IWARA2018 - 8th International Workshop on Astronomy and Relativistic Astrophysics

Saturday 8 September 2018 - Saturday 15 September 2018

Book of Abstracts

The event is the eighth in a series of meetings gathering scientists working on astroparticle physics, cosmology, gravitation, nuclear physics, and related fields. As in previous years, the IWARA 2018 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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Inka Astronomy

Author: Milton Rojas Gamarra[1]

[1] *Physics Department, Faculty of Science, UNSAAC*

The Inkas had their own "Science", in all areas of knowledge. In this contribution, we will present their ancestral knowledge which refers to Astronomy, mainly we will present its constellations. This study is based on the triangulation of the chronicles, oral tradition and the complexes and archaeological elements that we can still locate.

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Cosmology of the Incas

Author: Steven Gullberg[1]

[1] *University of Oklahoma*

The Incas worshipped the Sun, with light and shadow effects in their constructs commonly denoting such events as the solstices and equinoxes. They as well honored and venerated many features of both natural and man-made landscapes that they felt to be endowed with superhuman powers. In Quechua, these shrines were known as huacas, and at the time of the Spanish conquest there were thousands of them. Soon after subduing the Inca empire, the Spaniards began a campaign against the indigenous religion that included a systematic eradication of huacas. Shrines that were large carved stones and outcroppings survived, however, and were subjects of this research for astronomical orientations marking significant solar events.

The Incas built multiple towers on the horizons of Cusco to mark the positions of the rising or setting Sun on specific dates of the year. They used these solar pillars to mark time passage for purposes of crop management and religious festivals. All were destroyed. Beyond Cusco, however, two solar pillars overlooking the modern village of Urubamba escaped the Spanish purge. This research has verified, when viewed from a large granite boulder in the center of the Huayna Capac's palace, Qwespiwanka, that they mark the position of the rising Sun at June solstice. Additionally, from the same boulder and in the direction of the December solstice sunrise, are located enigmatic stone structures on the summit of Cerro Unoraqui.

Below Machu Picchu, near the Urubamba River, lies a large and complex shrine initially identified by Hiram Bingham as the Urubamba Intihuatana. The massive granite stone lies between the Sacred Plaza of Machu Picchu and the Sun Temple of Llactapata along the axis of the June solstice sunrise and December solstice sunset. With the scientific discovery of Llactapata in 2003 came the realization that a great ceremonial complex once existed between Machu Picchu, the River Intihuatana, and Llactapata.

These and other examples of Inca astronomy are explored in this paper. The approach is a holistic one in that it considers multiples levels of meaning including cultural motifs, topographic and astronomical contexts, sightlines, as well as light and shadow effects throughout the year, especially at times of the solstice, equinox, zenith and anti-zenith suns. Astronomy was thoroughly interwoven throughout many facets of Inca society.

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Thermodynamics of noncommutative black holes

Author: Eri Mena[1]

Co-authors: Lenin Escamilla Herrera [2]; Andrés Crespo Hernandez [1]; Miguel Sabido Moreno [3]; José Torres Arenas [3]

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[2] *UNAM*

[3] *Universidad de Guanajuato*

We study the noncommutative formalism for black holes and their thermodynamics properties in the classical and quantum scenarios.

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Some remarks on black holes with fluid of strings: solutions, thermodynamics and Hawking radiation

Authors: Valdir Bezerra[1]; Geusa Marques[2]; Jefferson Toledo[1]

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[2] *Universidade Federal de Campina Grande*

In the early 1980´s, Letelier introduced a gauge invariant model of a fluid of strings with the aim to treat gravity coupled to these array of strings, in the framework of general relativity. Thus, using the fluid formed by strings as a source of the gravitational field, he obtained a solution of the Einstein equations corresponding to a spherically symmetric space-time. In the case of spherical symmetry, he obtained a generalization of the Schwarzschild solution to the one corresponding to a black hole surrounded by a spherically symmetric fluid of strings.
These results were based on a similar formalism introduced by him, to treat a cloud of strings, which means that the pressure is not taken into account. In this scenario, he obtained a class of solutions of the Einstein equations corresponding to plane-symmetric, spherically and cylindrically symmetric space-times.
The main motivation to construct those models was based on the fact that the universe can be represented, in principle, by a collection of extended objects, like one-dimensional strings, rather than of point particles, in a more appropriate way.
Recent theoretical developments suggest that it is necessary to consider extended objects because they offered a potential alternative to be used as the fundamental elements to describe physical phenomena which occur in the universe. From the gravitational point of view, it is important to investigate, for example, a black hole immersed in a fluid of strings, due to the fact that these sources have astrophysical observable consequences.
In this talk, we obtain the solution corresponding to a static and spherically symmetric charged de Sitter-anti de Sitter black hole immersed in a fluid of strings. We discuss some aspects of the thermodynamics. We also present a discussion about Hawking radiation of particles, in the background under consideration.

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Particle motion analysis in a regular black hole solution

Author: Katharine Ivette Cuba Quispe[1]

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The main goal of this work is to analyze the motion of diferent types of particles in a regular black hole solution obtained by Bronnikov in 2001. The trajectories are obtained through numerical integration of the equations of the orbits (using the program Maple), after the analysis of the effective

potential of each case. The results are compared to those of the Reissner-Nordstrom black hole. It is also important to mention that we look to expand this work to study the energy conditions at the center of the regular solution. Due to Raychaudhuri's theorem, the regularity of the solution has to do with the violation of the strong energy condition.

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Non-linear perturbation of black branes at large D

Author: Umpei Miyamoto[1]

[1] *Akita Prefectural University*

The Einstein equations describing the black-brane dynamics both in Minkowski and AdS background were recently recast in the form of coupled diffusion equations in the large-D(imension) limit. Using such results in the literature, we formulate a higher-order perturbation theory of black branes in time domain and present the general form of solutions for arbitrary initial conditions. For illustrative purposes, the solutions up to the first or second order are explicitly written down for several kind of initial conditions, such as a Gaussian wave packet, shock wave, and rather general superposed sinusoidal waves. These could be the first examples describing the non-trivial evolution of black-brane horizons in time domain. In particular, we learn some interesting aspects of black-brane dynamics such as the Gregory-Laflamme (GL) instability and non-equilibrium steady state (NESS). The formalism presented here would be applicable to the analysis of various black branes and their holographically dual field theories.

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Evolution of stellar binaries from supermassive black hole binaries

Author: Ye-Fei Yuan[1]

Co-authors: Bin Liu [2]; Yi-Han Wang

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[2] *USTC*

The evolution of main-sequence binaries resided in the galactic centre is influenced a lot by the central supermassive black hole (SMBH). Due to this perturbation, the stars in a dense environment are likely to experience mergers or collisions through secular or non-secular interactions. In this work, we study the dynamics of the stellar binaries at galactic centre, perturbed by another distant SMBH. Geometrically, such a four-body system is supposed to be decomposed into the inner triple (SMBH–star–star) and the outer triple (SMBH stellar binary–SMBH). We survey the parameter space and determine the criteria analytically for the stellar mergers and the tidal disruption events (TDEs). For a relative distant and equal masses SMBH binary, the stars have more opportunities to merge as a result from the Lidov–Kozai (LK) oscillations in the inner triple. With a sample of tight stellar binaries, our numerical experiments reveal that a significant fraction of the binaries, ~70 per cent, experience merger eventually. Whereas the majority of the stellar TDEs are likely to occur at a close periapses to the SMBH, induced by the outer Kozai effect. The tidal disruptions are found numerically as many as ~10 per cent for a close SMBH binary that is enhanced significantly than the one without the external SMBH. These effects require the outer perturber to have an inclined orbit ($\geq 40°$) relatively to the inner orbital plane and may lead to a burst of the extremely astronomical events associated with the detection of the SMBH binary.

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Study of white dwarfs, neutron stars and black holes through astrometric microlensing

Author: Kailash Sahu[1]

[1] *Space Telescope Science Institute*

Astrometric microlensing provides a powerful tool to study white dwarfs, neutron stars and black holes, particularly the isolated ones. We have two such projects to study stellar remnants through astrometric microlensing, the details of which will be discussed: (i) In a reprise of the famous 1919 solar eclipse experiment that confirmed Einstein's general theory of relativity, the nearby white dwarf Stein 2051B passed very close to a background star in March 2014. As Stein 2051 B passed by, the background star's position was deflected. Measurement of this deflection with HST - the first such measurement of deflection by a star outside the solar system - allowed us to determine the mass of Stein 2051 B as 0.675 ± 0.051 solar mass. (ii) All stars with initial masses of larger than 20 solar mass are expected to end their lives as black holes (BHs). Theoretical studies suggest that there should be about 100 million stellar-mass BHs in the Galaxy, and a large fraction of these BHs are expected to be single. Yet, no isolated BH has ever been unambiguously found within our Galaxy. The only technique available to detect such isolated BHs is astrometric microlensing. Initial results from our HST programs specifically aimed at the first detection of solitary BHs through astrometric microlensing will be presented.

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Oscillations of black hole accretion disks and neutron star atmospheres

Author: Wlodek Kluzniak[1]

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Quasi-periodic oscillations (QPOs) in the kHz range have been reported in the X-ray flux of several accreting black hole and neutron star systems. While several models have been suggested, such variability has been difficult to reproduce in numerical simulations. I will report on Radiative General Relativistic Hydrodynamic Simulations of accretion disks in which several high-frequency oscillations of the accretion disk have been found, and their nature identified. Similar periodicities have also been reported during thermonuclear X-ray bursts in neutron stars. A calculation of damped oscillations of neutron star atmospheres in the super-Eddington regime will be presented, which allows a direct and simultaneous determination of the mass and radius of the neutron star from the value of the maximum oscillation frequency alone.

Refs.: Mishra et al. 2017, 2018; Bollimpali et al. 2018.

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Black holes binaries from globular clusters as sources of gravitational waves

Authors: Dorota Rosinska[1]; Magdalena Szkudlarek[1]; Abbas Askar[2]; Mirek Giersz[2]; Tomek Bulik[3]

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[2] *CAMK*

[3] *University of Warsaw*

The direct detection of gravitational waves from binary black hole mergers by the advanced Laser Interferometer Gravitational-Wave Observatories has ushered astrophysics into a new era of observing cosmic events that were previously invisible. Using results for around two thousand star cluster models simulated using well-tested the MOCCA Monte Carlo code for star cluster evolution we determine the astrophysical properties and local merger rate densities for coalescing binary black holes (BBHs) originating from globular clusters. We extracted information for all coalescing BBHs that escape clusters and subsequently merge within Hubble time along with BBHs that are retained in our GC models and merge inside the cluster via gravitational wave (GW) emission or collide. By obtaining results from a substantial number of realistic star cluster models that cover different initial parameters (masses,metalicities, densities etc), we have an extremely large statistical sample of BBHs that merge within Hubble time. In my talk I will discuss the importance of BBH mergers originating from GC for gravitational wave observations.

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Probing astrophysical black holes via gravitational lensing

Author: Q. Daniel Wang[1]

[1] *University of Massachusetts*

Black holes (BHs) represent the most extreme objects in the universe and play an important role in astrophysics. We have been exploring various ideas of using gravitational lensing to probe the population and astrophysics of BHs. Supermassive BHs of million solar masses or greater are usually detected as active galactic nuclei (AGN). We show that the innermost X-ray-emitting structure of AGN can be greatly amplified and hence effectively probed by microlensing of nearby foreground stars. For stellar mass BHs in our Galaxy, we may estimate their overall population via their astrometric microlensing effect on background sources. This capability is within the reach of available near-IR/radio interferometry facilities. Particularly interesting is the possibility to detect a concentration of stellar mass BHs (including ones of ˜30 solar masses, similar to those discovered recently via gravitational waves) around the very center of our Galaxy. Furthermore, we can effectively study the formation and evolution of both stellar mass and supermassive BHs at high redshifts via strong gravitational lensing by foreground massive galaxies or galaxy clusters.

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Nucleus 3-flavored

Author: Renxin Xu[1]

[1] *Peking University*

Normal nuclei inside atoms are 2-flavored. What if normal baryonic matter is compressed intensely by gravity so that a huge number of nuclei would gradually merge to form a gigantic nucleus? It is proposed that gigantic nuclei could be 3-flavored, to be manifested in the form of compact stars, cosmic rays, and even dark matter.

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Relativistic corrections to large scale structures

Author: Clement Stahl[1]

[1] *PUCV*

We investigate the relativistic corrections to the standard model of formation of large scale structures. In matter domination and in the Poisson gauge, we use the weak-field approximation which allows to keep compact expressions even for the one-loop bispectrum. Whereas in the Newtonian limit, the choice of gauge is marginally important as all gauge coincides, when relativistic corrections are taken into account, it matters as a change of gauge may induce a change of gravitational potential and introduce fictitious modes in the finial result for the power spectrum. It is precisely what happens in the example presented in this talk as the equivalence principle is not fulfilled in the Poisson gauge and the cancellation of the IR divergence at one-loop does not occur. We will discuss how other choices of gauge may solve this issue.

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Magnetic field effect on the effective potential of a heavy charged scalar field

Author: Angel Sanchez Cecilio[1]

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In the context of a warm inflation scenario in this work we study the effects of a primordial magnetic field on the effective potential of a heavy charged scalar field in a magnetized thermal bath. It is known that models, based on global supersymmetry with a new-inflation-type potential and a coupling between the inflaton and a heavy intermediate superfield, preserve the flatness required for slow-roll conditions even after including thermal contributions. Preliminary results indicate that the magnetic field makes the potential even flatter, retarding the transition and rendering it smoother.

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Infinite nuclear matter characteristics of finite nuclei within relativistic mean field formalism

Authors: Mrutunjaya Bhuyan[1]; Brett Carlson[2]; S K Patra[3]; S.-G Zhou[4]

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[4] *Institute of Theoretical Physics, CAS, Beijing, China*

The present study establishes a correlation between the neutron skin thickness and the infinite nuclear matter characteristics for the even−even isotopes of Fe, Ni, Zn, Ge, Se, and Kr. The axially deformed self-consistent relativistic mean field for the non-linear NL3* is used for the analysis. The coherent density functional method is adopted to formulate the symmetry energy, the neutron pressure and the curvature of finite nuclei as a function of the nuclear radius. The mass dependence on the symmetry energy in terms of the neutron-proton asymmetry for mass $70 \le A \le 96$ are studied. From this analysis, we found a notable signature of a shell closure at $N = 50$ in the isotopic chains of Fe, Ni, Zn, Ge, Se and Kr nuclei. The present study reveals an interrelationship between the characteristics of infinite nuclear matter and the neutron skin thickness of finite nuclei

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Strongly interacting matter under intense magnetic fields

Author: Norberto Scoccola[1]

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Different aspects of the behavior of quark and hadronic matter under intense magnetic fields are analyzed within the framework of Nambu-Jona-Lasinio models.

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Equations of boson-fermion star and the basic equation discussions under Newtonian approximation

Authors: Zhifu Gao[1]; Xiangdong Li[2]; Cixing Chen[3]; Na Wang[1]

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There is accumulating evidence that scalar fields may exist in nature. The gravitational collapse of a boson cloud would lead to the formation of a boson star just like white dwarfs and neutron star. In generally, as one of candidates of dark matter, a boson star holds a stable configuration and has deserved intensive attention and extensive researches in the past 50 years. At first, we examined the properties of a complex-scalar–field boson star, and analyze the ground state solutions, then analyzed the configuration of a star composed of bosons and fermions, and gave coupling equations. At last, we considered the hydrostatic equilibrium equation of the boson-fermion star, and gave the virial equation with different orders and investigated how scale fields impact the virial equation.

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Testing black-hole near-horizon effects and pseudo-complex general relativity with gravitational waves

Author: Alex Nielsen[1]

[1] *Max Planck Institute for Gravitational Physics (AEI)*

The detection of gravitation waves by LIGO has allowed a great number of new tests of strong gravity and near-horizon models for black holes. One such model, pseudo-complex general relativity, agrees with Einstein gravity in the weak-field limit, but diverges dramatically in the near-horizon regime, with certain parameter ranges excluding the existence of black holes altogether. We show how simple limits can be placed on this model in both the inspiral and ringdown phase of coalescing compact objects. We discuss how these bounds relate to current observational limits and future prospects with gravitational wave observations and the Event Horizon Telescope.

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Numerical analysis of the Biermann battery mechanism of magnetogenesis for relativistic MHD turbulence

Author: David Garrison[1]

[1] *University of Houston Clear Lake*

We present the results of Relativistic Magnetohydrodynamic simulations utilizing a range of initial conditions in order to see if seed magnetic fields may be generated via the Biermann battery mechanism of magnetogenesis. These simulations occur in a simulated early universe around the time of the electroweak era 10^{-11} seconds after the Big Bang. Our results are characterized by the characteristic turbulent velocity of the magneto fluid and whether or not the relativistic version of the Biermann battery was utilized.

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Equation of state at finite chemical potential, based on the PNJL Lagrangian

Author: Joerg Aichelin[1]

[1] *Subatech/CNRS*

The NJL and PNJL approach had problems to describe the lattice equation of state for zero chemical potential. This made this Lagrangian, despite of its great merits, less attractive to study what happens for a finite baryon chemcial potential. A finite baryon chemical potential is expected for the experiments at FAIR/Germany and NICA, Russia but also during the merger of two neutron stars which has been observed recently by gravitational waves. Using a systematic expansion of the Lagrangian in next to leading order in N_c and modifying slightly the interaction between the quarks and the Polyakov loop potential we obtained now result which are in the error bars of the present lattice calculations for zero chemical potential. For the PNJL Lagrangian the extension to finite chemical potential is straight forward. We present these results and discuss what kind of phase transition is expected at low temperature and finite chemical potential and hope to give also preliminary results for the termodynamical properties of merging neutron stars.

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Electromagnetic probes of QGP

Author: Elena Bratkovskaya[1]

[1] *FIAS*

Dileptons are considered as one of the cleanest signals of the quark-gluon plasma (QGP), however, the QGP radiation is masked by many 'background' sources from either hadronic decays or semileptonic decays from correlated charm pairs.
We investigated the relative contribution of these channels in heavy-ion collisions from $\sqrt{s_{\mathrm{NN}}} = 8$ GeV to 5 TeV with a focus on the competition between the thermal QGP radiation and the semileptonic decays from correlated $D-$meson pairs. As a 'tool' we employ the parton-hadron-string dynamics (PHSD) transport approach to study dilepton spectra in Pb+Pb (Au+Au) collisions in a wide energy range incorporating for the first time a fully microscopic treatment of the charm dynamics and their semileptonic decays. We find that the dileptons from correlated $D-$meson decays dominate the 'thermal' radiation from the QGP in central Pb+Pb collisionsat the intermediate masses (1.2 GeV $< M <$ 3 GeV) for $\sqrt{s_{NN}} > 40$ GeV, while for $\sqrt{s_{\mathrm{NN}}} = 8$ to 20 GeV the contribution from $D, \bar{D}$ decays to the intermediate mass dilepton spectra is subleading such that one should observe a rather clear signal from the QGP radiation. We, furthermore, study the p_T-spectra and the $R_{AA}(p_T)$ of single electrons at different energies as well as the excitation function of the inverse slope of the m_T- spectra for intermediate-mass dileptons from the QGP and from charm decays. We find moderate but characteristic changes in the inverse slope parameter for $\sqrt{s_{NN}} > 20$ GeV which can be observed experimentally in high statistics data.

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The Athena X-ray observatory

Author: Giorgio Matt[1]

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Athena (the Advanced Telescope for High-Energy Astrophysics) will continue the series of large X-ray observatories inaugurated by Chandra and XMM-Newton, offering transformational capabilities in several key areas. It is the second large-class ESA mission (L2), and it is planned for a launch towards the end of the next decade.
In this talk, the main science objectives of Athena, and its main technical characteristics, will be presented and discussed.

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The imaging X-ray Polarimetry Explorer

Author: Giorgio Matt[1]

[1] *Dipartimento di Matematica e Fisica, Universita' Roma Tre*

IXPE, the Imaging X-ray Polarimetry Explorer, has been selected by NASA on January 2017 as the next mission in the Small Explorer Program, for a launch in early 2021. IXPE, a collaboration between NASA and ASI (the Italian Space Agency), is led by M. Weisskopf (MSFC) and is composed by three identical telescopes with, at the focal plane, a Gax Pixel Detector based on the photoelectric effect. In this talk the main characteristics of the mission and its scientific objectives will be described.

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Observation of ultra-high-energy cosmic rays with the Telescope Array experiment

Author: Kazumasa Kawata[None]

The Telescope Array (TA) is the largest ultra-high-energy cosmic-ray (UHECR) detector in the northern hemisphere, which consists of 507 surface detector covering a total 700 km^2 and three fluorescence detector stations. In this presentation, we will discuss our recent results on the UHECR energy spectrum, mass composition and anisotropy based on the latest dataset collected by the Telescope Array experiment. Finally, we will introduce current status of the TAx4 project which will cover 4 times larger detection area than that of the TA.

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The X-Ray Astronomy Recovery Mission

Author: Brian Williams[1]

Co-authors: Makoto Tashiro [2]; Robert Petre [1]; Richard Kelley [1]; Kyoko Matsushita [3]; Matteo Guainazzi

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[3] *Tokyo University of Science*

The X-Ray Astronomy Recovery Mission (XARM), an international collaboration led by JAXA and involving major participation from NASA and ESA, will employ an advanced X-ray observatory with capabilities to carry out a science program to address some of the important questions of present-day astrophysics. XARM is essentially a rebuild of the the Hitomi (Astro-H) spacecraft that was lost due to an operational mishap early in the mission in 2016, but only employs two of the original four instruments on Hitomi. The Resolve Soft X-ray Spectrometer is being developed jointly by a team led by NASA/GSFC and institutions in Japan under the direction of JAXA's Institute of Space and Astronautical Science. It is a high-resolution, non-dispersive X-ray spectrometer operating between 0.3-12 keV. It is the core instrument on XARM, providing a high-resolution spectroscopic capability (˜ 5 eV) for the mission and covering the energy band where all of the astrophysically abundant elements have characteristic emission lines that can be used for a wide range of spectral studies of matter under extreme conditions. The other instrument, called Xtend and provided by JAXA, extends the field of view to produce an observatory with extraordinary capabilities using a state of the art X-ray charged couple device camera. Xtend is the responsibility of JAXA, but NASA will provide an X-ray Mirror Assembly for the instrument identical in design to the Resolve mirror assembly. XARM will be launched into low-Earth orbit (nominally 575 km circular, 31° inclination) from the Tanegashima Space Center, Japan, using a JAXA H-IIA rocket. This talk will summarize the status of the mission, and will outline the science objectives to be addressed, namely: 1) structure formation of the Universe and evolution of clusters of galaxies; 2) the life cycle of baryonic matter in the universe; 3) evolution and feedback from black holes; and 4) new science achieved through unprecedented high resolution X-ray spectroscopy.

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Exploring the structure of neutron stars in low-mass X-ray binaries

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Transient low-mass X-ray binaries containing a neutron star which sporadically accrete matter from a low-mass companion provide a unique opportunity to study the internal structure of neutron stars. During accretion phase the neutron star is heated and driven out of thermal equilibrium. During the following quiescent phase, when no accretion is occurring, the thermal relaxation of the neutron star can, and has, been observed. Modelling of these sequences of accretion/heating and cooling has allowed to find evidence for extremely fast neutrino emission in the neutron star core by the Direct Urca process, and to put constraint on the specific heat of the core. Several properties of the neutron star crust are also naturally being constrained, as its thermal conductivity and specific heat, and possibly the presence of neutron superfluid.

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Relativistic X-ray jets at high redshift

Author: Dan Schwartz[1]

Co-authors: Diana Worrall [2]; Mark Birkinshaw [2]; Teddy Cheung [3]; Doug Gobeille [4]; Herman Marshall [5]; Giulia Migliori [6]; Aneta Siemiginowska [1]; John Wardle [7]

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Powerful radio sources and quasars emit relativistic jets of plasma and magnetic fields that travel hundreds of kilo-parsecs, ultimately depositing energy into the external medium. In the rest frame of the jet, the energy density of the cosmic microwave background is enhanced by the bulk Lorentz factor as Γ^2, and when this exceeds the magnetic energy density the primary loss mechanism of the relativistic electrons is via inverse Compton scattering. At large redshift, the microwave energy density is further enhanced by a factor $(1+z)^4$. We are surveying a z > 3 sub-sample of radio sources selected with flux density > 70 mJy, and with a spectroscopic redshift. We find cases of the X-rays extending beyond the detectable radio jet, and a case we interpret as an X-ray lobe where the radio emitting electrons have faded below detectable limits.

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Fermi/GBM's key role at the dawn of the era of multimessenger astronomy

Author: Andreas von Kienlin[1]

[1] *MPE*

The detection of the gravitational wave event GW170817 by LIGO and Virgo was accompanied by the independent detection of the short Gamma-ray Burst GRB 170817A by the Gamma-ray Burst Monitor (GBM) of NASA's Fermi mission. This discovery was complemented by the detection of a weak coincident signal in the data of the Anti-Coincidence Shield ACS of Spectrometer SPI onboard ESA' s INTEGRAL mission. Here we focus on the results by Fermi-GBM, discussing the characteristics of this ordinary short GRB, which extraordinarily confirms that at least some short GRBs are produced by binary compact mergers. We show that the observed time delay between the gravitational and electromagnetic event of about 1.7 s could impose constraints on fundamental physics. Finally, we want to discuss Fermi/GBM's prospects for the upcoming O3 observation run of LIGO/Virgo.

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The 4 meter New Robotic Telescope

Author: Carlos Gutierrez[1]

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The time domain astronomy will radically change in the coming decade, with the advent of facilities like LSST, SKA, CTA, etc that will find huge numbers of transients across the electromagnetic spectrum, and with the detections via non-electromagnetic signals, such as gravitational waves. Within this context, we plan to build the New Robotic Telescope (NRT), a 4 m optical and near infrared telescope that will be installed at the ORM observatory in La Palma (Spain), and will operate in an entirey autonomous and robotic way. The project is promoted by the Liverpool John Moores University (UK) and the Instituto de Astrofisica de Canarias (Spain). The telescope is being designed for extremely rapid response, so it will be able to start collecting take data within 30 seconds after receiving a trigger from another facility. When NRT enters into operation in 2023 will make it a world-leading facility for the study of fast fading transients and explosive phenomena discovered at early times. In addition, it will allow great efficiency for large-scale programmes of low-to-intermediate resolution spectral classification of transients. Here, we present the status and scheduling of the project, and the main science drivers.

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Probing the universe at the highest energies with the Pierre Auger Observatory

Author: Jakub Vicha[1]

[1] *Institute of Physics of the Czech Academy of Sciences*

The Pierre Auger Observatory is the currently largest cosmic-ray detector covering ultra-high energies from 10^{18} eV to 10^{20} eV. The size of exposure accumulated since 2004 granted measurements of unprecedented precisions on energy spectrum, mass composition and anisotropy searches. These measurements guide us slowly to the sources of ultra-high energy cosmic rays, which is a tantalizing mystery of physics. A brief introduction of the Pierre Auger Observatory will be given. Then, an overview of the most interesting results of the Observatory will follow with aim to the recent findings on anisotropy searches and multi-messenger surveys.

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High-precision cosmology from the Sloan Digital Sky Survey

Author: Alexander Mayer[1]

[1] *N/A*

Analysis of galaxy redshift data and theta-z data from the Sloan Digital Sky Survey (SDSS) provides surprising new insights in cosmology, which overturn prior results.

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Characterization of orbits for the MacMillan problem with test particle of variable mass

Authors: Edgar Andrés Acosta Pinzón[1]; Fredy Leonardo Dubeibe[2]; Guillermo Alfonso González Villegas[1]

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In the present study, we conduct a numerical analysis of the MacMillan problem in which the mass of the test particle varies in time according to the Jeans'law. The MacMillan problem is a particular case of the circular three body problem, where the third body moves along an axis passing through the center of mass of the system, and is perpendicular to the plane of the primaries. Since the formulation of the MacMillan equations of motion, several variations of this problem have been addressed in the literature, all of them with something in common: cons- tant mass. In this master thesis, the focus is laid on the characterization of orbits for the MacMillan problem, assuming that the mass of the third body is variable in time according to the Jeans'law.

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Classical features of polynomial higher-derivative gravities

Author: Breno Giacchini[1]

[1] *Centro Brasileiro de Pesquisas Físicas*

Local gravitational theories with more than four derivatives have remarkable quantum properties. Namely, they are super-renormalizable and may be unitary in the Lee-Wick sense, if the massive poles of the propagator are complex. It is important, therefore, to explore also the IR limit of these theories and identify possible observable signatures of the higher derivatives. In this talk we present recent results in this direction. Specifically, we discuss the effect that those higher-order terms can have on the Newtonian potential and related singularities. The result is that any polynomial model with at least six derivatives in both spin-2 and spin-0 sectors has regular curvature invariants in the weak-field limit. Under this same condition the collapse of spherical null shells is also regular. We also discuss the viability of a gravitational seesaw-like mechanism, which could be a mean of avoiding the Planck suppression of the higher derivatives' effects.

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Merger of two compact stars: predictions from the two-families scenario

Author: Giuseppe Pagliara[None]

Co-author: Alessandro Drago

The detection of GW170817 and its electromagnetic counterparts has marked the beginning of multi-messenger astrophysics which could allow, in the near future, to finally establish which is the internal composition of neutron stars. I will discuss what we have learned from this first binary neutron star GW's detection on the equation of state in particular concerning the possibility of having "strange matter" in the form of hyperonic matter and/or strange quark matter. Finally, I will present a scenario in which two families of compact stars co-exist: hadronic stars and quark stars and I will discuss what are the expectations, within this scenario, for the next future GW's detections and their counterparts (short-GRBs and kilonovae).

The talk is based on the following papers: Astrophys.J. 852 (2018) no.2, L32; Astrophys.J. 846 (2017) no.2, 163; Eur.Phys.J. A52 (2016) no.2, 41; Eur.Phys.J. A52 (2016) no.2, 40.

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The primordial B-modes search in the CMB polarization with LSPE/SWIPE

Author: Fabio Columbro[1]

Co-author: Paolo de Bernardis

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Measurements of the cosmic microwave background (CMB) polarization represent the best technique to study physical phenomena happening a split-second within the big bang and to test the standard cosmological model. In this scenario, the Large-Scale Polarization Explorer (LSPE) aims at the measurement of polarization at the largest angular scales, where cosmic inflation left its imprint in the form of a curly pattern (B-modes) of linear polarization.

The LSPE is a coordinated ground-based and balloon-borne experiment. The balloon-borne instrument of LSPE, named SWIPE (Short Wavelength Instrument on the Polarization Explorer), is in an advanced phase of development, aiming at a long-duration polar-night flight for a two-weeks-long observation, in the Arctic region. This allows SWIPE to reach a sensitivity in terms of tensor to scalar ratio $r = 0.01$, roughly 10 times better than current upper limits.

SWIPE will observe 25% of sky in 3 frequency bands (90 GHz, 220 GHz and 240 GHz) by means of an array of 330 multi-mode TES bolometers, cooled at 0.3 K, collecting a total of 8800 modes of the CMB. The detectors are fed by a 500 mm aperture cryogenic Stokes polarimeter/telescope, with a continuously rotating polarization modulator as the first optical element. The half-wave plate (HWP) is cooled at 4 K to reduce the radiative loading on the detectors, and spins at 120 rpm, thanks to a superconducting magnetic bearing with a very low friction electromagnetic motor.

In this contribution we describe the SWIPE instrument, its development, and present a forecast performance study. See http://planck.roma1.infn.it/lspe for further information.

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Reconstruction of large-scale CMB temperature anisotropies with primordial CMB induced in galaxy cluster

Author: Guo Chin Liu[1]

Co-authors: Kiyomoto Ichiki [2]; Hiroyuki Tashiro [3]; Naoshi Sugiyama [2]

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[3] *Department of Physics, Graduate School of Science, Nagoya University*

Scattering of cosmic microwave background radiation in galaxy clusters induces polarization signals determined by the quadrupole anisotropy in the photon distribution at the location of clusters. This remote quadrupole derived from the measurements of the induced polarization in galaxy clusters provides the information of local CMB temperature anisotropies. Here we present an algorithm of the reconstruction of large-scale CMB temperature map and conclude that the reconstruction can be good enough to be a consistency test on the puzzles of CMB anomaly, especially for the low quadrupole and axis of evil problems reported in WMAP and Planck data.

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Time-domain astrophysics of galactic nuclei in radio to submillimeter

Author: Q. Daniel Wang[1]

[1] *University of Massachusetts*

I will review ideas as to how a joint monitoring program at radio to submillimeter wavelengths may be used to study the relativistic jet formation and circumnuclear environment of supermassive black holes. At least some tidal disruption events (TDE) of (sub-)stellar objects around black holes form relativistic jets. Such a jet can first be detected in (sub)millimeter and only gradually become optically thin and observable at longer wavelengths. The jet evolution depends strongly on the density structure of the circumnuclear gas, including the accretion flow, while its associated magnetic field can be traced by the Faraday's rotation of polarization as a function of time. I will use the nearest known TDE, IGR J12580+0134, in NGC 4845 (d = 17 Mpc) as an example to illustrate both the existing feasibility and the potential power of such a (sub)millimeter to radio follow-up program.

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Cosmological mass transport on galactic nuclei and the growth of high z quasars

Author: Andres Escala Astorquiza[1]

[1] *Universidad de Chile*

By using AMR cosmological hydrodynamic N-body zoom-in simulations, with the RAMSES code, we studied the mass transport processes onto galactic nuclei from high redshift up to $z \sim 6$. Due to the large dynamical range of the simulations we were able to study the mass accretion process on scales from ~ 50 kpc to $\sim$ pc. The SMBHs are modelled as a sink particles at the center of our galaxies, which allowed us to quantify the BH growth in relation with the mass transport processes associated to different angular momentum fluxes. Such a quantification allowed us to identify the main mass transport process as a function of the scales of the problem. We found that in simulations that include radiative cooling and SNe feedback, the SMBH grows at the Eddington limit most of the time, transporting mass at a rate of $\sim$ 1-10 $M_{\odot}$/yr. Only if efficient AGN feedback is included in tandem with SNe feedback, the mass transport decreases at a rate below ~ 1 $M_{\odot}$/yr. This level of SMBHs accretion rates found in our cosmological simulation, are needed in all models of SMBH growth attempted to explain the formation of redshift 6-7 quasars.

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Magnetic field effect on the decay process of a neutral scalar boson

Authors: Gabriella Piccinelli Bocchi[1]; Jorge Igor Jaber Urquiza[2]; Angel Sanchez Cecilio[2]

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The effect of a homogeneous weak magnetic field on the decay process of a neutral scalar field to a pair of charged fermions is studied. The decay rate is calculated through the imaginary part of the self-energy of the scalar particle interacting with the charged fermions, at one loop. We find that the effect depends on the kinematical regime of the progenitor particle: for low transverse momenta, the decay is inhibited, while for high ones, the process is favored. We briefly discuss the possible physical reasons for this situation. The phenomenon can be relevant in early universe events or in high energy collisions.

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Observational constraints on the NS equation of state

Author: Zhaosheng Li[1]

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The measurement of neutron star mass and radius is one of the most direct ways to distinguish between various dense matter equations of state. The mass and radius of accreting neutron stars hosted in low-mass X-ray binaries can be constrained by several methods, including photospheric radius expansion from type I X-ray bursts, gravitational redshift measurement and from quiescent spectra. In this talk, I will report the neutron star mass and radius constraints in Aql X-1 and GRS 1747-312.

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Unification of strongly magnetized neutron stars with regard to X-ray emission from hot spots

Author: Tomokage Yoneyama[1]

Co-authors: Kiyoshi Hayashida [1]; Hiroshi Nakajima [2]; Hironori Matsumoto [1]

[1] *Osaka University*

[2] *Kanto Gakuin University*

Strongly magnetized isolated neutron stars (NSs) are categorised into two families, according mainly to their magnetic field strength. The one with a higher magnetic field of 10^{14} - 10^{15} Gauss is called "magnetar", and the other is the X-ray isolated neutron star (XINS) with 10^{13} Gauss. Both magnetars and XINSs show thermal emission in X-rays, whose spectra are different. The spectrum of a magnetar is reproduced with a two-temperature blackbody (2BB), whereas that of an XINS show only a single-temperature blackbody (1BB) with the temperature being even lower. On the basis of the magnetic field and temperature, it is often speculated that XINSs may be old and cooled magnetars. However, no strong observational evidence has yet been reported to support the speculation. Here we report that all the seven known XINSs show high-temperature emission, which should have a similar origin to that of magnetars. Analysing all the XMM-Newton data of the XINSs with the highest statistics ever achieved, we find that their X-ray spectra are all reproduced with a 2BB model, similar to magnetars, as opposed to the traditional 1BB model. Their emission radii and temperature ratios are also similar to those of magnetars except for two XINSs, which show significantly smaller radii than the others. The remarkable similarity in the X-ray spectra between XINSs and magnetars suggests that their origins of the emission are also the same. The lower temperature in XINSs can be explained if XINSs are older than magnetars. Therefore, this results is the first observational indication that supports the standard hypothesis of classification of highly-magnetised NSs. With our results, new questions have also emerged. For example, the temperature is separated clearly between magnetars and XINSs, which may suggest potential existence of a "missing link"between them.

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The high time resolution universe survey for pulsars

Authors: Marilyn Cruces[1]; David Champion[1]; Michael Kramer[1]

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Abstract:

Pulsars are neutron stars, detected mainly through the pulses of electromagnetic radiation emitted from their poles, which is modulated by their stable rotation. Since their discovery in 1967 they have become fundamental tools for understanding subject such as stellar evolution, theories of gravity, the electron content of our Galaxy and understanding the behavior of matter at extreme conditions. Further discoveries will allow us to advance in these areas.
Although more than 2500 pulsars have been found so far, most of them are normal isolated pulsars. Of the more rare objects, only fewer than 20 are double neutron stars systems and just one is a double pulsar system. Moreover, no neutron star-black hole system has been detected to date. With the aim of finding the most intriguing pulsars and potentially a pulsar-black-hole binary, in early 2008 the High Time Resolution Universe (HTRU) collaboration began, an all sky blind survey for pulsars and radio-transients. In the southern hemisphere the survey was conducted with the 64-m Parkes radio telescope, while in the northern hemisphere the observations were carried out with the 100-m radio telescope Effelsberg. The data have a high time- and frequency-resolution that allows an unprecedented volume of the Galaxy to be searched. This has led to the discovery of hundreds of new pulsars, among them tens of pulsars with millisecond spin periods, gamma-ray pulsar, the first radio-loud magnetar, two pulsar-planet systems and the most relativistic pulsar to date. Additionally, among its findings, the HTRU establish the existence of a cosmological population of Fast Radio Bursts (millisecond duration radio bursts whose origins remain unknown).

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Investigations of the Ohmic decay and the soft X-ray emission of high-braking index pulsar PSR J1640−4631

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In this work, we investigate the Ohmic decay of surface dipole magnetic field of high-braking index pulsar PSR J1640−4631, and interpret the observed soft X-ray flux $F_x^{\infty}[2-10\mathrm{keV}]$ from $Chandra + NuStar$ telescopes. We obtain the ohmic decay timescale $\tau_{\rm ohm} \sim 3.23\times10^6$ yr. Observations indicate that magnetic multipole fields could exist in a neutron star and the toroidal component of multipole fields at and near the pulsar cap is thought to be responsible for the star's unique pulse profile. A possible application of ohmic decay timescale to thermoplastic wave (TPW) heating due to toroidal fields dispassion is studied for interpreting the observed soft x-ray emission of PSR J1640−4631, and other heating mechanisms for the star's surface thermal emission are also investigated.

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Anti-correlation between X-ray luminosity and pulsed fraction in the Small Magellanic Cloud pulsar SXP 1323

Author: Jun Yang[1]

Co-authors: Daniel Wik [1]; Andreas Zezas [2]; Malcolm Coe [3]; Jeremy Drake [2]; JaeSub Hong [2]; Silas Laycock [4]

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[3] *University of Southampton*

[4] *University of Massachusetts, Lowell*

We report the evidence for the anti-correlation between pulsed fraction (PF) and luminosity of the X-ray pulsar SXP 1323, found for the first time in a luminosity range 10^{35}–10^{37} erg s^{-1} from observations spanning 15 years. The phenomenon of a decrease in X-ray PF when the source flux increases has been observed in our pipeline analysis of other X-ray pulsars in the Small Magellanic Cloud (SMC). It is expected that the luminosity under a certain value decreases as the PF decreases due to the propeller effect. Above the propeller region, an anti-correlation between the PF and flux might occur either as a result of an increase in the un-pulsed component of the total emission or a decrease of the pulsed component. Additional modes of accretion may also be possible, such as spherical accretion and a change in emission geometry. At higher mass accretion rates, the accretion disk could also extend closer to the neutron star (NS) surface, where a reduced inner radius leads to hotter inner disk emission. These modes of plasma accretion may affect the change in the beam configuration to fan-beam dominant emission.

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Pions near condensation under compact star conditions

Author: Cristian Villavicencio[1]

Co-authors: Marcelo Loewe [2]; Alfredo Raya [3]

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[2] *Pontificia Universidad Catolica de Chile*

[3] *Universidad Michoacana de San Nicolás de Hidalgo*

The behavior of pions is studied in systems where their normal leptonic decay is forbidden. When thermal fluctuations are present, a low decay rate is generated, and as a consequence of lepton recombination, the amount of pions remains almost unaltered. Compact stars conditions are favorable for the formation of such intermediate state of charged pions: near condensation and almost stable, leading to a continuum source of anti-neutrinos. In particular, protoneutron stars could be an scenario where this state of matter is relevant.

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Electron-positron pair creation in pulsars

Author: Andrey Timokhin[1]

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Pulsars are among the most extreme objects in the universe, where physical processes work in regimes of extreme densities as well as gravitational and electromagnetic field strengths. It is widely agreed upon that pulsar activity is intimately connected to the copious generation of electron-positron pairs in the magnetosphere - a rapidly rotating magnetized neutron star is active as pulsar only as long as it can create pairs. Here I briefly overview recent progress in theoretical studies of pulsar magnetospheres and report on the most recent results of self-consistent numerical simulations of pair creation in pulsars. I discuss the implication of these results for our understanding of the physics of pulsars and Pulsar Wind Nebulae.

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Cooling of small and massive hyperonic stars

Authors: Rodrigo Negreiros[1]; Laura Tolos[None]; Mario Centelles[None]; Àngels Ramos[2]; Veronica Dexheimer[3]

[1] *Universidade Federal Fluminense*

[2] *University of Barcelona*

[3] *Kent State University*

We perform cooling simulations for isolated neutron stars using recently developed equations of state for their core. The equations of state are obtained from new parametrizations of the FSU2 relativistic mean-field functional that reproduce the properties of nuclear matter and finite nuclei, while fulfilling the restrictions on high-density matter deduced from heavy-ion collisions, measurements of massive $2M_{\odot}$ neutron stars, and neutron star radii below 13 km. We find that two of the models studied show very good agreement with cooling observations, even without including extensive nucleon pairing. This suggests that the cooling observations are compatible with an equation of state that produces a soft nuclear symmetry energy and, hence, generates small neutron star radii.

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Was GW170817 indeed a merger of two neutron stars?

Author: David Blaschke[1]

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The merger of two compact stars is the celebrated event in Astrophysics which provides highest baryon densities and temperatures simultaneously as well as compact objects at the limit of stability, most likely in a transition stage to a black hole which, triggered by a gravitational wave signal, is then observable in all wavelengths of the electromagnetic spectrum, in some cases also in neutrinos. The first example of such an event is GW170817 [1] which marks the begin of the era of multi-messenger Astronomy and is traditionally referred to as "neutron star (NS) merger". With a total mass of 2.73 $M_\odot$ its progenitor was most likely a binary system like the Hulse-Taylor system of the "double pulsar"system J0737-3039 with stars of the typical binary radio pulsar mass of 1.35 $M_\odot$ involved. We discuss the characteristic features of an equation of state (EoS) of compact star matter with a strong phase transition that would allow for the occurrence of mass twin compact stars in that mass range as a consequence of a "third family"branch of hybrid stars (HSs) in the mass range from ˜1.3 to ˜2.0 $M_\odot$ [2-5]. This offers the possibility of a scenario of HS-NS or HS-HS merger for GW170817 which should therefore be taken into consideration when implications of GW170817 for nuclear and particle physics are discussed. If the NICER experiment on board of the ISS would measure a large radius of ˜14 km for the nearest millisecond pulsar PSR J0437-4715, this would give strong support to the idea that a HS was involved in GW170817 [2].

[1] B.P. Abbott et al. [LIGO Scientific and Virgo Collaborations], Phys. Rev. Lett. 119, 161101 (2017).
[2] D. Blaschke and N. Chamel, "Phases of dense matter in compact stars", [arxiv:1803.01836] (2018).
[3] A. Ayriyan et al., Phys. Rev. C 97, 045802 (2018).
[4] V. Paschalidis et al., Phys. Rev. D 97, 084038 (2018).
[5] D. E. Alvarez-Castillo et al., "Third family of compact stars within a nonlocal chiral quark model equation of state", [arxiv:1805.04105] (2018).

95

Properties of hypothetical quark-hadron lattices in the cores of neutron stars

Authors: Fridolin Weber[1]; William Spinella[2]

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[2] *Wentworth Institute of Technology*

In this talk, we investigate the effect a crystalline quark-hadron mixed phase can have on the neutrino emissivity from the cores of neutron stars. To this end we use relativistic mean-field equations of state to model hadronic matter and a nonlocal extension of the three-flavor Nambu-Jona-Lasinio model for quark matter. The extent of the quark-hadron mixed phase and its crystalline structure is determined using the Glendenning construction, which allows for the formation of spherical blob, rod, and slab rare phase geometries. The neutrino emissivity due to electron-lattice interactions are calculated utilizing the formalism developed for the analogous process in neutron star crusts. It is

found that the contribution to the neutrino emissivity due to the presence of a crystalline quark-hadron mixed phase is substantial compared to other mechanisms at fairly low temperatures ($< 10^9$ K) and quark fractions ($< 30\%$), and that contributions due to lattice vibrations are insignificant compared to static-lattice contributions.

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The evolving story of pulsar wind nebulae

Author: Patrick Slane[None]

The expanding winds generated by pulsars produce nebulae whose properties track both the composition and energetics of the winds and the properties of the environments into which they expand. From early expansion through cold supernova ejecta, through re-formation after disruption from interactions with the supernova remnant reverse shock, the evolution of a pulsar wind nebula is complex. However, recent modeling coupled with important observations from nearly all parts of the electromagnetic spectrum has placed important constraints on a significant number of individual systems and their host remnants, and on the population as a whole. Here I summarize results from such observations and modeling efforts with particular concentration on recent hydrodynamical studies of PWNe evolving within their host supernova remnants.

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Can loop quantum cosmology describe an unified and consistent scenario since bounce until the end of inflation?

Authors: Eunice Valtânia de Jesus Bezerra[1]; Oswaldo Duarte Miranda[1]

[1] *Instituto Nacional de Pesquisas Espaciais (INPE)*

The inflationary model was introduced by Guth in the 80's as a way of solving the so-called three cosmological problems: flatness of the space-time, the problem of the horizon, and the question of the magnetic monopoles. Since it was proposed, inflation has become much more than a cosmological model. The inflationary period may perhaps give us some clues about the transition from a continuum space-time (as is the universe at the end of the inflationary period) to a space-time still quantized at the beginning of the inflationary period. In this work, we try to establish a possible transition scenario between loop quantum gravity and inflation (as described by a Higgs model). The main characteristics of this possible connection will be discussed in the present work.

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Correlations functions of primordial perturbations from symmetries

Authors: Juan Pablo Beltrán-Almeida[1]; César Alonso Valenzuela-Toledo[2]; Josué Motoa-Manzano[2]

[1] *Universidad Antonio Nariño*

[2] *Universidad del Valle*

In this work we use the correspondence between a field theory in de Sitter space in 4-dimensions and the dual conformal field theory in an euclidean space in 3-dimensions to constraint the form of correlation functions of primordial perturbations. To this end, we use an inflationary model, in which the inflaton field is interacting with a vector field trough the term $f1(\phi)F_\nu F^\nu + f2(\phi)\tilde{F}_\nu F^\nu$.

The first step of this method consists in solving the equations of motion for the fields in de Sitter 4D space-time, then evaluate these solutions in super-Hubble scales and compute the conformal weight of the projection of these fields in the 3D space. In a second stage, we propose a general form for the correlators, which involves scalar, vector and tensor perturbations and, using the result of the first step, find its momentum dependence by imposing that those are invariant under dilatations and special conformal transformation (SCT).

31

Magnetars: Pi in the sky?

Author: Nayasinganahalli Hari Dass[1]

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Abstract: Magnetars are incredible astrophysical objects with the largest ever observed magnetic fiels that are more than a thousand times larger than Pulsar magnetic fields.They are also associated with some of the most powerful flares ever seen. The origin of such strong magnetic fields is a fascinating problem in physics. I shall describe in this talk work done with V. Soni, with earlier participation by Dipankar Bhattacharya, wherein we have proposed neutral pion condensation in high baryon density phase transitions as the source for such strong magnetic fields. I will also review related work by Nielsen and Soni. This model naturally explains many highly puzzling features of magnetars. A full understanding of magnetars will require ideas and concepts from particle physics, condensed matter physics and plasma physics.

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Lethal radiation from nearby supernovae helps to explain the small cosmological constant

Author: Tomonori Totani[1]

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The observed value Λ_{obs} of the cosmological constant Λ is extremely smaller than theoretical expectations, and the anthropic argument has been proposed as a solution to this problem because galaxies do not form when $\Lambda \gg \Lambda_{obs}$. However, the contemporary galaxy formation theory predicts that stars form even with a high value of $\Lambda/\Lambda_{obs} \sim 50$, which makes the anthropic argument less persuasive. Here we calculate the probability distribution of Λ using a model of cosmological galaxy formation, considering extinction of observers caused by radiation from nearby supernovae. The life survival probability decreases in a large Λ universe because of higher stellar density. Using a reasonable rate of lethal supernovae, we find that the mean expectation value of Λ can be close to Λ_{obs}, and hence this effect may be essential to understand the small but nonzero value of Λ. It is predicted that we are located on the edge of habitable regions about stellar density in the Galaxy, which may be tested by future exoplanet studies.

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Progenitor mass distribution of core-collapse supernova remnants in our galaxy and Magellanic Clouds

Authors: Satoru Katsuda[1]; Tomoya Takiwaki[2]; Nozomu Tominaga[3]; Takashi Moriya[2]; Ko Nakamura[4]

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[2] *NAOJ*

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[4] *Fukuoka University*

We investigate a progenitor mass distribution of core-collapse supernova remnants (CCSNRs) in our Galaxy and the Large and Small Magellanic Clouds, for the first time. We use the zero-age main-sequence mass, $M_{\rm ZAMS}$, estimated from elemental abundances and count the number of the CCSNRs in three mass ranges:
A: $M_{\rm ZAMS} < 15\ {\rm M}_{\odot}$,
B: $15\ {\rm M}_{\odot} < M_{\rm ZAMS} < 22.5\ {\rm M}_{\odot}$,
C: $22.5\ {\rm M}_{\odot} < M_{\rm ZAMS}$.
Simple compilation of progenitor masses in the literature yields a progenitor mass distribution of $f_{\rm A} : f_{\rm B} : f_{\rm C} = 0.24 : 0.28 : 0.48$, where f is the number fraction of the progenitors. The distribution is inconsistent with any standard initial mass functions. We notice, however, that previous mass estimates are subject to large systematic uncertainties because most of the relative abundances (X/Si) are not really good probe for the progenitor masses. Instead, we propose to rely only on the Fe/Si ratio which is sensitive to the CO core mass ($M_{\rm COcore}$) and $M_{\rm ZAMS}$. Comparing Fe/Si ratios in SNRs in the literature with the newest theoretical model, we estimate 33 $M_{\rm COcore}$ and $M_{\rm ZAMS}$, leading to a revised progenitor mass distribution of $f_{\rm A} : f_{\rm B} : f_{\rm C} = 0.47 : 0.32 : 0.21$. This is consistent with the standard Salpeter initial mass function, implying that the most massive progenitors in $6\ {\rm M}_{\odot} < M_{\rm COcore}$ or $22.5\ {\rm M}_{\odot} < M_{\rm ZAMS}$, which have often been considered to collapse to black holes without explosions, can actually explode. However, the relation between $M_{\rm COcore}$ and $M_{\rm ZAMS}$ could be affected by binary evolution which is not taken into account in this study. The effect of stellar multiplicity should be considered in the future work to derive a better progenitor mass distribution estimate.

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Magnetorotational instability in supernova explosion

Author: Sergey Moiseenko[1]

Co-author: Gennady Bisnovatyi-Kogan [2]

[1] *Space Research Institute*

[2] *Space Research Institute RAS*

We represent results of numerical simulation of magnetorotational (MR) instability which develops in MR core-collapsed supernova explosion. The MR instability leads to the exponential growth of all components of the magnetic field. It significantly reduce the time for the development of MR exlosion. The MR instability is of Tayler type with rotation. The maximal values of magnetic field found in our simulations is 10(16) Gauss.

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Mergers and GRBs: past, present and future

Author: Tsvi Piran[1]

[1] *The Hebrew University*

The observed GRB (170817A) that followed GW170817 confirmed the longstanding prediction of association of short GRBs with neutron star mergers. The unique large scale observational campaign that followed provided numerous surprising observations. I discuss past predictions concerning binary mergers. I then turn to current observations of GW 170817 and its EM counterpart and their

interpretation that lead to deciphering of the exact geometry of this event and their implications. I also discuss future prospects of joint detection of GRBs and GW signals. Among the latter, most exciting is the possibility that the gravitational waves observations will teach us about the nature of the inner engine and the acceleration process of relativistic jets.

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Neutrinos from SN1987A: temperature models for two neutrinos' bursts

Author: Rodolfo Valentim[1]

Co-authors: Eraldo Rangel [2]; Jorge Horvath [3]

[1] *Unifesp - Diadema*

[2] *Engebras*

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The neutrinos'burst from SN1987A were detected on different experiments around the World on February in 1987 until today it is theme of discussions and re-analysis. All events were approximately twenty five in the following detectors: Kamiokande II (KII) in Japan ˜ 12, Irvine-Michigan-Brookhaven (IMB) in USA˜8 and Baksan in Soviet Union ˜ 5. The neutrinos play a key role on cooling mechanism into Neutron Star (NS) remnant, ˜ 99% energy of collapse was lost with neutrinos emission in the first few seconds and it is possible "to see"the inner structure of NS in the initial instants after newborn NS. This work proposes to analyze two temperature models that presuppose two neutrinos'bursts with temporal interval ˜ 5s between them. The main motivation is: the dataset shows two distinct groups of neutrinos where the second group would come from Strange Quark Matter scenario. We used Bayesian Information Criterion (BIC) to select the best model with two temperatures.

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Searching for baryon number violation with neutrino experiments

Author: Jennifer Raaf[1]

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The observation of a violation of baryon number conservation would have tremendous impact and implications for the fields of particle and astrophysics and cosmology. Observation of baryon number violating processes such as proton decay or neutron-antineutron oscillation would point to grand unification of the EM, strong, and weak forces at very high energies. This talk will present the motivation to search for baryon number violation and give the landscape of neutrino experiments capable of performing these searches.

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Everything you were eager to know about information relativity theory (but were afraid to ask)

Author: Ramzi Suleiman[1]

[1] *Triangle Center for Research & Decvelopment*

Information Relativity Theory is a simple, axiom-free, epistemic relativizing of Newtonian physics. It attempts to answer the following question: What information will a proper measurement device in laboratory A, register about an occurrence in another laboratory B, which is in a state of motion relative to A. We assume that information about the respective occurrence (e.g., the start, and end times of an experiment conducted in B) is conveyed to A using an information carrier, which travels with constant and known velocity, V_c, in the medium which connects A and B. We put no restrictions on the nature of the information carrier (wave or matter), nor on its velocity V_c, except for the practical condition: $V_c > v$, where v is the mean velocity of B relative to A during the occurrence. However, to avoid futile conflicts with Einstein's ontological relativity, we unwillingly restrict our theorizing to situations, in which V_c is strictly lower than c, where c is the velocity of light in vacuum.

For the situation described above we derive transformations for predicting the time interval, length, mass, and energy densities, measured in A, as functions of the corresponding physical variables as measured in B, and the normalized velocity $\beta\,(= v/V_c)$. We show that the same set of derived equations is successful for predicting and explaining a multitude of physical phenomena in the fields of small particle physics, quantum mechanics, astrophysics, and cosmology, and in proposing natural and testable answers to key standing questions, including the nature of dark matter and dark energy. We shall also point to the aesthetic beauty of the new theory, and the connectedness it unveils between physics, the rest of sciences, and the arts.

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Celestial tidal effect on clock comparison

Authors: Yujie Tan[1]; Chenggang Shao[1]

[1] *Huazhong University of Science & Technology*

With the rapid development of the clock technology, the unprecedented accuracy and stability provides a potential to measure the solar gravitational redshift with the clock-comparison experiments in the laboratory. The clock-comparison model is discussed in both the Barycentric Celestial Reference System (BCRS) and the Geocentric Celestial Reference System (GCRS), in which the transformations of the coordinates and the metric related to the gravitational potential between the two systems are also analyzed. In the GCRS, one must note that the influence of external matters (such as the solar and moon) on clock comparison should be treated as the tiny tidal potential, which has been suppressed due to the equivalence principle.

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Experimental design and progress for testing Lorentz symmetry in gravity

Authors: Chenggang Shao[1]; Yujie Tan[1]

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Local Lorentz invariance (LLI) is an important component of General Relativity (GR). The test of LLI can not only probe the foundation stone of GR, but also help to explore the physics beyond GR and Standard Model. In the previous work, we have limited the LLI coefficients with the gravitational experiments (gravitational inverse square law) performed in our lab. As the Lorentz-violation signal between two parallel plates is dominated by the edge effects, we made a special experimental design to enhance the violation signal, hoping to test LLI at a more accuracy level. At present, the experiment is ongoing.

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Gravity waves speed in the non-Abelian Galileon vector theory

Author: Yeinzon Rodriguez Garcia[1]

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Galileon theories are built with the purpose of having the most general scalar-tensor theory free of the Ostrogradski instability. Quite recently, the vector Galileon theories have been formulated, in particular its non-Abelian version (invariance under a global SU(2) symmetry). The theory, together with a cosmic triad configuration, is able to reproduce the present dark energy epoch, following a nice self-tuning mechanism. However, the theory inevitably contains non-minimal couplings to gravity that can alter the gravity waves speed. This may rule out the theory in view of the recent constraints coming from the detection of a gravity wave and its electromagnetic counterpart from the merger of two neutron stars, as it has happened with most of the Galileon scalar and single-vector field theories. The purpose of this talk is to describe the gravity waves speed calculation in the non-Abelian Galileon vector theory, in a Friedman-Lemaitre-Robertson-Walker background, in order to determine whether the theory is ruled out or not.

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The galaxy center with scalar field dark matter (ultra-light boson) haloes

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Recent analysis of the rotation curves of a large sample of galaxies with very diverse stellar properties reveal a relation between the radial acceleration purely due to the baryonic matter and the one inferred directly from the observed rotation curves. Assuming the dark matter (DM) exists, this acceleration relation is tantamount to an acceleration relation between DM and baryons. This leads us to a universal maximum acceleration for all halos. Using the latter in DM profiles that predict inner cores implies that the central surface density $\mu_{DM} = \rho_s r_s$ must be a universal constant, as suggested by previous studies in selected galaxies, revealing a strong correlation between the density ρ_s and scale r_s parameters in each profile. We then explore the consequences of the constancy of μ_{DM} in the context of the ultra-light scalar field dark matter model (SFDM). We find that for this model $\mu_{DM} = 648 M_\odot/\mathrm{pc}^2$, and that the so-called WaveDM soliton profile should be an universal feature of the DM halos. Comparing with data from the Milky Way and Andromeda satellites, we find that they are consistent with a boson mass of the scalar field particle of the order of 10^{-21} eV/c^2, which puts the SFDM model in agreement with recent cosmological constraints.

1

Inflation, dark energy and dark matter in supergravity

Author: Sergei Ketov[1]

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We review some recent developments in describing cosmological inflation, dark energy, dark matter and primordial black holes in supergravity. Their relations to string cosmology on the one side, and to reheating after inflation, on the other side, are also outlined. Open problems of the theory are emphasised too.

Literature: our papers in arXiv:1708.05393, 1703.08993, 1701.08240, 1701.02450, 1607.05293, 1607.05366, 1606.02817, 1510.03524, 1509.00953, 1408.6524, 1406.0252, 1309.7494.

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The Euclid survey: a new window on the last 10 billion years of cosmic history

Author: Xavier Dupac[1]

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Observational cosmology has made incredible progress in the last couple of decades, thanks to, notably, very precise observations of the Cosmic Microwave Background fluctuations, supernovae, galaxy clusters and large galaxy surveys. We now have good evidence that we live in an ever-expanding, accelerating Universe, spatially very close to flat, and the main cosmological parameters have been determined with accuracy, even though some residual controversies may remain on H0 and others. However, the “elephant in the room”of this picture-perfect knowledge of our Universe is the massive presence of Dark Matter and Dark Energy (or vacuum energy), together accounting for ˜95% of the energy content of the Universe.
In order to better understand these mysterious components, the European Space Agency is implementing the Euclid mission, a 1.2 m space telescope with two focal instruments: the Visual Imaging Channel (VIS) and the Near-Infrared Spectrometer and Photometer (NISP). Each field of view is a 0.8 x 0.7 deg. tile with four dithers, with each dither in turn split into VIS imaging, NISP imaging and NISP spectrometry observations. VIS observes in a large unique visible band (0.55 −0.9 μm) with a 24.5 mag (10 σ ext.) sensitivity thanks to 36 4kx4k CCD arrays, and reaches a pixel size of about 0.1”. NISP photometry consists of three wide near-infrared bands (Y: 0.9 −1.1 μm, J: 1.1 −1.4 μm, H: 1.4 −2 μm) with a sensitivity of 24 mag (5 σ point source) and 0.3”pixel size. The NISP slit-less spectrometer works in the 1.1 −1.85 μm range with a spectral resolution > 380 assuming a 0.5”aperture. Euclid will be launched in 2021 by Soyuz from Kourou, French Guiana, to the Sun-Earth L2 point.
In this presentation, I will explain how the Euclid survey will help bettering our knowledge of DM and DE, through a very large survey of galaxies, most of them at z < 3, and also through three deep fields that are targeting higher-redshift galaxies. I will also give some details on the way the Euclid team is building the survey and plans to operate it during the six years of Euclid lifetime.

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Generalized equations in the (S,0)+(0,S) representations of the Lorentz group

Author: Valeriy Dvoeglazov[1]

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I present several explicit examples of generalizations in relativistic quantum mechanics which may be used in astrophysics and cosmology.

First of all, I discuss the generalized spin-1/2 equations for neutrinos. They have been obtained by means of the Gersten-Sakurai method for derivations of arbitrary-spin relativistic equations. Possible physical consequences are discussed. Particularly, we look for relations between the corresponding solutions and dark 4-spinorsin the Ahluwalia-Grumiller elko model. They are also not

the eigenstates of the helicity. They may also be applied to the known helicity flip of neutrinos in stars.

Next, it is easy to check that both Dirac algebraic equation $\det(\hat{p}-m) = 0$ and $\det(\hat{p}+m) = 0$ for $u-$ and $v-$ 4-spinors have solutions with $p_0 = \pm E_p = \pm\sqrt{\mathbf{p}^2 + m^2}$. The same is true for higher-spin equations. Meanwhile, every book considers the equality $p_0 = E_p$ for both $u-$ and $v-$ spinors of the $(1/2, 0) \oplus (0, 1/2))$ representation only, thus applying the Dirac-Feynman-Stueckelberg procedure for elimination of the negative-energy solutions. The recent Ziino works (and, independently, the articles of several others) show that the Fock space can be doubled. We reconsider this possibility on the quantum field level for both $S = 1/2$ and higher spin particles.

The third example is: we postulate the non-commutativity of 4-momenta, and we derive the mass splitting in the Dirac equation. The applications are discussed.

6

Zerilli equation within a modified theory of General Relativity

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For a modified theory of General Relativity, the pseudo-complex version, the stability of the Schwarzschild solution is investigated. The extended Zerilli equation is derived and the scattering of graviational waves investigated, which are the solutions of the Zerilli equation. Consequences for the ring-down frequency, after the fusion of two black holes, are studied.

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Effects of delta-matter in neutron stars structure

Author: Riccardo Belvedere[1]

Co-authors: Sergio B. Duarte [1]; Carlos M. Cedeño [1]

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We investigate the effects due to the introduction of delta resonances in the neutron star matter. We compare and contrast the mass-radius diagram obtained for four different nuclear equations of state in the relativistic mean field theory. More precisely we vary the coupling constants for the delta-mesons interactions in the limits defined by the constraints on the relativistic mean field of delta-isobar in nuclear matter. Our aim is to suggest a new equation of state that could better fit the observational data of neutron stars, as well as to use the last observational constraints to narrow the range allowed for the delta-meson's coupling constants values.

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Born-Infeld magnetars: larger than classical toroidal magnetic fields and implications for gravitational-wave astronomy

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Magnetars are neutron stars presenting bursts and outbursts of X- and soft-gamma rays that can be understood with the presence of very large magnetic fields. In this setting, nonlinear electrodynamics should be taken into account for a more accurate description of such compact systems. We study that in the context of ideal magnetohydrodynamics and make a realization of our analysis to the case of the well known Born-Infeld (BI) electromagnetism in order to come up with some of its astrophysical consequences. We focus here on toroidal magnetic fields as motivated by already known magnetars with low dipolar magnetic fields and their expected relevance in highly magnetized stars. We show that BI electrodynamics leads to larger toroidal magnetic fields when compared to Maxwell's electrodynamics. Hence, one should expect higher production of gravitational waves (GWs) and even more energetic giant flares from nonlinear stars. Given current constraints on BI's scale field, giant flare energetics and magnetic fields in magnetars, we also find that the maximum magnitude of magnetar ellipticities should be $10^{-6} - 10^{-5}$. Besides, BI electrodynamics may lead to a maximum increase of order $10\% - 20\%$ of the GW energy radiated from a magnetar when compared to Maxwell's, while much larger percentages may arise for other physically motivated scenarios. Thus, nonlinear theories of the electromagnetism might also be probed in the near future with the improvement of GW detectors.

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Gravitational waves from protoneutron stars and nuclear EOS

Author: Hajime Sotani[1]

[1] *National Astronomical Observatory of Japan*

We focus on spacetime oscillations, the so-called w-modes, of gravitational waves emitted from a protoneutron star in the postbounce phase of core-collapse supernovae. By adopting numerical results from recent relativistic three-dimensional supernova models, we find that the w1-mode frequency multiplied by the radius of the protoneutron star is expressed as a linear function with respect to the stellar compactness insensitively to the nuclear equation of state. Combining with another universal relation of the f-mode oscillations, which are a kind of acoustic oscillations, it is shown that the time dependent mass-radius relation of the protoneutron star can be obtained by observing both the f- and w1-mode gravitational waves simultaneously. That is, the simultaneous detection of the two modes could provide a new probe into finite-temperature nuclear equation of state that predominantly determines the protoneutron star evolution.

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Gravitational waves astrophysics - a review talk

Author: Dorota Rosinska[1]

[1] *University of Zielona Gora*

One of the most important prediction of Einstein's general theory of gravity is gravitational radiation. I will discuss the importance of the recent LIGO and Virgo direct detections of gravitational-waves. The observations of gravitational waves provide a different view on astrophysical processes hidden from electromagnetic astronomy and expand our knowledge of the Universe dramatically. I will outline the current state and the future for gravitational wave astronomy.

22

Oblique magnetic fields and the role of frame dragging

Author: Vladimir Karas[1]

Co-authors: Ondrej Kopacek [1]; Tahamtan Tayebeh [2]

[1] *Astronomical Institute, Czech Academy of Sciences*

[2] *Charles University, Faculty of Mathematics and Physics; and Astronomical Institute, Czech Academy of Sciences*

Magnetic null points can develop near the ergosphere boundary of a rotating black hole by the combined effects of strong gravitational field and the frame-dragging mechanism. The electric component does not vanish in the magnetic null and an efficient process or particle acceleration can occur. The situation is relevant for low-accretion-rate nuclei of some galaxies which exhibit episodic accretion events (such as the Milky Way's supermassive black hole) embedded in magnetic field field of an external origin. We propose that such a situation develops while a magnetized neutron star approaches the supermassive black hole during late stages of its inspiral motion. The field lines of the neutron star dipole thread the black hole's event horizon.

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Gravitational waves from core-collapse supernovae

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[1] *Space Research Institute RAS*

Gravitational waves from core-collapse Supernovae.

G.S. Bisnovatyi-Kogan, S.G. Moiseenko

A mechanism of formation of gravitational waves in the universe is considered for the nonspherical collapse of matter. Nonspherical collapse results are presented for a uniform spheroid of dust, and a finite entropy spheroid. Numerical simulation results on core-collapse supernova explosion are presented for the neutrino and magneto-rotational models. These results are used to estimate the nondimensional amplitude of the gravitational wave of a frequency about 1000 Hz, radiated during the collapse (calculated by the authors in 2D) of the rotating nucleus of a pre-supernova. This estimate agrees well with many other calculations, which have been done in 2D and 3D settings and which rely on more exact and sophisticated calculations of the gravitational wave amplitude.
It is noted that the gravitational wave radiated during a core-collapse supernova flash in our Galaxy is of sufficient amplitude to be detected by existing gravitational wave telescopes.

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Neutrino structure functions predictions for high energy and high precision neutrino experiments

Author: Mairon Melo Machado[1]

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[2] *IF - Farroupilha, Campus São Borja*

[3] *IF-UFRGS*

A QCD based analysis of the neutrino structure functions $xF2$, $xF3$ and Δ_{xF3}, for charged current and neutral neutrino DIS is performed focusing on high energy and high precisions neutrino experiments. The investigation is done taking into account the color dipole formalism, considering a wide region of the kinematical variables Bjorken-x and boson virtuality Q^2. We consider the state of art about the dipole cross section, which describe successfully the deep inelastic inclusive ans exclusive production. The theoretical predictions will be compared to the prospects for future experimental projects in the small-x region, as for instance the neutrino scattering experiments NuSOnG and Minerva.

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Relativistic polytropic spheres with electric charge: Compact stars, compactness and mass bounds, and quasiblack hole configurations

Authors: José Arbañil[1]; Vilson Zanchin[2]

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[2] *Universidade Federal do ABC*

We study the static stellar equilibrium configurations of uncharged and charged spheres composed by a relativistic polytropic fluid, and compare with those of spheres composed by a non-relativistic polytropic fluid, the later case already being studied in a previous work [J. D. Arbañil, P. S. Lemos, V. T. Zanchin, Phys. Rev. D 88, 084023 (2013)]. For the two fluids under study, it is assumed an equation of state connecting the pressure p and the energy density ρ. In the non-relativistic fluid case, the connection is through a non relativistic polytropic equation of state, $p = \omega\rho^{\gamma}$, with ω and γ being respectively the polytropic constant and the polytropic exponent. In the relativistic fluid case, the connection is through a relativistic polytropic equation of state, $p = \omega\delta^{\gamma}$, with $\delta = \rho - p/(\gamma - 1)$, and δ being the rest mass density of the fluid. For the electric charge distribution, in both cases, we assume that the charge density ρ_e is proportional to the energy density ρ, $\rho_e = \alpha\rho$, with α being a constant such that $0 \leq\mid \alpha \mid\leq 1$. The study is developed by integrating numerically the hydrostatic equilibrium equation, i.e., the modified Tolman-Oppenheimer Volkoff equation for the charged case. Some properties of the charged spheres such as mass, total electric charge, radius, redshift, and the speed of sound are analyzed. The dependence of such properties with the polytropic exponent is also investigated. In addition, some limits that arise in general relativity, such as the Chandrasekhar limit, the Oppenheimer-Volkoff limit, the Buchdahl bound and the Buchdahl-Andr\'easson bound, i.e., the Buchdahl bound for the electric case, are studied. As in a charged non-relativistic polytropic sphere, the charged relativistic polytropic sphere with $\gamma \to \infty$ and $\alpha \to 1$ saturates the Buchdahl-Andréasson bound, thus indicating that it reaches the quasiblack hole configuration. We show by means of numerical analysis that, as expected, the major differences between the two cases appear in the high energy density region.

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Constraining the nuclear EOS and neutron star models with QPOs from giant flares

Author: Hajime Sotani[1]

[1] *National Astronomical Observatory of Japan*

We examine crustal torsional oscillations, newly taking into account the effect of the pasta structure. We find from eigenmode analyses for various models of the equation of state of uniform nuclear matter that the fundamental frequencies of such oscillations are almost independent of the incompressibility of symmetric nuclear matter (K0), but strongly depend on the slope parameter of the nuclear symmetry energy (L). On the other hand, we also find that the frequencies of the 1st overtones depend strongly on not only L but also K0. By comparing the resultant frequencies to the quasi-periodic oscillations observed in the giant flares, we can constrain the values of L and K0. Furthermore, considering the constraints on K0 obtained from the terrestrial nuclear experiments, we can successfully make a more severe constant on not only L but also the neutron star model for SGR 1806-20.

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Investigating the photon and pomeron - induced dijets production at LHC

Authors: Anderson Kendi Kohara[1]; Eduardo Basso[None]; Murilo Santana Rangel[2]; Victor Gonçalves[3]

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We present a detailed comparison of the dijet production by photon–photon, photon–pomeron and pomeron–pomeron interactions in pp, pA and AA collisions at the LHC energy. The transverse momentum, pseudo-rapidity and angular dependencies of the cross sections are calculated at LHC energy using the Forward Physics Monte Carlo (FPMC), which allows one to obtain realistic predictions for the dijet production with two leading intact hadrons. We see that the photon-Pomeron channel is dominant at forward rapidities in pp collisions and in the full kinematical range in the nuclear collisions of heavy nuclei. Our results indicate that the analysis of dijet production at the LHC can be useful to test the resolved pomeron model as well as to constrain the magnitude of the absorption effects.

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Investigating the physics of ultrahigh energy neutrinos in neutrino telescope experiments

Author: Magno Machado[1]

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We compute the corresponding number of events for PeV energy neutrinos for typical neutrino telescope experiments (Auger and IceCube experiments). We consider different parametrizations for the neutrino-nucleon cross section, including predictions from the geometric scaling phenomenon. The theoretical uncertainty for the number of events is investigated.

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Hyperonic neutron star matter in light of GW170817

Author: William Spinella[1]

Co-author: Fridolin Weber [2]

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[2] *San Diego State University*

Since 2013 the mass of pulsar PSR J0348+0432 ($M = 2.01\,M_\odot$) has provided a tight constraint on the neutron star equation of state. However, a number of different analyses of the recently detected binary neutron star merger (GW170817) point to a higher maximum neutron star mass of around $2.16\,M_\odot$. In addition, a recent study determined the mass of the millisecond pulsar PSR J2215+5135 to be $2.27^{+0.17}_{-0.15}\,M_\odot$. In this work we investigate the presence of hyperons in neutron star matter in light of these new mass measurements using equations of state calculated in the relativistic mean-field (RMF) approximation. Particular attention is paid to the use of the available empirical data from the study of hypernuclei and that of the SU(3) symmetry relations in fixing the meson-hyperon coupling constants. We find that hyperonic equations of state with reasonable choices for the meson-hyperon coupling constants can satisfy these new mass constraints, with hyperons potentially accounting for more than 10% of the baryons in the core of a neutron star.

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Determination of metallicity in Seyfert galaxies

Author: Claudio Castro[1]

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During the last decades the work involving objects known as $Active\ Galactic\ Nuclei$ (AGNs) has been gaining more and more attention from several authors aiming at improving the already acquired knowledge. This knowledge provide us with the understanding of the physical processes occurring in AGNs as well as with a better mapping of the Universe. The initial proposal of the thesis project started from the fact of exploring the values available in the literature for AGNs, of the metallicity (Z) and the ionization parameter (U) taking the values from the emission line intensities observed in the infrared, optical and ultraviolet spectra. We compared the literature values with predictions from a grid of photoionization models computed with CLOUDY code. When we started doing this investigation, only three (theoretical) calibrations relating the emission line intensites with the models were available in the literature, one in the ultraviolet region and two in the optical region. Among the AGNs types, the so-called Seyfert galaxies were chosen for this analysis. The ($Z-N2O2$) calibration ($N2O2 = \log([NII]\lambda6584/[OII]\lambda3727)$) in the optical was obtained for about 60 objects. For this region of the electromagnetic spectrum, the calibration for the selected AGNs covers a wide range of metallicities ($0.30 \leq Z/Z_\odot \leq 2.00$), with an average value of $< Z >\approx Z\odot$. For the ultravioleta, the $Z - C43$ calibration ($C43 = \log[(CIV\lambda1549 + CIII]\lambda1909)/HeII\lambda1640]$) was derived for a sample of about 10 objects. In this case, the calibration covers a narrower range in metallicities ($1.00 \leq Z/Z_\odot \leq 1.75$), with an average value of $< Z >\approx 1.4Z_\odot$. It is worth noticing that the interpolation on the grids ($CLOUDY$ code) was perfomed through the so-called "diagnostic diagrams". Comparing the values of the emission line intensities of the galaxies with those from the grids, and the same way, the values of the ionization parameters were be obtained. We define with this work new metallicity calibrations (semi-empirical) for a sample of Seyfert galaxies. This opens possibilities for estimating the metallicity values of other objects (AGNs) and comparing them with the value of some of their physical proprieties.

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Electromagnetic counterpart of supermassive black hole binary mergers

Author: Fabrícia Pereira[1]

Co-authors: Giuseppe Lodato [2]; Irapuan Rodrigues [1]; Márcio Alves [3]; Daniel Price [4]

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[4] *Monash University*

When a circumprimary gaseous disc is pushed into the primary supermassive black hole (SMBH) by the tidal force of the decaying secondary black hole, it can produce an increase in luminosity. In the case of a disc that lies in the same plane of the SMBHs binary, that luminosity exceeds the Eddington limit. However, in this work we show that misaligned binary-disc systems can present the mass accretion rates also exceeding the Eddington limit. We concentrate in geometrically thin disc models with inclination angles varying from 1 to 180 degrees and binary SMBHs with mass ratio q = 10^{-3}. We find that discs with small inclination angles (< 10 degrees) produce primary SMBH accretion rates reaching up to 6.58 M_{Edd} (L_{prim} ˜ 8.56 x 10^{46} erg s^{-1}). On the other hand, we also find that discs with inclinations between 20 and 30 degrees have a rise in the accretion rate less than Eddington rate, while discs inclined at 180 degrees showed no peak in the SMBHs accretion rate. These results show that the effectiveness of the tidal torques drops rapidly with increasing inclination angle. We compare our numerical results with previously obtained analytical results in the literature. Discs misaligned to small angles surrounding a primary SMBH can lead to an electromagnetic counterpart of the gravitational waves signal emitted from final stages of the SMBHs binary orbital decay.

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Constraints on the 3-3-1 model from dark matter searches

Authors: Carlos Enrique Alvarez-Salazar[1]; Orlando Peres[1]; Bruce Sánchez-Vega[2]

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We analyze the dark matter problem in a class of models with gauge symmetry $SU(3)_C \otimes SU(3)_L \otimes U(1)_X$, taking into account the constraints coming from Planck observations of the dark matter relic density, direct detection searches with Xenon1T and indirect detection experiments.

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On the Schwarzschild-Kottler black hole with cloud of strings

Authors: Geusa Marques[1]; Valdir Bezerra[2]

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[2] *UFPB*

In the later 1970´s and early 1980´s, Letelier presented in a series of papers a formalism to treat gravity coupled to a cloud of strings, in the general relativity. Using this formalism, he obtained a generalization of the Schwarzschild solution in the sense that the resulting space-time is generated by a source constitued by a spherically symmetric body of mass M, surrounded by a spherically symmetric cloud of strings, which we are calling Letelier spacetime Using this same formalism he also obtained the solution of the Einstein's equations corresponding to plane symmetry, as well as, a particular case with cylindrical symmetry. This formalism was motivated by the idea to analyze the role played by a cloud of strings, as source of gravitational fields due to the fact that the universe can be represented, in principle, by a collection of extended objects, like one-dimensional objects, like strings. The use of extended objects, instead of point particles, offers a potential alternative to describe appropriately the physics of the universe with fundamental elements Otherwise, from the

gravitational point of view, it is important to investigate, for example, a black hole with an atmosphere of cloud of strings. On the other hand, the presence of the cosmological constant in different approaches in the framework of general relativity indicates that it is important to take into account the role played by this constant because of its connection with possible gravitational effects of its vacuum energy density in the physics of black holes. With the proposal to analyze the combined effects of the cloud of strings and the cosmological constant, we obtain the solution corresponding to black hole in this scenario and analyze the influence of these sources on the scattering of particles by examining the effective potential, which is investigated in detail, in terms of the parameters involved, namely, the mass of the black hole, the parameter which codifies the presence of the cloud of strings and the cosmological constant, The analysis of these parameters form the point of view of their roles on the conditions necessary for the existence of bound orbits is also discussed.

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High energy processes in Wolf-Rayet stars

Author: Stephen Skinner[1]

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Wolf-Rayet (WR) stars are massive stars that have evolved off the main-sequence and are undergoing advanced nuclear burning in their cores, rapidly approaching the end of their lives as supernovae. They are losing mass at very high rates and shocks associated with their metal-rich supersonic winds can produce strong X-ray emission, non-thermal (synchrotron) radio emission, and are potential sites for Galactic cosmic ray acceleration. I will summarize high-energy processes in WR stars, focusing on recent observations with the Chandra X-ray Observatory which are stringently testing current X-ray emission models based on the shocked wind paradigm.

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Nonthermal afterglow of GW170817: a more natural electron energy distribution leads to a new solution with radio flux in the low frequency synchrotron tail

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The nonthermal afterglow of the binary neutron star merger GW170817 has been modeled by synchrotron radiation of nonthermal electrons accelerated in the shock generated by ejecta or outflow from the merger. The previous afterglow modelings assumed that all the electrons in the shock are accelerated as a nonthermal population, and the minimum electron Lorentz factor gamma_m is the only parameter to control the total energy given to nonthermal electrons. However, in reality only a small fraction would be accelerated and the majority of electrons should remain as a thermal population, as normally observed in supernova remnant. Here we report the afterglow modeling with one more degree of freedom, i.e., the fraction of accelerated electrons, while gamma_m is another parameter corresponding to the degree of proton-electron equipartition. In the framework of stratified, quasi-spherical ejecta model, we performed a Markov-Chain Monte-Carlo analysis to find the best-fit parameters and allowed regions for the data of GW170817. We find a new solution in which the radio flux in the early phase is in the regime of low frequency synchrotron tail (nu < nu_m), in contrast to previous fits that found the entire spectrum above nu_m. Implications of this new result for physics of the outflow and ambient medium are discussed.

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Mass dependent parameters of extensive air showers with anomalous longitudinal profiles

Authors: Vladimir Novotny[1]; Dalibor Nosek[2]; Jiri Blazek[3]

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We investigate possibilities to determine a mass of primary particle from anomalous longitudinal profiles of extensive air showers. Such profiles are predicted utilizing a Monte Carlo technique together with the contemporal high-energy interaction models. The depth of shower maximum, that is commonly used for the mass composition analyses, is inspected and its performace to discriminate between primary species is studied. We search for alternative observables that have better properties in case of anomalous profiles.

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Three-dimensional simulations of rapidly rotating core-collapse supernovae

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We report results from a series of three-dimensional (3D) rotational core-collapse simulations for 11.2 and 27.0 $M_\odot$ stars employing neutrino transport scheme by the isotropic diffusion source approximation. By changing the initial strength of rotation systematically, we find a rotation-assisted explosion for the 27 $M_\odot$ progenitor, which fails in the absence of rotation. The unique feature was not captured in previous two-dimensional (2D) self-consistent rotating models because the growing non-axisymmetric instabilities play a key role. In the rapidly rotating case, a strong spiral flow is generated by the so-called low $T/|W|$ instability. That enhances the energy transport from the proto-neutron star (PNS) to the gain region, which makes the shock expansion more energetic. The explosion occurs oblately, which is different from previous 2D predictions.

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Follow-up of FAST pulsar discoveries

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Abstract:
Pulsars are fundamental tools for astronomy and physics. Every single new pulsar has the potential to provide an outstanding laboratory for a wide variety of physics, ranging from a better understanding of the stellar evolution to testing theories of gravity and placing limits on the equation-of-state. The most stable pulsars, who's precision approaches that of atomic clocks, are our only window into the extremely low-frequency ($< 10^{-8}$ Hz) gravitational waves expected from supermassive black hole binaries, which are not detectable by LIGO or LISA (Zoltan et. al 2017).

With the aim of finding the most exciting pulsars (e.g. a pulsar-black-hole binary), the Chinese Academy of Science (CAS), the MPI für Radioastronomie (MPIfR) and the Australia Telescope National Facility (ATNF) have started a major pulsar survey using the giant "Five-hundred-meter Spherical-dish Telescope" (FAST), the world's biggest radio-telescope. Since first light in September 2016, FAST has been undergoing commissioning observations. Already at this early stage, the pulsar survey is producing exciting science by finding new pulsars, demonstrating FAST's unprecedented sensitivity. The survey using FAST is one of the first science projects at the telescope. It makes use of the drift-scan mode and a wide-band receiver covering from 270 MHz to 1.6 GHz to search for pulsars and radio-transients. The follow-up observations of the promising candidates are carried by the 100m Effelsberg and 64m Parkes radio-telescopes given their the excellent pointing precision, positional and frequency agility.
Up to date, around two dozens of candidates have been confirmed and followed-up by Effelsberg and Parkes. Highlight of the discoveries are millisecond pulsars and binary systems.

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Thermodynamic stability of extremal black holes coupled to scalar fields

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We discuss thermodynamic stability of Riessner-Nördstrom (A)dS black hole in four dimensions, when it is coupled to the complex scalar field. Surprisingly, we show that it is unstable above or below some critical charge, if the scalar non-linearly couples to the black hole. This instability produces a second order phase transition near the critic point.

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CoLiTecVS –new tool for automated reduction of photometric observations

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The capabilities of telescopes allow us to make the plotting of light curves a routine task. This one shifts the main attention of astronomer from the plotting to research. To achieve this goal, we developed a new tool for automated reduction of photometric observations, which includes the computational method for the brightness assessment of the investigated and comparison stars; brightness equalization of astronomical images using inverse median filter; light curve plotting and its processing using different tools.

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V348 Pav - A polar with an extremely low-mass white dwarf

Author: Matheus Palhares[1]

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Cataclysmic Variables (CVs) are close binary systems composed of a white dwarf and a main sequence red star transferring mass to the compact object as it fills its Roche lobe. Polars are CVs where the white dwarf presents an intense magnetic field and material is transferred not by an accretion disc but is guided by the magnetic field lines to the white dwarf magnetic poles and have both stellar components rotating synchronously with the orbital period. In polars the emitted light is polarized due to the interaction of transferred material with the magnetic field lines that produce, for example, the cyclotron radiation. In a project to search for new magnetic Cataclysmic Variables (Oliveira et al. 2017), we selected the candidate V348 Pav for detailed observational follow-up. This source presents many kinds of variability in the CRTS (Catalina Real-Time Transients Survey) light curve: long (years) and short (one month) term variations between magnitudes 18 and 15, and 1 mag variations in timescales of few days. We obtained 13 h of time-resolved spectroscopic data with the Goodman spectrograph at the SOAR Telescope and 20 h of time-resolved polarimetric and photometric data with the P&E Telescope on OPD/LNA. The radial velocities of Hβ line present an orbital period ≈80 min. The photometric data show an 0.7 mag amplitude senoidal lightcurve with a period of 0.05556 days and a circular polarization modulated with an amplitude of about 30%. We present a model for V348 Pav using the CYCLOPS code (Costa & Rodrigues 2009). The resulting mass diagram using spectral emission lines, assuming a Roche lobe-filling secondary, shows a system with inclination of 30-40 degrees and a primary mass of 0.28-0.38 $M_\odot$.

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Rotating compact stars using M.I.T bag model and QHD-I model

Authors: Fábio Köpp[1]; Cesar Augusto Zen Vasconcellos[None]

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In this work we study hybrid composition stars using the M.I.T bag model and Walecka's linear model (QHD-I) for the core. For the region of lower density matter, i.e, the crust, we have used the Negele-Vautherin equation of state. When studying non- rotating stars, it is necessary to solve the conventional form of TOV's equations. However, for rotating stars, the metric must be modified to get the apropriate equations for pressure, gravitational and baryon masses. In order to obtain the result for rotating stars, we have used the free code RNS. Finally, we compared the M-R relation for static stars and rotating stars with the most recent corresponding results from pulsar observations.

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Possible influence of neutron star magnetic field on the frequencies of twin-peak quasi-periodic oscillations

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Motion of accreted gas approaching a neutron star (NS) in a NS low-mass X-ray binary (LMXB) system is determined by the relativistic scaling of orbital frequencies. The gas radiation dominates the NS LMXBs emissivity and accounts for most of the observed variability. As a likely consequence twin-peak quasi-periodic oscillations (QPOs) are observed in more than a dozen of sources. Motivated by the proportionality between the periods of orbital motion and NS mass we present a straightforward comparison between these sources. We investigate relations between QPO periods and their ratios and identify characteristic time scales of QPOs associated to individual sources. We show that in two millisecond pulsars these timescales are clearly longer than those in other NS LMXBs. We suggest that the origin of this difference relies in a relatively strong magnetic field of the pulsars. Our suggestion agrees with the scenario in which the magnetic field increases the gap between the accretion disc inner edge and the NS surface making the characteristic timescale of the orbital motion longer. Alternatively, based on any QPO model considering only geodesic orbital frequencies, the X-ray pulsars' mass has to be of a factor of 50% higher than a typical mass of other sources.

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Non-geodesic corrections to mass-spin estimates for Galactic microquasars implied by QPO models

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We study frequencies of axisymmetric and non-axisymmetric epicyclic modes of accretion disc oscillations and explore the influence of pressure forces present in the disc. We discuss the implications for estimations of black hole spin in the three Galactic microquasars, GRS 1915+105, GRO J1655-40, and XTE J1550-564, that have been carried out based on several models of 3:2 high-frequency quasi-periodic oscillations (QPOs). Our findings show that in the particular case of 3:2 epicyclic resonance model the presence of pressure forces affects the predicted QPO frequencies only slightly when $a < 0.9$. On the contrary, when $a > 0.9$, the influence of pressure forces is non-negligible. For several models this influence can be quite significant even for low values of spin. We furthermore discuss the differences between results obtained based on approximative analytic methods and those carried out using exact numerical methods.

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Contribution of QCD condensates to the OPE of Green functions of chiral currents

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Co-authors: Jiri Novotny [1]; Karol Kampf [1]

[1] *Charles University*

In this contribution, basic properties of QCD condensates will be presented, together with theirs relation to the operator product expansion (OPE) and the two-point and three-point Green functions constructed of chiral currents. Next, we will discuss our newest results for contribution of the QCD condensates with dimension $D < 6$ to the Green functions calculated within the framework of

chPT/RChT, i.e. chiral perturbation theory or resonance chiral theory. This matching of the OPE and such effective theories can lead to some coupling constants constraints and, therefore, thus allows us to obtain some unknown parameters of the chiral/resonance Lagrangian.

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Constraint interaction in dark sector with standard sirens

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The gravitational waves (GW) as standard siren directly determines the luminosity distance d_L from progenitor source without assuming any cosmological model, of which the redshift z can be obtained with the electromagnetic counterpart like GW events from coalescence binary neutron star (NS-NS) or neutron star/black hole (NS-BH) pair. In the near future, with the third generation GW detector like Einstein Telescope (ET) and Laser Interferometer Space Antenna (LISA), standard sirens will be a very useful cosmological probe to help in constraint cosmological parameters. The interaction dark matter - dark energy (DM-DE) models consider a non trivial dark sector, where dark energy and dark matter interact with each other. We obtain the constraints in DM-DE coupling constant provide by a $d_L - z$ standard siren simulated catalog. We generate 100 to 1000 GW events from NS-NS pair which can be detected by Einstein Telescope and constraint model parameters using Monte Carlo Markov Chain (MCMC) algorithm.

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Optimization of scintillators, applied to nuclear medicine and high energy physics

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The project is focused on the optimization and characterization of inorganic scintillators. Scintillators are materials that emit light (flashes), when an energy particle deposits energy in its volume, it serves to collect light from the ionization process and has a wide range of applications that are find from the study of high-energy physics, astrophysics, nuclear physics, cosmic rays, geophysics and for basic instruments in nuclear medicine (Computed Tomography: CT , Positron Emission Tomography: PET, Single Positron Emission Tomography: SPECT).
Inorganic scintillators will be optimized and characterized by the simulation of several types (PWO4, ZnWO4, CaWO4, BGO and LSO) and geometries (cylinder and parallelepiped) of scintillators, this simulation will be analyzed in GEANT4 (GEometry ANd Tracking), a platform to simulate the passage of particles through matter and LITRANI (LIght TRansmission in ANIsotropic media), is a program to simulate the propagation of photons.
The studies carried out in scintillators are always considered polished surfaces, the improvement in this project is to use roughness surfaces to improve the light collection in the detector and on the other hand the scintillators PWO4, ZnWO4, CaWO4, for high energy physics and for BGO and LSO nuclear medicine.

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Constraints on axionic dark matter in the 3-3-1 model

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Dark matter in the form of axions can be included in a model with $SU(3)_C \otimes SU(3)_L \otimes U(1)_X$ symmetry with right handed neutrinos, where the strong CP problem can be solved. This version of the model has the appealing characteristic of giving the observed dark matter abundance measured by the Planck collaboration, for suitable values of the parameters in the model.
We studied the constraints on the parameter space of the model obtained when the axion mass is calculated taking into account both QCD effects and gravitationally induced operators.

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Eclipsing binaries stars in the Bulge Galactic direction with OGLE and MACHO data

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The OGLE catalogue contains position and photometry information in the I band of 200000 variable stars in the direction of Bulge Galactic. Another project, MACHO, scanned the same region obtaining information from millions of variable stars but in bands b and r. We chose the OGLE fields that were intercepted with the MACHO fields and we calculated the light curves of the stars contained in the first catalog, from which we selected only the eclipsing binaries. Using the positions of both catalogs, we calculate the possible counterparts of the OGLE eclipsing binaries in the MACHO catalog and use the periods to finally deduce which were the counterparts. We obtained approximately 5400 eclipse binaries from OGLE with counterparts in the MACHO catalog. We hope to obtain preliminary information about the characteristics of these systems from the light curves of this type of objects in three bands.

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Exchange potential in KN scattering

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The Fock-Tani formalism is a first principle method to obtain effective interactions from microscopic Hamiltonians. Originally, derived for meson-meson or baryon-baryon scattering, we present the corresponding equations for meson-baryon scattering. Then we include the meson-quark coupling constant to the interaction potencial between quarks with gluon exchange. In particular, we shall obtain the low energy total cross section for the $K^- + p \rightarrow K^- + p$ channel.

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Constraints on the number of X-ray pulsars in IC 10 from a deep XMM-Newton observation

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We report the most sensitive search yet for X-ray pulsars in the dwarf starburst galaxy IC 10, which is known to contain a population of young high mass X-ray binaries. A total of 207 point-like X-ray sources were detected in the direction of IC 10 by a 2012 XMM-Newton observation with a total exposure time of 134.5 ks. We searched for pulsations in 207 sources. Pulsation searches in faint objects can be sensitive to the energy bands of the light curves and the background subtraction areas. Hence we analyzed separately the PN and Metal Oxide Semi-conductor (MOS) barycenter corrected 0.2-12 keV data, with good time interval (GTI) filtering, and fixed background subtraction. The searches were then repeated in the narrower 0.5-8 keV energy band to increase the signal-to-noise ratio with different background subtraction regions. Overall, 5 point sources produced significant peaks in the Lomb-Scargle periodogram (assuming white noise). A $\sim$4100 s period seen in all 3 instruments for the black hole (BH) + Wolf-Rayet (WR) binary IC 10 X-1 is probably due to red noise of astrophysical origin. Considering the periods, luminosities, and spatial distribution of the pulsar candidates in the direction of IC 10, they do not belong to the same distribution as the ones in the Magellanic Clouds and Milky Way. This result holds even if the candidates are spurious, since if the Small Magellanic Cloud (SMC) were placed at the distance of IC 10, we would expect to see $\sim$5 pulsars at $L_x > 10^{36}$ erg/s inside the D_{25} contour, and their periods would be of order 100 seconds, rather than the mostly $\sim$1 s periods for the candidates reported here, which lie outside the main body of the galaxy.

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Condensation of tetraneutron in neutron stars

Authors: Oleksii Ivanytskyi[1]; Angeles Perez-Garcia[1]; Conrado Albertus Torres[1]

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Based on recent experimental and theoretical hints on possible formation of a resonant four-neutron system we study effects of appearance of such a cluster in neutron rich baryon matter inside NSs. For this purpose we employ a relativistic mean field approach which includes nucleons, Δ-baryons as well as light nuclear clusters. Our analysis demonstrates that tetraneutrons existing as the Bose-Einstein condensate can affect the equation of state of cold baryonic matter and observable characteristics of neutrons stars. Tetraneutron driven suppression of Δ-baryons is another important result of our study. Influence of tetraneutrons on formation of superconducting phase is also discussed.

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Entropy evolution in CCDM cosmological models

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The second Law of Thermodynamics is an important approach to testing models and theories. If a model is not consistent with a constant or increasing entropy to achieve thermodynamic equilibrium must be discarded. Therefore, the study of Entropy suggests that it is possible to validate models or not. In this work, an approach is developed in light of the Second Law of Thermodynamics for Cold Dark Matter (CCDM) models in a context of the De Sitter Universe ages that allows us to test the thermodynamic consistency of CCDM models from the study of S'>0 and S"<0, suggesting limits of the parameters that these models have.

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Chiral phase transition in nonlocal NJL-like models under strong magnetic fields

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We study the behavior of quark matter under an external magnetic field in the context of nonlocal chiral quark models, focusing on the features of the chiral restoration transition. It is seen that these models naturally lead to the inverse magnetic catalysis effect found in lattice QCD calculations.

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Multi-particle fields as a method for hadron's description

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The development of multi-particle field method in the quarks scattering problem was considered. This method has been used to describe the differential cross section of elastic scattering by square of the transferred four-momentum. It is shown that the measurement of the interacting particles coordinates with simultaneity condition leads to impossible binding of probability amplitudes arguments, which are the coordinates of Fock column by Lorentz transformation or any other way. The state does not change in the transition from one inertial system to another in the case when the internal state of the particle can be considered as non-relativistic state, even if these systems are moving with relativistic velocities relative to one another [1]. With this result we consider dynamical equations for multi-particle fields, which describe creation and annihilation of hadrons after quantization and appreciate hadrons quark structure. Methods are similar for single-particle fields and it describes the hadrons processes and leads us to expressions of hadrons energy-momentum conservation law. If we consider single-particle field operators we will get expressions for constituent quarks and gluons.
It is shown that multi-particle fields method allows to describe formation of quarks bound state, bound states interaction and scattering in one model. In addition multi-particle gauge fields consideration allows to find interaction potential between quarks, which describes quarks confinement. It is also shown that dynamic equations for two-particle gluon field describe the gluons confinement [2]. The results are obtained for differential cross section of protons elastic scattering by square of the transferred four-momentum calculation. Unfortunately we could not achieve quantitative agreement with experiment, but qualitative results reproduce the experiment.
References:
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Chemical analysis of B stars in Orion

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In this work, a chemical analysis of a sample of B stars in the Orion Association is presented. This analysis consists in the calculation of the physical parameters: effective temperature ($T_{\rm eff}$) and surface gravity ($\log g$) by ionization equilibrium, and the determination of metal abundances of C, N, O, and Mg by a consistent analysis in non-LTE with TLUSTY. That is, the line formation and the model atmospheres are in non-LTE, unlike the analysis frequently used with line formation in non-LTE and model atmospheres in LTE.

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Stellar structure models of magnetized white dwarfs

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Standard models of non-rotating compact stars assumes perfect spherical symmetry. However, due to high magnetic fields, these compact stellar objects can be deformed making them oblate or prolate spheroids with distinct equatorial and polar radii. Recent work on models of the global structure of highly magnetized neutron stars indicate the macroscopic stellar properties such as masses and radii along with the gravitational redshift can change depending on the type of deformation. In this work, we apply these deformation models on the global stellar structure of highly magnetized white dwarfs in the framework of general relativity and calculate said stellar properties. We further examine these deformities by calculating the gravitational quadrupole moment (mass distribution) which is expected to be non-zero and investigate any changes from traditional spherical models.

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EFT for rotating neutron stars with WIMPS and strong sigma(-) repulsion in the pc-GR theory

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On the scope of the pseudo-complex General Relativity (pc-GR), we investigate the role of many-body correlations in the maximum mass of rotating neutron stars with degrees of freedom of hyperons and weakly interacting massive dark matter particles (WIMPs) in their composition. In the baryon sector, we consider the effective relativistic QHD-model with parameterized couplings, which represents an extended compilation of other effective models found in the literature. Our model exhausts the whole fundamental baryon octet and simulates corrections to the minimal Yukawa couplings by considering many-body nonlinear self-couplings and meson-meson interaction terms involving scalar-isoscalar, vector-isoscalar, and scalar-isovector components. Following recent experimental results, we consider in our calculations the extreme case where the Sigma(-) experiences such a strong repulsion that it does not appear at all in nuclear matter. The dark mater sector consists of Standard Model (SM) gauge singlet Dirac fermions originated in the Higgs portal of dark matter. In our approach, we decouple the physical Higgs from the dark Higgs. This assumption also decouples dark matter from ordinary matter and transforms the fermion singlet system to a non-interacting Fermi gas of WIMPs. There is a residual interaction of the fermion singlets with the dark Higgs. However, after symmetry breaking in the dark sector, the fermion singlets acquire a mass, which

we shall treat as a free parameter. In the pc-GR, the field equations have an extra term, associated to the nature of spacetime, of repulsive character, which is believed to halt the gravitational attractive collapse of matter distributions in the evolution process of compact stars. This additional extra term arises from micro-scale phenomena due to vacuum fluctuations, which simulate the presence of dark energy in the Universe. In this contribution, we explore the presence of this additional term and study the role of dark energy in the structure of neutron stars composed by nucleons, hyperons, mesons, and dark matter held together by the presence of the nuclear and gravitational interactions superimposed to the repulsive background of dark energy. The corresponding version of the Tolman-Oppenheimer-Volkoff equations in the pc-GR formalism is solved and the mass-radius relations as well as the maximum mass of the star are determined for different parameter configurations. Star rotation is implemented via the Lorene Code.

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Strangeness content of rotating neutron stars with hyperons and WIMPs degrees of freedom in the pseudo-complex general relativity

Authors: M.V.T. Machado[1]; D. Hadjimichef[1]; M. Razeira[2]; F. Köpp[1]; G. Volkmer[1]; B. Bodmann[1]; G.A. Degrazia[3]; C.A.Z. Vasconcellos[1]

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A new constraint on the equation of state and matter composition of neutron stars has been provided by the measurement of the mass of PSR J0348+0432 (2.01 $M_\odot$). In this contribution, we investigate, in the domain of the pseudo-complex General Relativity (pc-GR) with baryons, mesons, electrons and weakly interacting massive dark matter particles (WIMPs) degrees of freedom, the role of the asymmetry parameter, which describes the relative neutron excess in the system as well as the behavior of the strangeness asymmetry parameter, which specifies the strangeness content in the system and is strictly connected with the appearance of the hyperon species in the system. We consider in particular the extreme case where the Sigma(-) experiences such a strong repulsion that it does not appear at all in nuclear matter. In the baryon sector, we consider the effective relativistic QHD-model with parameterized couplings which represents an extended compilation of other effective models found in the literature. Our model exhausts the whole fundamental baryon octet and simulates corrections to the minimal Yukawa couplings by considering many-body nonlinear self-couplings and meson-meson interaction terms involving scalar-isoscalar, vector-isoscalar, and scalar-isovector components. The dark mater sector consists of Standard Model (SM) gauge singlet Dirac fermions originated in the Higgs portal of dark matter. In our approach, we decouple the physical Higgs from the dark Higgs. This assumption also decouples dark matter from ordinary matter and transforms the fermion singlet system to a non-interacting Fermi gas of WIMPs. There is a residual interaction of the fermion singlets with the dark Higgs. However, after symmetry breaking in the dark sector, the fermion singlets acquire a mass, which we shall treat as a free parameter. In the pc-GR, the field equations have an extra term, associated to the nature of spacetime, of repulsive character, which is believed to halt the gravitational attractive collapse of matter distributions in the evolution process of compact stars. This additional extra term arises from micro-scale phenomena due to vacuum fluctuations, which simulate the presence of dark energy in the Universe. In this contribution, we explore the presence of this additional term and study the role of dark energy in the structure of rotating neutron stars composed by nucleons, hyperons, mesons, and dark matter held together by the presence of the nuclear and gravitational interactions superimposed to the repulsive background of dark energy. The corresponding version of the Tolman-Oppenheimer-Volkoff equations in the pc-GR formalism is solved and the mass-radius relations as well as the maximum mass of the star are determined for different parameter configurations. Star rotation is implemented via the Lorene Code.

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Baryon-quark phase transition in rotating hybrid stars

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In this work, we study the behavior of nuclear matter at high densities considering the hadronic and quark phases at zero temperature. We describe the hadron-meson phase using a phenomenological Lagrangian, which exhibits a parametrization, through mathematical constants, of the intensity of the several meson-nucleon couplings. We have included in the formalism the chemical equilibrium equations, lepton degrees of freedom, the fundamental octet of baryons degrees of freedom, and the charge neutrality conditions. In the quark matter study, we have considered the classic MIT bag model with a constant bag pressure. Phase transition is determined by the Gibbs criteria. The influence of the model couplings in the determination of the phase transition density is discussed. We have also calculated maximum mass and radius for rotating hybrid stars. Star rotation is implemented via the Lorene Code.

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Effective field theory for rotating neutron stars with genuine many-body forces

Authors: M. Razeira[1]; D. Hadjimichef[2]; M.V.T. Machado[2]; F. Köpp[2]; G. Volkmer[2]; B. Bodmann[2]; G.A. Degrazia[3]; C.A.Z. Vasconcellos[2]

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The aim of our contribution is to shed some light on open questions facing the high-density nuclear many-body problem. We focus our attention on the conceptual issue of naturalness and its role in the baryon-meson coupling for nuclear matter at high densities. As a guideline for the strengths of the various couplings, the concept of naturalness has been adopted. In order to encourage possible new directions of research, we discuss relevant aspects of a relativistic effective theory for nuclear matter with natural parametric couplings and genuine many-body forces. Among other topics, we discuss in this work the connection of this theory with other known effective Quantum Hadrodynamics (QHD) models found in the literature and how we can use our approach to describe a new physics for rotating neutron stars. We also show some results for the equation of state, population profiles and mass-radius relation for rotating neutron stars assuming local charge neutrality and beta equilibrium. Star rotation is implemented via the Lorene Code.

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Rotating dark matter compact star in the framework of the pseudo-complex general relativity

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In the theory of pseudo-complex General Relativity (pc-GR), the field equations have an extra term, associated to the nature of spacetime, of repulsive character, which is believed to halt the gravitational attractive collapse of matter distributions in the evolution process of compact stars. This additional term arises from micro-scale phenomena due to vacuum fluctuations, which simulate the presence of dark energy in the Universe. In this contribution, we explore the presence of this additional term and propose a toy model consisting of dark matter, represented by Standard Model Fermi gauge singlets having their origin in the Higgs portal model, held together by the presence of the gravitational interaction and superimposed to the repulsive background of dark energy forming a type of unconventional and non-luminous star, composed only by dark matter and dark energy, a rare compact object formed solely by exotic content. The combination of these two ingredients, gravitational attraction and dark energy repulsion, allows the hydrostatic equilibrium condition of the star to hold. Solving the corresponding field equations and the TOV equations, and assuming that the fluid components interact only gravitationally, we determine the hydrostatic equilibrium equations of the star. We them analyze the corresponding results obtained for the equation of state and for the mass-radius relations and we them determine the maximum mass of the exotic rotating star for different parameter configurations. Star rotation is implemented via the Lorene Code.

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Universal accelerations and the Tully-Fisher relation for spiral galaxies in conformal gravity

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In a recent paper McGaugh, Lelli, and Schombert showed that in an empirical plot of the observed centripetal accelerations in spiral galaxies against those predicted by the Newtonian gravity of the luminous matter in those galaxies the data points occupied a remarkably narrow band. While one could summarize the mean properties of the band by drawing a single mean curve through it, by fitting the band with the illustrative conformal gravity theory with fits that fill out the width of the band we show here that the width of the band is just as physically significant. We show that at very low luminous Newtonian accelerations the plot can become independent of the luminous Newtonian contribution altogether, but still be non-trivial due to the contribution of matter outside of the galaxies (viz. the rest of the visible universe). We present a new empirical plot of the difference between the observed centripetal accelerations and the luminous Newtonian expectations as a function of distance from the centers of galaxies, and show that at distances greater than 10 kpc the plot also occupies a remarkably narrow band, one even close to constant. Using the conformal gravity theory we provide a first principles derivation of the empirical Tully-Fisher relation. The idea for this talk was first prompted in a conversation during IWARA 2016, and all relevant conclusions will be explored.

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Compatibility of the dark matter condensation inside the neutron stars and their observed properties

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We study a compatibility of the dark matter condensation inside the neutron stars with the observational constraints on the properties of these astrophysical objects. Effects of the baryon-lepton matter are taken under control based on the well tested novel equation of state of nuclear matter, which is able to fulfil a rich collection of constraints from nuclear physics and heavy ion collision experiments. Considering the dark matter as a free Fermi gas coupled to usual matter only by gravity we explicitly introduce mass and quantum mechanical degeneracy of these particles to the problem. Integration of the Tolman-Oppenheimer-Volkoff equation allows us to obtain the mass-radius diagram of neutron stars for different concentrations of dark matter particles and their masses from 100 MeV to 1 TeV. We argue, that concentrations of the dark matter typical for the Milky Way galaxy do not allow its particles to be heavier than several hundreds of GeV. This result can serve as a constraint for beyond the Standard Model theories aiming to explain the dark matter nature in terms of WIMPs.

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Pseudo-complex general relativity and the slow-rotation approximation for neutron stars

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Pseudo-complex General Relativity is an algebraic extension of the standard theory of gravitation that relies on pseudo-complex numbers in order to get new metric degrees of freedom. The pseudo-complex formalism has an extra contribution to the Einstein equations with a repulsive character that has been called *dark energy*. This dark energy is relevant only when intense gravitational fields are present, therefore neutron stars are an interesting environment to test predictions. Since all neutron stars rotate, it follows that a complete account of the implications of Pseudo-complex General Relativity for compact stars should discuss rotation. In this work we analyze the impact of the pseudo-complex formalism in different physical quantities using the slow-rotation approximation for relativistic stars.

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Exact solutions of a model for strange stars with interacting quarks

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The search for the true ground state of dense matter remains open since thestrange matter hypothesis was proposed by E. Witten in 1984. In this hypothesis the strange matter is assumed to be composed of u, d and s quarks, having an energy per baryon lower than that of quark matter (only u and d), and even than of the nuclear matter. In this sense, neutron stars would actually be strange stars. Later work showed that a color flavor locked (CFL) state would be preferred to the one without any pairing for a wide range of the parameters (gap Δ, strange quark mass m_s, and bag constant B). We use an approximate, yet very accurate CFL equation of state (EoS) to obtain exact solutions for the static Einstein Field Equations (EFE) that describe a compact relativistic object. A density profile and mass-radius relation are constructed.

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Impact of magnetic field on shape and velocities of compact objects

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We study two macroscopic signals where the contribution of the magnetic field has an important role. The first one is related to kicks pulsar induced by neutrino emission from the core of neutron stars. The anisotropic neutrino emission produces a rocket effect that contributes to the star's kick velocity. We find that the computed values for the kick velocity lie within the range of the observed values. On the other hand, we study the shape of strange stars generalizing the Tolman-Oppenheimer-Volkov equations based on the metrics where the parameter relates the deformation with the anisotropy in the pressures.

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Effective field theory with genuine many-body forces and tidal effect in neutron stars

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In this contribution we combined our predictions for the tidal parameter with recent gravitational wave observation of merging system of binary neutron stars of the event GW170817 with quasi universal relations between the maximum mass of rotating and nonrotating neutron stars. Our results indicate that predictions of the tidal parameter represent an useful constraint of the EoS of neutron star matter.