Abstracts book

Compact Stars in the QCD phase diagram V

AND

Working Group 2 Meeting of COST Action MP1304

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1. GW150914: First observation of gravitational waves

The ground-breaking detection of gravitational waves, predicted exactly 100 years ago by Albert Einstein, opens a totally new field of the universe exploration and will have a deep impact on the future of astrophysical observations. On September 14th 2015, for the first time, a transient signal of gravitational waves has been observed by the two LIGO detectors. The signal matches the waveform predicted by general relativity for the inspiral and merger of a pair of black holes and the ringdown of the resulting single black hole. The talk will discuss the path that led to the discovery and the new perspectives opened in the field.

Primary authors: FAFONE, Viviana (ROMA2)
Presenter: **FAFONE, Viviana** (ROMA2)
Contribution type: Oral

2. Chiral Transport Phenomena

For systems made up by chiral fermions the conventional hydrodynamics and transport equations are modified, leading to new transport phenomena related to the quantum anomalies of quantum field theories. I will explain how to derive these equations and effects from simple semi-classical arguments, and focus on the dynamical evolution of systems with an initial chiral fermion imbalance. I will emphasize that these ideas are relevant for systems made up of quasi-massless fermions, that is, with applications in cosmology, astrophysics, heavy-ion collisions and condensed-matter physics (with the new recently discovered materials, the so called Weyl semimetals). It is believed that these ideas might be useful to explain the generation of magnetic fields with magnetic helicity in cosmological and astrophysical scenarios (magnetars).

Primary authors: MANUEL, Cristina (CSIC)
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Contribution type: Oral

3. Compact stars in the braneworld: a new branch of stellar configurations with arbitrarily large mass

We study the properties of compact stars in the Randall-Sundrum II type braneworld model. To this end, we solve the braneworld generalisation of the stellar structure equations for a static fluid distribution with spherical symmetry considering that the spacetime outside the star is described by a Schwarzschild metric. We integrate the stellar structure equations employing the causal limit equation of state (EOS), which is obtained adopting a well established EOS at densities below a fiducial density, and an EOS with the sound velocity equal to the speed of light above it. We find that the equilibrium solutions in the braneworld model can violate the limit of causality for General Relativity and, for sufficiently large mass they approach asymptotically to the Schwarzschild limit M = 2 R. Then, we investigate the properties of hadronic and strange quark stars using two typical EOSs: a nonlinear relativistic mean-field model for hadronic matter and the MIT bag model for quark matter. For masses below ~ 1.5 - 2 solar masses, the mass versus radius curves show the typical behaviour found within the frame of General Relativity. However, we also find a new branch of stellar configurations that can violate the general relativistic causal limit and that in principle may have an arbitrarily large mass. The stars belonging to this new branch are supported against collapse by the nonlocal effects of the bulk on the brane. We also show that these stars are always stable under small radial perturbations. If they exist in Nature, these objects may be hidden among the population of black hole candidates. The future observation of compact stars with masses and radii falling above the causal limit of General Relativity but below the Schwarzschild limit maybe a promising astrophysical evidence for the existence of extra dimensions.

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4. Short and Long Gamma Ray Bursts in the proto-magnetar model with quark deconfinement

It will be discussed how the process of quark deconfinement modifies the proto-magnetar model description of short and long GRBs. We propose a model for short duration gamma-ray bursts (sGRBs) based on the formation of a quark star after the merger of two neutron stars. We assume that the sGRB central engine is a proto-magnetar, which has been previously invoked to explain the plateau-like X-ray emission observed following both long and short GRBs. We show that: i) a few milliseconds after the merger it is possible to form a stable and massive star made in part of quarks; ii) during the early cooling phase of the incompletely formed quark star, the flux of baryons ablated from the surface by neutrinos is large and it does not allow the outflow to achieve a bulk Lorentz factor high enough to produce a GRB; iii) after the quark burning front reaches the stellar surface, baryon ablation ceases and the jet becomes too baryon poor to produce a GRB; iv) however, between these two phases a GRB can be produced over the finite timescale required for the baryon pollution to cease; a characteristic timescale of the order of $\sim$ 0.1 s naturally results from the time the conversion front needs to cover the distance between the rotational pole and the latitude of the last closed magnetic field line; v) we predict a correlation between the luminosity of the sGRB and its duration, consistent with the data; vi) our model also predicts a delay of the order of ten seconds between the time of the merger event and the sGRB, allowing for the possibility of precursor emission and implying that the jet will encounter the dense cocoon formed immediately after the merger.
We show that quark deconfinement can also help explaining the late-time activity observed in many long GRBs. We assume that the proto-magnetar, formed immediately after the Supernova explosion, is a rapidly rotating neutron star. The magnetic breaking reduces the angular momentum of the star, whose central density increases. When a critical density is reached quark deconfinement takes place. The process of formation of a quark star is strongly exo-thermic, the star heats up again and a second prompt event can take place.

We apply this mechanism in particular to GRB 110709B, showing that the second event can be associated with the process of quark deconfinement.

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Contribution type: Oral

5. On the possible rotation-power nature of SGRs and AXPs

We show that 40% of the entire observed population of soft gamma repeaters (SGRs) and anomalous X-ray pulsars (AXPs) can be described as canonical pulsars driven by the rotational energy of neutron stars (NSs), for which we give their possible range of masses. We also show that if the blackbody component in soft X-rays is due to the surface temperature of NSs, then 50% of the sources could be explained as ordinary rotation-powered pulsars. Besides, amongst these sources we find SGRs/AXPs with observed radio emission and others possibly associated with supernova remnants, suggesting as well a natural explanation as ordinary pulsars. Assuming, on the other hand, an alternative model in which SGRs/AXPs are rotation-powered white dwarfs (WDs), we show that the entire population can be explained within this scenario and predict tight bounds to their masses, radii, and magnetic fields by requesting their gravitational and rotational stability.

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Contribution type: Oral

6. Phase lags of quasi-periodic oscil-lations across source states in the low-mass X-ray binary 4U 1636-53

While there are many dynamical mechanisms and models that try to explain the origin and phenomenology of quasi-periodic oscillations (QPOs) in low-mass X-ray binaries, few of them address how the radiative processes occurring in these extreme environments give rise to the rich set of variability features actually seen in the X-ray light curves of these systems. A step towards that end is the study of the energy and frequency dependence of the phase lags of the QPOs in the light curves. Here we studied the phase lags of all QPOs in the range of 1 Hz to 1300 Hz detected in the low-mass X-ray binary 4U 1636-53 using a methodology that allowed us to study, for the first time, the dependence of the phase lags upon energy and frequency as the source changes its states as it moves through the colour-colour diagram. Our results suggest that within the context of models of up-scattering Comptonization, the phase lags dependencies upon frequency and energy can be used to extract size scales and physical conditions of the medium that produces the lags.

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7. Ultra-Magnetized White Dwarfs and High Energy Emission

Recently, an alternative model based on white dwarfs pulsars has been proposed to explain a class of pulsars known as Soft Gamma Repeaters (SGR) and Anomalus X-Ray Pulsars (AXP) (Malheiro et al. 2012), usually named as magnetars. In this model, the magnetized white dwarfs can have surface magnetic field $B \sim 10^7 - 10^{10}$ G and rotate very fast with angular frequencies $\Omega \sim 1$ rad/s, allowing them to produce large electromagnetic (EM) potentials and generate electron-positron pairs. These EM potentials are comparable with the ones of neutron star pulsars with strong magnetic fields and even larger. In this study we consider two possible processes associated with the particle acceleration, both of them are common used to explain radio emission in neutron star pulsars: in the first process the pair production happens near to the star polar caps, i.e. inside of the light cylinder where magnetic field lines are closed; in the second one the creation of pair happens in the outer magnetosphere, i.e. far away of the star surface where magnetic field lines are open (Chen & Ruderman 1993). The analysis of the possibility of radio emission were done for 23 SGRs/AXPs of the McGill Online Magnetar Catalog (Olausen & Kaspi 2014) that contains the current information available on these sources. The results of this work show that the model where the particles production occur in the outer magnetosphere emission "o2" is the one process compatible with the astronomical observations of absence of radio emission for almost all SGRs/AXPs when these sources are understoond as white dwarf pulsars. We explicitly show that the radius R of these sources modeled as white dwarfs, increases the polar cap radius R p ' R sin α and the polar cap angle. In the case of SGRs/AXPs that have long periods $P \sim 10$ s, the light cylinder radius $R L \sim 10^{10}$ cm is too large compared to the neutron star radius $R \sim 10^6$ cm, but only around 100 times large than the radius of a dense white dwarf, essentially the same scale for the ratio R/R L of radio neutron star pulsars. This ratio is also important to explain the absense of radio emission in SGRs/AXPs in the outer magnetosphere emission model, where the dipole magnetic field is calculated on the light cylinder radius, much smaller than its value at the star surface. Furthermore, the polar cap model predict radio emission for all sources represented as neutron star pulsars. Our work is a first attempted to find an explanation for the puzzle why for almost all the SGRs/AXPs were expected radio emission, but it was observed in only four of them. These four sources, as it was suggested recently (Coelho 2013), seem to belong to an high magnetic field neutron star pulsar category, different from all the others SGRs/AXPs that our work indicate to belong to a new class of white dwarf pulsars, very fast and magnetized.

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Contribution type: Oral

8. Rotating stellar structures based on the Lagrangian variational principle

A new method for multi-dimensional stellar structures is proposed in this study. As for stellar evolution calculations, the Heney method is the defacto standard now, but basically assumed to be spherical symmetric. It is one of the difficulties for deformed stellar-evolution calculations to trace the potentially complex movements of each fluid element. On the other hand, our new method is very suitable to follow such movements, since it is based on the Lagrange coordinate. This scheme is also based on the variational principle, which is adopted to the studies for the pasta structures inside of neutron stars. Our scheme could be a major break through for evolution calculations of any types of deformed stars: proto-planets, proto-stars, and proto-neutron stars, etc.

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9. Properties of relativistic rotating compact stars

The equation of state of dense matter such as compact stars is still in hot debate. Apart from the conventional neutron star model, the existences of hyperon/free quarks in compact stars are also suggested. Models such as solid quark cluster stars can explain many puzzling observations of pulsars. In order to distinguish between different equation of states, I focus on the properties of rotating quark stars. We use a 3D numerical relativity code to build models of rotating quark stars. With this tool, not only can we explore the axisymmetric configuration of slowly rotating compact stars, but also triaxial deformed (Jacobian ellipsoid) fast rotating compact stars (for $T/W > 0.1375$). In this talk, I will also show the differences in the deformability of rotating compact stars with different EoSs and how we are going to test these differences by
observation.

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Contribution type: Oral

10. Global properties of rotating neutron stars with QCD equations of state

We numerically investigate global properties of rotating neutron stars using the allowed band of equations of state derived by Kurkela et al. This band is constrained by chiral effective theory at low densities and perturbative QCD at high densities, and thus is, in essence, a controlled constraint from first-principles physics. Previously, this band of equations of state was used to investigate nonrotating neutron stars only; in this work, we extend these result all the way to the mass-shedding limit. We investigate mass-radius curves, allowed mass-frequency regions, radius-frequency spin-up curves for a typical 1.4 solar mass star, and the values of the moment of inertia of PSR J0737-3039A, a pulsar whose moment of inertia may be constrained observationally in a few years. We present various limits on observational data coming from these constraints.

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Contribution type: Oral

11. The quark-nova and the mechanism behind double-humped superluminous supernovae

A novel and clear mechanism to explain double-humped superluminous, hydrogen poor, supernovae (SLSNe) is introduced and explained. The key aspect to this explanation is a quark-nova (QN; the spontaneous transition from a neutron star into a quark star) occurring in a massive binary system. In the massive binary, the H envelope of the less massive companion is ejected during the first Common Envelope (CE) phase, while the QN occurs deep inside the second, He-rich, CE phase after the CE has expanded in size to a radius of a few tens to a few thousands of solar radii; this yields the first peak in our model. The second peak results from the merging of the quark star with the CO core leading to black hole formation and accretion. I will present different SLSNe with double-humped light curves and our model fits to these. Special emphasis will be made to ASASSN-15lh, the most superluminous supernova without a widely accepted mechanism behind it.

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Contribution type: Oral

12. Constraints on the isospin dependence of the lambda-nucleon force from hypernuclear binding energies

The recent experimental effort in measuring hypernuclear properties is strictly related to the determination of the accurate equation of state of matter at supersaturation density. The measurements could in principle provide more constraints to the hyperon nucleon interaction. However, there are still many open issues. In particular, we will discuss the problem of the dependence of the interaction on the asymmetry parameter. By means of a phenomenological analysis and Quantum Monte Carlo calculations, we show that contributions coming from lambda-neutron-neutron interactions are essentially suppressed in symmetric hypernuclei, and therefore not efficiently constrained by binding energy measurements. Such contributions are instead obviously relevant in the neutron star core. This analysis points out the need of a new series of experiments, and the corresponding theoretical analysis, on neutron rich hypernuclei as a possible way to gain further insight on the hyperon puzzle.

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Contribution type: Oral

13. Equation of state of hot nuclear matter from the CBF effective interaction approach

The CBF effective interation approach, whose accuracy has been extensively tested studying the properties of the fermion hard-sphere system at T=0, is employed to describe nuclear matter at temperatures up to 30 MeV. The relevance of the the properties hot nuclear matter to the understanding of the evolution of protoneutron stars is discusssed.

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Contribution type: Oral

14. The supranuclear equation of state stiffness (once again...)

We revisit the issue of the stiffness of the supranuclear equation of state. The state-of-the-art of models containing hyperons and allowing $> 2 M_{\odot}$ models, with particular emphasis on the possible transition to quark matter is discussed. We argue that ``exotic'' physics is required either because of the hyperon repulsion or the stringent condition suppressing quark matter in nature.

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Contribution type: Oral

15. Quark degrees of freedom in Nuclear Matter

The microscopic theory of Nuclear Matter has been approached along the years by different many-body approaches and different nucleon-nucleon (NN) interactions. The realistic NN interactions can be classified mainly into two categories. One relies on the meson-nucleon coupling scheme, within relativistic or non-relativistic framework. The so-called chiral interactions is based on the assumption that, once the pion exchange contribution has been explicitly isolated, it is possible to expand the NN interaction in a series of point interaction terms which respect the underlying QCD chiral symmetry. In both schemes thre-body (TBF) or higher forces can be constructed, which can have different degrees of phenomenological character. The TBF are essential to get the Nuclear Matter saturation point close to the phenomenological one. However the QCD quark degrees of freedom are not explicitly introduced. It will be shown that a realistic NN interaction that is constructed from the quark degrees of freedom can produce the correct saturation point without the need of TBF. The corresponding Equation of State is compatible with all the phenomenological contraints, including the Neutron Star maximum mass limit. Taking this result literally, one can say that quarks have been revealed in Nuclear Matter. Another conclusion is that the effect of TBF is model dependent.

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Contribution type: Oral

16. The CSS parameterization for FCM models of quark matter in hybrid stars

I will discuss the phase transition in hybrid stars built with equations of state (EoS) derived in the Field Correlator Method (FCM) for quark matter, and in the Bruckner-Hartree-Fock (BHF) theory for the hadronic matter. I will show that the FCM equation of state can be accurately represented by the “constant speed of sound” (CSS) parameterization, even in the superconducting phase. A mapping between the FCM and CSS parameters can be performed, and turns out to be dependent on the chosen values of the quark-antiquark potential and the gluon condensate. The observation of a 2M neutron star mass allows FCM equations of state in a restricted subspace of the CSS parameters. A comparison with NJL-like and Dyson-Schwinger models is also discussed.

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Contribution type: Oral

17. A self-consistent study of magnetic field effects on hybrid stars

In this work we study the effects of strong magnetic fields on hybrid stars by using a full general relativity approach, solving the coupled Maxwell-Einstein equation in a self-consistent way. Themagnetic field is assumed to be axi-symmetric and poloidal. We take into consideration the anisotropy of the energy-momentum tensor due to the magnetic field, magnetic field effects on equation of state, the interaction between matter and the magnetic field (magnetization), and the anomalous magnetic moment of the hadrons. The equation of state used is an extended hadronic and quark SU(3) non-linear realization of the sigma model that describes magnetized hybrid stars containing nucleons, hyperons and quarks. According to our results, the effects of the magnetization and the magnetic field on the EoS do not play an important role on global properties of these stars. On the other hand, the magnetic field causes the central density in these objects to be reduced, inducing major changes in the populated degrees of freedom and, potentially, converting a hybrid star into a hadronic star.

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Contribution type: Oral

18. Neutron stars structure with chiral interactions

We calculate the energy per particle of symmetric nuclear matter and pure neutron matter using the many-body Brueckner-Hartree-Fock approach and employing the Chiral Next-to-next-to-next-to leading order (N3LO) nucleon-nucleon (NN) potential supplemented with various parametrizations of the Chiral Next-to-next-to leading order (N2LO) three-nucleon interaction. Such combination is able to reproduce several observables of the physics of light nuclei for suitable choices of the parameters entering in the three-nucleon interaction. We find that some of these parametrizations provide a satisfactory description of nuclear matter at saturation density. We finally explore the predictions of our models at large baryonic density calculating the structure of neutron stars. The possibility of a deconfinement phase transition to quark matter is also considered.

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Contribution type: Oral

19. Rotating NSs/QSs and recent astrophysical observations

Detailed structures of the Vela pulsar (PSR B0833-45, with a period of 89.33 milliseconds) are predicted by adopting a recently-constructed unified treatment of all parts of neutron stars: the outer crust, the inner crust and the core based on modern BHF calculations. By confronting the glitch observations with the theoretical calculations for the crustal moment of inertia, we find that despite some recent opposition to the crisis argument, the glitch crisis is still present, which means that besides the crustal superfluid neutrons, core neutrons might be necessary for explaining the large glitches of the Vela pulsar.

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Contribution type: Oral

20. Effects of magnetic fields on compact stars

In this talk I will discuss about the effects of strong magnetic fields on hybrid stars and on super-heavy white dwarfs. The later models possibly contribute to super-luminous SNIa. The magnetic field is assumed to be axi-symmetric and poloidal. In the case of hybrid stars, the magnetic field causes the central density in these objects to be reduced, inducing major changes in the populated degrees of freedom and, potentially, converting a hybrid star into a hadronic star. As a spin-off of these studies, we show that the magnetic field can also be enhanced due to the phase transition from normal hadronic matter to quark matter on highly magnetized neutron stars. Therefore, in parallel to the spin-up era, classes of neutron stars endowed with strong magnetic fields may go through a magnetic-up era in their lives.

Primary authors: FRANZON, Bruno (FIAS)
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Contribution type: Oral

21. Many-body forces in magnetic hyperon stars

The observation of compact objects with surface magnetic fields as strong as $10^{14}-10^{15}\,G$, denominated magnetars, has drawn the attention to the study of the effects of strong magnetic fields on nuclear matter and compact stars observational properties. In this work, we study the effects of strong magnetic fields on the equation of state and structure of neutron stars using a mean field theory (MFT) approach that considers many-body forces in the nuclear interaction. We describe the nuclear matter inside the stars in a relativistic mean field formalism that takes many-body forces into account, by means of a field dependence of the nuclear interaction coupling constants. Assuming that the matter is at zero temperature, charge neutral, beta-equilibrated and populated by the baryon octet, electrons and muons, in the context of the named \emph{hyperon puzzle}, we investigate the role of magnetic fields and many-body forces on the equation of state (EoS), population and global properties of hyperon stars. The presence of the magnetic fields generates a Landau quantization on the energy levels of the charged particles and also an anisotropy in the energy-momentum tensor of the system, which leads to a departure of the spherically symmetric case. The magnetic field is introduced in the structure of the stars by solving the Einstein-Maxwell equations self-consistently. This solutions lead to stationary and axisymmetric stellar models, in which a poloidal magnetic field is assumed. The matter is considered to be under a static density dependent magnetic field, reaching intensities of the order of 10^{18} G at the center of the stars. We discuss the effects of many-body forces and magnetic fields separately on the mass and deformation, as well as the density and magnetic field distribution to each configuration.

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Contribution type: Oral

22. Meson Properties in Asymmetric Matter

Meson properties in presence of nonzero chemical potentials and zero temperature are very important to determine QCD phase diagram. In my talk I am going to highlight recent progresses made in this field using the Chiral Perturbation Theory approach, focusing both on dynamic (masses and decays) and termodynamic (Equation of State). I will also present comparison with predictions obtained with other methods (Lattice, Perturbative QCD) when possible.

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Contribution type: Oral

23. Crystalline condensates in dense quark matter

In this talk I will discuss the possibility that the phase diagram of cold and dense quark matter might be characterized by the presence of crystalline phases where inhomogeneous chiral condensates are formed. After briefly describing some basic properties of these condensates, I will discuss their relevance for compact star phenomenology and their possible interplay with other competing phenomena in dense matter such as the formation of color-superconducting phases.

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Contribution type: Oral

24. Hadronic-To-Quark-Matter Conversion in Neutron Stars: Recent Developments and Astrophysical Implications

The latest investigations of the hadronic-to-quark-matter conversion in neutron stars by different groups will be reviewed. I will then present the upgraded version of Burn-UD code developed by the Quark-Nova group and how it can be used to simulate the hydrodynamics and the microphysics of the conversion front in multi-dimensions. The resulting observables and implications to explosive Astrophysics and avenues for future research will be discussed.

Primary authors; OUYED, Rachid Ouyed (University of Calgary)
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Contribution type: Oral

25. Dissipationless Hall Current and other Anomalous Transport Properties of Dense QCD in a Magnetic Field

In this talk I will discuss several anomalous effects of quark matter in the Dual Chiral Density Wave (DCDW) phase that develops at intermediate densities in the presence of a magnetic field. This phase is relevant for neutron stars and for the planned heavy-ion collision experiments at higher densities at NICA. I will show how the interaction of the electromagnetic field with the magnetic DCDW medium leads to the equations of axion electrodynamics with anomalous electric charge and dissipationless Hall current. This phase exhibits magnetoelectricity and wave attenuation for certain frequencies, properties all associated with the nontrivial topology produced by the asymmetry of the Lowest Landau Level modes in the DCDW condensate. The analogies between this phase of dense QCD and the properties of new topological materials will be outlined.

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Contribution type: Oral

26. EoS's of Different Phases of Dense Quark Matter

Compact stars with significant high densities in their interiors can give rise to quark deconfined phases that can open a window for the study of strongly interacting dense nuclear matter. Recent observations on the mass of two pulsars, PSR J1614-

2230 and PSR J0348+0432, have posed a great restriction on their composition, since their equations of state must be hard enough to support masses of about at least two solar masses. The onset of quarks tends to soften the equation of state, but due to their strong interactions, different phases can be realized with new parameters that affect the corresponding equations of state and ultimately the mass-radius relationships. In this talk I will review how the equation of state of dense quark matter is affected by the physical characteristics of the phases that can take place at different baryonic densities, as color superconducting BCS and BEC phases, as well as in the magnetized crystalline phase of isospin-asymmetric chiral density waves.
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Contribution type: Oral

27. Numerical Simulations of the Neutron Star Crust

The structure of neutron stars is highly complex, encompassing a high-density homogeneous core of leptons, nucleons and potentially more exotic particles like hyperons and quarks in the center, followed by a solid crust of exotic nuclear structures and nuclei, finally surrounded by an atmosphere of light nuclei. The crust itself can be divided into an outer region with nuclei arranged in a crystal structure embedded in an electron plasma and the inner crust beyond the neutron drip, which includes a gas of free neutrons. The structure and properties of the crust region are important for many aspects in neutron star and supernova physics like heat transport and neutrino opacities. In order to study the inner crust we developed an efficient code that can be used for large-scale quantum molecular dynamics simulations of the system. In particular we studied the development of the pasta phase in the transition region between crust and core. We investigated the sensitivity of the specific pasta structures and the density range of the transition on the isospin dependence of the nuclear interactions. As a check of the viability of the approach we also computed ground state nuclear matter and nuclei as well as the nuclear liquid-gas transition with our simulations. First results will be presented in the talk.

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Contribution type: Oral

28. Neutrino microphysics of the hadron-quark combustion flame

The combustion of (u,d) to (u,d,s) quark matter releases much of its energy in the form of neutrinos. Neutrino radiation in turn, interacts with the hydrodynamics and the weak-interaction reaction rates of the combustion flame. Thus, in order to see how the weak-interaction rates, neutrinos and the hydrodynamics couple, a proper micro-physical treatment of the flame is necessary. In this talk, I will show how the equations for neutrino transport are solved self-consistently with the reaction-diffusion-advection equations of

hadron-quark burning in the context of Burn-UD - a hydrodynamic combustion code for hadron-quark burning. A micro-physical treatment of the flame and consistent neutrino transport could reveal instabilities that have astrophysical implications such as neutron star detonations (quark-novae) and delayed supernova explosions.

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Contribution type: Oral

29. From strangelets to strange stars: a unified description

We develop a new type of theoretical descriptions that unify the conventionally separated treatments for strangelets and strange stars. At given total particle number and entropy, we minimize the mass with respect to the particle distribution and entropy distribution. The most stable structure of a spherically symmetric strange quark matter (SQM) object is then obtained with the effects of gravity and electrostatic interactions treated on the macroscopic scale, while the strong and weak interactions are considered locally. The properties of objects ranging from strangelets and strange stars are investigated with the surface effects properly treated. It is found that there exists nonzero charge within a strange star. Meanwhile, the properties of strangelets as well as the surface profiles of strange stars depend crucially on the surface treatments.

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Presenter: **XIA, Cheng-jun** (Institute of Theoretical Physics, Chinese Academy of Sciences)
Contribution type: Oral

30. A General Bodmer-Witten's Conjecture

Although normal micro-nuclei are 2-flavour (u and d flavours of quark) symmetric, we argue that 3-flavour (u, d, and s) symmetry would be restored in macro/gigantic-nuclei compressed by gravity during supernovae since "Bigger is different". This argument could be considered as an extension of the Bodmer-Witten's conjecture, where quarks would not be necessarily free but could be still localized as in the case of a nucleus. In principle, different manifestations of compact objects could be explained in the regime of this general conjecture.

Primary authors: XU, Renxin (School of Physics, Peking University)

Presenter: **XU, Renxin** (School of Physics, Peking University)
Contribution type: Oral

31. Supernovae and neutron stars as playgrounds of dense matter and neutrinos

Core-collapse supernovae are vital as the birthplace of compact objects, where we expect interesting phases of the dense matter. I would like to overview the current status of supernova studies with the nuclear data for dense matter and neutrino reactions. I focus on recent progress of the neutrino-radiation hydrodynamics in 2D/3D and remaining mysteries. The equation of state is also essential to predict the neutrino bursts, which can be used to probe deep inside the compact objects. By looking into the pattern of neutrino signals in relation with dynamics and dense matter, I try to discuss variations of the extreme conditions for hyperons and quarks in central objects during explosive phenomena.

Primary authors: SUMIYOSHI, Kosuke (Numazu College of Technology)
Presenter: **SUMIYOSHI, Kosuke** (Numazu College of Technology)
Contribution type: Oral

32. The Strange Star Crust: Structure & Astrophysics

A strange quark star can have a heterogeneous crust made of quark nuggets and electrons at its surface provided the surface tension of quark matter is small. We present a model independent description of the crust and results from a simplified model of dense quark matter for the thickness, density profile and shear modulus of the crust. We address some of the astrophysical implications of this crust, including the modification of acoustic modes of oscillation by shear stresses. This can lead to very different signatures of strange stars in gravitational wave mergers depending on whether they have a crust or not.

Primary authors: JAIKUMAR, Prashanth (California State University Long Beach)
Presenter: **JAIKUMAR, Prashanth** (California State University Long Beach)
Contribution type: Oral

33. Thermal Evolution of Spinning-Down(up) Neutron Stars

In the work we continue our research of the thermal evolution of rotating neutron stars. We have previously calculated the thermal evolution of neutron stars undergoing spin-down, focusing on the effects that a dynamic composition change may have on the cooling. We havel also calculated the thermal evolution of rotating neutron stars (with a constant frequency) under the full effect of general relativity. The work presented here is the culmination of these two studies, in which we show, for the first time, the thermal evolution of rotating neutron stars that are undergoing spin-down (or up). We self-consistently calculate the evolution of the structure of the star during its spin-down, coupled to the thermal evolution of the object. In such manner, we are able to see how the dynamical composition together with the structure and metric composition affect the thermal evoluion of such objects. This work opens the possibility for the investigation of several scenarios, forbidden by the traditional "frozen-in" cooling calculations, such as thermal evolution of accreting neutron stars, whose composition changes due to the addition of mass and heat.

Primary authors: NEGREIROS, Rodrigo (Universidade Federal Fluminense)
Co-authors: SCHRAMM, Stefan (Frankfurt Institute for Advanced Studies) ; WEBER, Fridolin (San Diego State University)
Presenter: **NEGREIROS, Rodrigo** (Universidade Federal Fluminense)
Contribution type: Oral

LNGS EXPERIMENTAL TALKS

34. LNGS, a laboratory with the vocation of the Dark Matter

The LNGS is presently one of the undeground laboratories with largest number of experiments devoted to the Dark Matter search. In this talk the detection principles, the status and the envisaged results of all of them will be reviewed. A quick glance at the future projects will also be given.

Primary authors: MESSINA, Marcello (Columbia University)
Presenter: **MESSINA, Marcello** (Columbia University)

Contribution type: Oral

35. The Borexino experiment: a sub-MeV solar neutrino observatory

Borexino is an unsegmented liquid scintillator calorimeter characterized by unprecedented low levels of intrinsic radioactivity, optimized for the study of the lower energy part of the spectrum, running at the Laboratori Nazionali del Gran Sasso laboratory in Italy. During Phase-I (2007~2010), Borexino first detected and then precisely measured the flux of the Be7 solar neutrinos, ruled out any significant day-night asymmetry of their interaction rate, made the first direct observation of the pep neutrinos, and set the tightest upper limit on the flux of solar neutrinos produced in the CNO cycle. Borexino set new records in radiopurity of liquid organic scintillator that allowed to perform an almost full solar neutrino spectroscopy.

Primary authors: GHIANO, Chiara (INFN-LNGS)
Presenter: **GHIANO, Chiara** (INFN-LNGS)
Contribution type: Oral

36. Neutrinoless double beta decays @ LNGS

TBA

Primary authors: BUCCI, Carlo (INFN-LNGS)
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Contribution type: Oral

37. Experimental challenges in Underground Nuclear Astrophysics Laboratory @ LNGS

Accurate knowledge of thermonuclear reaction rates is important in understanding the generation of energy, the luminosity of neutrinos, and the synthesis of elements in stars. The LUNA Collaboration has shown that, by going underground and by using the typical techniques of low background physics, it is possible to measure nuclear cross sections down to the energy of the nucleosynthesis inside stars. This talk will give an overview of the experimental techniques adopted in underground nuclear astrophysics and will present a summary of the main recent results and achievements. The future developments of the LUNA experiment will also be shown.

Primary authors: JUNKER, Matthias (INFN-LNGS)
Presenter: **JUNKER, Matthias** (INFN-LNGS)
Contribution type: Oral

38. Supernova Neutrinos Detection @ LNGS

We review the goals and the status of the Supernova neutrinos detection in the Gran Sasso National Laboratory. In particular we describe expectations for a galactic Core-Collapse Supernova in LVD and Borexino detectors and the prospect for the combined search of distant supernovae by using a network of gravitational waves and neutrinos detectors.

Primary authors: PAGLIAROLI, Giulia (GSSI)
Presenter: **PAGLIAROLI, Giulia** (GSSI)

Contribution type: Oral

POSTERS

39. Chemical potential effect on the production of electromagnetic radiation

We study the total photon spectra produced in heavy ion collision within a space-time framework. We find appreciable enhancement in the photon production at RHIC and LHC as a result of high temperature and chemical potential using quark phenomenological flow parameter. The result with simple phenomenological model provides useful information for understanding the properties of QGP.

Primary authors: KUMAR, Yogesh (University of Delhi, Deshbandhu College)
Co-authors: SETHY, P. K. (University of Delhi)
Contribution type: Poster

40. The joint search for Gravitational Wave and Low Energy Neutrino signals from Core-Collapse Supernovae

The discovery of gravitational waves opens a new era in physics. Now it’s possible to observe the Universe using a fundamentally new way. Gravitational waves potentially permit getting insight into the physics of Core-Collapse Supernovae (CCSNe). However, due to significant uncertainties on the theoretical models of gravitational wave emission associated with CCSNe, significant benefits may come from multi-messenger observations of CCSNe; such benefits include increased confidence in detection, extending the strophysical reach of the detectors and allowing deeper understanding of the nature of the phenomenon. Fortunately, CCSNe have a neutrino signature confirmed by the observation of SN1987A. The gravitational and neutrino signals propagate with the speed of light and without significant interaction with interstellar matter. So that they must reach an observer on the Earth almost simultaneously. These facts open a way to search for the correlation between the signals. However, this method is limited by the sensitivity of modern neutrino detectors that allow to observe CCSNe only in the Local Group of galaxies. The methodology and status of a proposed joint search for the correlation signals are presented here.

Primary authors: CASENTINI, Claudio (R)
Co-authors: GROMOV, Maxim (Lomonosov Moscow State University)
Contribution type: Poster

41. Chiral Phase Transition in Soft-Wall AdS/QCD

A brief discussion on how to realize spontaneous chiral symmetry breaking of QCD vacuum and its restoration at finite temperature in soft-wall AdS/QCD will be given. Both the dilaton profile and the scalar potential are essential for generating correct mass and temperature dependent behavior of chiral condensate. Under proper dilaton and scalar potential, in the two-flavor case, it gives a second order chiral phase transition in the chiral limit, while the transition turns to be a crossover for any finite quark mass. In the case of three-flavor, the phase transition becomes a first order one in the chiral limit, while above sufficient large quark mass it turns to be a crossover again. This scenario agrees exactly with the current understanding on chiral phase transition from lattice QCD and other effective model studies.

Primary authors: LI, Danning (Institute of High Energy Physics, Chinese Academy of Sciences)
Contribution type: Poster

42. Effects of rotation and lattice contribution in magnetic white dwarfs

The properties of magnetic white dwarfs are computed for an equation of state which describes white dwarf matter in terms of a regular crystal lattice of atomic nuclei at zero temperature, immersed in a totally magnetized electron gas. The minimum critical densities at which electron capture reactions and possibly pycnonuclear fusion reactions occur inside of rotating white dwarfs are studied for different magnetic fields and stellar rotation rates. Moreover we calculate the mass-radius relationships of magnetic white dwarfs for magnetic fields ranging from zero up to 1013 Gauss and rotational stellar frequencies between zero and the Kepler frequency, which sets an absolute limit on rapid rotation. Our results show that the presence of strong magnetic fields in white dwarfs decreases the value of the critical density for the onset of electron capture and of pycnonuclear reactions. We also find that rotating magnetized white dwarfs may be up to one hundred times less dense than ordinary white dwarfs, depending on their rate of rotation.

Primary authors: OTONIEL DA SILVA, Edson (Brazil)
Co-authors: MALHEIRO, Manuel (Instituto Tecnologico de Aeronautica) ; WEBER, Fridolin (San Diego State University)
Contribution type: Poster

43. Torsional Oscillations of Nonbare Strange Stars

We consider a model of a strange star having an inner core in the color-flavor locked phase surmounted by a crystalline color superconducting (CCSC) layer. These two phases constitute the quarksphere, which we assume to be the largest and heaviest part of the strange star. The next layer consists of standard nuclear matter forming an ionic crust, hovering on the top of the quarksphere and prevented from falling by a strong dipolar electric field. The ionic matter and the CCSC matter constitute two electromagnetically coupled crust layers. We study the torsional oscillations of these two layers. We find taht the maximum stress generated by the torsional oscillation is located inside the ionic crust, very close to the star surface.

Primary authors: TONELLI, Francesco (LNGS)
Contribution type: Poster

44. Restoration image degraded by a fuzzy variable in the field

The atmospheric turbulence is the biggest obstacle to terrestrial astronomical observations. It prevents us to obtain precise images of equality precision of the space telescopes. In spite of the attempt to minimize this inconvenience by choosing good site for the creation of new observatories, this is certainly not sufficient, it is indispensable to know with precision the state of the turbulence in order to correct it with adaptive or active optics. During these last years, the scientists try to know details and characteristics of the atmosphere. The knowledge of these characteristics such as the parameters: r0, L0, h is of a major interest in astronomical observation for angular high-resolution optimization of techniques (adaptive or active optics). The objective of this study is to estimate these parameters the case of observation of the sun by the statistical analysis of arrival angle fluctuation and this can be directly obtained from the observations of the solar edge.

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Contribution type: Poster