring a Magnetic Warm Inflationary Scenario

Author: Angel Sánchez[1]

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In this work we study the consequences a possible primordial magnetic field could have on the inflaton effective potential, taking as the underlying model a warm inflation scenario, based on global supersymmetry with a new-inflation-type potential. In the warn inflation scenario, the decay scheme for the inflaton field is a two-step process of radiation production, where the inflaton couples to heavy intermediate superfields, which in turn interact with light particles. In this context, by considering that the heavy and light sectors are charged, we work in the strong magnetic field approximation for the light fields. Our findings show that the trend of the magnetic contribution is to make the potential flatter, preserving the conditions for a successful inflationary process. This result is backed up by the behavior of slow-roll parameter ε. The viability of this magnetic warm inflation scenario is also supported by the estimation of the effect of the magnetic field on the heavy particles decay width.

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A novel multimessenger study of Starburst galaxies: implications for neutrino astronomy

Author: Antonio Marinelli[1]

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Starburst galaxies (SBGs) and more in general starforming galaxies represent a class of galaxies with a high star formation rate (up to 100 Mo/year). Despite their low luminosity, they can be considered as guaranteed "factories"of high energy neutrinos, being "reservoirs"of accelerated cosmic rays and hosting a high density target gas in the central region. The estimation of their point-like and diffuse contributions to the neutrino astrophysical flux measured by IceCube can be crucial to describe the diffuse neutrino spectral features as well as the peculiar point-like excess like NGC1068. To this aim we used the most updated gamma-ray catalog of this class of objects to perform a multimessenger study and describe their gamma-ray emission through a calorimetric scenario.
A whole sky analysis was performed through a blending of the measured spectral indexes and obtained a multi-component description of extragalactic background light (EGB), high energy starting events (HESE) and high-energy cascade IceCube data. Remarkably, we found that, differently from recent prototype scenarios, the spectral index blending allows starburst galaxies to account for up to 40% of the HESE events at 95.4% CL and favors a maximal energy of the accelerated cosmic rays at tens of PeV. The same calorimetric approach has been applied also to the known
SBGs within 100 Mpc, considering, where possible, a source-by-source description of the star formation rate obtained from IR and UV observations. On this regard we showed how Future CTA measurements will be crucial to link the observed gamma-ray fluxes from resolved SBGs with their star-forming activity as well as to disentangle the cosmic-ray transport inside the core of these galaxies. The expected neutrino emission, related to this scenario, are then compared with what can be expected from the Global Neutrino Network.

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Inflation models embedded in Lee-Wick theories

Author: Gabriella Piccinelli Bocchi[1]

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Cosmological models supported by Lee-Wick theories have the interesting feature of a cosmological bounce that solves the singularity problem. Besides, non-canonical fields, which are present in these theories, may be invoked to provide scenarios of dark energy or inflation. In inflation, some desirable features are present, such that the slow-roll conditions and the tensor- to-scalar relationship are more easily satisfied compared to canonical inflationary models. We present here work in progress concerning an inflationary model that includes higher derivatives in the scalar field. We explore the effect of these higher derivatives on its effective potential and its decay process, in the framework of warm inflation.

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Highlights from the X-ray all-sky survey eROSITA mission on AGN

A). Ionized Gas Outflows in AGN from the gravitational radius scale up to the kiloparsec scale:

We present the first look to the spectral and timing analysis of Narrow-Line Seyfert 1 Galaxies (NLS1s) with eROSITA based on the SDSS DR12 catalogue. 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 per cent 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, which is 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 correlate the variability to the multi-wavelength properties during the individual survey scans as well as between the survey scans.

B). 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 a combination of 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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Studying Primordial Non-Gaussianity with LSS tracers

Authors: Alejandro Aviles Cervantes[1]; Jennifer Meneses Rizo[None]; Mariana Vargas Magaña[1]; Sébastien Fromenteau[2]

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[2] *ICF-UNAM*

Considering that inflation is the mechanism that introduces the seeds for the formation of structures which distribution is close to Gaussian, generating a universe similar to ours introducing deviations from Gaussianity in the initial conditions could give us information about this inflationary period. In particular, the local primordial non-Gaussianities that generate a scale-dependent bias between the density of matter and the density of galaxies are studied, which makes their signal increase at large scales. Enhancement of the PNG signal makes it possible to search for, measure, and constrain it with large-scale structure tracers such as QSOs, LRGs, and ELGs. In this talk I will present the methodology for measuring PNG parametrized by the FNL factor from LSS of the Universe and some results of the validation process of this pipeline with simulations.

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The BAO method and the DESI experiment

Author: Alejandro Perez Fernandez[1]

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Before the epoch of recombination, the Universe was permeated with a baryon-electron-photon plasma. While gravity gave rise to the collapse of the initial overdensities, the radiation pressure served as a counterforce, thus resulting in the free propagation of sound waves within the primordial plasma. This corresponds to the oscillatory pattern that can be observed in the CMB two-point statistics and is referred to as the Baryon Acoustic Oscillations (BAO) phenomena. Furthermore, the same feature can be measured in the two-point statistics of the late-time large-scale structure clustering of galaxies. The characteristic scale associated to the oscillations can then be used a standard ruler, which in turn can served as a powerful probe of Dark Energy. The Dark Energy Spectroscopic Instrument (DESI) is currently on a 5-year quest to measure the spectra of more than 30 million galaxies in order to produce the most comprehensive 3D map of the Universe ever created. One of the main objetives of the DESI Collaboration is the measurement of the BAO feature. With the expected level of accuracy in mind, it becomes paramount to revise the methodology of the BAO method.

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Hot and Massive White Dwarfs: importance of general relativity and nuclear reactions in their structure and stability

Author: Manuel Malheiro[None]

The structure and stability of hot and massive white dwarfs against radial oscillations, pycnonuclear reactions, and inverse β-decay are investigated, We find that the temperature produces importante effects on the equilibrium and radial stability of white dwarfs. The stable equilibrium configuration results are compared with those for white dwarfs estimated from the Extreme Ultraviolet Explorer survey and the Sloan Digital Sky Survey. We derive masses, radii, and central temperatures for the most massive white dwarfs according to the surface gravity and effective temperature reported by the surveys. We note that these massive stars are in the mass region where general relativity effects are important, and also near the threshold of instabilities due to radial oscillations, pycnonuclear reactions, and inverse β-decay. Regarding the radial stability of these stars as a function of the temperature, we find that it decreases with the increment of central temperature.

89

Neutron Star or Neutral Star - the 90-anniversary of Landau (1932)

Author: Renxin Xu[1]

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What is the real nature of compact stars/pulsars? This is a question historically judged exactly 90 years ago by Lev Landau for the first time, and is also focused to be the first big problem to be solved in this era of multi-messenger astronomy, including the gravitational-waves. Nucleons were supposed to be elementary particles in Landau's time, but actually quarks are instead in the standard model of particle physics. I would like to explain that Landau's original idea should be improved if one thinks in the same way with the inclusion of strangeness in today's physics. More and more astrophysical phenomena, e.g., cosmic Gamma-ray bursts and fast radio bursts, are closely coupled with the answer to the big problem.

52

LIGO Compact Binaries from Isolated Stellar Binaries

Since the first detection of gravitational waves on September 14 2015, there have been over 90 different GW events detected by LIGO. One of the formation scenarios for such compact binaries involve the evolution of isolated stellar binaries, which undergo multiple mass transfer episodes that ultimately lead to the formation of a tight binary composed of two compact objects such as neutron stars or black holes, product of the death of the massive stars.

In this work, we explore the scenario of the formation of the second compact object through a supernova explosion. The energy deposited on the explosion will ultimately determine if a NS or BH is formed, its spin, and the amount of material accreted by the companion. As a result we're able to calculate the effective spin of the resulting compact binary and compare it with LIGO observations. We find that this scenario produces systems with effective spins consistent with what is observed by LIGO.

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Techniques in HAWC Observatory for classification of the air showers

Authors: Tomás Capistrán[1]; Kwok Lung Fan[2]; James Thomas Linnemann[3]; Torres Ibrahim[4]; Pablo Saz Parkinson[5]

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One of the main challenges of the HAWC Observatory is to separate showers produced by gamma-rays from those produced by charged particles that represent almost 99.9% of the total particles arriving on Earth. HAWC applies a technique to distinguish them and to remove the most hadron-induced showers considered in the analysis. In this work, some techniques that have been applied to the HAWC data are described. One is the official that uses a simple cut on two parameters, and the other two techniques use machine learning. All these techniques are used and compared to observe three astrophysical sources (the Crab Nebula, and two blazars). We acknowledge the support from DGAPA PAPIIT IG101320.

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Correlation between X-rays and TeV gamma-rays in blazars

Author: Mabel Osorio[1]

Co-authors: Magdalena González [1]; Rodrigo Sacahui [2]; José Andrés García-González [3]

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The spectral energy distribution (SED) of blazars is described by two radiative components, which are commonly modeled within the standard one-zone synchrotron self-Compton (SSC) leptonic framework. In this model, it is expected a strong correlation between energy band fluxes of the SED components, such as between soft X-ray and TeV gamma-ray fluxes. The correlations previously reported for some sources are often in small periods of time and are described by a broad variety of functions, from linear to almost cubic correlations. Even for the same source, several types of correlations have been reported. To know if there is a unique correlation behavior per source or in general for all sources, a long period of observation is required for several sources. In this work, we present the long-term soft X-ray vs TeV gamma-ray correlation of 4 HBL blazars at $z<0.1$ and try to find common behaviors between them. We acknowledge the support from DGAPA PAPIIT IG101320.

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Different modern methods for constructing equilibrium models of uniformly rotating compact stars

Authors: Balázs Kacskovics[None]; Dániel Barta[1]

[1] *Wigner RCP*

In recent years we have collected essential information on the integral parameters of neutron stars from multi-messenger observations of binary neutron-star mergers. In the light of these observations, we investigate the effects of rapid rotation on the structure and observable parameters of rapidly rotating relativistic compact stellar models based on the angular velocity and on the equations of state. We construct uniformly rotating stellar solutions to quartic order in the angular velocity in a Hartle–Thorne slow-rotation expansion, while for rapidly rotating stars, we solve the coupled system of non-linear elliptic PDEs that are associated with the Einstein field equations by implementing multi-domain spectral methods in the LORENE/rotstar codes. The multipole moments are extracted from the numerical stellar solutions are compared with the quartic-order slow-rotation approximation in the low spin-frequency regime.

58

Search for GRBs possibly associated with GW using HAWC

Authors: Yunior Frainen Pérez Araujo[1]; Jose Rodrigo Sacahui Reyes[None]; Maria Magdalena González Sánchez[1]; Nissim Fraija[1]

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Detecting gravitational waves (GWs) associated with Gamma-ray bursts (GRBs) has reaffirmed their importance and interest. In particular, short GRBs have been associated as the electromagnetic counterpart of GWs, the first being the burst GRB 170817A associated with the event GW170817. Due to its large field of view and duty cycle and its many improvements in the reconstruction of events, HAWC is an ideal observatory to study transient phenomena during and after the main emission in the TeV energy regime. In this work, we present the search for TeV emission in the HAWC Observatory from the trigger time to 200 days in GRB 170817A and others with similar characteristics to this burst. We acknowledge the support from PAPIIT IG101320 and IN105921.

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Deducing Neutron Star Equation of State From X-ray Telescope Spectra with Machine Learning

Authors: Aishik Ghosh[1]; Andrew Steiner[2]; Atharva Kavitkar[None]; Daniel Whiteson[1]; Delaney Farrell[None]; Fridolin Weber[3]; Jordan Ott[4]; Lee Lindblom[5]; Pierre Baldi[4]

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Neutron stars provide a unique laboratory for studying matter at extreme pressures and densities. While there is no direct way to explore their interior structure, X-rays emitted from these stars can indirectly provide clues to the equation of state (EOS) of the nuclear matter within through the inference the star's mass and radius. However, inference of EOS directly from a star's X-ray spectra is extremely challenging from systematic uncertainties in observation. The current state of the art is to use simulation-based likelihoods in a piece-wise method, which first infer the star's mass and radius to reduce the dimensionality of the problem, but likely sacrifice some information, and from those quantities infer the EOS. We demonstrate a series of enhancements to the state of the art, in terms of realistic uncertainty quantification and improved regression of physical properties with machine learning. We also demonstrate the first inference of the EOS directly from the high-dimensional spectra of observed stars, avoiding the intermediate mass-radius step. Our network is conditioned on the sources of uncertainty of each star, allowing for natural and complete propagation of uncertainties to the EOS.

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Gravitational Waves Astronomy - Breakthrough Discoveries

Author: Dorota Rosinska[None]

I will review the Ligo-Virgo-Kagra breakthrough discoveries and discuss their importance for astronomy, fundamental physics and cosmology.

5

The effects of a minimal length on the structure of black holes within the pseudo-complex General Relativity

Authors: Leila Maghlaoui[1]; Peter Otto Hess[2]

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The effects of a minimal length, on the structure near the event horizon of a Schwarzschild black hole, are investigated within the pseudo-complex General (pcGR) Relativity. It is shown that for small mass black holes there are strong effects, e.g., avoiding the accumulation of mass which might be important in the formation of black holes during the Big Bang. The pcGR adds to the metric a contribution characterized by a parameter, which has a critical value at which barely an event horizon exists. For macroscopic black holes, these effects vanished for below and above this critical value, but at the critical value effects still persist though quickly disappearing. For very large mass black holes the minimal length can be safely neglected. The limit between a small and a macroscopic black hole, in units of length, is between 10^{15}cm and 10^{13}cm.

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Weyl and Majorana for Neutral Particles

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We compare various formalisms for neutral particles. It is found that they contain unexplained contradictions. Next, we investigate the spin-1/2 and spin-1 cases in different bases. Next, we look for relations with the Majorana-like field operator. We show explicitly incompatibility of the Majorana anzatzen with the Dirac-like field operators in both the original Majorana theory and its generalizations. Several explicit examples are presented for higher spins too. It seems that the calculations in the helicity basis only give mathematically and physically reasonable results. They can be discussed in the context of recent observatioal controversies with solar and atmospheric neutrinos.

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Equations of State for Dense Matter

Due to the present large uncertainty in the composition and interactions of dense nuclear matter, there are many different equation of state (EoS) models that can fulfill nuclear and astrophysical constraints. EoS repositories allow for a fast exchange of EoS between providers and simulation users, accelerating our understanding of dense matter. I discuss different EoS repositories, focusing on the MUSES infrastructure, and different EoSs, focusing on the CMF model.

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Landau-Lifshitz and Weinberg energy-momentum complexes for a f(R)-modified gravity black hole solution with electric and magnetic charges

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The problem of energy-momentum localization for a four-dimensional, spherically symmetric, electrically as well as magnetically charged black hole solution in a $f(R)$-type modified gravity with $(R) = R + 2\beta\sqrt{R - 8\Lambda}$ is studied. Asymptotically this solution behaves as an AdS or dS spacetime, while it transforms to the Reissner-Nordstr\"{o}m solution in the case of zero magnetic charge. The energy and momentum distributions are computed by utilizing the Landau-Lifshitz and the Weinberg energy-momentum complexes. In both prescriptions all the momenta vanish, while the energy is found to depend on the electric and the magnetic charge, the mass m, the dimensional metric parameter β, the cosmological constant Λ, and the radial coordinate r. The behavior of the energy is examined near the origin and near infinity, while the special case of zero electric charge is also considered. Furthermore, some investigations of a possible astrophysical interest are performed.

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Revisiting the approximations on the cosmological solutions of ultra-light axions

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Ultra-light axions are promising dark matter candidates, but the computation of their cosmological observables is challenging because of the rapid oscillations of the axion field around the minimum of its potential. Different approaches have been discussed in the literature to avoid such difficulty, mainly by using approximated formulas for the axion equation of state and sound speed. Here, we revisit an alternative method that makes a change of variables and which allows to spot more easily the rapidly oscillating terms in the equations of motion. Such terms can be cut-off directly in the differential equations without spoiling the accuracy of the final output, and without manipulating the equation of state and the sound speed. A comparison between numerical and semi-analytical is shown to asses the appropriateness of the method to solve the original axion equations.

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Investigation of the magneto-thermal evolution in a magnetar's crust

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Assuming that the timescale of the magnetic field decay is approximately equal to that of the stellar cooling via neutrino emission, we calculate the effective soft X-ray luminosity emitted from the surface of a magnetar. The three heating mechanisms of the magnetic-plastic flow, the magnetic domain and Ohmic decay powered by toroidal magnetic fields inside a magnetars's crust are investigated and the related comparisons are presented.

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The fundmental plane of black hole activity for radio loud sources

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It is very controversial whether the X-ray emission of strong radio black hole sources is from jet or acrretion disk. In this work, we collected a sample of radio loud and lower luminosity black hole sources (e.g., active galaxy nuclei and X-ray binaries) to explore their radio−X-ray correlation and fundamental plane of black hole actities. We consider the beaming effect on the radio emission and find that the X-ray−radio relation follow a shallower ($F_{\rm R} \propto F_{\rm X}^{\rm b}, b \sim 0.60$) and the fundamental plane is consisted with the result of Merloni et al.(2003). This results implied that the X-ray emission of strong radio black hole sources is originated from radiatively inefficient accretion mode (e.g., ADAF).

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Investigating the magnetic field evolution and electron capture processes in a magnetized White Dwarf

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White dwarf(WD) are compact stars with electron degenrate pressure resisting against gravitational collapse. Using Zeeman splitting of optical spectra, polarization measurements, or optical rotation spectrophotometry, the magnetic field(MF) strengths of WDs can be observed directly. At present, the observed magnetic field intensity at the surface of a strongly magnetized WD is about 10^{9}-10^{12} G, and its core's MF strength may exceed the quantum critical magnetic field of electrons. In this paper, by considering a strongly magnetized WD model with variable MFs, we investigate the MF decay and electron capture(EC) processes in the interior of the WS and calculate the release rate of MF energy and neutrino production rate in these two processes. This study will be useful for the study of internal thermal evolution, surface thermal radiation and internal stability of magnetized WDs in the future.

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Finite temperature effects on magnetized Bose-Einstein Condensate stars

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We study the role of temperature on the macroscopic properties of magnetized Bose-Einstein condensate stars. These compact objects are composed of a gas of interacting neutral vector bosons coupled to a uniform and constant magnetic field. We assume that the boson-boson interactions are independent of the temperature and the magnetic field, and modeled them as tow-body contact interactions, while the thermal part was described through the exact thermodynamic potential of a hot gas of free vector bosons under the action of an uniform and constant magnetic field, including antiparticles. To obtain the macroscopic properties we used the γ-structure equations since they properly describe the axial deformation of magnetized stars. The main consequence of a finite temperature in the magnetized equations of state is to increase the inner pressure of the star. As a consequence, magnetized hot Bose-Einstein condensate stars are, in general, larger and heavier than their zero-temperature counterparts. However, the maximum masses given by the model remain almost unchanged, and the magnetic deformation of the star increases with the temperature. Besides, augmenting the temperature reduces the number of stable stars, an effect that the magnetic field enhances. The implications of our results for other stars´ observables and evolution are analyzed.

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Condensation of a magnetized gas of charged scalar bosons

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Charged scalar bosons may naturally form in the interior of neutron stars due to the pairing of protons with antiparallel spins. Although the concentration of proton pairs is small with respect to that of neutrons or neutron pairs, they might still have a relevant role in the macrophysics of these compact objects, especially in connection to their response to the strong magnetic fields of neutron stars. In this work, we study the effects of a uniform and constant magnetic field on the Bose-Einstein Condensation (BEC) of a magnetized gas of charged scalar bosons. The condensation of relativistic magnetized charged bosons is discussed usually in the weak (WF) or strong (SF) field regimes separately. In the WF limit, the gas undergoes a usual transition to the BEC, and the critical temperature depends on the magnetic field. In the SF regime, all the particles are confined to the lowest Landau level, making the system effectively one-dimensional. Since one-dimensional Bose gases do not exhibit BEC, it has been debated whether or not a magnetized scalar gas condenses. Indeed, in the SF regime, a critical temperature cannot be defined, but it can be shown that there exists an interval of temperatures along which the bosons start to concentrate around the ground state, indicating the occurrence of a diffuse phase transition. Here we review these limits and develop a low-temperature analysis suitable for any field. It allows us to observe how the gas evolves from one regime to the other and to answer the question of whether magnetized charged scalar bosons condense or not. To do so, we will study the particle density and the specific heat of the gas as a function of the temperature and the magnetic field.

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Tidal deformability of magnetized strange stars

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We study the effects of magnetic fields in the gravitational wave signals. Two main scenarios are explored, the first is the gravitational waves emitted from isolated neutron stars due to the deformation caused by the strong magnetic field, the second one is the effects of the magnetic field in the gravitational wave signal of a binary system. This work is a preliminary step towards that direction. First, we find the mass-radius relations for Strange Stars and compare them with the theoretical and observational constraints from modern literature. Finally, we calculate the tidal deformability of magnetized Strange Stars.

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A short review on pulsars' magnetic incline angles and their evolution

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The inclination angle of magnetic to rotation axisis (the inclination angle) of pulsars is an important parameter in pulsar physics. The changes in the inclination angle of a pulsar would lead to observable effects, such as changes in the pulse beam width and braking index of the star. On the one hand, a change in the charge density and/or a change in the current density in a pulsar's magnetosphere will lead to a change in the magnetospheric torque, thus the inclination angle will change accordingly. On the other hand, there are two magnetic moments inside a neutron star, one is generated by the rotation effect of a charged sphere, M_1, and the other is generated by the magnetization of ferromagnetically ordered material, M_2.The interaction between these two magnetic moments will also lead to the change of the magnetic inclination. The change in the inclination angle caused by the latter may be more permanent and sustained, but its change manner remains unclear. In this paper, we first perform a short review on the evolution of pulsar's magnetic inclination angle, as well as the latest research progress, then present possible relationships among the inclination angle, the spin-down, magnetic field decay and braking index for the Crab pulsar, and finally give some expections on the pulsar magnetic inclination angle evolution in the future.

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Entropic fragmentation of strange quark matter

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This presentation will introduce a maximum entropy model for the fragmentation and hadronization of strange quark matter (SQM) ejected in the event of strange star mergers.
The present formalism is capable of not only distinguishing the probabilities of mass spectra yielded by the fragmentation but also characterize the hadron zoo produced at the ejecta of strange star mergers and therefore a more accurate estimation of Ye and the following nucleosynthesis.

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Gamma-ray production in supermassive black hole binary OJ 287

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OJ 287 is one of the most studied BL Lac objects with very long optical measurements which spectrum has been well measured through radio to X-ray band. The most outstanding characteristic of OJ 287 is its 12-year period, which is discovered in the optical range and has also been confirmed in the X-ray band. OJ 287 is supposed to be a binary black hole system in which a secondary black hole passes the accretion disk of the primary black hole and produces two impact flashes per period. It has also been proposed to be a GeV - TeV source. Observations of OJ 287 in the GeV –TeV energy range reveal the variable gamma-ray connected with the flare activity of this object. The spectral energy distributions of blazars consist of two broad peaks. The first, lower frequency peak is due to the synchrotron emissions of relativistic electrons in the jet. Leptonic and hadronic emission mechanisms are considered to describe the second, higher frequency spectrum part. The Inverse Compton emissions of the same electrons (synchrotron self-Compton model) or combined with an external Compton mechanism are considered in the leptonic scenario. The last one supposes the existence of the external to jet photon cloud. The high energy spectrum part is also supposed to be generated due to the acceleration of the cosmic ray hadrons in shock produced by outflow, which expands and then collides with the wind of the primary black hole. The detection of GeV –TeV energy fluxes can help find the parameters of the configuration of the two-black hole system.

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Scattering properties of charged black holes in nonlinear and Maxwell' s electrodynamics

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We investigate the scattering properties of a massless scalar field in the background of a charged Ayón-Beato-García regular black hole solution. Using a numerical approach, we compute the differential scattering cross section for arbitrary values of the scattering angle and of the incident wave frequency. We compare our results with those obtained via the classical geodesic scattering of massless particles, as well as with the semiclassical glory approximation, and show that they present an excellent agreement in the corresponding limits. We also show that Ayón-Beato-García and Reissner-Nordström black hole solutions present similar scattering properties, for low-to-moderate values of the black hole electric charge, for any value of the scattering angle.

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Nuclear shape and orientation effect on the heavy-ion fusion cross-section

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The low-energy heavy ion fusion reactions play a crucial role in elucidating various aspects of nuclear physics as well as astrophysics. The dynamics of these heavy-ion fusion reactions depend upon the internal structure properties such as the deformations of the interacting target and projectile nuclei [1]. This study aims to explore the influence of nuclear shape degrees of freedom on the fusion

mechanism within the relativistic mean-field (RMF) approach [2]. The nuclear interaction potential is obtained by folding the well-known M3Y effective nucleon-nucleon (NN) potential with the axially deformed RMF densities [2]. The fusion barrier characteristics such as the barrier position and height are obtained at different orientations for the deformed ^{154}Sm target nucleus fused with spherical ^{16}O projectile. The fusion and/or capture cross-section is obtained within the Wong model [3] and the results are compared with the available experimental data [4]. The barrier characteristics and consequently the cross-section is observed to be significantly affected by the quadrupole deformation as well as the orientation of the target nucleus.

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New scalar Field Models and Their Relatives

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In this work, we investigate novel kinklike structures in a scalar field theory driven by Dirac-Born-Infeld (DBI) dynamics. Analytical features are reached through a first-order formalism and a deformation procedure. The description analyzed ensures the linear stability of the solutions found, and the deformation method permits to detect new topological solutions, given some systems of known solutions. The proposed models vary according to the parameters of the theory. However, in a certain parameter regime, their defect profiles are precisely obtained by standard theories. These are the models relatives. Besides that, we investigate the β−Starobinsky potential in the perspective of topological defects; and we have shown that it can support kinklike solutions, for both canonical and non-canonical kinetics. As a result, we proposed two new kinds of generalizations on the β−Starobinsky model, considering the DBI approach. Then, we explored their main characteristics in this modified scenarios.

These new models and their relatives can be useful to provide both the topological and cosmological inflaton solutions. While in the first case we look for static solutions with spatial dependence, in the second case we look for homogeneous solutions, i.e., time dependent only solutions. From the inflationary cosmology point of view, we need scalar dynamics that can roll slowly enough to get the precise amount of inflation to solve the horizon, flatness and monopole problem. One of the main problems in string theory or supergravity is to find such potentials able to develop this precise behavior. One has found several potentials in these contexts that are easily ruled out by the cosmological observational data. Thus several other approaches keeping some characteristics around fundamental theories as brane inflation, flux compactifications, to quote a few have been addressed in the literature. On the other hand, the DBI dynamics for being directly related to brane dynamics seems to be a good place to look for potentials that can overcome such difficulties. Same can be said to their deformed counterparts since the deformation can make an initial unsuitable potential to a final completely acceptable potential to describe inflationary cosmology. In this sense we consider one of the most celebrated potentials to describe dynamics of inflation, the Starobinsky potential, to address its deformation in the DBI dynamics. As we shall show, their relatives may find applications in both cosmology and (non-)topological solutions.

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On possible quantization of the fundamental tensor

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When the minimal length approach emerging from the gravitational consequences on the fundamental theory of quantum mechanics, the generalization of the noncommutative Heisenberg algebra, is applied on quantum mechanics, possible gravitization of quantum mechanics and quantization of metric tensor could be suggested. The resulting spacelike second-derivative of coordinate on relativistic eight–dimensional spacetime tangent bundle, Finsler spacetime, shall be substituted from a geodesic equation derived from a similarly extended Lagrangian density equation.

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A code that solves the Schrodinger-Poisson-Euler system with periodic boundary conditions

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We present a code that simultaneously solves the Schrödinger-Poisson (SP) system together with the Euler equations. We have developed a tool that allows the study interation between the scalar dark matter described by the SP system weakly coupled to the luminous matter modeled by the Euler equations through the Poisson equation using periodic boundary conditions in each of the system components. We describe the numerical methods used together with convergence tests in some simple scenarios. The boundary conditions in these simulations play a very important role since depending on the type of condition used, it can lead to different density profiles outside a galactic core. Our code uses periodic boundary conditions which allow the formation of core-halo structures.

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Effect of Landau quantization of the electron on neutron star crust within effective relativistic mean-field model

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The crystalline nature of neutron star crust is responsible for various fascinating observational effects such as the crustal moment of inertia, rotational frequency, quasi-periodic oscillations (QPOs) in soft gamma repeaters (SGRs), cooling etc [1, 2]. Most of the observed neutron stars possess a magnetic field of the order of 10^{15} G at the surface and much stronger in the solid crust (also known as magnetars) [3]. In light of this, the structure of the crust in the presence of magnetic field becomes essential to understand the magnetar equation of state (EoS). In this work, we present the outer and inner crust structures to study the role of electron energy quantization using the effective relativistic mean-field model (E-RMF). For outer crust, we minimize the Gibbs free energy using the pioneering variational formalism originally proposed by Baym-Pethick-Sutherland (BPS) [4]. We use the atomic mass evaluation of AME2020 [5], along with the Hartree-Fock-Bogoliubov (HFB) data for nuclear mass. To model the inner crust, which is explicitly model-dependent, we employ the compressible liquid drop model (CLDM) [6], used extensively in recent times for various problems of neutron star crust [7]. We study the effect of quantization of electron motion due to the magnetic field on various

crust properties such as the crust composition, transition properties such as density and pressure, pasta structure etc.

Keywords—Neutron star crust, Magnetic field, E-RMF, CLDM

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Decay properties of ^{253,255}Rf using the Relativistic Mean-Field Framework.

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Most neutron-deficient α-emitters are known to be of great relevance to the astrophysical rapid neutron-capture process (r-process) in superheavy nuclei [1, 2]. Thus, in this work, the decay properties of the newly observed 249No isotope from the α-decay of 253Rf [3] is theoretically investigated within the relativistic mean-field (RMF) framework [4,5] using the NL3* parameter set [6]. The α-decay chain of 255Rf is also considered. The RMF densities are folded with the R3Y NN potential to deduce the nuclear interaction potential between the decaying fragments. A balanced understanding of the penetration of an α-particle across the nuclear-Coulomb barrier gives an outstanding credence to the assumptions of quantum mechanics. The presence of shell/sub-shell closure is indicated by the formation of peaks along the decay chain and found to alter the conventional scaling factor of the preformed cluster-decay model (PCM) [5]. The calculated half-lives are in close agreement with the recent experimental measurement. The sensitivity of the nuclei around the shell closures can provide valuable information about the r-process abundance in this mass region.

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Origin of Emission in TeV J2032+4130 object of unresolved nature

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Cygnus Region contains many objects that are bright in all wavelengths, including one of the most powerful active star formation regions: Cyg OB2, pulsars, and supernova remnants. Some of the sources have been detected at high and very high energies. One of them was discovered due to the proximity to the well-known microquasar Cyg X-3 is TeV J2032+4130 object. This object is still of unresolved nature and is being intensively studied in the different energy ranges. The numerous X-ray point sources and diffuse X-ray emission regions were found within the TeV J2032+4130 region by Chandra and Suzaku. Intensities detected in X-rays from these regions may favor a scenario with the dominantly nucleonic, not electronic origin of TeV emission. The results of the twenty-year observation of the TeV J2032+4130 object by the SHALON experiment are presented. The collected experimental data on fluxes, spectrum shape, and morphology of TeV J2032+413 can help to determine the object's nature.

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Model dependence of the magnetic field effects on compact stars

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Compact stars possess the highest observed surface magnetic fields, and they are supposed to reach even bigger values at their centres. The magnetic field influences the mass, stability, size, and shape (magnetized stars are spheroidal) of compact objects. In the latest years, several theoretical models have been developed to analyse their role in the physics of these objects, sometimes leading to contradictory or opposite results. Here, we aim to establish to what extent the macroscopic features of magnetized stars will depend on the models used to compute them. To do so, we compute the observables of uniformly magnetized white dwarfs, strange stars, and Bose-Einstein condensate stars using two sets of structure equations. The equations of state of the stars that we considered take into account the anisotropy in the energy-momentum tensor caused by the magnetization, and the pressure and energy density of the magnetic field. To properly deal with the energy-momentum anisotropy, the space-times selected to construct the two sets of structure equations are axisymmetric, but besides that, the requirements and approximations of each macroscopic model are rather different. Both models are relatively simple since to construct them it is considered that the quantities inside the star depend only on one of the coordinates, giving, as a result, a set of ordinary differential equations. This has the advantage of a low computational cost and allows us to keep track of the approximations providing a better understanding of the physical origins of the characteristics of the stars. We found that, in general, the effects of the magnetic field predicted by each set of structure equations are consistent, and for the stable stars depend mostly on the equation of state.

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Effects on the WIMPs capture efficiency in the neutron star temperature surface

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Surface temperatures of neutron star have been used as a probe for weakly interacting dark matter (WIMPs) models. While this is masked by a variety of heat sources at young age, in later stages of neutron stars the capture of dark matter by the star, after thermalization, renders a steady state and becames equal to photon emission. In this way, the heat generate by dark matter can rise the internal temperature, which is in turn reflected by the surface temperature . We study the framework of contact operators which are applicable for the DM capture in the limit that the transfer momentum is small compared to any intermediate particles. We also take into account the vector-vector interaction between dark matter and neutrons within a fermionic dark matter model. This kind of operators is spin-independent (and thus have a much better chance of first direct detection discovery), have a cutoff scale lambda and quark Yukawa coupling as required by minimal flavor violation. We find that the surface temperature of neutron star due this mechanism is reduced and constrain the cutoff lambda using the collider condition.

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Systematic analysis on α-decay of the superheavy elements within the relativistic mean-field model

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Theoretical and experimental investigations of the α-decay properties of superheavy nuclei are the key parameter for understanding the nuclear structure and reaction dynamics. A comprehensive analysis of the α-decay half-lives underlying 55 superheavy nuclei with $100 \leq Z \leq 120$ is performed within the axially deformed relativistic mean-field (RMF) formalism using the NL3* parameter set[1]. The α-decay energies (Q-values) are calculated from the RMF binding energies and are compared with the available experimental data [2] as well as the theoretical global nuclear mass model WS4 [3]. To evaluate the relative numerical dependency of the half-life for specific α-decay energy, the decay half-lives are calculated using four different formulae, namely; the modified Viola-Seaborg formula (MVS), modified scaling law Brown formula (MSLB), Yibin et al. formula (YQZR), and modified Yibin et al. formula (MYQZR) [4]. For all chosen nuclei, we observe a strong dependence of the half-life on the decay formula. Like the UDL and MUDL, the decay energy and predicted half-lives for YQZR are found to be congruent with experimentally determined half-lives [5,6]. From the microscopic perspective, the current study can be beneficial for the future experiment in the superheavy region.

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Structure Formation in Modified Gravity Models

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In this work, the structure formation for different modified gravity models will be described: Brans Dicke, $f(R)$, DGP, Symmetron. Such description is made through cosmological simulations carried out with the MG-PICOLA code that follows the COmoving Lagrangian Acceleration method. From them, the mass power spectrum is obtained, which we will compare with the resulting ones for the cosmological standard model ΛCDM.

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Cosmology of a Chaplygin gas model under f(T) gravity and evolution of primordial perturbations

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This work investigates the cosmological application of interacting modified Chaplygin gas in the f(T) gravity framework, where T is the torsion scalar. The interacting MCG has been found to have the equation of state (EoS) parameter behaving like quintessence. However, the f(T) gravity reconstructed via the interacting MCG has been found to have EoS crossing the phantom boundary of -1. Thus, one can generate a quintom-like EoS from an interacting MCG model in the flat universe in the modified gravity cosmology framework. Cosmological evolution of primordial perturbations has also been investigated and the self-interacting potential has been found to increase with cosmic time and the squared speed of sound has been found to be non-negative.

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Cosmological bounce in a modified gravity framework

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In the present study, we have considered a scale factor corresponding to the bouncing universe. For this scale factor, we have demonstrated the reconstructed f(T) gravity in presence of bulk viscosity. The bulk viscosity coefficient has been chosen as a function of the Hubble parameter. In presence of this bulk viscous pressure, we have checked how the equation of state parameter is behaving in a bouncing universe. Also, the generalized second law of thermodynamics has been tested. Finally, we have discussed how this bounce can occur with the scalar field model.

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Studying remapping effects on 21cm mocks

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In this work we extend the remapping method proposed by Mead and Peacock (MNRAS 440, 1233–1247 (2014)). This method allow us to remmap N-body simulations catalogues from one cosmology into another different cosmology directly without necessity of running an N-body simulations for each cosmology. On the other hand, it is well known that 21 cm mocks are constructed from, for example, halo or galaxy N-body simulations catallogues. Here we are interested in extending and validating, Mead and Peackok method to the 21 cms mocks conctructions. This will allows to construct 21cm intensity maps in different cosmologies in a more computationally eficient and faster way. The resulting mocks are going to be used in the BINCO telescope analysis.

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The effect of rotation on α-decay half-lives even-even ^{254,256}Rf isotopes using different semi-empirical formulae

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The present work is a theoretical study on the α-decay half-lives of the even-even ^{254,256}Rf isotopic chains using six different semi-empirical formulae, namely, the Viola-Seaborg semi-empirical formula (VSS), Modified Brown formula (mB1), Semiempirical formula based on fission theory (SemF IS2), Royer Formula (R), Wang Formula (wang), and Modified YQZR formula (MYQZR)[1]. The predictive accuracy of each of these formulae is evaluated by comparing them to the experimental data[2]. The decay energies (Q_α) for the alpha decay chain are calculated from the relativistic mean field (RMF) formalism [3] using the PC-PK1 parameter set [4]. Furthermore, the effect of rotation on the stability of these neutron-deficient nuclei is separately appraised. Our calculation reveals that the relative dependency of the employed formulae is hinged on their constituents. Thus, the modified YQZR formula of α-decay half-lives gives a closer agreement with the experimental measurement due to its inclusion of the asymmetry terms. The relevance of this study in the superheavy region to astrophysics is concisely discussed.

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The modification and application of the Neutrino Rocket Jet Model by long-period pulsars

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With the increase of pulsar observation data, it is found that the relationship between the spin period P and its derivative P_{dot} of a long-period pulsar in the $P - P_{dot}$ diagram cannot be described by the standard magnetic dipole radiation (MDR) model. Recently, in order to explain pulsars' high-speed proper motions, we have proposed a Reutrino Rocket Jet Model (Li et al. 2022,ApJ,931,123),which is a potentially competitive model to explain the relationship between the spin periods and their derivatives of long-period pulsars. Benifitted by a increase in the number of long-period pulsars with

$P > 10S$, we have made approximate calculations for the Neutrino Rocket Model, and discussed the model parameters related. Finally, we use this modified Neutrino Rocket Jet Model to discuss the related properties of five recently-discoved pulsars with long-periods.

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Scattering-state solutions to the Dirac spinors with negative-energy eignstates in a rotating spheroid

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Based on our previous work of Fu et al.\,(2020), we derive the rest seven scattering-state ($\chi^{(0)}, \phi^{(1)}, \chi^{(1)}, \phi^{(2)}$, $\chi^{(2)}, \phi^{(3)}$ and $\chi^{(3)}$) solutions to the Dirac equation when $E = -im \pm ik \approx -im$, and establish a relation between differential scattering cross-section, $\sigma_{i*}(p, \theta, \varphi)$, and stellar matter density, μ, using the long-wave approximation. It is found that the sensitivity of average scattering cross-sections $\bar{\sigma}_i(p, \theta)$ to the change
in μ is proportional to μ^2. We find that the average scattering amplitudes $\bar{f}_i(p, \theta)$, as well as average scattering cross-sections $\bar{\sigma}_i(p, \theta)$, are independent of the mass of particles, m, for four scattering-states\,$\chi^{(i)}$, i=0,1, 2 and 3, while $\bar{f}_i(p, \theta)$ and $\bar{\sigma}_{i*}(p, \theta)$ depend on m, for the rest four scattering states,$\phi^{(i)}$, i=0,1, 2 and 3.
This work will be useful in understanding the properties of anti-Dirac spinors and the physical effects in a rotating spheroid.

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Shell-type Supernova remnants and very high energy Cosmic rays

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The investigation of supernova remnants at very high energy gamma-rays touches on the problem of the cosmic ray origin and, accordingly, the role of the Galaxy in their generation. As the presence of the electron cosmic-ray component is clearly seen by the emission generated by it in an SNR in a wide wavelength range, from radio to high-energy gamma-rays, while the nuclear cosmic-ray component can be detected only by very high energy gamma-ray emission. Recent observations at TeV energies have yielded the results on Galactic supernova remnants (SNR) of different ages. Among them are the shell-type SNRs: Tycho's SNR, Cas A, IC 443, γCygni SNR, G166.0+4.3 as well as the classical nova GK Per. Observational results like spectral energy distribution and emission maps are compared with other experimental data at high and very high energies. TeV images of SNRs by SHALON are overlaid with ones obtained with X-ray experiments Chandra ACIS, ROSAT, and radio-observations from Canadian Galactic Plane Survey DRAO in order to compare SNR TeV gamma-ray morphology with structures viewed through the X-ray and radio images and revealed its essential features. Also, the spectral energy distributions of discussed SNRs together with the theoretical predictions are shown. The collected experimental data confirm the prediction of the discussed models and estimations about the hadronic generation mechanism of very high energy gamma-rays in the Tycho's SNR, Cas A, IC 443, γCygni SNR and can help to solve the problem of cosmic ray origin.

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Generation of Cosmic Rays in Pulsar Wind Nebulae

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The overall observations of plerions from radio to the very high energy gamma-rays could provide information about the evolution of PWN from the young Crab-like stage to the older plerion stages. Geminga is a nearby (250 pc) and middle-aged pulsar of 3.4×10^5 years. The Geminga pulsar wind nebula was detected in X-rays, and the detailed studies reveal the morphological and spectral variability, which may raise a high energy emission. The extended MeV-TeV emission from Geminga in SHALON, Milagro, HAWC observations, and Fermi-LAT detection and upper limits could arise from the PWN associated with the Geminga SNR. 3C 58 is similar to the Crab Nebula (explosion of the 1054 year) on many parameters, but these two objects differ significantly in luminosity and size at X-rays and radio-emission. The 3C 58 estimated age varies from ~800 to $(5-7) \times 10^3$ years. MeV-GeV The gamma-ray emission from the nebula has been detected by Fermi-LAT. The gamma-ray source associated with the 3C 58 was detected above 800 GeV for the first time by SHALON in observations of 2011year and systematically studied since then. The overall spectral energy distribution and information about the extension of PWN from radio to GeV-TeV energies can contribute to particle transport models and also to the understanding of the mechanisms of PWN expansion, which is, in turn, can shed light on the age of 3C 58 and the history of progenitor SN explosion.

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AstroSAt observed broad-band Thermonuclear X-ray (Type-1) Bursts: 4U 1702-429

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We present the detection of 3 thermonuclear type-1 X-ray bursts in the LMXB neutron star 4U 1702-429. The data with the AstroSat payload SXT and LAXPC instruments. It is characterized by the bursts having a sharp rise and slow decay, representing the burning of H/He mixed fuel. We perform the time-resolved spectroscopy of bursts. We used three different techniques to analyze the bursts spectra. In the beginning, the assumptions have been followed that the presistent spectra remain constant during the bursts and reveal Planck's feature black body temperature and flux throughout the bursts. Further, we used the scaling factor to the persistent emission (fa method) and found the fa value significantly immense at peak emission of the bursts. The elevation of fa indicates the expansion of pre-burst emission, especially near the peak. The flux ratio in both of phenomena introduce the new component in bursts emission. At last, we employed a thermal comptonization model to show the emission may be reprocessed from the star's corona and disk.

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Thermodynamics of a scale-invariant nonlinear sigma model

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A variational resummation technique incorporating renormalization group properties has been proposed as an alternative to solve the scale dependence problem which plagues the evaluation of thermodynamical quantities within the framework of approximations such as HTLpt (Hard Thermal-Loop Perturbation Theory). Here, this new method is used to evaluate the pressure of an interesting theory that naturally displays asymptotic freedom, the nonlinear sigma model (NLSM), which is renormalizable in 1+1 dimensions and also displays trace anomaly and the generation of a mass gap as Yang-Mills theories. Among the works based on this model, its thermodynamics has been evaluated at LO (leading order) and NLO (next to the leading order) within the 1/N expansion as well as within the model calculated on a lattice. However, none of these applications has treated the NLSM scale-invariance. Then our first step within the NLSM was to look for a way in which it could, simultaneously, be subject to the renormalization group properties and the OPT (Optimized Perturbation Theory), using the Renormalization Group Improved OPT (RGOPT) to evaluate the pressure of the NLSM. We show, considering only the first trivial contribution, the convergence of the RGOPT, as well as its scale invariance properties. Therefore, the work presented here supports the RGOPT as a robust nonperturbative method that can eventually be applied to QCD at finite baryonic densities where, so far, LQCD predictions are not possible.

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Effects of a non-universal IMF and binary parameter correlations on compact binary merger populations

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Binary population synthesis (BPS) provides a direct way of studying the effects of different choices of binary evolution models and initial parameter distributions on present-day binary compact merger (BCM) populations, which can then be compared to empirical properties such as observed merger rates. Samples of zero-age main sequence (ZAMS) binaries to be evolved by BPS codes are typically generated from a universal IMF and simple, uniform, distributions for orbital period P, mass ratio q and eccentricity e. More recently, however, mounting observational evidence has suggested the non-universality of the IMF and the existence of correlations between binary parameters. In this study, we implement a metallicity- and redshift-dependent IMF alongside correlated distributions for P, q and e in order to generate representative populations of binaries at varying redshifts, which are then evolved with the COMPAS rapid BPS code in order to study the variations in merger rates and overall population properties.

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Pulsar Timing Irregularities using Indian Radio Telescopes (uGMRT and ORT)

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Pulsars are rotating neutron stars emitting a beam of radio light from the magnetic axis. They are known to have extreme stable periods. However, two types of rotational irregularities are seen in pulsars: glitches and timing noise. Glitches are the sudden jumps in the rotational frequency whereas timing noise is the slow wander of the rotational period of the pulsar. Both of these phenomena are indirect probes to the neutron star interior composition and dynamics. This talk will present a brief overview of the various observational and theoretical aspects of pulsar timing irregularities

and the major results from the investigations of these phenomena using Indian radio telescopes: the upgraded Giant Metrewave Radio Telescope (uGMRT) and Ooty Radio Telescope(ORT). The talk will also highlight the possible contributions of Indian astronomers and astrophysicists in such programs with the future telescope like the Square Kilometer Array (SKA).