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Book of Abstracts

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$X(3872)$ production in high energy collisions

Author: Fernando Navarra[1]

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We present a short review of the theoretical and experimental status of $X(3872)$ production in high energy proton-proton and nucleus-nucleus collisions at the LHC. We then discuss the interaction of the $X(3872)$ with light mesons in a hadron gas.

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A QCD sum rules calculation of the J/ψD*sDs strong coupling constant

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In this work, we calculate the form factors and the coupling constant of the strange-charmed vertex $J/D_s^* D_s$ in the framework of the QCD sum rules by studying their three-point correlation functions. All the possible off-shell cases are considered, D_s, D_s^* and $J/$, resulting in three different form factors. These form factors are extrapolated to the pole of their respective off-shell mesons, giving the same coupling constant for the process. Our final result for the $J/D_s^* D_s$ coupling constant is $g_{J/D_s^* D_s} = 4.30^{+0.42}_{-0.37} GeV^{-1}$.

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A covariant model for the negative parity resonances of the nucleon

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One of the challenges of the modern physics
is the description of the internal structure
of the baryons and mesons.
The electromagnetic structure
of the nucleon N and the nucleon resonances N^* can be accessed
through the $\gamma^* N \to N^*$ reactions,
which deppend of the (photon) transfer momentum squared Q^2 [1–4].
The data associated with those transitions

are represented in terms of helicity amplitudes and have been collected in the recent years at Jefferson Lab, with increasing Q^2.
The new data demands the development of theoretical models based in the underlying structure of quarks and mesons states [3,4].
Those models can be also very useful to predict the results of the future Jlab−12 GeV upgrade, particularly for resonances in the second and third resonance region (energy $W = 1400$–1750 GeV) [4].
In that region there are several resonances N^* from the supermultiplet $[70, 1^-]$ of $SU(6) \otimes O(3)$, characterized by a negative parity [5].
According with the single quark transition model, when the electromagnetic interaction is the result of the photon coupling with just one quark, the helicity amplitudes of the $[70, 1^-]$ members depend only of three independent functions of Q^2: A, B and C [5,6].
In this work we use the covariant spectator quark model [4,6,7] developed for the $\gamma^* N \to N^*(1520)$ and $\gamma^* N \to N^*(1535)$ transitions [8], also members of $[70, 1^-]$, to calculate those functions.
With the knowledge of the functions A, B, and C we predict the helicity amplitudes for the transitions $\gamma^* N \to N^*(1650)$, $\gamma^* N \to N^*(1700)$, $\gamma^* N \to \Delta(1620)$, and $\gamma^* N \to \Delta(1700)$ [6].
To facilitate the comparison with future experimental data at high Q^2, we provide also simple parametrizations of the amplitudes $A_{1/2}$ and $A_{3/2}$ for the different transitions, compatible with the expected falloff at high Q^2 [6].

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G. Ramalho and K. Tsushima,
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A very simple statistical model to quarks asymmetries

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A simple statistical model is developed with the Fock states being the meson-hadron fluctuation. As expected, a insight about the violation of the Gottfried sum rule is obtained,and we discussed the possible relation between the temperature and the scattering energy. We notice that with this model, there is small decrease of the GSR, with very high energies. The model may predict also small a difference between the strangeness amount in proton and neutron .

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An overview about the High Luminosity upgrade of the LHC and the detector upgrades

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An overview about the of High Luminosity upgrade of the LHC and the detector upgrades

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Baryons, as they really are

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Baryons, as they really are

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Bethe-Salpeter equation in 2+1 dimensions for the bound state of two bosons in Minkowski space

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In this work, the Nakanishi perturbative integral representation is, for the first time, used to numerically solve the problem of relativistic bound state of two bosons in 2 + 1 dimensions in space Minkowski.
The Nakanishi perturbative integral representation of the
Bethe-Salpeter amplitude in three (2+1) dimensions is used
in order to obtain the spectrum and structure of bound states, solutions of
the homogeneous Bethe-Salpeter Equation, in Minkowski space.
The projection onto the light-front of the three dimensional
homogeneous Bethe-Salpeter Equation is used to derive
an integral equation for the Nakanishi weight function for bound states.
The formal development is presented in detail and
applied in the study of the bound system, composed by two massive scalars interacting
through the exchange of a massive scalar. A quantitative study of the bound-state solutions of the Bethe-Salpeter equation in 2+1 dimensions is performed by solving numerically the integral equation for the nakanishi weight function. The method was validated quantitatively by comparing our results with calculations of the Euclidian Bethe-Salpeter equation.

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CP Violation in three-body $B^{\pm}$ decay with final state interaction and CPT invariance

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In three-body charmless $B^{\pm}$ meson decay CPT symmetry is an important constraint that must be obeyed by the decay amplitude. Consistent with this requirement the final state interaction (FSI) in the decay amplitude has a important relationship with the CP asymmetry pattern in the decay of charge conjugates mesons $B^{\pm}$ as shown in [1]. Recent experiments of LHCb [2] bring results for the charged channels $K^{\pm}K^{+}K^{-}$, $K^{\pm}\pi^{+}\pi^{-}$, $\pi^{\pm}K^{+}K^{-}$ and $\pi^{\pm}\pi^{+}\pi^{-}$. In this work we propose an extension of the formalism of reference [1], which was the final state interaction introduced in the decay of $B^{\pm}$ in the coupled channels $K^{\pm}\pi^{+}\pi^{-}$ and $K^{\pm}K^{+}K^{-}$. In this previous work it was considered only two interacting mesons and the other meson $K^{\pm}$ was acting only as a spectator.
In the present contribution we symmetrize the decay amplitude in the $K^{\pm}K^{+}K^{-}$ channel based on the two-body formalism presented in [1] but including interference effects due to the dynamical role of the third meson. The new experimental data of reference [2] suggests the presence of such interference in different regions of the Dalitz plot.

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Calculating the $\mathcal{D}^*$ off-shell case of $g_{\eta_c \mathcal{D}^* \mathcal{D}}$ using the QCD sum rules approach.

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In the past few decades, the QCD sum rules (QCDSR) community, has been working actively in the calculation of strong coupling constants of a large variety of interaction vertices between mesons. Particularly, our QCDSR group has been working extensively in the charm sector, with the calculation of a vast number of coupling constants as the $D^* D\pi$, $D^{(*)}D^{(*)}\rho$, $J/\psi D^{(*)}D^{(*)}$ and more recently, the $J/\psi D_s D_s$ and $J/\psi D_s^* D_s$. Continuing this line of research, we started the study of charmed vertices that include the pseudo-scalar meson η_c.

The $\eta_c D^* D$ is one of these vertices. It is related to physical problems of current interest, as the η_c decay in two light vector mesons ($\eta_c \to VV$). Experimental data indicates that this type of decay, as the $\eta_c \to \rho\rho$ and $\eta_c \to K^*(892)\bar{K}^*(892)$, is among the most contributing decay channels for the η_c, with branching ratios of $(1.8 \pm 0.5) \times 10^{-2}$ and $(6.8 \pm 1.3) \times 10^{-3}$ respectively for the mentioned channels. However, these decays should be suppressed by the helicity selection rule (HSR). This is an intriguing problem that shares some similarities with the notorious $\rho\pi$ puzzle, in which the decay $J/\psi \to \rho\pi$ also presents a branching ratio of the order 10^{-2} even though being a suppressed decay according to the OZI rule. One way to circumvent the HSR suppression is to consider the $\eta_c \to VV$ decay with an intermediate step through the mesons D and D^*, i.e. $\eta_c \to D\bar{D}^* \to VV$. In this picture, the coupling constant $g_{\eta_c D^* D}$ will be necessary to the calculation of these decay amplitudes, making it necessary to have a good estimate for this coupling constant.

In this work, we will calculate the $g_{\eta_c D^* D}$ coupling constant using the QCDSR technique for the case where the D^* mesons is considered off-shell. We will take advantage of the similarities between the mesons $D^{(*)}$ and $D_s^{(*)}$ in order to also calculate the $g_{\eta_c D_s^* D_s}$ coupling constant for the D_s^* off-shell case and we will compare both of them according to the SU(4) symmetry.

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Challenges and developments in detector technologies, electronics and computing

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Challenges and developments in detector technologies, electronics and computing

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Charmless three-body B-decays: final state interaction and CP violation

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We will discuss recent results for the formulation of charged three-body B decays in charmless channels, like KKK,
$\pi\pi$, $KK\pi$, and $\pi\pi\pi$, introducing the final state interaction in the decay amplitude with
relation to the CPT constraint, while CP violation is allowed. We consider the s-wave interaction between the mesons, coupling between different decay channels and a resonance. The p-wave interaction in the resonant states, as the formation of the ρ-meson in the $\pi\pi$ channel is considered within the general formulation of the three-body decay channel. In this case the CP violation has contributions from the interference between different mechanisms, like e.g. interference from s and p-wave amplitudes. In particular, we will present preliminary results for the CP asymmetry with dependence on $\cos(\theta)$ in charmless charged channels, as revealed by the recent data from LHCb.
We will also discuss briefly a relativistic three-body formalism for the final sate interaction based on the projection of the inhomogeneous Bethe-Salpeter equation onto the light-front with application to the D decay in $K\pi\pi$ channel.

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Chiral symmetry breaking with unquenched lattice ingredients

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We study in detail the nonperturbative modifications caused to the dynamical quark mass by the inclusion of a small number of quark families in the gluon propagator and ghost dressing function obtained from the unquenched lattice simulations. We solve the quark gap equation using a non-Abelian Ansatz for the quark-gluon vertex which displays a crucial dependence on the ghost dressing function and the quark-ghost scattering amplitude. As a result, we obtain, in the chiral limit, dynamical quark masses of the order of 300 MeV for a different numbers of quark flavors and we find a good agreement with lattice data availaible in the literature.

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Cold magnetized quark matter phase diagram within a generalized SU(2) NJL model

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We study the effect of intense magnetic fields on the phase diagram of cold, strongly interacting matter within an extended version of the Nambu-Jona-Lasinio model that includes flavor mixing effects and vector interactions. Different values of the relevant model parameters in acceptable ranges are considered. Charge neutrality and beta equilibrium effects, which are specially relevant to the study of compact stars, are also taken into account. In this case the behavior of leptons is discussed.

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Complex Langevin dynamics as a solution to the sign problem

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Complex Langevin dynamics as a solution to the sign problem

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Continuum nonperturbative QCD approaches to charm physics

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We discuss theoretical approaches to form factors in heavy-meson decays, e.g. weak decay constants, transition form factors and effective heavy-to-light meson couplings, which are hadronic expressions of nonperturbative QCD. After motivating their origin in QCD factorization and heavy quark effective theories, we retrace their evolution from earlier quark-model calculations to nonperturbative QCD techniques with an emphasis on the formulation of bound states within the framework of the quark's gap equation and the meson's Bethe-Salpeter equation, both of which are nonperturbative continuum approaches to QCD. We shall show how the heavy meson's bound state wave function can be projected onto the light front and thus obtain the so-called light-cone distribution amplitudes (LCDA) from the knowledge of the meson's Bethe-Salpeter amplitude.

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Conversion of nuclear matter in strange matter into neutron star

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In this work we present a schematic description of the dynamical evolution of a protoneutron star which begins to burn neutron matter into strange matter inside the core. We have used a simple two-shell model where the inner shell medium is initially composed of a small lump of strange quark matter surrounded by an outer shell composed of free neutron matter. In a first attempt, we have utilized a polytrophic equation of state (EOS) for the outer hadronic medium description and the MIT bag model EOS describing for the strange quark matter. The combustion mode can actually become a detonation process (faster) or a burning process (slower), in this work we assume the conversion is a detonation. The main purpose of the work is to study the formation and propagation of the shock front generated by the detonation process. An effective description for the thermodynamic global evolution of the burning shell is developed and we also investigate the possibility of mass ejection as a consequence of the detonation process, which could produce a pure quark star as a remnant or even an hybrid neutron star. The masses and radii values obtained for the final equilibrium configurations are compared with the observational data of compact stars.

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Cooling of neutron stars and emissivity of neutrinos by the direct Urca process under influence of strong magnetic field

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One of the most interesting kind of neutron stars are the pulsars, which are highly magnetized neutron stars with fields up to 10^{14}G at the surface.
The strength of magnetic field in the center of a neutron star
remains unknown. According to the scalar virial theorem, magnetic field
in the core could be as large as 10^{18}G. Emissivity of neutrinos by the direct Urca process is the mechanism more efficiently of cooling of the neutron stars. It is believed to be the process responsible for the cooling
of proto-neutron stars after the first 100 years of life.
In this work we study the influence of a magnetic field on the cooling of neutron stars due to the neutrino emissivity by the direct Urca process. The matter is described through a relativistic mean-field model at zero temperature. We calculate numerically the emissivity of neutrinos and the cooling due to the direct Urca process for different magnetic fields.

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Decay constants of the pion and its excitations in holographic QCD

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There is a remarkable prediction of QCD that the leptonic decay constants of the excited states of the pion are dramatically suppressed relative to that of the ground-state pion - in the chiral limit, the decay constants of the excited pions are exactly zero. Although within a quark model perspective a suppression of a leptonic decay constant for excited states is expected, as it is proportional to the wave-function at the origin, there is, however, no a priori reason, within such

a perspective, for the dramatic suppression predicted by QCD.
Lattice computations give conflicting results. In the present talk we present results of a recent study of the structure of excited pions within a chiral holographic QCD model; we present results on the leptonic decay constants of pion's excited states and present new predictions concerning their quark mass dependence. Comparisons are made with corresponding results obtained in light-front holography.

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Dirac-Hartee-Bogoliubov calculation for spherical and deformed hot nuclei

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We present relativistic mean field (RMF) calculations in the Dirac-Hartree-Bogoliubov (DHB) formalism for hot nuclei considering not only the self-consistent temperature and density dependence of the relativistic interaction, but also the vapour phase to take in account the unbound nucleon states. The temperature dependence of the pairing gaps, nuclear deformation, radii, binding energies, entropy and caloric curves of spherical and deformed nuclei is obtained where the temperature is introduced in the DHB approximation by using the Matsubara formalism. We do not include the Fock term and use a zero-range approximation to the relativistic pairing interaction to calculate proton–proton and neutron–neutron pairing gaps and energies. A vapor subtraction procedure is used to account for unbound states and to remove long range Coulomb repulsion between the hot nucleus and the gas as well as the contribution of the external nucleon gas. We show that n–n pairing gaps in the $^1S_0$ channel vanish for low temperatures in the range $T_{c^p} = 0.4 - 1.0$ MeV both for spherical nuclei such as ^{90}Zr and ^{140}Ce and the deformed nuclei ^{150}Sm and ^{168}Er. Thus, the nuclear superfluid phase - at least for this channel - can only survive at very low nuclear temperatures. For these nuclei the shell effects and nuclear deformation disappear at slightly higher temperatures of $T_{c^s} = 2.0 - 4.0$ MeV.

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Direct CP Violation in charmless three-body decays of B mesons

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Charmless three-body decays of B^+ mesons are an excellent laboratory for direct CP violation (CPV) studies. While in two-body decays one measures a single number - the CP asymmetry in the partial decay rates -, in three-body decays the distribution of CP asymmetries across the two-dimensional

phase space brings additional information on the underlying mechanisms.
Recently the LHCb collaboration performed a study of CP asymmetries in the Dalitz plot of the decays $B^+ \to \pi^+\pi^-\pi^+$, $B^+ \to K^+\pi^-\pi^+$, $B^+ \to K^+\pi^-K^+$, and $B^+ \to K^+K^-K^+$. CP asymmetries as large as 80% were found in regions of the Dalitz plots. The distribution of the CP asymmetry across the phase space exhibit a complex pattern, which may be a consequence of the interplay between the weak and strong phases. In this talk these results will be presented and a possible interpretation will be discussed.

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Double parton scattering at the LHC

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The Large Hadron Collider (LHC) is a good place to study Quantum Chromodynamics (QCD), which describes the hard interactions between the quarks and the gluons, i.e., the hadrons constituents. Because of the asymptotic freedom, the collisions between hadrons can be perturbatively calculated in the high energy limit of the parton collisions, if the parton distribution functions (PDFs) are available. Often Double Parton Scattering (DPS) can occur when two pairs of partons interact in a same and single p-p (proton-proton) collision. Until the advent of LHC, this kind of process was not very well understood, because collisions at very high energies are necessary for a more visible double scattering contribution. Naively, the DPS process can be calculated by the multiplication of two independent parton cross sections and dividing the result by an effective cross section. We review this possibility.

Field theoretical approaches to QCD / 96

Dynamical AdS/QCD model for light-mesons and baryons

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We construct a Dynamical AdS/QCD model for Light-Mesons and Baryons. The model is a solution of five-dimensional Einstein-dilaton equations that encodes essential features of holographic QCD backgrounds dynamically. Our solution for the gravity background corresponds to a deformed Anti-de Sitter metric at the relevant QCD scale. In this unified model we obtained Regge Trajectories for Light-Mesons and Baryons.

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Effects of time evolution and fluctuating initial conditions on heavy flavor electron R_{AA} in event-by-event relativistic hydrodynamics

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Central Au+Au collisions at RHIC exhibit a strong particle suppression when compared to p+p collisions. Anisotropic flow is also observed in experiments. The particle suppression is usually associated with jet quenching or energy loss of partons inside the quark-gluon-plasma (QGP) where the anisotropic flow might be due to lumps of high-density inside the medium. These fluctuations in initial conditions can cause considerable quark suppression at early stages of the collision evolution, furthermore the QGP dynamics might cause these high-density spots to expand differently from the rest of the plasma which can affect higher harmonic orders of anisotropic flow such as v_3.

In this work we aim to investigate the effects caused by the medium formed in heavy ion collisions on the heavy quark dynamics using a 2D+1 Lagrangian ideal hydrodynamic code which is based on the Smoothed Particle Hydrodynamics (SPH) algorithm, following an event-by-event paradigm. We use an energy loss parametrization on top of the evolving space-time energy density distributions to propagate the quark inside the medium until it reaches the freeze-out temperature where they fragment and hadronize. The resulting mesons are forced to decay giving us the final electron p_{T} distribution that can be compared with experimental data of electron spectrum R_{AA} and v_2. The simulations are run for different centrality classes for both RHIC and LHC collision energies.

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Electrically charged strange quark stars: equilibrium and stability

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We investigate the hydrostatic equilibrium configuration and the stability versus radial perturbation of electrically charged strange quark stars composed by a charged perfect fluid. We consider that the pressure of the fluid is computed from the MIT bag model equation of state and the charge distribution from a power-law function of the radial coordinate. These studies are possible through the numerical solutions of the hydrostatic equilibrium equation (Tolman-Oppenheimer-Volkoff equation) and the Chandrasekhar's equation pulsation, both equations are modified of their original versions for the inclusion of the electric charge. We consider only electrical charge values that affects appreciably the star structure, which implies an electric field around $10^{20}[\mathrm{V/cm}]$. Compared to the radial pressure, the electrical energy density associated to this electric field is appreciable near the surface of the star. We found that for some range of parameters the electric charge helps to grow the stability of the objects under study. We determine that the zero frequency of oscillation is found in a central energy density larger than the one considered to obtain the maximum mass reached for the charged strange star.

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Electromagnetic form factor for the K meson with a symmetric light-front model

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The study of the lightest pseudoscalar mesons plays an important role in order to understand the low energy QCD,being
the lightest strongly bound quark-antiquark states as well as the
Goldstone bosons associated with chiral symmetry
breaking. Their static and dynamical properties have also been investigated theoretically and experimentally.
With respect to the description
of bound states on the light cone, a detailed review of hadronic wave functions in QCD models can be found.
Additional important knowledge about the meson's internal structure can be inferred from their
valence-quark parton distribution functions. The theoretical framework we adopt is the light-front
field theory formalism, more specifically, we here ameliorate the
light-front approach, where two classes of quark-antiquark bound-state
models for the Bethe-Salpeter amplitude of the K meson must be distinguished:
the nonsymmetric and the symmetric vertex model.
The light-front component J^+ of the electromagnetic current has been successfully
used to calculate elastic form factors.
For the symmetric vertex model, the components of the current are
conveniently obtained in the Drell-Yan
frame, where that on the light-cone the bound state wavefunctions are defined
on the hypersurface $x^0 + x^3 = 0$
and are covariant under kinematical boosts due to the stability of
Fock-state decomposition.
In this work, we consider the symmetrical quark-antoquark bound-state vertex function with the intention
to optimize and unify the parameter set which simultaneously reproduces
the K meson decay constants,
charge radii and their electromagnetic form factors, for the latter, our
numerical results are compared with experimental
data up to 10 GeV^2 in order to explore the validity of the model at large q^2 transfer.

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Energy-dependent form factors in a QCD-inspired model

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Using an eikonal QCD-based model in order to connect the semihard parton-level dynamics to the hadron-hadron scattering, we obtain predictions for the pp and $\bar{p}p$ total cross sections, $\sigma_{tot}^{pp,\bar{p}p}$, and the ratios of the real to imaginary part of the forward scattering amplitude, $\rho^{pp,\bar{p}p}$. We consider the phenomenological implications of a class of energy-dependent form factors in the high-energy behavior of the forward amplitude. Our results are consistent with the recent data from the TOTEM experiment.

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Exclusive photoproduction of light vector meson in coherent collisions at the LHC energies

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In this work we analyse the theoretical uncertainties on the predictions for the photoproduction of light vector mesons in coherent pp and AA collisions at the LHC energies using the color dipole approach. In particular, we present our predictions for the rapidity distribution for ρ^0 and ϕ photoproduction and perform an analysis on the uncertainties associated to the choice of vector meson wavefunctionand the phenomenological models for the dipole cross section. Comparison is done with the recent ALICE analysis on coherent production of ρ^0 at 2.76 TeV in PbPb collisions.

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Formulation in terms of two component spinors of the theory of classical Proca fields in curved space-times without torsion

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The theory of classical Proca fields in curved spacetimes without torsion is presented. In particular, the wave equation for a Proca potential is deduced. A two-component spinor version of the theory is subsequently exhibited on the basis of the use of certain calculational techniques that are already available in the literature concerning the spinor formalisms of Infeld and van der Waerden. Then, it will be shown that no couplings between Proca fields and photons coming from curvatures ultimately occur in the spinor wave equations for the theory. However, the procedures for deriving such wave equations produce a new coupling term which involves an Infeld-van der Waerden affine potential and a Proca potential. Additionally, these procedures suggest the implementation of a subsidiary condition that carries the covariant divergence of a Proca potential and the skew part of a potential coupling term. One of the motivations for elaborating the work comes from the absence from the literature of the theory to be described here. The present work will hereby presumably fill in the gap related to the absence from the literature of any detailed formulation of the theory of Proca fields in General Relativity.

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Forward particle production in the CGC formalism: average transverse momentum and τ scaling

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In this work we have used the Color Glass Condensate (CGC) formalism of forward particle production to describe the transverse momentum spectra of charged particles in proton-lead collisions at the LHC. We have also investigated the rapidity dependence of the average transverse momentum, $< p_T >$, and the so called scaling variable, $< \tau = p_T^2/Q_s^2 >$, where Q_s represents the saturation scale of these processes. We compute the ratios of these quantities at a given rapidity y to the value at $y = 0$, going from $y = 0$ towards the proton fragmentation region. Our analysis, based on (gluon) saturation and geometrical scaling, shows that these ratios decrease strongly with y (above midrapidities) and decrease slightly with the energy. We briefly discuss the implications of our results and present predictions for the forthcoming LHC data.

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Gamma-ray lens: development and test

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We will describe the LAUE project, supported by the Italian Space Agency, whose aim is to demonstrate the capability to build a focusing optics in the hard X-/soft gamma-ray domain (80–600 keV). To show the lens feasibility, the assembling of a Laue lens petal prototype with 20 m focal length is ongoing. Indeed, a feasibility study, within the LAUE project, has demonstrated that a Laue lens made of petals is feasible. Our goal is a lens in the 80-600 keV energy band. In addition to a detailed description of the new LARIX facility, in which the lens is being assembled, we will report the results of the project obtained so far.

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Generalized scalar Duffin-Kemmer-Petiau electrodynamics

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The main goal of this work is to investigate the quantum interaction between scalar particles and gauge field in the context of Generalized Scalar Duffin-Kemmer-Petiau Electrodynamics (GSDKP) by quantizing the theory in a functional approach. The Hamiltonian structure is obtained with the Dirac method and the Faddeev-Senjanovic procedure is established in order to write the transition amplitude in an alternative gauge fixing, known as the non-mixing gauge. At least, the Schwinger-Dyson-Fradkin equations and the Ward-Takahashi-Fradkin identities are obtained.

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Gluon Schwinger-Dyson equation in the PT-BFM scheme

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One of the most widely used approach for studying the IR sector of QCD are the Schwinger-Dyson equations. This infinite system of coupled non-linear integral equations for all Green's functions of the theory is inherently
non-perturbative and can accommodate phenomena such as chiral symmetry breaking and dynamical mass generation. In practice, however, their usefulness hinges crucially on one's ability to devise a self-consistent truncation scheme that would select a tractable subset of these equations, without compromising the physics one hopes to describe. Here in this work, we will review, the PT-BFM truncation scheme, which is based on the synthesis of the pinch technique (PT) and the background field method (BFM). We will show that this truncation scheme implements a drastic modification already at
the level of the building blocks of the Schwinger-Dyson series, which after being rearranged, satisfy the Abelian Ward identities instead of the usual Slavnov-Taylor identity. As a result, gluonic and ghost contributions are separately transverse, within each order in the "dressed-loop" expansion. We will show explicitly, it is much easier to devise truncation schemes that manifestly preserve the transversality of the gluon self-energy.

Lattice QCD - methods and results / 143

Gluon correlations and the deconfinement phase transition

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We investigate the critical behavior of electric and magnetic gluon propagators around the deconfinement phase transition for SU(2) gauge theory on the lattice. We test the critical properties of these correlation functions and extract screening masses from their behavior.

Hadronic structure - reactions, production and decays / 47

Hadronic states with both open charm and bottom in effective field theory

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We perform a field-theoretical study of possible deuteron-like molecules with
both open charm and bottom, using the Heavy-Meson Effective Theory. In
this approach, we analyze the parameter space of the coupling constants and discuss the
formation of loosely-bound $D^{(*)}B^{(*)}$-states. We estimate
their masses and other properties.

Strong and electroweak interactions in the standard model / 113

Hadronic tau decays in resonance chiral theory

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Tau decays are analyzed within the framework of resonance chiral theory. This is an extension of chiral perturbation theory in which resonances are incorporated as dynamical states in the Lagrangian, making use of both chiral symmetry and large N_C considerations. It is seen that after imposing asymptotic QCD constraints, a few effective coupling constants need to be fitted from experiment in order to describe the spectral functions for various decay channels.

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Hadrons in holographic AdS/QCD models

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We review some hadron properties obtained from holographic AdS/QCD models.

Relativistic heavy-ion reactions - new data, analyses and models / 121

Heavy Ion physics at LHCb

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The LHCb collaboration studied the production of J/Psi and Upsilon mesons in proton-lead collisions at a proton nucleon centre-of-mass energy of 5 TeV. The measurements have been used to determine the nuclear modification factor and to compare the results with theoretical predictions. A measurement of Z boson production in proton-lead collisions is presented as well. The analyses are based on a data sample corresponding to an integrated luminosity of about 1/nb.

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Heavy-quarkonium potential from the lattice gluon propagator

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There is interest in the study of heavy-quark systems since the decays of heavy-quarks can be used in the search of Beyond the Standard Model physics [1]. A commonly used approximation to the spin-independent interquark potential for heavy quarks is the so-called Cornell (or Coulomb plus linear) potential, which interpolates the perturbative regime and non-perturbative regime by considering the potential a sum of two terms [2, 3, 4]. The first term is a Coulomb potential multiplied by a numerical factor and is obtainable through the one-gluon-exchange approximation (OGE), i.e. perturbation theory applied at first order only [5]. The second term is a linearly-rising potential and inspired by lattice simulations. It corresponds to the static quark potential from the Wilson loop at strong-coupling approximation. Recent results using lattice simulations and Bethe-Salpeter equation show agreement of the interquark potential with the Cornell potential in the infinitely heavy quark limit[6].

In order to see if nonperturbative information can improve the Coulomb-like term of the potential, we propose to substitute the free gluon propagator by a nonperturbative one, obtained from lattice simulations. The propagator used is obtained from a simulation of a pure SU(2) gauge theory available in Ref. [7], corrected by a numerical (color) factor. We fix the normalization by imposing that at large momentum q, the propagator should behave as $1/q^2$. The model has as free parameters the string force F_0, and the masses of charm m_c and bottom m_b quarks. The spectrum can be obtained by numerical solution of the Schrödinger equation and then fitted to experimental data. State wave functions and consequently the average radius are also obtainable. Our conclusion is that the potential obtained this way shows small but visible improvements over the Cornell potential, indicating that it carries information not present in the Cornell potential. We presented partial results previously in Refs. [8, 9].

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Field theoretical approaches to QCD / 85

Hydrodynamic transport coefficients for the non-conformal quark-gluon plasma from holography

Authors: Hugo Marrochio[1] ; Jorge Noronha[1] ; Rômulo Rougemont[1] ; Stefano Finazzo[1]

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We obtain holographic formulas for the transport coefficients κ and τ_π present in the second-order derivative expansion of relativistic hydrodynamics in curved spacetime associated with a non-conformal strongly coupled plasma described holographically by an Einstein+Scalar action in the bulk. We compute these coefficients as functions of the temperature in a bottom-up non-conformal model that is tuned to reproduce (2+1)-flavor lattice QCD thermodynamics at zero baryon chemical potential. We directly compute, besides the speed of sound, 6 other transport coefficients that appear at second-order in the derivative expansion. We also give estimates for the temperature dependence of 11 other transport coefficients taking into account the simplest contributions from non-conformal effects that appear near the QCD crossover phase transition. Using these results, we construct an Israel-Stewart-like theory in flat spacetime containing 13 of these 17 transport coefficients that should be suitable for phenomenological applications in the context of numerical hydrodynamic simulations of the strongly-coupled, non-conformal quark-gluon plasma.

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Impact of a magnetic field on the thermodynamics of magnetized quark matter

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Motivated by the fact that strong magnetic fields B may be produced in noncentral heavy-ion collisions, investigations of the effects of B on the phase diagram of strongly interacting matter became a subject of great interest in recent years. Results from lattice QCD simulations show that the pseudo critical temperature $T_{\rm pc}$ for chiral-symmetry restoration decreases with B, a phenomenon known as inverse magnetic catalysis (IMC); but $T_{\rm pc}$ increases with B for unrealistically large values of pion masses. The decrease of $T_{\rm pc}$ with B is in disagreement with effective models like the linear sigma model and the Nambu–Jona-Lasinio (NJL) model. Motivated by a recent work employing a NJL model with a coupling constant dependent on temperature and
magnetic field, $G(eB, T)$, we reexamine the effects of a magnetic field on the thermodynamic quantities like pressure, entropy, specific heat, and trace anomaly.

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Implicit and explicit renormalization of effective interactions

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Effective interactions can be obtained from a renormalization group analysis in two complementary ways. One can either explicitly integrate out higher energy modes or impose given conditions at low energies for a cutoff theory. While the first method is numerically involved, the second one can be solved almost analytically. In both cases we compare the outcoming effective interactions as functions of the cutoff scale Λ. We carry out a comprehensive analysis of a toy-model which captures the main features of the nucleon-nucleon S-wave interaction at low energies and find a strikingly wide energy region where both approaches overlap

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Inclusive photon production at forward rapidities in pp collisions at LHC energies with the ALICE experiment

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Measurements of multiplicity and pseudorapidity distributions of particles produced in pp collisions are important for the study of particle production mechanisms and to obtain baseline distributions to be compared with those from heavy-ion collisions. The inclusive photon measurements (dominated by π^0 decays) are complementary to the charged particle measurements. The present work focuses on the forward rapidity region with comparisons to different models such as PYTHIA and PHOJET.

We report the measurements of multiplicity and pseudorapidity distributions of inclusive photons using the ALICE Photon Multiplicity Detector (PMD) at forward rapidities ($2.3< \eta <3.9$) in pp collisions at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV. It is observed that the photon multiplicity distributions are well described by negative binomial distributions (NBD). Multiplicity distributions are studied in terms of KNO variables for each energy. It is shown that the increase in the average photon multiplicity as a function of beam energy is compatible with both a logarithmic and power law dependence. The results are compared to different model predictions. These models reproduce experimental results at lower energy while they are not accurate at higher energies.

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Information theoretical methods as discerning quantifiers of the equations of state of neutron stars.

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In this work we use the statistical measures of information entropy, disequilibrium and complexity to discriminate different approaches and parametrizations for different equations of state for quark stars.

We confirm the usefulness of such quantities to quantify the role of interactions in such stars. We find that within this approach, a quark matter equation of state such as SU(2) NJL with vectorial coupling and phase transition is slightly favored and deserves deeper studies.

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Jet fragmentation and energy loss in ultrarelativistic heavy ion collisions

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In this work we study the suppression of charged and neutral hadrons in ultrarelativistic heavy ion collisions, where the quark gluon plasma (QGP) is believed to be produced. Jet quenching is one of the important phenomena to study the properties of QGP. Jet energy loss in the QGP is the main explanation for jet quenching, which may suppress the number of hadrons produced while the jets traverse the dense and colorful medium created. Here we consider some models to include the energy loss effects, which affect both the p_T spectra and the kinematic region for jet fragmentation. One approach takes into account the energy loss of the partons traversing the medium via a shift in the momentum fraction z of the fragmenting parton carried by the produced hadrons. In addition to that, more complete approaches consider that the fragmentation functions are themselves modified by the medium. Here we also apply the quenching weights formalism, where a parton looses energy through medium-induced gluon radiation. We quantify the medium effects by calculating the nuclear ratio R_{AA} as a function of the transverse momentum of the produced hadron, for several centrality classes. The main ingredients are the shadowing of the nuclear parton distributions, the jet energy loss and the fragmentation functions modified by the hot and dense medium. Our results are compared with RHIC and LHC data, from which we intend to extract properties of the QGP such as its transport coefficient and opacity.

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Kaon predictions in the spectral quark model

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This work presents the first results of an extension of the spectral quark model which includes different flavors. The spectral quark model is an approach based on a generalization of the Lehmann representation for the quark propagator. Electromagnetic and chiral invariance are ensured with the help of gauge technique which provides particular solutions to the Ward-Takahashi identities. General conditions on the quark spectral function follow from natural physical requirements. In particular, the function is normalized, it's all positive moments must vanish, while the physical observables depend on negative moments and so-called log moments. As a consequence, the model is made finite. The inclusion of different flavors of quarks in the model, from the determination of the two different spectral functions and n-point functions constructed from Ward-Takahashi identities,

permits the physical description of meson kaon, considered a light meson constituted by an up and strange quark. A large number of predictions and relations were deduced from our approach, as quark condensate, vacuum polarization, weak decay and form factors for light mesons.

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Kinematic cutoff in Drell-Yan process at the LHC

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Drell-Yan process is a standard used in determination of parton distribution functions (PDFs) and has been measured in LHC experiments: ATLAS, CMS and LHCb. A theoretical possibility is to analyse the Drell–Yan process with a kinematical cutoff, with next-to-leading order accuracy and including Sudakov form factors. With the cutoff, a relatively small dilepton mass of 20 GeV, and forward rapidities, the region of small longitudinal momentum fraction can be probed at the LHC, provided a optimal scale specific to the process is calculated.

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Lattice QCD at nonzero baryon number

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Lattice QCD at nonzero baryon number

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Mass generation and the problem of seagull divergences

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The gluon mass generation is a purely non-perturbative effect and, the natural framework to study it, in the continuum, are the Schwinger-Dyson equations (SDEs) of the theory. At the level of the SDEs the generation of such a mass is associated with the existence of infrared finite solutions for the gluon propagator. From the theoretical point of view, the dynamical gluon mass generation has been traditionally plagued with seagull divergences. In this work, we will review how such divergences can be eliminated completely by virtue of a characteristic identity, valid in dimensional regularization. As a pedagogical example, we will first discuss, in the context of scalar QED, how it is possible to eliminate all seagull divergences, by triggering the aforemementioned special identity, which enforces the masslessness of the photon. Then, we will discuss what happens in QCD and

present an Ansatz for the three gluon vertex, which completely eliminates all seagull divergences and at same time allows for the possibility of a dynamical gluon mass generation.

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Measurements of open heavy-flavour nuclear modification factors with ALICE at the LHC

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ALICE is the LHC experiment dedicated to the study of the Quark-Gluon Plasma (QGP). The QGP is a high energy-density state of strongly-interacting matter in which partons are deconfined. This state of matter can be studied experimentally only via heavy-ion (A-A) collisions where the necessary energy density for the phase transition to the QGP can be attained. Measurements of heavy-flavour production are of particular interest since charm and beauty quark-antiquark pairs are dominantly produced in the early stages of the collision, such that they experience the whole evolution of the system. This makes them sensitive probes of the QGP. The nuclear modification factor, which is defined as the ratio of the p_T-differential yield measured in A-A collisions and the corresponding cross section in pp collisions (multiplied by the average nuclear overlap function), is used to quantify the energy loss in the medium. This same quantity is studied in a control experiment, in p-A collisions, to quantify cold nuclear matter effects. With ALICE, open heavy-flavour production is studied via the measurement of heavy-flavour decay leptons (electrons and muons) and via D mesons reconstructed through their hadronic decay channels. We present the correspondent ALICE nuclear modification factor measurements in pp, p-Pb and Pb-Pb collisions at 7 TeV, 5.02 TeV and 2.76 TeV, respectively.

Colloquium / 43

Modelling hadronic matter

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Hadron physics stands somewhere in the diffuse intersection between nuclear and particle physics and relies largely on the use of models. Historically, around 1930, the first nuclear physics models known as the liquid drop model and the semi-empirical mass formula established the grounds for the study of nuclei properties and nuclear structure. These two models are parameter dependent. Nowadays, around 500 hundred non-relativistic (Skyrme-type) and relativistic models are available and largely used and the vast majority are parameter dependent models. I will discuss some of the shortcomings of using non-relativistic models and the advantages of using relativistic ones when applying them to describe hadronic matter. I will also show possible applications of relativistic models to physical situations that cover part of the QCD phase diagram: I will mention how the description of compact objects can be done, how heavy-ion collisions can be investigated, how parameter dependent the critical end point can be (if it really exists) and show the relation between liquid-gas phase transitions and the pasta phase. Finally, hadronic matter subject to strong magnetic fields will be shortly discussed.

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Models of general relativistic white dwarfs at zero-temperature

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The white dwarfs represents the endpoint of stellar evolution, they are formed when a star, with masses between approximately 0.07 and 8-10 $M_{\odot}$, exhausts its nuclear fuel, then the process that sustain its stability will stop. After this, the internal pressure can no longer stand the gravitational force and the star collapses. In this work we investigate the structure of these stars which are described by the equations of Tolman - Oppenheimer - Volkoff (TOV) and the newtonian equations of gravitation. These equations show us how the pressure varies with the mass and radius of the star. We consider the TOV equations for both relativistic and non-relativistic cases for equation of state (EoS). In the case of white dwarf (WD) star the internal pressure that balances the gravitational one is essentially the pressure coming from the degeneracy of fermions. To have solved the TOV equations we need a equation of state that shows how this internal pressure is related to the energy density. Instead of using politropic equations of state we have solved the equations numerically using the exact relativistic energy equation for the model of fermion gas at temperature $T = 0$ and compare with the solution using the politropic approaches. We discuss the instability due to neutronization threshold and the coulomb corrections to the model of Chandrasekhar for WD of homogeneous composition that was performed by Hamada and Salpeter (HS) and concluded that for same mass the model of HS gives a smaller radius and larger central density if compared with the models of Chandrasekhar, finally in our results we compute the difference in the maximum mass for WDs composed of different nucleus . We also look for a fit of the numerical solution of the TOV with the general EoS for the WD mass-radius relation to make use of this as a more realistic analytic relation between mass and radius for general relativistic WDs than that newtonian $M \sim 1/R^3$.

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Multiple photon production in double parton scattering at the LHC

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The high density of gluons in the initial state of hadronic collisions at LHC implies that the probability of multiple parton interactions within one proton - proton collision increases. In particular, the probability of having two or more hard interactions in a collision is not significantly suppressed with respect to the single interaction probability. It has motivated a rapid development of the theory of double parton scattering (DPS) processes and several estimates of the cross sections for different processes have been presented in recent years.

In this contribution we study the production of prompt photons in DPS processes. In particular, we estimate the rapidity and transverse momentum distribution for the double Compton processes, which lead to two photons plus two jets in the final state, and the production of three and four photons in the final state, which are backgrounds to physics beyond the Standard Model. Our predictions for the total cross sections are compared with those for the production of the same final states in single parton scattering processes.

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Non-perturbative BRST breaking, confinement and Gribov copies

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In this seminar, we investigate the role of a non-perturbative breaking of the BRST invariance in the infrared regime of non-Abelian gauge theories and its possible relation to confinement.

This breaking naturally arises from the procedure of quantization of Landau-gauge Yang-Mills theories that takes into account the presence of Gribov copies. The resulting non-perturbative framework – the Refined Gribov-Zwanziger theory – is consistent with different lattice data. One can also construct direct signatures of BRST breaking in the matter sector of confining Yang-Mills theories that are in principle accessible via lattice simulations, allowing for a new non-perturbative model of matter confinement that can be treated (semi-)analytically.

Steiner / 133

Nuclear structure and the neutron star crust

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Nuclear structure and the neutron star crust

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On gravitomagnetism and the solar system

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In 1918, Joseph Lense and Hans Thirring, discovered the gravitomagnetic effect when studied solutions to the Einstein field equations, using the weak field approximation, of rotation systems. They noted that when a body falls towards a massive object in rotation feel a force perpendicular to its movement. The equations that they obtained were similar to Maxwell's Equations of Electromagnetism, now known as Maxwell's equations for gravitomagnetism.
Bearing in mind the concepts and formalism of gravitomagnetics equations, we meansure the influence that the Sun exerts on the planets of the solar system, taking into account the gravitomagnetic field that the Sun produces to ratate around the center of mass os the solar system. In addition, we

consider the field genereted by sphere rotating around its own axis, taking into account that the current density varies radially, and verified the value of gravitomagnetic force of interection Sun-Mercury (and the other planets of the solar system), which is the gravitational countepart to the Lorentz force in eletromagnetism.
The intention is to calulate the value of this force in the entire solar system to see if there is any case where the gravitomagnetic force approaches, equals or is greater than the force of Newton's Universal Gravitation.

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One step beyond Glauber Model for ultra high energy hadronic collisions

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The multiple scattering theory was first developed in late 50´s by Glauber, and then applied extensively in various areas to calculate high-energy scattering amplitude of composite particles [1]. According to Glauber-Velasco model [2], the (anti-)proton is expressed as a cluster of partons, which pass through each other, and interact through the collisions of partons. It's well known since early 60's that the pp (or p anti-p) elastic cross section increases with the incident energy (limited by the Froissart bound of $ln^2(\sqrt{s})$). This fact can now be understood in terms of QCD, as the number of partons also increase with the collision energy. This model has been successfully applied to a pp scattering data in TeV domain [3] by imposing unitary condition.

On the other hand, the Stochastic Vacuum Model [4] is a QCD-inspired model, proposed in mid-80's, which also well reproduced the available pp (and p anti-p) elastic scattering data from $\sqrt{s} \sim 20$ GeV to 7 TeV [5]. The above two models reflect the two complementary aspects of QCD, particle and field. Our main goal with this work is clarify the relation between Glauber-Velasco model and the Stochastic Vacuum Model in view of QCD. Both models agree that the proton does not behaves as a black disk, in the way that the probability of a inelastic interaction decreases smoothly as the impact parameter increases, reaching the value less than the black disk limit, 50%. This certainly reflects the vacuum property of QCD and the mechanism of confinement.

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Opening angle as an evolution variable for parton distributions

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We consider the opening angle as an evolution variable for parton distributions. This allow us to take into account both DGLAP and BFKL leading logarithms and arrive at a single evolution equation, useful for Monte Carlo simulations. Most current global analysis only take into account DGLAP effects, therefore the use of our evolution equation should be particularly important at small x.

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Pasta in QMC

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In the present paper we employ the quark-meson coupling model (QMC) to investigate the onset of the pasta phase in nuclear matter under conditions such as those expected in neutron star crusts.
Pasta is obtained with fixed proton fractions and for beta equilibrated matter.
We probe our results into restrictions imposed on the the values of the density and pressure at the inner edge of the crust, recently achieved by observation, as well as comparing them to the pasta obtained from Walecka-type models.

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Pasta phases in core-collapse supernova matter

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The pasta phase in core-collapse supernova matter (finite temperatures and fixed proton fractions) is studied within relativistic mean field models. Three different calculations are used for comparison, the Thomas-Fermi (TF), the Coexistence Phase (CP) and the Compressible Liquid Drop (CLD) approximations. The effects of including light clusters in nuclear matter and the densities at which the transitions between pasta configurations and to uniform matter occur are also investigated. The free energy and pressure, in the space of particle number densities and temperatures expected to cover the pasta region, are calculated. Finally, a comparison with a finite temperature Skyrme-Hartree-Fock calculation is drawn.

Phase structure of cold magnetized color superconducting quark matter

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The phase diagrams for cold color superconducting quark matter are obtained in the frame of SU(2)_f NJL model in the presence of magnetic field and chemical potential. Two sets of parameters and different values for the quark-quark and quark-antiquark couplings ratios were considered to study how the phase diagram is modified.
The regularization procedure is discussed, showing that dimensional regularization removes in a natural way the unphysical oscillations in the order parameters with respect to other regularizations types discussed in the literature.

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Phase transitions in neutron star equation of state induced by the delta resonances matter

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With the high production of delta-resonances (~30 % of baryonic population) in the dense phase of relativistic heavy ion collisions arises a great interest in the study of the delta matter formation in neutron star structure. In previous work we determine the equation of state and the population of baryons and leptons, and also we discuss the implication of changes in the baryons-meson coupling constants to the formation of delta matter in stellar medium. We use the nonlinear Walecka model including the octet of baryons of spin 1/2 $(n, p, \Lambda^0, \Sigma^-, \Sigma^0, \Sigma^+, \Xi^-, \Xi^0)$ and baryonic resonances of spin 3/2, represented by the delta resonances $(\Delta^-, \Delta^0, \Delta^+, \Delta^{++})$ and Ω^-, in the baryonic sector, and of the electrons and muons in the leptonic sector. We note that the delta resonance interaction induces a liquid-gas type phase transition accompanying delta matter formation at densities values of neutron star interior. In present work this phase transition is explored with respect to the domain of the delta-mesons coupling constants.

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Pions near the chiral critical point

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The discovery of the chiral critical point would represent a major breakthrough in the study of the phase diagram of strong interactions and is one of the main goals of the RHIC Beam Energy Scan program. Its neighborhood is characterized by the arising of intense fluctuations of the chiral field which could, in principle, generate pronounced experimental signatures. However, experimental uncertainties which are inherent to heavy ion collisions, as well as the modest size and duration of the formed plasma in these collisions, might severely attenuate these signatures, demanding a careful search for robust and reliable signals of the critical point neighborhood. In this work, using Monte Carlo techniques, we study the viability of correlations of pions and protons as signatures of the chiral critical point in a realistic scenario, similar to the ones which are found in RHIC.

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Primer on continuum QCD

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Primer on continuum QCD

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Production of the Y(4260) state in B meson decay

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We calculate the branching ratio for the production of the meson $Y(4260)$ in the decay $B^- \to Y(4260)K^-$. We use QCD sum rules approach and we consider the $Y(4260)$ to be a mixture between charmonium and exotic tetraquark, $[\bar{c}\bar{q}][qc]$, states with $J^{PC} = 1^{--}$. Using the value of the mixing angle determined previously as: $\theta = (53.0 \pm 0.5)^\circ$, we get the branching ratio $\mathcal{B}(B \to Y(4260)K) = (1.34 \pm 0.47) \times 10^{-6}$, which allows us to estimate an interval on the branching fraction $3.0 \times 10^{-8} < \mathcal{B}_Y < 1.8 \times 10^{-6}$ in agreement with the experimental upper limit reported by Babar Collaboration.

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Prompt photon measurements with ALICE experiment for quark-gluon plasma study

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The ALICE experiment is mainly devoted to the study of quark-gluon plasma (QGP) expected to be created in heavy ion collisions. Since electromagnetic probes do not interact strongly whith the QGP, direct photons are reliable witnesses of the energy of the initial hard process. This property allows one to investigate, e.g., hadrons energy loss mechanisms in the medium via gamma-jet studies. The measurement of direct photons production is also interesting in p-p collisions, as it provides a test of the QCD cross section as well as it constrains the proton parton distribution function (PDF).

The ALICE Electromagnetic Calorimeter (EMCal) efficiently detects photons up to pt=100 GeV/c. To identify direct photons, a combination of techniques including (electromagnetic) shower shape analysis and isolation cut has been used. These methods are efficient in getting rid of decay photons background, dominant in p-p collision at the TeV energy scale.

An overview of ALICE prompt photon measurements in pp and Pb-Pb collisions will be presented. Finally the complementarity of ALICE and the other experiments (CMS and ATLAS) will be highlighted.

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Relativistic BEC-BCS crossover in a magnetized Nambu-Jona-Lasinio model

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The motivation to study the phase structure of quantum chromodynamics (QCD) is related to investigations of the relativistic heavy ion collisions, compact stars and the early universe. Motivated by the fact that strong magnetic fields may be produced in noncentral heavy-ion collisions, investigations of the effects produced by a magnetic field in the phase diagram of strongly interacting matter became a subject of great interest in recent years. Since perturbation theory of QCD only can be applied in asymptotic regimes of temperatures and densities, and the study on the phase transitions at moderate temperatures and densities cannot be implemented on lattice QCD ($N_c = 3$) calculations, due to the fermion sign problem, many low energy effective models, such as chiral perturbation theory, linear sigma model and others are used to study the phase structure of strongly interacting matter. It is generally expected that there would exist a crossover from Bose-Einstein condensation (BEC) to Bardeen-Cooper-Shriffer condensation (BCS) for diquarks at finite baryon density. In this work we review the investigations of the BEC-BCS crossover in cold QCD at finite baryon chemical potential using the $SU(2)$ version of the Nambu-Jona-Lasinio model for $N_c = 2$ and $N_c = 3$ in mean field approximation, and we study in details the effect of the external magnetic field on the crossover.
We hope that our results will explain the real role developed by the magnetic field in the crossover BEC-BCS.

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Scattering process in the Scalar Duffin-Kemmer-Petiau gauge theory

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In this work we calculate the cross section of the scattering process of the Duffin-Kemmer-Petiau theory coupling with the Maxwell's electromagnetic field. Specifically, we find the propagator of the free theory, the scattering amplitudes and cross sections at Born level for the Moeller and Compton scattering process of this model. For this purpose we use the analytic representation for free propagators and take account the framework of the Causal Perturbation Theory of Epstein and Glaser .

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Self-gravitating compact objects

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Clouds of dusts containing hydrogen in abundance are very common in the Universe. For some reason, this system can have gravitational instabilities, later generating a star that can have three possible finals: Black Holes, White Dwarfs or Neutron Stars. The latter was studied in this work, which has the main objective of defining the profile of these stars, by finding the mass x ratio curve for a specific equation of state. Therefore, it was introduced the concepts of General Relativity, considering the Schwarzschild metric on a perfect fluid, in order to find the Tolman-Oppenheimer-Volkoff equations. A program in FORTRAN95 was created to solve these equations using the fourth order method of Runge-Kutta for a certain equation of state; the user has to insert the central density of the star and it analyses the case where the pressure is zero (corresponding to the star border), returning the values of mass and ratio at this point (which corresponds to the total mass and the star ratio). Based on some values of central density, the stars behavior can be analyzed from a graphic of mass x ratio curve for an equation of state, which values were obtained from the program.

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Strong magnetic fields and radio emision in magnetars and pulsars of white dwarfs

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Recently, several highly magnetized white dwarfs have been observed with fields up to $10^9 G$. Strong magnetic fields can change the structure of the star, such as mass, radius, electromagnetic radiation, pair production and also its period of rotation. In this work, we investigated the role of strong magnetic field in white dwarfs. We present the degenerated electron fermi gas to equation of state (EoS) under huge magnetic field close to the upper limit of $B \sim 10^{13} G$ obtained by the virial condition of equilibrium magnetized white dwarfs (Das, 2013; Kundu, 2012). We see that effect of the landau level the stiffness of the EoS, that is important to change the maximum white dwarfs mass limits obtained by Chandrasekhar, $M \sim 1.43 M_{\odot}$ as recently presented in the literature (Coelho, 2014b). An alternative description bored in very fast and highly magnetized white dwarfs has been recently proposed to the Soft Gamma Repeaters (SGR) and Anomalous X-Ray Pulsars (AXP), usually known

as Magnetars (Malheiro, 2012). A spinning very magnetized white dwarf generates huge electromagnetic potential differences on its surface, producing electromagnetic emission radiation as neutron pulsars. Using several emission pulsar models (Chen, 1993), we investigated the electromagnetic radiation for white dwarf (WD) pulsar. We show that emission far the WD star surface, near the light cylinder radius may explains why only some of the SGRS and AXPs emits in radio.

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Studies of transverse momentum dependent parton distributions and Bessel weighting

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In this paper we present a new technique for analysis of transverse momentum dependent parton distribution functions, based on the Bessel weighting formalism. The procedure is applied to studies of the double longitudinal spin asymmetry in semi-inclusive deep inelastic scattering using a new dedicated Monte Carlo generator which includes quark intrinsic transverse momentum within the generalized parton model. Using a fully differential cross section for the process, the effect of four momentum conservation is analyzed using various input models for transverse momentum distributions and fragmentation functions. We observe a few percent systematic offset of the Bessel-weighted asymmetry obtained from Monte Carlo extraction compared to input model calculations, which is due to the limitations imposed by the energy and momentum conservation at the given energy/Q2. We find that the Bessel weighting technique provides a powerful and reliable tool to study the Fourier transform of TMDs with controlled systematics due to experimental acceptances and resolutions with different TMD model inputs.

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Study of pseudoscalar mesons (π^+, K^+) with a symmetric vertex in the light front formalism

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In this study, we investigate the electromagnetic form factors, $F^{em}_{X^{0^-}}$, decay constants, $f_{X^{0^-}}$, and charge radii, $\langle r_{X^{0^-}} \rangle$, where $X^{0^-} = \pi^+$ or K^+, for pion and kaon within the frame work of light-front field theory formalism using symmetric vertex function as a quark-meson interaction vertex. The above mentioned observables are evaluated for the plus component of the electromagnetic current, J^+, in the Breit frame while, both, the valance and the non-valance contributions are taken into account. We also study the sensitivity of $F^{em}_{X^{0^-}}$, $f_{X^{0^-}}$ and $\langle r_{X^{0^-}} \rangle$ on the model's parameters, namely, quark masses, $m_u = m_d$, $m_{\bar{s}}$, and on the regulator mass, m_R. It is found that, after fine tuning of regulator mass i.e. $m_R = 0.6$ GeV, the model is suitable to fit the experimental values of $f_{X^{0^-}}$ and $\langle r_{X^{0^-}} \rangle$ within the theoretical uncertainties, both, for pion and kaon.

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Study of the $Z_b(10610)$, $Z_b(10650)$ states through $B\bar{B}^*$ and $B^*\bar{B}^*$ interactions using hidden local symmetry

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Using the Hidden Local symmetry approach we study the $B\bar{B}^*$ and $B^*\bar{B}^*$ interactions for $I = 1$. We show that both interactions via one light meson exchange are OZI forbidden. For that reason, we calculate the contributions for those interactions coming from the exchange of two pions, interacting and noninteracting among themselves, and also due to the heavy vector mesons exchange. Then, to compare all these contributions, we use the potential related to the heavy vector exchange as an effective potential corrected by a factor which takes into account the contribution of the others light mesons exchange. In order to look for poles, this effective potential is used as the kernel of the Bethe-Salpeter equation. As a result, for the $B\bar{B}^*$ interaction we find a loosely bound state with mass in the range $10587 - 10601$ MeV, very close to the experimental value of the $Z_b(10610)$ reported by Belle Collaboration. For the $B^*\bar{B}^*$ case, we find a cusp at 10650 MeV for all spin $J = 0, 1, 2$ cases.

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Subtractive regularization of the NJL model

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The NJL model is an effective model for the strong interaction, which is one of the four fundamental forces in nature [1]. Despite the simplicity of the model, it gives a very good description of some fundamental properties of the underlying theory of quantum chromodynamics, like the dynamical chiral symmetry breaking and its corresponding effective mass generation [2, 3]. Here we propose to use another approach to make the gap equation finite but keeping the momentum integration up to infinity. The alternative approach is based on a subtractive renormalization method and has been applied to the nuclear force with great success [4].

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Telescope performance and image simulations of the balloon-borne coded-mask protoMIRAX experiment

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In this work we present the results of imaging simulations performed with the help of the GEANT4 package for the protoMIRAX hard X-ray balloon experiment. The instrumental background was simulated taking into account the various radiation components and their angular dependence, as well as a detailed mass model of the experiment. We modeled the meridian transits of the Crab Nebula and the Galactic Centre region during balloon flights in Brazil (~ −23° of latitude and an altitude of ~ 40 km) and introduced the correspondent spectra as inputs to the imaging simulations. We present images of the Crab and of three sources in the Galactic Centre region: 1E 1740.7−2942, GRS 1758−258 and GX 1+4. The results show that the protoMIRAX experiment is capable of making spectral and timing observations of bright hard X-ray sources as well as important imaging demonstrations that will contribute to the design of the MIRAX satellite mission.

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Testing effective models for compact stars

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The study of the inner structure of compact stars requires the knowledge of the equation of state (EoS) for this
kind of exotic stellar matter. This show us how the balance between gravitational attraction and microscopic
interaction by means of the other fundamental interactions gives rise to the state of equilibrium in which they
are observed currently. In the case of quark or hybrid neutron stars, it is known that the strong interaction
plays the dominant role. In principle one could find the EoS for this kind of star matter using the fundamental
equations of quantum chromodynamics (QCD). However, the non-perturbative regime of this theory is highly
nontrivial and therefore one cannot find an exact EoS for the interior of such stars that takes into account
all the physical and mathematical structure of QCD. Up to now one is only able to solve the fundamental
equations if one simplifies QCD, keeping some relevant symmetries, in order to build effective models. In this
work we test some EoS's, which were obtained by using approximate results from effective models, by solving
the Tolman-Oppenheimer-Volkoff (TOV) equations in order to determine some important intrinsic properties
of such exotic stars, like the mass-radius relation, etc.

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The EOS of dense matter and neutron star structure

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The QCD phase diagram at real and imaginary chemical potential

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The QCD phase diagram at real and imaginary chemical potential

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The influence of 4π vertex on $p\,p\,\rightarrow\,p\,n\,\pi+$ reaction near threshold

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Theoretical efforts to describe the pion production at threshold have been made since the new data [1], [2] have shown a disagreement with the description of the earlier work due to Koltun & Reitan (KR) [3]. In this pioneer work of KR, the interaction is split into two parts: one describes the correlations between the nucleons before and after production of a pion and the other is responsible for the dynamic of pion production from nucleon. The correlations are described by eigenfunctions of a Schrodinger equation with realistic nucleon-nucleon potential and the production dynamics is given by amplitude which is calculated from diagrams known as the impulse term and the reescattering term. This first model predicted the correct energy dependence of the cross section, but its magnitude is underestimated by a factor of five.

Due to threshold conditions (soft pion produced at S-wave) the process exhibits conditions to apply effective field theories and the Chiral Perturbation Theory have been applied [4] to evaluate the amplitude of $pp\,\rightarrow\,pp\pi^0$ reaction. This calculation shows that reescattering term contributes destructively to the impulse term in contrast to KR calculation. In spite of this difference, these two ways of description point to critical role played by short range dynamics in this process and we address our concern to the scalar-isoscalar component of the interaction, which is represented, by the S scalar-isoscalar meson field, which is used in this short range dynamics. To preserve chiral symmetry, we need to include also the contribution of the S meson decay into two pions, $S\rightarrow\pi\pi$, where one pion is emitted and the other one is absorbed by the second nucleon. Since we do not know the value of this decay coupling constant, we use the approach of the S scalar meson being a 2π scalar ressonance and doing this the decay vertex become a 4π pion interaction.
This work will present the results for the contributions given by this 4π vertex to pion production at threshold.

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The ins and outs of mesons

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The ins and outs of mesons

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The physics reach and the performance requirements for the experiments

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The physics reach and the performance requirements for the experiments

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The role of the Unruh effect in multi-particle processes

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We discuss the relevance of the Unruh effect in multiparticle processes.
We review the cases where it is nothing more than an effective description of "conventional" multi-particle processes describeable, in the inertial frame, through standard scattering theory, and discuss cases where this equivalency breaks down.
We suggest that an experimental investigation of this issue, achievable in the foreseeable future via strong laser physics, is a promising avenue to investigate fundamental physics, using beta decays as an example.

Field theoretical approaches to QCD / 93

Thermodynamics of an exactly solvable confining quark model

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The grand partition function of a model of confined quarks is exactly calculated at arbitrary temperatures and quark chemical potentials. The model is inspired by a softly BRST-broken version of QCD and possesses a quark mass function compatible with nonperturbative analyses of lattice simulations and Dyson-Schwinger equations. Even though the model is defined at tree level, we show that it produces a non-trivial and stable thermodynamic behaviour at any temperature or chemical potential. Results for the pressure, the entropy and the trace anomaly as a function of the temperature are qualitatively compatible with the effect of non-perturbative interactions as observed in lattice simulations. The finite density thermodynamics is also shown to contain non-trivial features, being far away from an ideal gas picture.

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Three and four quarks effective interactions

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Higher order quark effective interactions, correcting the usual NJL interaction, are derived by considering polarization effects [1,2,3]. A set of auxiliary fields is introduced one of which yields the scalar chiral quark-antiquark condensate. Fluctuations are shown to provide effective quark couplings. The leading fourth order coupling provides a correction the Nambu-Jona-Lasinio model. The sixth order interaction corresponds to the ‘t Hooft interaction and the eighth order ones correspond to already known chiral invariant quark interactions. Other chiral invariant quark-quark couplings are found. The precise shape of the gluon propagator is not necessarily relevant for the shape of the resulting effective couplings although it might be important for numerical estimations.

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Transport properties in dense matter and neutron star evolution

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Transport properties in dense matter and neutron star evolution

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Ultra high energy cosmic rays: the highest energy frontier

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Ultra-high energy cosmic rays (UHECR) are the highest energy messengers of the present universe, with energies up to 10^{20} eV. Studies of astrophysical particles (hadrons, neutrinos and photons) at their highest observed energies have implications for fundamental physics as well as astrophysics. The primary particles interacts in the atmosphere and generates an extensive air shower. Analysis of those showers enables one not only to estimate the energy, direction and most probable mass of the primary cosmic particles, but also to obtain information about the properties of their hadronic interactions at an energy more than one order of magnitude above that accessible with the current highest energy human-made accelerator. In this contribution we will review the state-of-the-art in UHECRs detection. We will present the leading experiments and discuss the cosmic ray energy spectrum, searches for directional anisotropy, studies of mass composition, the determination of the number of shower muons (which is sensitive to the shower hadronic interactions), and limits on the fluxes of primary photons and neutrinos.

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Updating an empirical analysis on the proton's central opacity and asymptotia

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We present an updated empirical analysis on the ratio of the elastic (integrated) to the total cross section in the c.m. energy interval from 5 GeV to 8 TeV. As in a previous work, we use a suitable analytical parametrization for that ratio (depending on only four free fit parameters) and investigate three asymptotic scenarios: either the black disk limit or scenarios above or below that limit. The dataset includes now the datum at 7 TeV, recently reported by the ATLAS Collaboration, which plays an important role in the data reductions. Our analysis favors, once more, a scenario below the black disk, providing now an asymptotic ratio consistent with the rational value 1/3, namely a gray disk limit. Upper bounds for the ratio of the diffractive (dissociative) to the inelastic cross section are also presented and discussed.

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Vector mesons within chiral quark models for strong interactions.

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We analyze meson properties within an SU(2) chiral quark model that includes nonlocal four-fermion couplings. In this work we concentrate in the description of basic features of nonstrange vector and axial-vector mesons, considering nonlocal form factors that are based in lattice QCD results for effective quark propagators.

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Wave function of valence of the pion from QCD

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In this work, we are studying the usual formalism of quantum field theory of quantum field theory in Light-Front formalism, with the goal of applying the properties of quantum chromodynamics (QCD) in the scheme nonperturbative.

The electromagnetic structure of the pion , wich is a pseudoscalar meson composed of a quark-antiquark bound state with total spin zero, is our first object of study. Our proposal is to obtain a wave function from QCD , wich describes the internal structure of the pion. So that can in particular calculate such as the electromagnetic form factorand meam square radius in energy low and intermediate.
In this case of the particle the wave function can be archieved using a model with constituent quark. In this model the quark mass range (running mass) according to the Dyson-Schwinger techniques. Specifically , we performed the calculations in the Light-Front formalism with a model for the constituent quarks bound state of the quark-antiquark pair.

The calculations will be compared with other models in the literature, wich on the other hand, are different designs using different wave functions for the pion.

In the case of particles of spin-0 as the pion can obtain a wave function, separating it in terms of the Dirac's matrices. In a first approximation we consider the function wave without the Dirac's structure, and thus make the first estimateof how shouldbe the behavior. The presence of poles in the Bethe-Salpeter amplitudecaused resortedthe Nakanish representation. Due to presence of the poles at the vertex of the Bethe-Salpeter amplitude, according to the proposal by reference hindered our attempt to use Nakanish representation. For this reason we are analyzing the poles in the Bethe-Salpeter amplitude in the Light-Front formalism, wich we integrate into terms of energy, via Cauchy's theorem, and thus obtain a wave function analytically.

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Why "black widow" pulsar systems are important for the quest of neutron star maximum mass

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Relativistic binary systems showing the ablation of the donor star by pulsar winds have been discovered in 1988 and studied recently using FermiLat and other facilities. We discuss in this presentation the evolution of the "black widow" systems, showing that theoretical tracks reveal i) the importance of illumination feedback of X rays onto the donor star, ii) a long (several Gyr) overall timescale to arrive to the observed orbital period-donor mass plane iii) their parenthood with the younger "redback" binary systems; and iv) the large mass transfer occurred along the evolution, which justifies the recent claims of very large masses ($> 2M_{\odot}$) of the neutron stars as measured in at least three cases. We show how these features impact the supranuclear equation of state and limit compositional possibilities.

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pp scattering at LHC and cosmic ray energies

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Using a unified analytic representation for the elastic scattering amplitudes of pp scattering for all energies, the behavior of observables at the LHC energies in the range 2.76 - 14 TeV is discussed. Similary to the case of 7 TeV data, the proposed amplitudes give excellent description of the preliminary data at 8 TeV. The energy dependence of the observables, with predictions for the experiments at 2.76, 13 and 14 TeV is discussed.

As an application of these results, we study p-air cross sections, with comparison to the data from Extensive Air Shower (EAS) measurements. The comparison with cosmic ray data is very satisfactory in the whole pp energy interval from 1 to 100 TeV.

High energy asymptotic behaviour of cross sections is investigated in view of the geometric scaling property of the amplitudes. It is predicted that the proton does not behave as a black disk even at asymptotically high enegies, and possible non-trivial consequences of this fact for pA collision cross sections are investigated.