The Modern Physics of Compact Stars and Relativistic Gravity 2017

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Book of Abstracts

Contents

7

Turbulence in Core-Collapse Supernovae

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Core-collapse supernovae are the powerful explosions of massive stars that occur at the end of their lives. They play a crucial role in the evolution of the Universe, producing most elements heavier than iron and leading to the formation of neutron stars and black holes. Despite their importance, the details of how they explode are still unclear. In this talk, I will review the recent progress in our understanding of the explosion mechanism, with an emphasis on the role of turbulence in facilitating an explosion.

Type of contribution:

Invited talk

17

Impact of the MIT bag model parameters values on the maximum mass of neutron star with a quark core

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The effect of model parameters of quark matter equation of state on the magnitude of the maximum mass of a hybrid star is investigated. The quark matter is described within the framework of the extended MIT bag model with one-gluon exchange corrections taken into account. For nucleon matter within the density region, corresponding to a phase transition, the relativistic equation of state is used and calculated with consideration of two-particle correlations, based on the Bonn meson-exchange potential. Using Maxwell's construction, the characteristics of a first-order phase transition are calculated, and it is shown that for a fixed value of the strong interaction constant α_s, the baryon concentrations of the coexisting phases grow monotonically with increasing bag constant B. It is shown that for a fixed value of the strong interaction constant α_s, the maximum mass of a hybrid star increases with decreasing bag constant B. For a given value of the bag parameter B, the maximum mass increases with increasing strong interaction constant α_s. It is shown that the hybrid star configurations, with maximal mass equal to or exceeding the mass of the currently known most massive pulsar, are possible for the values of the strong interaction constant $\alpha_s > 0.6$, also for sufficiently small values of the bag constant B.

Type of contribution:

Talk

32

Supporting the existence of the QCD critical point by compact star observations

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In order to prove the existence of a critical end point (CEP) in the QCD phase diagram it is sufficient to demonstrate that at zero temperature $T = 0$ a first order phase transition exists as a function of the baryochemical potential μ, since it is established knowledge from ab-initio lattice QCD simulations that at $\mu = 0$ the transition on the temperature axis is a crossover.

We present the argument that the observation of a gap in the mass-radius relationship for compact stars which proves the existence of a so-called third family (aka "mass twins") will imply that the $T = 0$ equation of state of compact star matter exhibits a strong first order transition with a latent heat that satisfies $\Delta\epsilon/\epsilon_c > 0.6$. Since such a strong first order transition under compact star conditions will remain first order when going to symmetric matter, the observation of a disconnected branch (third family) of compact stars in the mass-radius diagram proves the existence of a CEP in QCD. Modeling of such compact star twins is based on a QCD motivated NJL quark model with high order interactions together with the hadronic DD2-MEV model fulfilling nuclear observables. Further approaches include multipolytrope EoS description and constant speed of sound for the quark matter EoS. Moreover, astrophysical applications of high mass twins phenomenon are presented.

Type of contribution:

Talk

8

Calculation of symmetry energy using Argonne family potentials with three nucleon interaction

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Calculation of symmetry energy using Argonne family potentials
with three nucleon interaction

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The symmetry energy has been given attention in recent years because of its fundamental impor
    In this work, we intend to apply lowest order constrained variational (LOCV) approach [2]
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Type of contribution:

Talk

11

Qualitative Investigation of the Cosmological Model in the Presence of a Conformally Coupled Scalar Field

Author: Roland Avagyan[None]

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Among currently existing approaches to solve the problem of accelerated expansion of the Universe at various stages of the evolution, a special attention is paid to cosmological models in the presence of various scalar fields. In the present work we consider a model with a non-minimal interaction term ψ2R in the Lagrangian density (ψ is a scalar field, R is the scalar curvature). The latter is obtained as a result of Beckenstein transformations within the framework of the Jordan-Branse-Dicke theory. The system of gravitational equations for such a problem is represented in the form of an autonomous dynamical system, which allows us to use the method of the qualitative theory of dynamical systems. We consider a cosmological vacuum model with the equation of state P = -ε, actually, the inflationary model of evolution, as well as the recent epoch with the predominance of dust matter. As a result, a qualitative analysis of the results is carried out.

Type of contribution:

Talk

35

Bayesian Analysis of Hybrid EoS Models Using Mass and Radius Data from Compact Star Observations

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A Bayesian analysis for a new class of realistic models of hybrid equations of state (EoS) with mixed phase is performed. The mixed phase is described by a one parameter simple model. The parameter represents the impact of the mixed phase structure to the pressure. It is demonstrated that the observation of a possible pair of high-mass twin stars would have a sufficient discriminating power to favour hybrid EoS with a strong first-order phase transition over alternative EoS.

Type of contribution:

Talk

2

Modification of Compact Star Observables due to Quantum Fluctuations

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We present the application of our technique to obtain equation of state (EoS) by the Functional Renormalization Group (FRG) method presented earlier. Using the expansion of the effective potential in a base of harmonic functions at finite chemical potential we can provide a general framework for the calculation of the EoS. Within this theoretical framework we determined the equation of state and the phase diagram of a simple model – as a proof-of-concept. To illustrate this we used the simplest, non-trivial case, where massless fermions coupled to scalars through Yukawa-coupling at the zero-temperature limit.

We compared our results to the 1-loop and the mean field approximation of the same model and other high-density nuclear matter equation of states. We found a $10-20\%$ difference between these approximations. As an application, we used our FRG-based equation of states to test the effect of the quantum fluctuations in superdense nuclear matter of a compact astrophysical object. To illustrate the magnitude of this effect, we calculated the mass-radius relation for a compact star using the Tolmann-Oppenheimer-Volkov equation and observed a 5% effect in compact star observables due to quantum fluctuations.

Type of contribution:

Talk

15

Induced fermionic current by a magnetic tube in the cosmic spacetime

Author: Eugenio Bezerra de Mello[1]

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In this talk we examine the vacuum fermionic current induced by a magnetic field confined in a cylindrical tube of finite radius a in cosmic string spacetime. Three distinct configurations of magnetic fields are taken into account:

· a cylindrical shell of radius a,
· a magnetic field proportional to 1/r,
· a constant magnetic field.

`In these three cases, the axis of the infinitely long tube coincides with the cosmic string.`

Type of contribution:

Invited talk

31

Quark-Nuclear Hybrid Star EoS with Excluded Volume Effects

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A two-phase description of the quark-nuclear matter hybrid equation of state that takes into account the effect of excluded volume in both the hadronic and the quark-matter phases is introduced. The nuclear phase manifests a reduction of the available volume as density increases, leading to a stiffening of the matter. The quark-matter phase displays a reduction of the effective string-tension in the confining density-functional from available volume contributions. The nuclear equation of state is based upon the relativistic density functional model DD2 with excluded volume. The quark-matter EoS is based upon a quasiparticle model derived from a relativistic density-functional approach and will be discussed in greater detail. The interactions are decomposed into mean scalar and vector components. The scalar interaction is motivated by a string potential between quarks, whereas the vector interaction potential is motivated by higher-order interactions of quarks leading to an increased stiffening at high densities. As an application, we consider matter under compact star constraints of electric neutrality and beta-equilibrium. We obtain mass-radius relations for hybrid stars that form a third family, disconnected from the purely hadronic star branch, and fulfill the 2M_sun constraint.

Type of contribution:

Talk

40

"Trapped ghost" wormholes and regular black holes. The stability problem.

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We briefly review the properties of static, spherically symmetric configurations of general relativity with a minimally coupled scalar field ϕ whose kinetic energy is negative in a restricted (strong-field) region of space and positive outside it [1–3]. This "trapped ghost" concept may in principle explain why no ghosts are observed under usual, weak-field conditions. The configurations considered are wormholes and regular black holes without a center, in particular, black universes (black holes with an expanding cosmology beyond the event horizon) [4–6]. Spherically symmetric perturbations of these objects are considered,

and it is stressed that, due to the universal shape of the effective potential near a transition surface from canonical to phantom behavior of the scalar field, such surfaces restrict the possible perturbations and play a stabilizing role.

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Type of contribution:

Invited talk

13

An empirical nuclear Equation of State constrained by nuclear observables

Authors: Debarati Chatterjee[1] ; Francesca Gulminelli[1] ; Adriana Raduta[2] ; Jerome Margueron[3]

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One of the challenges in nuclear physics is to describe finite nuclei and neutron stars within the same theoretical framework. A crucial entity is the nuclear Equation of State (EoS), which can be defined in terms of a set of empirical parameters (saturation density, compressibility, symmetry energy and its derivatives etc). In turn, these quantities are constrained using experimental data on ground state nuclear properties. The phenomenological models that are extensively employed in nuclear calculations have parameters that are fit to well-determined empirical nuclear observables, which must be updated with the rapidly improving experimental data. Further, they may contain spurious correlations with the empirical quantities. In this work, we develop a model-independent unified description of nuclear matter, that can be related directly to empirical quantities specifically sensitive to the EoS. We then apply this model to predict experimental observables such as charge radii and the neutron skin.

Type of contribution:

Talk

16

Null congruences crossing generic shells

Authors: Hovhannes Demirchian[1] ; Martin O'Loughlin[2]

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We present a new technique for describing geodesic congruences (for example the trajectory of a gas of photons or particles) crossing a generic light-like shell in vacuum. In particular the change in the direction of the vector field of the congruence has been derived and shown to be in agreement with the results of Barrabes and Hogan thus demonstrating the validity of this technique. For the case of null shells generated by infinitesimal BMS supertranslation type soldering, the expansion and shear tensors of the congruence have also been calculated. We derived the surface equation, for relative motion orthogonal to the congruence after it crosses the shell, proving also that the congruence is always hypersurface orthogonal and the rotation tensor is always zero. This means that the Eikonal approximation can be applied to describe it as a wave on the future, and this has been carried out for a special BMS type soldering. The conditions for focusing, defocusing and formation caustics have been studied.

Type of contribution:

Talk

41

Phase diagram of hadron matter in effective models of QCD

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For a description of matter at high temperature and density effective models of Nambu-Jona-Lasinio type have proven most useful. The Polyakov loop extended NJL (PNJL) model can reproduce results of lattice QCD at zero and imaginary chemical potential, where LQCD has no sign problem. In the contribution we present the dependence of the first-order phase transition line and its critical endpoint in the PNJL model phase diagram when the following aspects are taken into account: the parametrization of the effective potential $U(\Phi, \bar{\Phi}; T)$; including of the quarks
repulsion (vector interaction);
an additional interaction between quarks and gluons.

Type of contribution:

Talk

9

A NEW APPROACH TO STUDY OF QUANTUM VACUUM - DARK ENERGY

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As is well known, in quantum field theory (QFT) the quantum vacuum (QV) is represented as an infinite set of different fluctuating virtual particles and fields in four-dimensional Minkowski space-time. In this connection, a natural question arises: what is the structure of QV, when the latter is in a state of statistical equilibrium and there is no external influence on it? It is obvious that satisfactory answers to these non-trivial questions we can obtained only within the framework of non-perturbative quantum field models. In this paper, we consider the quantum equation of a massless field in the fluctuating four-dimensional Minkowski space-time, which is equivalent to an uncountable-dimensional space-time. As the basic equation is used the Langevin type stochastic matrix equation, regardless of the formalism of second quantization. It is assumed that, on small four-dimensional space-time intervals, the quantum field equation coincides with a regular matrix equation analogous to the Weyl equation for a neutrino. It is proved that in the statistical equilibrium limit the initial uncountable space-time is reduced to a ten-dimensional space-time, where four dimensions are Minkowski space-time, and the remaining six dimensions are compact topological subspaces. In detail is studied conditions of quantization of vacuum fields in compact subspaces and it is shown that these quantized states can claim the role of dark energy. It is shown that even weak external electromagnetic fields are capable of deforming compact subspaces, because of which the refractive indices of a vacuum can vary measurably. The latter, in particular, means that the developed representation allows for the existence of a new mechanism of interaction between photons through the deformation of compact subspaces, which is fundamentally differ from the usual mechanisms of photon-photon scattering, described by the fourth order Feynman's diagrams.

Type of contribution:

Talk

25

Cooling of massive neutron stars

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The existence of the high mass pulsars PSR J1614-2230 and PSR J0348-0432 with masses of about 2 M_sun requires a sufficiently stiff equation of state (EoS) of the stellar matter to fulfill this constraint. We succeeded to explain the thermal evolution of compact stars with stiff hadronic EoS in the framework of the "nuclear medium cooling" scenario. We have also investigated the case when due to phase transition to quark matter the third family of compact stars for higher densities can exist. In this case high-mass twin stars could show different cooling behavior. The cooling scenarios have a discriminating power for selection of optimal EoS models for compact stars.

Type of contribution:

Talk

19

Stability and mass defect of hot strange dwarfs

Authors: Ani Alaverdyan[1] ; Gevorg Hajyan[1]

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The dependences of the mass and the mass defect on the baryonic mass of the isothermal (the stars with the same core temperature) and the isentropic (the stars with the same entropies per one baryonic charge) series of the hot strange stars are investigated .The stability of these stars is determined by these dependences. It is shown that isentropic series of the hot strange stars are also isothermic series of these stars for the surface temperatures. It is also shown that the proximity of the points of the maximum mass and the loss of stability on the isothermal series is determined by very weak dependence of the numerical value of the maximum mass of strange stars on the value of the central temperature.

Type of contribution:

Talk

18

Is it possible to determine whether the EG 50 is a white or strange dwarf by the nature of its cooling?

Authors: Gevorg Hajyan[1] ; Yury Vartanyan[1]

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Taking into account the neutrino energy losses the time dependences of the luminosities of a white dwarf and four strange dwarfs with masses of $0.5M_{\odot}$ (the mass of white dwarf EG 50 with the surface temperature $2.1 \cdot 10^4 K$) has been determined. It was assumed that these configurations radiate only at the expense of thermal energy reserves. It has been shown that the sources of thermal energy due to nonequilibrium β -processes and the phenomenon of crystallization of the electron-nuclear matter in determining the cooling time of white and strange dwarfs with a mass of $0.5M_{\odot}$ are insignificant . It has been shown that in the considered approximation, the time dependences of the luminosities of the white and strange dwarfs with a mass of $0.5M_{\odot}$ differ noticeable only at surface temperatures $T_R > 7 \cdot 10^4 K$. So it is impossible to determine the whether EG 50 belongs to white or strange dwarfs.

Type of contribution:

Talk

27

Transport coefficients of two-flavor quark matter from the Kubo formalism

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We compute the transport coefficients of quark matter in the strong coupling regime within the two-flavor Nambu–Jona-Lasinio model. We apply the Kubo formalism to obtain the thermal (κ) and the electrical (σ) conductivities as well as the shear (η) and the bulk viscosities (ζ) at leading order in the $1/N_c$ power counting scheme. In this approximation the conductivities and the shear viscosity are given by single-loop skeleton diagrams, whereas the bulk viscosity includes an infinite geometrical series of multi-loop diagrams. The dispersive effects that lead to nonzero transport coefficients arise from quark-meson fluctuations above the Mott transition temperature T_M, where meson decay into two on-mass-shell quarks is kinematically allowed.

We find that the conductivities and the shear viscosity are decreasing functions of temperature and density above T_M. We also show, that the Wiedemann-Franz law for the ratio σ/κ does not hold. The ratio of the shear viscosity to the entropy density is larger than unity close to the Mott temperature and approaches the AdS/CFT bound $1/4\pi$ at higher temperatures. We conjecture on the basis of the uncertainty principle that the ratio $\kappa T/c_V$, where c_V is the heat capacity per unit volume, is bounded from below by 1/18.

The case of the bulk viscosity turns out to be special, because the multi-loop contributions dominate the single-loop contribution close to the Mott line in the case where the chiral symmetry is explicitly broken. The resulting bulk viscosity exceeds the shear viscosity close to the Mott line by factors 5-20. In the high-temperature domain the bulk viscosity is negligible compared to the shear viscosity. For practical applications we provide simple, but accurate fits to the transport coefficients which can facilitate the implementation of our results in hydrodynamics codes.

Type of contribution:

Talk

28

Electromagnetic vacuum densities induced by a cosmic string in de Sitter space

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We investigate the influence of a cosmic string on the vacuum fluctuations of the electromagnetic field in background of (D+1)-dimensional de Sitter spacetime.
The expectation values (VEVs) of physical characteristics for the Bunch-Davies vacuum state are evaluated. The VEVs are presented in a decomposed form where
the topological parts induced by the cosmic string are explicitly extracted. The asymptotic behavior of the VEVs at large and small distances from the string is discussed.

Type of contribution:

Talk

14

Low-Energy Nuclear Interaction Chamber for Experiments in Nuclear Astrophysics

Authors: Amur Margaryan[1] ; Vachik Khachatryan[1]

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A Low-EneRgy Nuclear Interaction Chamber, LERNIC, has been developed to be used as an active target system for nuclear astrophysics experiments. LERNIC is a position and time sensitive detector system based on the low-pressure MWPC technique. While the astrophysically relevant nuclear reaction processes at stellar burning temperatures are dominated by radiative captures, in this experimental scheme we will measure the time-reversed processes. Due to the transformation of phase space, the photodisintegration cross-sections are up to two orders of magnitude higher. The main advantage of this new target-detector system is a capability to operate at high intensity photon beams, high sensitivity to the low-energy, highly ionizing particles and insensitivity to the γ-rays and minimum ionizing particles, thus allowing us to detect only the products of the nuclear reaction of interest. The main disadvantage of this detector is a density several orders of magnitude lower than conventional gas targets. It can be compensated by using multi-module detector system and highly directed, intense, laser Compton backscattered γ-ray beam. The test results of the prototype detector as well as the possibility of measurement of the cross section of γ + 16O ⟶ 12C + α reaction are discussed.

Type of contribution:

Talk

30

Charged ρ-meson condensate in neutron stars within RMF models

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Knowledge of the equation of state (EoS) of cold and dense baryonic matter is essential to describe the properties of neutron stars (NSs). With an increase of the density new baryon species can appear in NS matter, as well as various meson condensates. In previous works we developed relativistic mean-field (RMF) models with hyperons and Δ-isobars, which passed the majority of known experimental constraints, including the existence of a $2\,M_\odot$ neutron star. In this contribution we present results of inclusion of ρ^--meson condensation into these models. We have shown that in one class of the models, where the additional stiffening mechanism is incorporated in the isospin-symmetric sector (KVOR-based models) the condensation gives only a small contribution to the EoS. In other class, where the stiffening is reached by modifying the isospin-asymmetric part of the model (MKVOR-based models), the condensation can lead to a first-order phase transition and a substantial decrease of the NS mass. Nevertheless, in all resulting models the condensation does not spoil the description of the experimental constraints.

Type of contribution:

Talk

3

Pulsar glitch dynamics in general relativity

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Pulsar glitches are commonly interpreted as angular momentum transfers occurring between two fluids present in the stellar interior, triggered by the rapid motion of superfluid vortex lines at large scales. We consider for the first time all general relativistic effects in a numerical model for glitches. First, we show numerical calculation of stationary configurations of neutron stars composed of a neutron superfluid and a fluid made of charged particles, spinning with different rotation rates. These general relativistic calculations are based on realistic equations of state accounting for entrainment effects between the fluids. These configurations are then used to build a numerical model for pulsar glitches in full general relativity. In particular, we study in details the characteristic time scale associated with the spin-up stage, during which the stellar dynamics are governed by a mutual friction force arising from the interactions between the superfluid vortices and the surrounding fluids. Taking general relativity into account leads to an additional coupling between the fluids through frame-dragging effects and is shown to affect significantly the actual value of the spin-up time scale.

Type of contribution:

Talk

4

Accelerating cosmology in modified gravity and neutron stars

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We give the review of modified gravity as applied to Universe evolution. It is shown that number of modified gravities may provide the consistent unification of the early-time inflation with late-time acceleration. Special attention is paid to F(R) gravity which represents the most developed class of such theories. Specific features of possible evolution in such theories are indicated: singular inflation, bounces, etc. We also show the possible modification of TOV equations for relativistic stars in modified gravities. As a result the mass-radius relation may change qualitatively giving the window for the increase of mass for relativistic stars with small radii.
The results are based on the following works:
1. S. Nojiri and S.D. Odintsov, Unified cosmic history in modified gravity: from F(R) theory to Lorentz non-invariant models. Phys. Rept. 505, 2011, 59, doi:10.1016/j.physrep.2011.04.001, arXiv:1011.0544 [gr-qc].
2. A.V. Astashenok, S. Capozziello and S.D. Odintsov, Extreme neutron stars from Extended Theories of Gravity, JCAP 1501, 2015, no.01, 001, doi:10.1088/1475-7516/2015/01/001, arXiv:1408.3856 [gr-qc].
3. A. V. Astashenok, A. de la Cruz-Dombriz and S.D. Odintsov, The realistic models of relativistic stars in f(R) = R + alpha R^2 gravity, arXiv:1704.08311 [gr-qc].

Type of contribution:

Invited talk

26

Hot neutron stars with hyperons

Author: Micaela Oertel[1]

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In this talk I will present a temperature dependent equation of state (EoS) including the entire baryon octet, being compatible with the main constraints from nuclear physics and, in particular, with a maximum mass for cold β-equilibrated neutron stars of $2M_\odot$ in agreement with recent observations. As an application, numerical stationary models for rapidly (rigidly) rotating hot neutron stars have been computed. I will discuss their maximum masses and the universality of I-Q-relations at nonzero temperature for fast rotating models.

Type of contribution:

Invited talk

23

Spectral Analysis of the Vela Pulsar and its Neutrino Cooling Rate

Authors: Dmitry Ofengeim[1] ; Dmitry Zyuzin[1] ; Dmitry Yakovlev[1]

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The PSR B0833-45 (the Vela pulsar) is the famous neutron star. Its age is about 11 kyr and it cools mainly via neutrino emission from its superdense core. Its surface temperature of $\sim$ 0.7 MK was obtained from the analysis of its X-ray spectrum assuming that the star's mass is $1.4\ M_{\odot}$ and the radius is 10 km (Pavlov et al. 2001, ApJ 552, L129). The Vela pulsar appears to be one of the coldest middle-aged neutron stars with measured surface temperature.

We have reanalyzed the Vela's X-ray spectrum inferred from archival *Chandra* observations (ObsID 127, 131 and 1852). We have employed a magnetic hydrogen (*nsmax*) atmosphere model from *Sherpa* package, considering a wide range of possible masses and radii. Our results show that, while the Vela's surface temperature is very close to that derived by Pavlov et al. (2001), the star has likely either large mass ($\geq 1.7\ M_{\odot}$) or large radius (≥ 13 km).

Using the results of spectral analysis, we have considered the cooling of the Vela pulsar. We have assumed that the star has a nucleon core with strong triplet neutron superfluidity, prohibited (or suppressed) direct Urca process and a partially accreted outer envelope (the so-called minimal cooling paradigm, Page et al. 2004, ApJSS 155, 623). Neutron pairing produces a sufficient enhancement of neutrino emission from the core (compared to the standard neutrino cooling via modified Urca process) so that the neutrino cooling can be responsible for the Vela's low temperature. Employing nuclear physics restrictions on neutron triplet pairing models, we can constrain the mass of the accreted matter (containing light elements) in the Vela's outer envelope.

Type of contribution:

Talk

36

Realistic compactification models in Einstein-Gauss-Bonnet gravity

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The abstract: In this talk I give a brief review of our recent development on the cosmological dynamics in the Einstein-Gauss-Bonnet gravity. The special attention is paid to the models which allow realistic compactification. We require only for model to be free of future singularities and has a "standard" cosmological singularity af the origin. Using such weak requirements, for the simplest spatially flat model, we are able to put constraints on the parameters of the theory and the number of extra dimensions. Consideration of more complex
models (with spatial curvature and additional anisotropies) allow us to tighten the constraints.

Type of contribution:

Talk

39

Scalar field dark energy reconstruction from the SNe Ia data

Author: Arpine Piloyan[None]

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I report the results of the scalar field dark energy reconstruction from the SNe Ia data. In our reconstruction we do not use any ansatz for the dark energy, which makes our procedure quite generic. We describe the reconstruction procedure and test it with mock data. After this, we apply it to real SNe data. Our results suggest that the current SNe Ia data is of insufficient quality for the scalar field dark energy to be reliably reconstructed.

Type of contribution:

Talk

6

Astrophysical and Cosmological Tests of Gravity

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The unknown nature of dark matter and dark energy, as well as rapid improvements in the accuracy of the astronomical data, inspired studies of extensions of Einstein's theory of General Relativity and ways of testing them against observations. I will review the current state of the very active field of Testing Gravity, and what we can expect to learn about Gravity from the next generation of cosmological surveys.

Type of contribution:

Talk

21

Hadron-Quark Transition in High Density Nuclear Matter

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The talk will focus on the dynamics of nucleon-nucleon repulsive core and
the mechanisms of quark-hadron transition in high density nuclear matter.
The strength of the nuclear repulsion plays an important role in the equation of state of
the nuclear matter and its mechanism is largely unknown.
There are several issues such as hidden-color degrees of freedom, supefast quarks as well as inelastic
excitations in nucleon-nucleon systems that currently considered as
possible mechanisms in generating nuclear repulsion. These mechanisms will
be discussed in detail considering their implication in the dynamics of the superdense
nuclear matter. Also the brief overview will be given on the possibilities of experimental
verification of the nuclear core dynamics in fixed target and collider experiments.

Type of contribution:

Talk

29

Magnetic field generation in hybrid neutron stars

Authors: David Sedrakian[1] ; Mekhak Hayrapetyan[1] ; Daniel Baghdasaryan[2]

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The mechanism of magnetic field generation in hybrid neutron stars (consisting of "npe" hadronic, "2SC" and "CFL" quark phases) is considered. We assume that rotational vortices in "npe" and "CFL" phases with quantum of circulation ⊠ℏ/⊠ are continued in "2SC" phase as well. Since superconducting matter in "npe" and "2SC" phases is charged, rotation induced entrainment currents
arise around vortices, which generate magnetic field. Mean value of generated magnetic field is about
1016Gs and exceeds one in "npe" phase by 3-4 orders of magnitude. The magnetic field enters the vicicnity of rotational vortices forming the clusters of magnetic vortices with quantum of magnetic flux Φ0 in "npe" phase and 2Φ0 in "2SC" phase. The radii of clusters are 0.1⊠ and0.3⊠, respectively, in "npe" and "2SC" phases, where ⊠ is a radius of rotational vortex. Magnetic field penetrates in "CFL"
phase via magnteic vortices with magnetic flux2Φ0. In "npe" phase this magnetic field can destroy proton superconductivity. Magnetic field on the surface of a star reaches the value of 10
15Gs, which is
comparable with magnetic field of magnetars. Therefore magnetars are candidates of compact objects
containing quark matter.
Due to high density of magnetic energy of vortices, vortex-free zone appears at the bound of "2SC" phase with width about several hundred meters. An outward motion of vortices during spindown
of a star leads to energy release when vortices reach to the boundary of vortex-free zone.
Magnetic energy of annihilated vortices may become the source of high-frequency radiation of objects like SGR and AXP.

Type of contribution:

Invited talk

10

Some theoretical aspects of magnetars

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Magnetars have been observationally determined to have surface magnetic fields of order of 10^{14}–10^{15} G, the implied internal field strength being several orders larger. We discuss the effect of strong field on the dense matter expected to be inside neutron stars. We describe the microphysics, phenomenology, and astrophysical implication of strong field induced unpairing effect that may occur in magnetars, if the local magnetic field in the core of a magnetar exceeds a critical value. The density dependence of pairing of proton condensate implies that the critical value required for unpairing effect to occur is maximal at the crust-core interface and decreases towards the center of the star. As a consequence, magnetar cores with homogenous constant fields will be partially superconducting for "medium-field" magnetars whereas "strong-field" magnetars will be void of superconductivity. We also discuss its effect on some observational effect which depend the nature and composition of matter inside neutron stars.

Type of contribution:

Talk

34

$f(R)$ relativistic gravity and inflationary models based on it

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The $f(R)$ gravity represents the simplest purely geometrical generalization of the Einstein general theory of relativity without undesirable ghosts. The pioneer $R + R^2$ model of inflation (1980) contains only one adjustable parameter taken from observations, has a graceful exit from inflation and a natural mechanism for creation and heating of matter after its end. It produces a very good fit to existing observational data on the power spectrum of primordial scalar (adiabatic density) perturbations. Due to the structure of this model, small quantum-gravitational loop corrections to it from quantum matter fields and gravity itself are important for its dynamics both during and after inflation and can lead to observable effects. I present solution of the inverse problem of reconstruction of slow-roll inflationary models in f(R) gravity using information on the power spectrum of scalar perturbations only and show how ambiguity in this procedure due to the absence of data for small scales can be fixed using simplifying and aesthetic assumptions on the absence of new physical scales during and after inflation. Also discussed is the problem on formation of inflation in f(R) gravity from generic classical curvature singularity preceding it, and which conditions are needed for this.

Type of contribution:

Invited talk

22

Anisotropic Self-gravitating Objects

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We study the anisotropic self-gravitating objects with polytropic equation of state in both contexts of Newtonian gravity and General Relativity.
First we discuss Newtonian case, where we start with hydrostatic equilibrium equation. By arriving at Lane–Emden equation we study the effects of an anisotropic pressure on the boundary conditions of the anisotropic Lane–Emden equation and the homology theorem.
Then we go to the relativistic case and by using the anisotropic Tolman–Oppenheimer–Volkov (TOV) equations, we explore the relativistic anisotropic Lane–Emden equations. After that we find how the anisotropic pressure affects the boundary conditions of these equations.
For both cases some new physically well-defined solutions are derived.

Type of contribution:

Talk

24

MAGIC - MAtter phase transitions at high baryon density, Gravitational waves and relativistic neutron star - and Ion- Collisions

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Gravitational waves, Electromagnetic radiation and emission of High Energy Particles probe the phase structure of the EoS of dense matter produced at the crossroad of the closely related relativistic collisions of heavy ions and of binary neutron stars.
3+1 dimensional special- and general relativistic hydrodynamic model studies reveal a unique window of opportunity to observe phase transitions in compressed baryon matter in statu nascendi by multimessenger observations. The FAiR facility at GSI allows to study the universe in the Laboratory.

Type of contribution:

Talk

5

Cosmological scenarios in Horndeski theory

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We present a systematic analysis of homogeneous and isotropic cosmologies in Horndeski model which is the most general scalar-tensor theory of gravity with second-order field equations.
A special attention is paid to the particular subclass of Horndeski theory, namely, the model with the scalar field ϕ possessing the nonminimal kinetic coupling to curvature given as $\eta G^{\mu\nu}\phi_{,\mu}\phi_{,\nu}$.
A very interesting and important feature of the model is that it provides an essentially new inflationary mechanism without any fine-tuned scalar potential.
Namely, at early cosmological times the domination of coupling terms in the field equations guarantees the quasi-De Sitter behavior of the scale factor: $a(t) \propto e^{H_\eta t}$ with $H_\eta = 1/\sqrt{9\eta}$.
Generally, the model admits a rich spectrum of solutions.
Some of them describe the standard late time cosmological dynamic dominated by the Λ-term and matter, while at the early times the universe expands with a constant Hubble rate determined by the value of the scalar kinetic coupling. For other solutions the Λ-term and matter are screened at all times but there are nevertheless the early and late accelerating phases. The model also admits bounces, as well as peculiar solutions describing "the emergence of time".
We find that the universe could transit from one de Sitter solution to another, determined by the coupling parameter. Furthermore, according to the parameter choices and without the need for matter, we can obtain a Big Bang, an expanding universe with no beginning, a cosmological turnaround, an eternally contracting universe, a Big Crunch, a Big Rip avoidance and a cosmological bounce. This variety of behaviors reveals the capabilities of the present scenario.

Type of contribution:

Invited talk

12

Equations of state of relativistic mean-field models with different parametrisations of density-dependend couplings

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Relativistic mean-field (RMF) models with density dependent (DD) couplings have been used successfully to describe nuclear matter and finite nuclei. They usually assume a dependence of the nucleon-meson couplings on the so-called vector density that is derived from the baryon current. A dependence on other densities, in particular the scalar density, was not really explored although suggested in early introductions of the DD-RMF approach. In this contribution, DD-RMF models, the corresponding equations of state (EoS), and symmetry energies are compared using DD couplings of different functional form and dependence on vector and scalar densities. They are obtained by fitting the same set of nuclear observables. The choice of the dependence changes the EoS and the characteristic nuclear matter parameters. Problems of some of the models are identified.

Type of contribution:

Invited talk

20

Cooling of neutron stars within ''nuclear medium cooling scenario"

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Neutrino emission from neutron stars is subject of strong modifications due to collective effects in nuclear matter like the pion polarization effect and the Cooper pairing of nucleons. The larger is the star mass (central density) the stronger is the pion polarization. The "nuclear medium cooling scenario" relates slow and rapid neutron star cooling to the neutron star masses (interior densities). Recent measurements of the masses of the pulsars PSR J1616-2230, PSR J0348-0432 and J00737-3039B and the companion of J1756-2251 provide independent proof for existence of compact stars with masses in a broad range from 1.2 to 2 solar mass. The hadronic equation of state should be rather stiff to explain existence of heavy neutron stars. The data on the cooling of neutron stars can be comfortably explained in the nuclear medium cooling scenario exploiting a stiff equation of state.

Type of contribution:

Invited talk

37

Informal discussion on perspectives in compact stars

38

Informal discussion on gravity problems and cosmology