PPGF UNIFAL-MG/UFSJ International Conference on Multimessenger Astrophysics

Report of Contributions

https://agenda.infn.it/e/40916

Contribution ID: **6** Type: **Poster Presentation**

Cálculo analítico e numérico das frequências do campo escalar no buraco negro BTZ

Neste trabalho consideraremos uma dimensão métrica $2+1$, o buraco negro BTZ (métrica BTZ), considerando a equação de Klein Gordon, que levará em conta a métrica BTZ, usamos um anzat, podemos chegar a uma equação diferencial de $R(r)$, que tem uma forma semelhante à equação de Schrödinger na mecânica quântica. Podemos calcular as frequências dada a equação diferencial em $R(r)$, para isso utilizamos a equação diferencial da função hipergeométrica, esta nos dará as soluções analíticas. Por outro lado, também podemos calcular essas frequências utilizando séries de potências, encontramos uma relação de recorrência, que depende da frequência, sob certas condições podemos calcular as frequências, para isso utilizamos o software MATHEMATICA,o último corresponde à solução numérica.

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Session Classification: Poster Presentation

Contribution ID: **7** Type: **Poster Presentation**

ONDAS GRAVITACIONAIS EMITIDAS POR SISTEMAS TRIPLOS

Este trabalho têm como objetivo analisar sistemas triplos hierárquicos com foco em obter as características das ondas gravitacionais que emitem. Começamos esta investigação com a definição fundamental de onda gravitacional e fomos gradativamente conceituando elementos necessários para abordar o nosso problema específico. Trata-se de uma construção analítica que incorpora o conhecimento sobre a emissão de ondas gravitacionais provenientes de sistemas binários, que serão estendidos para a construção da análise dos sistemas triplos hierárquicos. Buscamos estabelecer uma conexão entre as propriedades do sistema triplo, como massas e distância dos objetos, e as características das ondas gravitacionais emitidas, como faixa de frequência e amplitude máxima. Essas caracterizações nos capacitarão, no futuro, a direcionar a busca por sinais de sistemas triplos hierárquicos com base nas medições realizadas pelos observatórios atuais, como LIGO, Virgo e KAGRA.

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Session Classification: Poster Presentation

Contribution ID: **8** Type: **Poster Presentation**

Enhancing Energy Efficiency in Electric Vehicles: The Role of the Torque Converter in Sustainable Mobility

The article explores the use of torque converters (gearboxes) in electric vehicles to optimize energy efficiency and sustainable mobility. A cargo tricycle was modified to include a 1000 W electric motor and a bicycle gear system. Tests conducted on a 12 km circuit showed that the first gear (higher torque and lower speed) consumed less energy compared to higher gears, which provide lower torque and higher speed. The results indicated that torque variation significantly influences energy consumption, with higher gears increasing consumption without a corresponding increase in average speed. It was concluded that the inclusion of a gearbox can be advantageous for electric vehicles, providing flexibility and better performance in different usage conditions. Future studies will aim to optimize the relationship between inclination, speed, gear ratio, and consumption.

Keywords: Electric vehicles; Efficiency; Torque converter; gearbox.

Primary authors: PAMPLONA DA SILVA, Daniel Juliano (UNIFAL-MG); BAZIOTTI, Thiago de Almeida (UNIFAL-MG); MANDAI, Ícaro Hissao Rocha (UNIFAL-MG)

Session Classification: Poster Presentation

Contribution ID: **9** Type: **Poster Presentation**

Recurrence Plots in Gravitational Waves emitted by Binary Neutron Star Mergers

Recurrence analysis is a method for visualizing the dynamics of a system given its time-series. In the case of Binary Neutron Star mergers, we use the simulations of the CoRe Database to identify possible patterns in their recurrence plots so it can be possible to characterize them. If particular patterns are effectively found, then the recurrence analysis can be a complementary tool to analyze the gravitational wave signals for this kind of mergers. In this work, we visualize some examples of the patterns that would characterize the inspiral and the post-merger stage in a binary neutron star coalescence.

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Session Classification: Poster Presentation

Contribution ID: **11** Type: **Poster Presentation**

The Method Of Detection Of Gravitational Waves By Interferometry And The Method Of Detection Of Neutrinos By Cherenkov Radiation

The simple Michelson interferometer is used as the basic method for detecting gravitational waves (GW). The arms of the ideal interferometer are hundreds of kilometers long, so it is necessary to implement a Fabry-Perot cavity (FP) to amplify the signal and detect the gravitational wave in a smaller-scale interferometer. The objective with the interferometer is to observe a phase difference in the electric field that propagates in the directions of the two arms, due to the passage of the gravitational wave. The neutrino detection method can be done using Cherenkov radiation. When the neutrino collides with an atomic nucleus in which the particle's speed is greater than the speed of light in the material medium, the product of this interaction can emit Cherenkov radiation. Then the emitted light is detected by optical sensors, allowing the trajectory and energy of the original neutrino to be reconstructed.

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Session Classification: Poster Presentation

Contribution ID: **12** Type: **Poster Presentation**

Dynamics of Accelerated Waves

This work aims to study higher-order field equations. To achieve this, starting from the equations of motion of coupled one-dimensional oscillators, we derive a set of fourth-order equations using the method of order-elevation decoupling. In the continuous limit, we identify a fourth-order field equation that generalizes the classical wave equation. This equation can describe waves with propagation acceleration, such as those propagating through heterogeneous mediums or crossing interfaces between different materials. We obtain a solution to this field equation using specific conditions. We conclude that, for high accelerations and low-frequency vibrational modes, the description can be approximated by a classical wave, but for high frequencies, an exact solution is necessary. This study is ongoing with an approach via singular perturbation theory.

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Session Classification: Poster Presentation

Contribution ID: **13** Type: **Poster Presentation**

Study of the Inflationary Paradigm

The General Relativity (GR) presents limitations that have been observed in the power spectrum of the Cosmic Microwave Background (CMB). For instance, there are issues like the horizon problem, flatness problem and superhorizon correlations. In this work we study inflation, a theory proposed as an extension to the standard cosmological scenario to address these issues, which is characterized by a primordial exponential accelerated expansion. We present the parameters ε and η that guarantee that inflation can last long enough to provide a region of causality and stretching of the curvature of space-time. Subsequently, we study the dynamics of the scalar field ϕ by calculating the specific equation of motion that governs it, based on the FLRW metric. Besides that, with the pressure derived from the continuity equation, we have the condition that allows for the inflationary potential to act as a cosmological constant. Furthermore, we present the slow-roll mechanism for the scalar field and its respective approximations for the parameters ε_V and η_V. Finally, we exemplify the theory with a quadratic potential and analyze under which conditions such potential leads to inflation.

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Session Classification: Poster Presentation

Contribution ID: **14** Type: **Poster Presentation**

Estudo do sistema de suspensão criogênica que comporá novas gerações de interferômetros a laser para observação de ondas gravitacionais

O Laser Interferometer Gravitational-Wave Observatory (LIGO) é um instrumento projetado para detectar ondas gravitacionais. As detecções do LIGO confirmaram a última previsão restante da Teoria da Relatividade Geral e inauguraram uma nova era da astrofísica de ondas gravitacionais, uma vez que os observatórios de ondas gravitacionais têm o potencial de observar diretamente a história inicial do Universo. Para melhorar a sensibilidade em um fator adicional de dois e reduzir pela metade o limite de baixa frequência para 10 Hz, está sendo planejada uma melhoria de terceira geração para o observatório chamada "LIGO Voyager". Esta nova geração está planejada para operar a uma temperatura de 123K, devido ao coeficiente de expansão térmica zero do silício nesta faixa. Nesse sentido, é necessário adaptar os componentes para operar em condições criogênicas, especificamente o sistema de suspensão. Este estudo produziu resultados preliminares em relação aos materiais com propriedades adequadas para compor o sistema de anti-molas criogênicas. O protótipo desenvolvido para obter os dados provou ser um modelo muito satisfatório, embora alguns ajustes sejam necessários para reforçar sua estrutura e a qualidade dos dados obtidos. Um segundo protótipo está em desenvolvimento com o objetivo de ser mais resistente às deformações e automatizar processos para aprimorar a coleta de dados. Materiais como tungstênio, nióbio, ligas de titânio-vanádio e aço inoxidável mostraram ser candidatos promissores que passarão por novas rodadas de medições. Observou-se também que quase todos os materiais, com exceção da liga titânio-vanádio, exibiram constantes elásticas mais altas em condições criogênicas. O molibdênio não é um candidato adequado, pois atinge seu ponto de ruptura em condições criogênicas. O maraging steel é um candidato que também será testado nesta segunda rodada de testes. Após a caracterização dos materiais e seleção dos mais promissores, serão confeccionadas anti-molas para acoplamento no sistema de multi-pêndulo aninhado, onde será possível realizar medições na câmara criogênica para determinar a função de transferência desse sistema com o uso de molas compostas por esses materiais.

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Session Classification: Poster Presentation

Contribution ID: **15** Type: **Poster Presentation**

Reused Notebook Batteries: A Sustainable Solution

This study explores the reuse of notebook battery cells in off-grid, or autonomous, photovoltaic systems, emphasizing the economic and environmental viability of this practice. The selection criterion, based on the cell charge capacity (Ccel ≥ 2000 mAh), has been shown to be robust, enabling the efficient use of these cells in batteries for off-grid systems. The cost analysis compared the assembly of batteries using reused and new cells, demonstrating the economic advantage of the former. Furthermore, the finding that about half of the 18650 cells discarded by notebook users are still usable highlights both the environmental value and the sustainability of this practice.

The study also underscores the importance of considering the entire life cycle of materials used in autonomous photovoltaic systems, aiming for a more sustainable and efficient approach. Incorporating reused 18650 cells not only reduces costs but also helps decrease electronic waste and utilizes resources already available in the market.

The results presented in this work provide valuable insights for the implementation of off-grid photovoltaic systems using reused notebook battery cells. The economic, environmental, and technical implications are discussed in detail, paving the way for future research and developments in this area. Reusing notebook battery cells appears as a promising solution to enhance the accessibility and sustainability of off-grid photovoltaic systems, aligning with the principles of a circular economy and efficient resource use.

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Session Classification: Poster Presentation

Contribution ID: **16** Type: **Poster Presentation**

Using Quantum Espresso to study optical properties of ZnO

This poster aims to introduce and elucidate the combined use of Density Functional Theory (DFT) and quantum mechanics for investigating the optical properties of metal-oxide semiconductors (MOS). The study of ZnO as a semiconductor experienced significant peaks in 1990 and 2010. In 2010, over 5,000 publications contained ZnO in the title, abstract, or keywords. This occurred because ZnO possesses a wide range of properties, depending on doping, including conductivity ranging from metallic to insulating, high transparency, piezoelectricity, wide bandgap semiconductivity, room temperature ferromagnetism, and significant magneto-optical, and chemical sensing effects. Due to these properties, there has been a significant increase in the number of relevant publications.

Because of the applications such as in solar cells, gas sensors, and photocatalysts, ZnO has garnered significant attention among metal oxide semiconductors (MOS). ZnO is characterized by a direct wide bandgap (~3.3 eV) and possesses a large exciton binding energy of 60 meV. These properties render it particularly intriguing as a laser material, with the potential for exciton recombination at room temperature or even higher. One of the challenges is to obtain a p-type doping for ZnO, which has been investigated by several researchers.

ZnO crystallizes in the wurtzite structure and has probably the richest variety of different nanostructures. Wurtzite structure has basic hexagonal symmetry. The two hcp lattices have the same axis \((a_{\textsubscript{3}}\text{-axis}) \) but one of them is displaced with respect to the other. The wurtzite structure may be considered as an hcp structure with a basis of two atoms. It also has uniaxial symmetry and a number of piezoelectric and pyroelectric crystals possess this structure.

Although GaN is considered the best candidate for optoelectronic devices, ZnO offers significant advantages for LEDs and LDs due to its wide and direct bandgap, as well as a high excitonic binding energy. ZnO exhibits excellent radiation resistance, making it suitable for space applications and high-energy radiation environments. Its bandgap energy can be adjusted through alloying processes, enabling its use in heterostructured LEDs and quantum well lasers. These features make ZnO a rich family of nanostructures with diverse promising applications. ZnO, a wide bandgap semiconductor, emerges as a promising candidate to replace conventional materials in various applications, including solar cells. Theoretical physics offers a powerful approach to explore these possibilities through quantum mechanical simulations, enabling the study of material behavior, such as in ZnO.

This work delves into the application of the Quantum ESPRESSO package to calculate band structures, density of states, and optical properties of ZnO. We highlight both the limitations and advancements of this package in recent years for MOS studies. The presentation will delve into the different calculations, approximations, and generalizations possible within QE, emphasizing the key distinctions between GGA and hybrid functional-based calculations. We will also discuss the theoretical, mathematical, and computational aspects of these methods, along with their operational and computational costs. The primary areas of knowledge covered in this poster include solid-state physics, quantum mechanics, and computational simulation.

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Session Classification: Poster Presentation

Contribution ID: **18** Type: **Poster Presentation**

Preliminary Studies on Black Holes

The investigation of black holes (BHs) and their properties is a subject exerting considerable attraction among those interested in the universe and its astrophysical content. This context motivated the studies conducted by the authors on black hole physics. Their methodology included a bibliographic review of papers and books addressing the theme pedagogically. We start with a historical introduction that highlights the importance of these fascinating objects, we proceed to establish the physical concepts underlying BHs, we qualitatively explore some topics in Einstein's theories of Special Relativity and General Relativity. In particular, we write down the Minkowski metric and Schwarzschild metric, and begin the journey of characterizing them quatitatively (e.g. through understanding their causal structure). The Schwarzschild metric is fundamental to understanding the so-called Schwarzschild BH, a spherical and static object that models the outer region of a massive star that has extinguished its nuclear fuel and collapsed under its own gravity (or curvature). We will present a summary of these preliminary Scientific Initiation studies in our poster.

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Session Classification: Poster Presentation

Contribution ID: **19** Type: **Poster Presentation**

Field equations of General Relativity via the variational principle

In the present work we deduce the field equations of General Relativity through the variational principle. By establishing an action S_g for the gravitational field and by taking its variation, it is possible to obtain Einstein's field equations in vacuum. Once the vacuum field equations have been deduced, it is possible to conclude that the interaction of matter with the gravitational field occurs through the energy-momentum tensor $T_{\mu\nu}$. Then, we obtain the field equations in the presence of a source by defining an action S_m for the matter involving $T_{\mu\nu}$, adding the action S_g for the gravitational field, and taking the variation with respect to $g^{\mu\nu}$. Finally, the variation of action for matter also leads to a definition of the energy-momentum tensor $T_{\mu\nu}$ in terms of the variation of the Lagrangian density of matter $\mathcal{L}_m$ with respect to the metric of the gravitational field.

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Session Classification: Poster Presentation

Contribution ID: **20** Type: **Poster Presentation**

Superradiant scattering in Bopp-Podolsky wormholes

Superradiance is a physical phenomenon involving the amplification of incident electromagnetic radiation through the extraction of energy from a system. This work analyzes the conditions for the occurrence of superradiance in electrically charged, spherical, and static wormholes, using Podolsky's generalized electromagnetic theory. Given a metric representing the wormhole and its electric field, minimal coupling is applied in the Klein-Gordon equation to determine the necessary conditions for superradiance in the solution of the radial equation. By using Maxwell's electromagnetic theory as a limiting case for generalized electrodynamics, we aim to estimate the parameter arising from the non-minimal coupling in Podolsky's theory. We estimate the reflection coefficient of an electromagnetic wave scattered by a wormhole in Bopp-Podolsky electrodynamics. Preliminary results are presented based on the approximation $\Delta_{00} \approx \Delta_{11}$ in the Bopp-Podolsky wormhole metric, justified by the low relative percentage error between the terms Δ_{00} and Δ_{11} of the metric components.

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Session Classification: Poster Presentation

Contribution ID: **21** Type: **Poster Presentation**

From Theory to Reality: A Historical Approach to Detecting Gravitational Waves

This work aims, through a historical approach, to demonstrate the trajectory of the discovery of gravitational waves predicted by Albert Einstein over a century ago as part of his theory of general relativity.

We are exploring the path that led to the confirmation of these elusive waves, from their initial theoretical indications of existence in the 1910s to the construction of current detectors like Virgo and LIGO, which allow us direct observation of the phenomenon.

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Session Classification: Poster Presentation

Contribution ID: **22** Type: **Poster Presentation**

Gravitational Waves in the Primordial Universe

This work aims to study gravitational waves in the primordial universe. Using the short wave approximation, it is possible to find the propagation equations of gravitational waves in a curved background. These equations make it possible to find the gravitational waves emitted in the primordial universe, using the FLRW metric, which is the standard metric for cosmology studies.

Keywords: Gravitational Waves. Shortwave approximation. Curved background Universe

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Session Classification: Poster Presentation

Contribution ID: **23** Type: **Poster Presentation**

Newtonian Stellar models

This article will study stellar parameters, based on equations and notions of theoretical physics, demonstrating how it is possible to obtain and understand the Lane-Emden equation, analyzing some aspects in a didactic way.
A Python computational language was used, attached to a numerical resolution method known as Runge-Kutta, with these tools it was possible to build some graphics and a data table, which relates the stellar parameters with the indexed numbers of the theoretical model.

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Session Classification: Poster Presentation