HADRONS 2025

Report of Contributions

https://indico.cern.ch/e/hadrons2025

Contribution ID: **40** Type: **Poster**

Parametrization of perturbative QCD in hadronic tau decays

Tuesday 11 March 2025 18:16 (2 minutes)

The determination of the strong coupling, α_s, from the theoretical description of inclusive hadronic tau decays in Quantum Chromodynamics (QCD), is one of the most precise extractions from experimental data. The theoretical description is dominated by perturbation theory but receives non-perturbative contributions from the Operator Product Expansion and duality violations, which cannot be neglected. The standard approach is to build sum rules where the QCD contribution is evaluated as closed-contour integrals in the complex plane. However, this method introduces complications related to the renormalization scale, notably in the perturbative series. Therefore, with its inherent complexity, the state-of-the-art five-loop QCD description is non-trivial. Although these complications are unavoidable in a realistic, high-precision analysis, it would be desirable to have a much simpler but reliable parametrization of the QCD result, including all correlations, to provide a simple interface with precision Electroweak Fits and Monte Carlo simulations for future accelerators, such as the FCC-ee. Furthermore, this parametrization could be applied in various fits where constraints from hadronic tau decays are of significant interest. In this work, we perform a parametrization for the perturbative QCD part, aiming to simplify the integration of theoretical predictions and check if this new version maintains the precision required.

Authors: BOITO, Diogo; OLIVEIRA, Rita (Universidade de São Paulo)

Presenter: OLIVEIRA, Rita (Universidade de São Paulo)

Session Classification: Poster session

Contribution ID: **41** Type: **Poster**

Yang-Mills correlation funcions due to percolating center vortices

Monday 10 March 2025 18:20 (2 minutes)

Lattice simulations show that Yang-Mills theory's infrared properties are captured by ensembles of collimated configurations formed by center vortices and monopoles. In this work, we continue to study the properties of these ensembles relying on an infrared vacuum wavefunctional peaked at center-vortex configurations that was recently proposed in Coulomb gauge. In particular, we compute and compare two-point spatial correlation functions within this framework with the same results obtained within a variational approach. We verify an agreement that suggests a universal behavior for theories whose confinement mechanism is related to the presence of a monopole condensate.

Authors: ROSA JUNIOR, David (Fluminense Federal University, University of Tübingen); KREIN, Gastao; OXMAN, Luis E. (Fluminense Federal University); SOARES, Bruno

Presenter: SOARES, Bruno

Session Classification: Poster session

Contribution ID: **42** Type: **Poster**

Extension of the Relativistic Thomas-Fermi model using the three-dimensional basis of the oscillator in oblate and prolate spheroidal coordinates

Monday 10 March 2025 18:06 (2 minutes)

The crust of neutron stars has been the subject of intense study due to its possible inhomogeneous structures, which arise from the complex interplay between strong nuclear forces and the Coulomb interaction among particles. These structures can significantly influence various star properties, such as thermal and electrical conductivity, shear viscosity, moment of inertia, and so forth, consequently impacting the star's magneto-thermal evolution, pulsar glitches, and gravitational waves. One of the most successful models for characterizing these peculiar structures, known as the nuclear pasta phase, is the Thomas-Fermi model. In most applications, calculations are simplified to involve only one degree of freedom. This research project aims to address this limitation by exploring the implications of an innovative modeling approach for a well-established problem.
The study will focus on neutron star phenomenology, particularly their crust and inhomogeneous structures. It will include a comprehensive literature review of the relativistic hadronic model of stellar matter based on the nonlinear Walecka model, followed by the relativistic Thomas-Fermi approximation for characterizing the pasta phase. Our main objective is to analytically extend the Thomas-Fermi model to the three-dimensional harmonic oscillator basis in oblate and prolate spheroidal coordinates.
Additionally, we intend to implement the obtained results into a custom algorithm, enabling us to analyze the implications of this new structural modeling approach using numerical computation methods. It is believed that this innovative approach may reveal new energetically favorable inhomogeneous structural formations not yet simulated. In other words, we aim to elucidate how these structures manifest in the universe with greater precision.
This research project is a crucial step toward a deeper understanding of neutron stars, illuminating the mysteries of their formations and characteristics. By exploring this new structural modeling tool, we open doors to a better comprehension of the intriguing effects of nuclear pasta in the stellar crust. Each discovery brings us closer to a clearer and more comprehensive understanding of these stars, transforming current astronomical data into richer and more meaningful narratives.

Authors: OLIVEIRA, Pamela; AVANCINI, Sidney (universidade federal de santa catarina)

Presenter: OLIVEIRA, Pamela

Session Classification: Poster session

Contribution ID: **43** Type: **Poster**

Tau polarization observables in neutrino - nucleus interactions at the LHC energy range

Tuesday 11 March 2025 18:18 (2 minutes)

Considering that the study of neutrino - nucleus interactions with incident neutrino energy ranges in the GeV - TeV range is feasible at the Large Hadron Collider, we investigate in this work the degree of polarization $calP$ of the (anti) tau lepton produced in (anti) tau neutrino - tungsten interactions. We include nuclear effects to examine their impact on $calP$. In this study we also investigate the impact of the tau polarization on the pions generated in its decay. In particular, we estimate the associated pion momentum, energy and angular distributions. The contribution of the F_5 structure function to these observables is also investigated. Our results indicate that the pion properties are sensitive to the tau polarization state as well as to the magnitude of F_5.

Authors: Dr GRATIERI, Diego (Universidade Federal Fluminense); FRANCENER, Reinaldo (Universidade Estadual de Campinas); GONCALVES, Victor

Presenter: FRANCENER, Reinaldo (Universidade Estadual de Campinas)

Session Classification: Poster session

Contribution ID: **44** Type: **Oral communications**

$U_A(1)$ symmetry breaking due to quark-antiquark interactions mediated by gluons

Monday 10 March 2025 16:30 (15 minutes)

Sixth order quark-antiquark interactions are derived by starting from a quark-antiquark interaction mediated by one (nonperturbative) gluon exchange. Vacuum polarization gives rise to such UA(1) symmetry breaking interactions for different Lorentz and flavor structures, among which interactions with the same shape as the ‘t Hooft interactions induced by instantons. Some phenomenological consequences are discussed, in the local limit of these interactions, in terms of corrections to the parameters of the Nambu-Jona-Lasinio model.

Authors: Dr BRAGHIN, Fabio (Federal University of Goias); L. BRAGHIN, Fabio

Presenters: Dr BRAGHIN, Fabio (Federal University of Goias); L. BRAGHIN, Fabio

Session Classification: Oral communications

Contribution ID: **45** Type: **Poster**

Hydrodynamics from local phase space dominance

Monday 10 March 2025 18:02 (2 minutes)

The apparent onset of hydrodynamics in small systems necessitates a description of hydrodynamics independent of the many-particle limit, and the proper treatment of fluctuations in conditions of near-local equilibrium. We propose an algorithm for the dynamic description of such a few-particle fluctuating fluid. The procedure consists of defining a spacetime lattice in which each cell, containing momentum and energy at a given instant of time, undergoes a production of particles in the regime of phase-space dominance in its respective rest frame followed by an energy-momentum exchange via these particles with neighboring cells. The number of particles (massless quarks and gluons) is generated by a Poisson distribution and Lorentz-invariant phase space weights are calculated by the routine RAMBO (R. Kleiss, W.J. Stirling and S.D. Ellis), a new Monte Carlo treatment that generates random four-momentum for particles in collision events. Performing a new transformation on the energy and momentum quantities to the initial fluid frame, there's a redistribution of values between cells, as after a time step, the particle will be in the neighboring cell (adjacent to the production cell). The process is then carried out for all cells (using the energy from the previous time-step), thus obtaining the total flow of momentum in space. The results obtained are then compared with hydrodynamics, with coarse-grained parameters (flow and energy density) obtained event-by-event.

Author: BARAUNA, Jadna Louise (UFSC)

Co-authors: TORRIERI, Donato Giorgio (Unicamp); JOSÉ NUNES DA SILVA, Tiago (UFSC)

Presenter: BARAUNA, Jadna Louise (UFSC)

Session Classification: Poster session

Contribution ID: **46** Type: **Poster**

Color Confinement and Topology in Lattice Gauge Theories

Monday 10 March 2025 17:46 (2 minutes)

Color confinement is still an open and challenging problem in modern physics, being the non-perturbative regime of $SU(N_c)$ Yang-Mills theory the primarily responsible for such difficulty. Among the various ideas proposed to understand the confinement mechanism, the center-vortex configurations seem to play a crucial role when reproducing the desired phenomenology.In this picture, the Yang-Mills vacuum consists of an ensemble of percolating magnetic flux lines, the center vortices (a "spaghetti" like vacuum), in what is known as center dominance. These vortex carry charges proportional to the weights of the gauge group, and can be oriented or not. The random fluctuation in the vortices degrees of freedom is (believed to be) the origin of area law of the Wilson loops. Yet, the study of these degrees of freedom is a complicated analytical task. At the same time, Monte Carlo simulations on the lattice provide us a very useful way to study these degrees of freedom, and nowadays a great deal of numerical evidence to the center-vortex scenario is available in the literature. However, the detection of these vortices is not so simple on the lattice. In the continuum, they can be identified by their guiding center while, on the lattice, the same cannot be done and one can only see plaquettes pierced by projected vortices on a dual lattice. In this work, we aim to present the techniques utilized to study the center-vortex picture on the lattice, discussing some difficulties that appear, and show some results obtained by our research group at IFSC/USP.

Authors: TONHON, Rafael; MENDES, Tereza

Presenter: TONHON, Rafael

Session Classification: Poster session

Contribution ID: **47** Type: **Oral communications**

Ensemble of topological defects and the confining flux tube

Thursday 13 March 2025 14:45 (15 minutes)

Understanding how the confining flux tube is formed in SU(N) Yang-Mills theory is an important step towards understanding color confinement in QCD. It is known that center vortices play an important role in this regard, but it remains a mystery how to take them into account in a non-perturbative manner. One way is by performing ensembles of percolating vortices using a phenomenological model. In this talk, a few of these ensembles will be explored and the importance of including attached monopoles and non-Abelian degrees of freedom will be highlighted. On top of that, it will be shown how this modeling can lead to an effective field representation and how the associated classical solutions, in the form of topological solitons, can accommodate a myriad of lattice results such as transversal profiles, asymptotic scaling, and N-ality, etc.

Authors: MOREIRA SIMÕES, Gustavo (IFSC-USP); OXMAN, Luis E. (Fluminense Federal University); ROSA JUNIOR, David (Fluminense Federal University, University of Tübingen)

Presenter: MOREIRA SIMÕES, Gustavo (IFSC-USP)

Session Classification: Oral communications

Contribution ID: **49** Type: **Poster**

The Effect of Acausality on Bayesian Analyses of Heavy-Ion Collisions

Tuesday 11 March 2025 18:14 (2 minutes)

Hydrodynamic models have been instrumental in uncovering the properties of quark-gluon plasma (QGP) in relativistic heavy-ion collisions, providing an effective framework to describe the system's evolution. However, their validity is challenged in scenarios where causality is violated, as such violations undermine their ability to represent the underlying relativistic quantum field theory accurately. Non-linear causality conditions offer a rigorous criterion for identifying these regimes, which arise in modern hydrodynamic simulations during the early stages of the system' s evolution.

In this study, we explore the consequences of enforcing causality constraints on Bayesian analyses used to infer QGP properties. Our results demonstrate that while causality violations typically involve a small fraction of the system's energy, imposing strict causal limits leads to significant changes in the inferred initial conditions and the preferred values of QGP transport properties. Notably, our findings reveal a marked reduction in the bulk viscosity, underscoring the sensitivity of QGP parameter estimates to early-time non-equilibrium dynamics.

These insights highlight the critical importance of incorporating causality constraints into hydrodynamic models to enhance the reliability of QGP property extraction and deepen our understanding of strongly interacting matter governed by quantum chromodynamics (QCD).

Based on: arXiv:2409.17127 or Phys.Rev.C 110 (2024) 6, 064904.

Author: SIQUEIRA DOMINGUES, Thiago

Co-authors: PAQUET, Jean-Francois (Vanderbilt University); Prof. LEITE NORONHA, Jorge Jose (University of Illinois at Urbana-Champaign); Prof. WILLIAM LUZUM, Matthew (University of São Paulo); Ms KRUPCZAK, Renata (Universität Bielefeld); JOSÉ NUNES DA SILVA, Tiago (UFSC)

Presenter: SIQUEIRA DOMINGUES, Thiago

Session Classification: Poster session

Contribution ID: **50** Type: **Poster**

Observables and spectral functions in pseudo-hermitian theories \ Observáveis e funções espectrais em teorias pseudo-hermitianas

Monday 10 March 2025 18:04 (2 minutes)

Until the 90's, quantum mechanis was developed almost exclusively with the considerarion that the hamiltonian should be hermitian and with a euclidean inner-product. However, given this scalar product, the hermiticity of the hamiltonian is a sufficient condition, but not necessary for the reality of its eigenvalues. Furthermore, if an alternative choice of inner-product was permitted, the time evolution affected by these so-called non-hermitian hamiltonians would be unitary. These elements led to the formulation of the pseudo-hermitian representation of quantum mechanics. In the present work, we utilize the concepts from this representation to treat a pair of harmonic oscillators with an imaginary coupling, showing, in the first place, that the eigenvalues of the system are real and that there is an inner-product which defines a unitary evolution, i. e., preserves the inner-product of the states in time. Afterwards, we show that the hermitian operators inicially used to describe the system do not constitute observables and give rise to spectral functions not strictly positive. Moreover, we obtain observables for the system and show that the spectral functions for these do not violate positivity. We effect calculations for the model in quantum mechanics and for its analogue in quantum field theory. Finally, we conjecture that the positivity violation of spectral functions in other theories, as in Yang-Mills for example, is due to an inadequate choice of observables and inner-products.

Até os anos 90, desenvolvia-se a mecânica quântica quase exclusivamente com a consideração que a hamiltoniana deveria ser hermitiana e com o produto euclidiano. Contudo, dado este produto escalar, a hermiticidade da hamiltoniana é uma condição suficiente, porém não necessária para a realidade dos seus autovalores. Além disso, caso seja permitida uma escolha alternativa do produto interno, a evolução temporal por hamiltonianas ditas não-hermitianas pode ser unitária. Estes elementos que conduziram à formulação da representação pseudo-hermitiana da mecânica quântica. No presente trabalho, utilizamos os conceitos desta representação para tratar um par de osciladores harmônicos com acoplamento imaginário, mostrando, em primeiro lugar, que os autovalores do sistema são reais e que existe um produto interno no qual a hamiltoniana define uma evolução unitária, ou seja, preserva o produto interno dos estados no tempo. Posteriormente, mostramos que os operadores hermitianos utilizados inicialmente para descrever o sistema não representam observáveis e dão origem a funções espectrais não estritamente positivas. Ademais, obtemos observáveis para o sistema e mostramos que as funções espectrais para estes não viola a positividade. Realizamos os cálculos para o modelo na mecânica quântica e para o seu análogo em teoria quântica de campos. Por fim, conjecturamos que a violação de positividade de funções espectrais em outras teorias, como as de Yang-Mills, por exemplo, se deve a uma escolha indevida de observáveis e de produto interno.

Authors: MINTZ, Bruno (UERJ); PINHEIRO, Itai; AQUINO, Rui (ICTP)

Presenter: PINHEIRO, Itai

Session Classification: Poster session

Contribution ID: **51** Type: **Oral communications**

Supernova Remnants with Mirror Dark Matter and Hyperons

Wednesday 12 March 2025 16:30 (15 minutes)

For the first time, we use relativistic mean-field (RMF) approximation with density-dependent couplings, adjusted by the DDME2 parameterization, to investigate the effects of dark matter on supernova remnants. We calculate the nuclear equation of state for nuclear and dark matter separately, under the thermodynamic conditions related to the evolution of supernova remnants. A mirrored model is adopted for dark matter, and its effect on remnant matter is studied using a two-fluid scenario. At each stage of the remnant evolution, we assume that dark and ordinary matter have the same entropy and lepton fraction, and a fixed proportion of dark matter mass fraction is added to the stellar matter to observe its effects on some microscopic and macroscopic properties of the star. We observe that dark matter in the remnant core reduces the remnant's maximum mass, radius, and tidal deformability. Moreover, dark matter heats the remnant matter and alters particle distributions, thereby decreasing its isospin asymmetry and increasing the sound speed through the matter.

Author: ISSIFU, Adamu (ITA)

Presenter: ISSIFU, Adamu (ITA)

Session Classification: Oral communications

Contribution ID: **52** Type: **Poster**

Constraining the neutron star equation of state by including the isoscalar-vector and isovector-vector coupling using the Bayesian approach

Wednesday 12 March 2025 17:52 (2 minutes)

We constrain the nuclear matter equation of state by including the isoscalar-vector and isovector-vector coupling using the Bayesian approach. We use the recent observation GW190814 (R. Abbott et al 2020 ApJL 896 L44) for the compact star of mass 2.6 M⊠ along with the nuclear saturation properties for finite and infinite nuclear matter at saturation properties at saturation and supra-saturation. Here we see that the cross coupling between isocalar-vector and isovector-vector is more effective to reach such high mass of compact star. We use FSUGold and IU-FSU parameters as the references. Finally, we discuss the effects of such coupling on the non-radial oscillations of neutron stars

Authors: Dr KUMAR, Deepak (Institute of Physics); Dr BHUYAN, Mrutunjaya (Instituto Tecnologico de Aeronautica); SAHU, Pradip Kumar (Institute of Physics (IN))

Presenter: Dr KUMAR, Deepak (Institute of Physics)

Session Classification: Poster session

Contribution ID: **53** Type: **Poster**

Soft and semi-hard components of multiplicity distributions in the k_T factorization approach

Monday 10 March 2025 18:00 (2 minutes)

The multiplicity distribution (MD) of charged particles in high-energy proton-proton collisions remains an intricate aspect of quantum chromodynamics (QCD). Traditional models, such as the Negative Binomial Distribution (NBD), were fitted and successfully described MDs at lower energies, but fail at higher energies, such as those probed by the Large Hadron Collider (LHC), where a "shoulder-like" structure emerges.

To address this, we employ the Double Negative Binomial Distribution (DNBD), a weighted combination of two NBDs, representing contributions from soft and semi-hard processes. This model typically involves six free parameters, but by incorporating the k_T factorization formalism and introducing an energy scale Λ, we effectively reduce the number of free parameters to four while maintaining a strong fit to high-energy MD data. The unintegrated gluon distribution used in this work is derived from the Golec-Biernat–Wüsthoff (GBW) model.

Additionally, we investigate the KNO scaling and use the k_T factorization formalism to describe the pseudo-rapidity distribution. Our approach demonstrates excellent agreement with recent experimental data, yielding low χ^2 values and highlighting the potential for improvements using more realistic gluon distribution model. This analysis provides valuable insights into the interplay of soft and semi-hard processes in high-energy collisions.

Authors: Dr SILVEIRA NAVARRA, Fernando (Instituto de Física da USP); Mr RODRIGUES MARTINS FONTES, Henrique (Instituto de Física da USP)

Presenter: Mr RODRIGUES MARTINS FONTES, Henrique (Instituto de Física da USP)

Session Classification: Poster session

Contribution ID: **54** Type: **Oral communications**

Nambu–Jona-Lasinio description of hadronic matter from a Bayesian approach

A microscopic nuclear matter formalism with explicit chiral symmetry based on the Nambu Jona-Lasinio model is considered to describe nuclear matter. To reproduce nuclear matter properties adequately at the saturation density, four-point and eight-point interactions are introduced. Within a Bayesian inference approach, the parameters of the model are determined by imposing nuclear matter, both experimental and from ab-initio calculations, and neutron star observational constraints. Nuclear matter properties are well reproduced with an effective mass of 0.75 to 0.8 nucleon mass at the saturation density. At 90% confidence level, the radius of a 1.4 M⊙ star varies between 11.48 km and 13.20 km, masses as large as 2.2 M⊙ are predicted and the radius of a 2 M⊙star is above 10.5 km. High-density perturbative QCD (pQCD) results exclude equations of state that predict larger maximum masses and radii. The speed of sound increases monotonically with density and reaches values as large as √0.7c–√0.8c in the center of massive stars. Several properties such as the polytropic index or the renormalized trace anomaly, that have been proposed to identify the deconfined phase transition, are analyzed. Interestingly, the radius of the obtained posterior that also meets pQCD constraints aligns closely with the mass-radius measurement of the recent PSR J0437-4715, which contrasts with other relativistic mean field model results.

Author: DALFOVO MARQUEZ, Kau (Instituto Tecnológico de Aeronáutica)

Presenter: DALFOVO MARQUEZ, Kau (Instituto Tecnológico de Aeronáutica)

Session Classification: Oral communications

Contribution ID: **55** Type: **Oral communications**

Modification of jets travelling through a brick-like medium

Thursday 13 March 2025 15:30 (15 minutes)

This work aims to shed light on the puzzle of small systems, which came about after the measurement of a non-zero high-$p_\perp$ v_2 in high multiplicity pA and pp collisions but the persistent absence of jet quenching in those systems. This was done using the JEWEL event generator with a brick-like medium definition mimicking a small collision system. We concentrate on two observables: R_{AA}, which measures the energy loss of jets, and v_2 of high $p_\perp$ hadrons, which quantifies the azimuthal anisotropy of produced particles. We obtain the results for those two observables as a function of number of scatterings (N_{scat}) in the brick-like medium, this way, our conclusions are largely independent of any assumptions about the medium evolution and expansion.

What we have found is that the observables do not depend only on the number of interactions but also on the screening mass (m_D), which controls how much energy and momentum are transferred at each interaction, and on how far in the parton shower evolution the interactions happen. In fact, we saw that R_{AA} and v_2 scale with $m_D^2 \cdot N_{scat}$. The results also strongly indicate that more interactions (and thus more energy/momentum transfer) are required to create a visible v_2 signal than an R_{AA} one. This means that, if we can see v_2, in principle, we should also be able to observe an R_{AA} in those systems. These results are discussed in our recent paper [1].

[1] C. Le Roux, J. G. Milhano and K. Zapp. "Modification of jets travelling through a brick-like medium": arXiv:2412.14983

Authors: LE ROUX, Chiara; ZAPP, Korinna; Dr MILHANO, Guilherme (LIP-Lisbon & CERN TH)

Presenter: LE ROUX, Chiara

Session Classification: Oral communications

Contribution ID: **56** Type: **Oral communications**

Nuclear physics, gravitational waves and dark matter as tools to probe neutron stars

Wednesday 12 March 2025 17:00 (15 minutes)

Although the class of stellar remnants that are neither white dwarves nor black holes is traditionally named neutron stars (NS), these objects are not composed solely of neutrons. Even the more naïve description of such objects must include protons and leptons to guarantee their stability. A neutron star was first detected as a pulsar in 1967, and since 2017, when the first gravitational wave resulting from an NS merger was detected, new constraints on the nuclear equations of state (EOS) used to describe NS have been obtained [1]. Also, the first data from the NICER telescope was available in 2021 with more contributions to clarify the scenario [2] after a very massive NS was confirmed. More recently, other exotic objects have been detected, with low masses an radii, HESS J1731-347 [3] and XTE J1814-338 [4].
With the advent of these detections, two conjectures have been explored: 1) the possibility that neutron stars are hybrid objects with a hadronic outer core and a central quark core, an idea proposed in the 60s by Ivanenko and Kurdgelaidze [5] and 2) the effects of dark matter on NS properties [6]. Different prescriptions to build an EOS that can describe hybrid stars exist [7] and are all based on the fact that a phase transition from a hadronic to a deconfined quark phase is possible [8]. Depending on the models used, it is possible to describe a 2.15 solar mass star and also a 2.03 solar mass star containing a quark core that corresponds to more than 80% of its total mass and radius [9], as suggested by the analysis of sound velocity in different stellar media [10]. Both massive hybrid stars [5] and the tiny objects HESS J1731-347 and XTE J1814-338 [11] can also be described if dark matter is considered.

[1] B.P. Abbott et al., Phys. Rev. Lett. 2017, 119, 161101.
[2] M.C. Miller et al, ApJL 918, L28 (2021); T.E. Ridley et al, ApJL 918, L27 (2021).
[3] V. Doroshenko, V. Suleimanov, G. Puhlhofer and A. Santangelo, Nature Astr. 6, 1444 (2022).
[4] Y. Kini, et al., Monthly Notices of the Royal Astronomical Society 527, 8118–8130 (2023).
[5] D.Ivanenko and D.F. Kurdgelaidze, Astrophysics 1965, 1, 251–252.
[6] C.H. Lenzi, M. Dutra, O. Lourenço, L.L. Lopes and D.P. Menezes, Eur. Phys. J. C (2023) 83:266.
[7] D.P. Menezes, Universe, 2021, 7, 267; A. Issifu, F.M. da Silva and D.P. Menezes
Monthly Notices of the Royal Astronomical Society 525 (2023) 5512-5519.
[8] L.L. Lopes, C. Biesdorf and D.P. Menezes, Monthly Notices of the Royal Astronomical Society 512, 5110 (2022).
[9] L.L. Lopes and D.P Menezes, Astroph. J. 936:41 (2022).
[10] E. Annala et al, Nature Phys. 2020, 16, 907–910.
[11] L.L. Lopes and A. Issifu, arXiv 2411.17105.

Author: MENEZES, Débora

Presenter: MENEZES, Débora

Session Classification: Oral communications

Contribution ID: **57** Type: **Poster**

Production of exotic states in photo-induced processes at LHC and EIC

Tuesday 11 March 2025 18:10 (2 minutes)

In this work we present a calculation of exotic charmonium production in photo-induced processes, in which the exotic state is explicitly treated as a meson molecule. Our formalism is general but we focus on the lightest possible exotic charmonium state: a D^+D^- molecular bound state. Here we study the production of the open charm pair in the process $\gamma\gamma \to D^+D^-$. Then we use a prescription to project the free pair $|D^+D^-\rangle$ onto a bound state at the amplitude level and compute the cross section of the process $\gamma\gamma \to B$ (where B is the bound state). Finally, we convolute this last cross section with the equivalent photon distributions coming from the projectile and target at the LHC and EIC and find the total cross sections.

Authors: Mr CÉSAR, Fernando (University of São Paulo); Prof. NAVARRA, Fernando (University of São Paulo)

Presenter: Mr CÉSAR, Fernando (University of São Paulo)

Session Classification: Poster session

Contribution ID: **58** Type: **Poster**

Heavy-Hadron Photoproduction in NRQCD Factorization Formalism at LHC Energies

Tuesday 11 March 2025 18:00 (2 minutes)

In ultraperipheral collisions, the electromagnetic fields can be approximated by a flux of quasi-real photons, according to the *Equivalent Photon Approximation* (EPA). This approach offers a powerful method for calculating physical observables in photo-induced processes.

Our goal is to predict the inclusive photoproduction of heavy hadronic states, including vector mesons and exotic states such as the fully-charmed tetraquark T_{4c}, in hadronic collisions. For this purpose, we use the EPA in combination with Non-Relativistic Quantum Chromodynamics (NRQCD). In this framework, a photon emitted by a charged particle interacts with a gluon from the target nucleon, leading to the final states of interest. The *NRQCD factorization* formalism is justified due to the large mass of these bound states.

Additionally, this study complemented by experimental data collected from LHC, can provide valuable insights into the gluon content of hadrons involved in these processes.

Author: NASCIMENTO, Rodrigo

Co-authors: MOREIRA, Bruno (Universidade Federal de Pelotas); GONÇALVES, Victor (Universidade Federal de Pelotas)

Presenter: NASCIMENTO, Rodrigo

Session Classification: Poster session

Contribution ID: **59** Type: **Poster**

$\mathcal{PT}$-Symmetric Hamiltonians: Fundamental Concepts and Applications

Monday 10 March 2025 17:42 (2 minutes)

Conventional quantum mechanics relies on Hermitian Hamiltonians, which guarantee real and positive energy spectra while ensuring probability conservation through the Dirac inner product. However, $\mathcal{PT}$-symmetric Hamiltonians, which are invariant under parity $\mathcal{P}$ and time-reversal $\mathcal{T}$ transformations, naturally ensure a real and positive energy spectrum. By adopting a pseudo-Hermitian inner product in the system, it is also possible to guarantee probability conservation for $\mathcal{PT}$-symmetric Hamiltonians. These Hamiltonians are referred to as pseudo-Hermitian, preserving the essence of 'hermiticity' in inner products beyond the conventional Dirac framework. This work aims to provide a simplified introduction to the concept of $\mathcal{PT}$-symmetric Hamiltonians, emphasizing their properties, mathematical structure, and potential applications.

Authors: Dr MINTZ, Bruno (UERJ); COLOMBO, Cristian (Universidade Estadual do Rio de Janeiro (UERJ))

Presenter: COLOMBO, Cristian (Universidade Estadual do Rio de Janeiro (UERJ))

Session Classification: Poster session

Contribution ID: **60** Type: **Oral communications**

Odderon Physics at High Energies

Wednesday 12 March 2025 17:15 (15 minutes)

In its simplest configuration from the QCD viewpoint, the Odderon is a color singlet made up of three gluons. More specifically, in perturbative QCD, the Odderon can be associated with a colorless C-odd t-channel state, with an intercept at or near one, that either does not vanish or decreases very slowly with increasing energy. We examine the constraints on the Odderon's properties and its description in perturbative QCD. Additionally, we discuss experimental evidence for Odderon's contribution to high-energy proton-proton elastic scattering and its potential manifestations in other processes.

Author: LUNA, Emerson

Presenter: LUNA, Emerson

Session Classification: Oral communications

Contribution ID: **62** Type: **Poster**

Exploring High-Energy QCD Through Diffractive Vector Meson Production in Ion Collisions

Tuesday 11 March 2025 18:08 (2 minutes)

Exclusive diffractive processes offer a unique window into Quantum Chromodynamics (QCD) in the high-energy regime. The foundation for these studies, established by Lipatov and collaborators, introduced the QCD Pomeron and the Balitsky-Fadin-Kuraev-Lipatov (BFKL) equation, which governs gluon ladder exchanges. Recent investigations have highlighted the impact of BFKL evolution on observables in photon-induced interactions at the LHC.

This work focuses on applying the BFKL formalism to study diffractive vector meson production at large momentum transfer (t) in pp,Pbp and $PbPb$ collisions. The rapidity distributions of vector meson cross-sections are evaluated within the forward rapidity range, $3.2 < y < 5.8$, which will be probed by the FoCal detector at the ALICE experiment during its operation in 2027-2029.

By bridging theoretical predictions with experimental measurements, this study aims to deepen our understanding of QCD in the high-energy limit, elucidating the role of diffractive processes and rapidity gaps in hadronic and nuclear collisions.

Author: Mr DA SILVA, João Vitor Bulhões (Federal University of Pelotas)

Co-authors: Prof. BARROS GONÇALVES, Victor Paulo (Federal University of Pelotas); Prof. KRAMBECK SAUTER, Werner (Federal University of Pelotas)

Presenter: Mr DA SILVA, João Vitor Bulhões (Federal University of Pelotas)

Session Classification: Poster session

Contribution ID: **64** Type: **Poster**

Exclusive ρ and J/Ψ photoproduction in ultraperipheral pO and OO collisions

Tuesday 11 March 2025 18:06 (2 minutes)

In the forthcoming years, proton-oxygen (pO) and oxygen-oxygen (OO) collisions will be conducted at the LHC. The high luminosities of Run 3 will provide valuable insights into processes involving the collision of light and heavy ions. Such collisions present an opportunity to study the nuclear dependence and the transition regime of various phenomena, which are expected to exhibit distinct behaviors in lead-lead collisions compared to proton-proton collisions. In this work, we calculate the rapidity, transverse momentum distributions, and total cross sections associated with the exclusive ρ and J/Ψ photoproduction in ultraperipheral pO and OO collisions at $\sqrt{s} = 9$ TeV and $\sqrt{s} = 5.52$ TeV, respectively. The calculations are performed using the dipole formalism with the bCGC and IP-SAT models for the dipole scattering amplitude, as well as the BG and GLC models for the overlap function, and predictions are presented for the kinematic ranges covered by the ALICE and LHCb experiments. Our results indicate that a future experimental analysis of the exclusive vector meson photoproduction in pO and OO collisions will be useful to constrain the description and improve our understanding of QCD dynamics at high energies.

Authors: SANTANA, Luana (Universidade Federal de Pelotas); GONÇALVES, Victor (Universidade Federal de Pelotas); Prof. MOREIRA, Bruno (Universidade do Estado de Santa Catarina)

Presenter: SANTANA, Luana (Universidade Federal de Pelotas)

Session Classification: Poster session

Contribution ID: **65** Type: **Poster**

Multistrange meson-baryon interactions

Wednesday 12 March 2025 18:16 (2 minutes)

Our aim is to study dynamically generated resonances on the multistrangess sector, using chiral unitary approach and hidden local symmetry. This work is an extension of ref [1] and the idea is to add s- and u-diagrams in the future for the pseudoscalar-baryon interactions, which is missing in ref [1]. Our work includes systems made of pseudoscalar and vector mesons, reproducing the calculation for the t-channel exchange to study the $\Xi(1690)$, $\Xi(2120)$ and also $\Xi(1620)$, using a coupled channel approach and we aim to compare our results with experimental data. We would like to present such results we have so far in this conference.
References:
[1]. K. P. Khemchandani et al. Phys. Rev. 2018, D 97 034005.

Authors: MARTINEZ TORRES, Alberto (University of Sao Paulo); Prof. KHEMCHANDANI, KANCHAN PRADEEPKUMAR; VELOSO BARRETO BEZERRA , Taísa (Universidade Federal de São Paulo)

Presenter: VELOSO BARRETO BEZERRA , Taísa (Universidade Federal de São Paulo)

Session Classification: Poster session

Contribution ID: **66** Type: **Poster**

Valence and sea parton correlations in double parton scattering from data

Monday 10 March 2025 18:14 (2 minutes)

The effective cross section of double parton scattering in proton collisions has been measured by many experiments with rather different results. Motivated by this fact, we assumed that the parton correlations in the transverse plane are different whether we have valence or sea partons. With this simple approach, we were able to fit the available data and found that sea parton pairs are more correlated in the transverse plane than valence–sea parton pairs.

Authors: HUAYRA, Edgar; OLIVEIRA, Emmanuel Gräve de (UFSC, Brazil); VITOR, Joao (Universidade Federal de Santa Catarina)

Presenter: VITOR, Joao (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **67** Type: **Poster**

Photoproduction of light vector mesons in the dipole picture

Tuesday 11 March 2025 18:04 (2 minutes)

We study the photoproduction of light vector mesons considering both the proton and the nucleus as targets. Utilizing the dipole picture and wave functions obtained via AdS/QCD, we were able to describe the HERA γp data and extend the analysis to the nuclear case by employing the Glauber–Gribov formalism. This formalism is supplemented by an effective nuclear suppression factor, R_G, which accounts for the gluon shadowing correction. Our results are compared to recent $PbPb \to \rho PbPb$ data from the LHC, and predictions for other light vector mesons are presented.

Author: TREBIEN, Haimon (Universidade Federal de Santa Catarina)

Co-author: OLIVEIRA, Emmanuel Gräve de (UFSC, Brazil)

Presenter: TREBIEN, Haimon (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **68** Type: **Poster**

Photoproduction of Vector Mesons at the LHC via Peripheral Heavy-Ion Collisions

Tuesday 11 March 2025 18:02 (2 minutes)

In this work, the excess of J/ψ production in peripheral collisions, which was experimentally observed at the LHC (ALICE) and RHIC (STAR) at low transverse momentum (p_T), is investigated. We use the color dipole formalism to calculate the photoproduction cross section, employing the phenomenological dipole models bCGC and IP-SAT, which take into account saturation effects, and the IP-NONSAT model, which does not account for saturation effects. In our calculations, we use the Gaus-LC and Boosted Gaussian models for the vector meson wave functions. The nucleus-nucleus cross section is described by the equivalent photon approximation using photon fluxes dependent on the impact parameter. Effective models for the photonuclear cross section and for the photon fluxes are used to consider the peripheral collisions. We present our results for the vector meson production in peripheral nuclear collisions in different centrality classes (50\%-70\% and 70\%-90\%).

Author: AZEVEDO DA COSTA, Pedro Eduardo

Co-authors: Dr VEIGA GIANNINI, Andre; Dr MOREIRA, Bruno (Universidade do Estado de Santa Catarina)

Presenter: AZEVEDO DA COSTA, Pedro Eduardo

Session Classification: Poster session

Contribution ID: **69** Type: **Seminar (invitees)**

Exploring high-multiplicity events in high-energy proton-proton collisions

Wednesday 12 March 2025 10:00 (30 minutes)

This work explores meson and isolated photon production in high-multiplicity proton-proton (pp) collisions at fixed energy and forward rapidities using the Color Glass Condensate (CGC) framework with running coupling Balitsky-Kovchegov (BK) solutions for the unintegrated gluon distribution. Self-normalized yields of these particles are studied as a function of charged hadron multiplicity and compared to experimental data when possible. We point that the simultaneous analysis of isolated photons and hadronic final states in high-multiplicity events may provide a test the CGC formalism and highlights the potential to disentangle initial- and final-state effects in high-energy hadronic collisions.

Based on: Y. N. Lima, A. V. Giannini and V. P. Goncalves, Phys. Rev. C 106, no.6, 065206 (2022), Eur. Phys. J. A 60, no.3, 54 (2024), Phys. Rev. D 109 (2024) 9, 094035.

Author: Dr VEIGA GIANNINI, Andre

Co-authors: GONCALVES, Victor; LIMA, Yuri (Universidade de São Paulo)

Presenter: Dr VEIGA GIANNINI, Andre

Session Classification: Morning

Contribution ID: **70** Type: **Poster**

Particle production by γ - γ interactions in future electron-ion colliders

Tuesday 11 March 2025 17:58 (2 minutes)

The particle production in photon-photon (γγ) interactions present in electron-ion collisions is investigated. We present calculations for the total cross sections and event rates related to the production of light mesons [η, η′, f0 and f2], charmonium [η_c and χ_c] and charmoniumlike [X(3915), X(3940), X(4140) and X(6900)] states, considering the EIC, EicC, LHeC and FCC-eh energies. Our predictions demonstrate that experimental studies of these processes are feasible and useful to constrain the properties of light mesons and quarkonium states and shed some light on the configuration of the considered charmoniumlike states.

Authors: Ms SOUZA, Juciene Teixeira (Institute of Physics and Mathematics, Federal University of Pelotas (UFPel)); Dr GONÇALVES, VICTOR PAULO (Institute of Physics and Mathematics, Federal University of Pelotas (UFPel),)

Co-authors: Mr FRANCENER, REINALDO (Instituto de Física Gleb Wataghin - Universidade Estadual de Campinas (UNICAMP); Dr BERTULANI, Carlos A. (1Department of Physics and Astronomy, Texas A&M University-Commerce, Commerce, TX 75429, USA.)

Presenter: Ms SOUZA, Juciene Teixeira (Institute of Physics and Mathematics, Federal University of Pelotas (UFPel))

Session Classification: Poster session

Contribution ID: **71** Type: **Poster**

The proton structure and particle production

Tuesday 11 March 2025 17:56 (2 minutes)

In the last years the matter distribution inside the proton has become an important topic discussed by the international community. After the measurement of the proton mass and scalar radius, which revealed the extent of its gluon distribution, one important question remains: what is the shape of matter distribution inside it? One possible answer, which will be explored in this work, is the baryon junction configuration. In this picture, the quarks are joined by an "'Y" shaped gluon string. In this work we make an Ansatz for this anisotropic structure, which can be separated into gluon and quark distributions, and use it as an initial condition for Monte Carlo event generators. After setting the initial conditions, we investigate the effects and consequences of the baryon junction on particle production.

Author: Mr TERRA, Richard (Instituto de Física da USP)

Presenter: Mr TERRA, Richard (Instituto de Física da USP)

Session Classification: Poster session

Contribution ID: **73** Type: **Poster**

Forward electroweak gauge boson production in the color dipole S-matrix framework

Monday 10 March 2025 17:40 (2 minutes)

The particle production at forward rapidities in hadronic collisions is one of the most promising processes to probe the QCD dynamics at small - x as well as to observe the breakdown of the collinear and kT factorization theorems, predicted to occur to high partonic densities. In this process, one has the interaction between projectile partons with large cone momentum fractions and target partons carrying a very small momentum fraction. Thus, the projectile parton scatter off a dense gluonic system in the target. In this contribution, we investigate the case where one of the particles in the final state is an electroweak gauge boson ($G = W^{\pm}, Z^0, \gamma$) and present the differential cross-section for the isolated gauge boson production in pp collisions at forward rapidities as a function of the dipole - proton cross-section or the unintegrated gluon distribution as presented in our paper (BANDEIRA; GONCALVES; SCHÄFER, 2024). Moreover, we also present the associated electroweak gauge boson production. These new formalism can be used to estimate the impact of the saturation effects in the gauge boson production at the LHC and future colliders. Moreover, we demonstrate that our general parton-level cross-section reduces to expressions previously used in the literature for the description of the real photon production and Drell - Yan process at forward rapidities in some particular limits.

BANDEIRA, Y. B.; GONCALVES, V. P.; SCHÄFER, W. Production of electroweak gauge bosons at forward rapidities in the color-dipole S-matrix framework. JHEP, v. 07, p. 171, 2024.

Author: BANDEIRA, Yan (Federal University of Pelotas)

Co-authors: GONÇALVES, Victor (Universidade Federal de Pelotas); SCHÄFER, Wolfgang (Institute of Nuclear Physics PAN)

Presenter: BANDEIRA, Yan (Federal University of Pelotas)

Session Classification: Poster session

Contribution ID: **74** Type: **Oral communications**

Double Parton Scattering in Ultraperipheral Collisions

Thursday 13 March 2025 17:00 (15 minutes)

Double parton scattering (DPS) is an important tool for investigating the parton distributions in protons and nuclei. In this work, we explore DPS in ultraperipheral collisions (UPC) between nuclei (AA) and between a nucleus and a proton (Ap), with photons and gluons in the initial state. We show how the effective cross section depends on the photon momentum fraction. We also make predictions for the associated production of heavy quark–antiquark pairs and dileptons.

Authors: STAHLHÖFER, Bruna (UFSC); HUAYRA, Edgar; OLIVEIRA, Emmanuel Gräve de (UFSC, Brazil)

Presenter: OLIVEIRA, Emmanuel Gräve de (UFSC, Brazil)

Session Classification: Oral communications

Contribution ID: **75** Type: **Oral communications**

Predictions for dimuon production in high-energy neutrino–proton collisions using the color dipole model

Tuesday 11 March 2025 16:45 (15 minutes)

Interactions of high-energy neutrinos with matter can be studied through the angular separation observed in dimuon production, an observable particularly sensitive to the transverse momentum dynamics of partons. In this work, we develop a Monte Carlo event generator based on the color dipole model, interfaced with Pythia8 for parton showering and hadronization simulations, to predict dimuon production cross sections in neutrino–proton collisions at energies relevant to IceCube and future detectors. The color dipole formalism generates larger transverse momentum compared to standard Pythia predictions, enhancing the yield of angularly separated high-energy muons.

Authors: TERNES COIMBRA, Caetano (UFSC); Dr FAGUNDES, Daniel Almeida (UFSC-Blumenau); HUAYRA, Edgar; DE OLIVEIRA, Emmanuel

Presenter: HUAYRA, Edgar

Session Classification: Oral communications

Contribution ID: **76** Type: **Seminar (invitees)**

Particle Production in Photon-Induced Processes

Wednesday 12 March 2025 15:30 (30 minutes)

In this work, we investigate particle production in ultraperipheral collisions at the LHC. In these collisions, hadrons act as sources of quasi-real photons, enabling the study of photon-hadron and photon-photon interactions. We focus on the photoproduction of vector mesons, the production of dileptons and their bound states, as well as the production of exotic states. Photon-induced processes provide a clean experimental environment to test QCD dynamics in vector meson production and to search for new particles in photon-photon interactions. We present a brief review of the formalism and report our predictions for the cross sections of these processes.

Author: Dr MOREIRA, Bruno (Universidade do Estado de Santa Catarina)

Presenter: Dr MOREIRA, Bruno (Universidade do Estado de Santa Catarina)

Session Classification: Afternoon

Contribution ID: **77** Type: **Poster**

Impact parameter description of the nucleus and the incoherent photoproduction of vector mesons in the color dipole approach

Tuesday 11 March 2025 18:24 (2 minutes)

We study the exclusive photoproduction of heavy vector mesons off nuclear targets using the color dipole model within the Glauber-Gribov formalism. We obtained the impact-parameter-dependent cross sections for both coherent and incoherent cases, with spatial correlations among nucleons to account for fluctuations in their positions. This approach aims to provide a more accurate description of the experimental data. Our results are compared to PbPb photoproduction measurements from ALICE, showing good agreement for the coherent case while highlighting the need for additional nuclear effects in the incoherent case.

Authors: OLIVEIRA, Emmanuel Gräve de (UFSC, Brazil); MELCHIORS TREBIEN, Haimon Otto (Universidade Federal de Santa Catarina); PERIN, Luiza (Universidade Federal de Santa Catarina)

Presenter: PERIN, Luiza (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **78** Type: **Seminar (invitees)**

The Infrared Regime of the Quark-Gluon Vertex in General Kinematics

Wednesday 12 March 2025 11:00 (30 minutes)

One of the key ingredients for describing chiral symmetry breaking and quark mass generation is the quark-gluon vertex. In this work, we determine the transversely-projected quark-gluon vertex in unquenched QCD with two degenerate light dynamical quarks in the Landau gauge. This is accomplished by solving the Schwinger-Dyson equation within the 3PI effective action formalism, employing lattice data for the gluon and quark propagators, and the three-gluon vertex. Our results demonstrate that the classical form factor exhibits pronounced angular dependence and aligns remarkably well with recent lattice data in the soft-gluon limit. The remaining form factors are obtained via a single integration, revealing a clear hierarchy consistent with previous studies.

Author: Prof. AGUILAR, Arlene Cristina (University of Campinas - Unicamp)

Presenter: Prof. AGUILAR, Arlene Cristina (University of Campinas - Unicamp)

Session Classification: Morning

Contribution ID: **79** Type: **Poster**

APPLICATION OF VARIATIONAL AUTOENCODERS TO GENERATE D0 MESON KINEMATICS AT THE LHC

Tuesday 11 March 2025 18:28 (2 minutes)

We develop a neural network based on variational autoencoders to generate D0 meson kinematics, i.e., transverse momentum, pseudorapidity, and azimuthal angle. The input dataset is a Monte Carlo (MC) simulation of the D0 meson production and the CMS detector at the LHC in PbPb collisions at 5.02 TeV. For training the method, a n-tuple with the kinematics of the D0 meson daughters (in the decay channel into charged pions and kaons) is used. The variational autoencoder method is based on dimensionality reduction of an input vector to the dimension of a latent vector that possesses the same probability distribution of the input one, then, the information is reconstructed and a new distinct vector with the same probability is created. The neural network architecture is composed of convolutional layers that are adjusted by hyperparameters, which must have values that optimize the network efficiency to perform the assigned task. The neural network efficiency is verified by a loss function that is calculated from a Kullback-Leibler divergence. The main goal of this work is to prove that this method can generate D0 meson kinematics compatible with the ones from the MC simulation. In this case, in the future, we can train the method based on real data events at the LHC.

Authors: FLORES GODOI FERREIRA, Allan Eduardo (Universidade Federal do Rio Grande do Sul); BERNARDES, Cesar (UNESP - Universidade Estadual Paulista (BR))

Co-authors: ORZARI, Breno (UNESP - Universidade Estadual Paulista (BR)); DE SOUZA, Davi Leon (Universidade Federal do Rio Grande do Sul); TOMEI FERNANDEZ, Thiago (UNESP - Universidade Estadual Paulista (BR))

Presenter: FLORES GODOI FERREIRA, Allan Eduardo (Universidade Federal do Rio Grande do Sul)

Session Classification: Poster session

Contribution ID: **80** Type: **Poster**

Investigating the Top Quark Production by Black Hole Evaporation in pp collisions at the LHC and FCC

Tuesday 11 March 2025 17:54 (2 minutes)

The Standard Model describes the electromagnetic, strong, and weak interactions, but the treatment of gravitational interactions at the quantum level remains an open question. Such an aspect has motivated the proposition of various models for physics beyond the Standard Model, based on the existence of extra spatial dimensions. In these models, the production of black holes in hadronic colliders becomes possible. In this contribution we assume the model proposed by Arkani-Hamed, Dimopoulos, and Dvali (ADD model), which introduces the concept of large compactified extra dimensions, and investigate the formation and subsequent evaporation of black holes in proton-proton collisions at the Large Hadron Collider (LHC) and the Future Circular Collider (FCC). Our analysis will focus on the production of a top quark pair. In particular, we estimate the production of top quarks from black hole evaporation using the Monte Carlo generator BLACKMAX and compare the associated predictions with those obtained with the PYTHIA generator for the top quark production via strong interaction. Results are presented for the rapidity and transverse momentum differential distributions considering the LHC and FCC energies assuming distinct values for the number of extra dimensions and for the mass of the black hole.

Author: Mrs R. A. MIRANDA, Brenda (Institute of Physics and Mathematics, Federal University of Pelotas (UFPel))

Co-authors: Dr E. MARTINS NETO, Daniel (The Henryk Niewodniczanski Institute of Nuclear Physics (IFJ)); Prof. P. GONÇALVES, Victor (Institute of Physics and Mathematics, Federal University of Pelotas (UFPel))

Presenter: Mrs R. A. MIRANDA, Brenda (Institute of Physics and Mathematics, Federal University of Pelotas (UFPel))

Session Classification: Poster session

Contribution ID: **81** Type: **Poster**

Study of the azimuthal asymmetry in heavy ion collisions combining initial state momentum orientation and final state collective effects

Tuesday 11 March 2025 17:52 (2 minutes)

In the present work we investigate the source of azimuthal asymmetry for nuclear collision using a model that contemplates particles produced in the initial hard collisions and the collective effects described by a Blast-Wave like expansion. The latter is described by the relaxation time approximation of the Boltzmann transport equation. The parameters regarding collective flow and asymmetry are fitted by the experimental data from p_T spectrum and v_2 for PbPb and XeXe collisions at different centrality classes. As a by-product the ratio of final elliptic flow with the initial anisotropy, v_2/ϵ_2, and the average transverse momentum are predicted.

Author: ROCHA, Érison (UFRGS)

Co-authors: MORIGGI, Lucas (Universidade Federal do Rio Grande do Sul); Dr MACHADO, Magno (IF-UFRGS)

Presenter: ROCHA, Érison (UFRGS)

Session Classification: Poster session

Contribution ID: **83** Type: **Oral communications**

Locating the QCD critical point via contours of constant entropy density

Wednesday 12 March 2025 16:45 (15 minutes)

We present a new method to investigate the existence and location of the conjectured high-temperature critical point of strongly interacting matter via contours of constant entropy density [1]. By approximating these lines as a power series in the baryon chemical potential μ_B, one can extrapolate them from first-principle results at zero net-baryon density, and use them to locate the QCD critical point, including the associated first-order and spinodal lines. As a proof of principle, we employ currently available continuum-extrapolated first-principles results from the Wuppertal-Budapest collaboration to find a critical point at a temperature and a baryon chemical potential of $T_c = 114.3 \pm 6.9$ MeV and $\mu_{B,c} = 602.1 \pm 62.1$ MeV, respectively, at expansion order $\mathcal{O}(\mu_B^2)$. We advocate for a more precise determination of the required expansion coefficients via lattice QCD simulations as a means of pinpointing the location of the critical endpoint in the phase diagram of strongly interacting matter.

[1] H. Shah, M. Hippert, J. Noronha, C. Ratti and V. Vovchenko,
"Locating the QCD critical point from first principles through contours of constant entropy density", arXiv:2410.16206 [hep-ph]

Authors: SHAH, Hitansh; HIPPERT, Mauricio (Universidade do Estado do Rio de Janeiro); Prof. LEITE NORONHA, Jorge Jose (University of Illinois at Urbana-Champaign); RATTI, Claudia; Dr VOVCHENKO, Volodymyr (University of Houston); HIPPERT TEIXEIRA, Mauricio (CBPF - Centro Brasileiro de Pesquisas Físicas)

Presenter: HIPPERT, Mauricio (Universidade do Estado do Rio de Janeiro)

Session Classification: Oral communications

Contribution ID: **84** Type: **Poster**

Neural Network-Based Approach for Inferring the Neutron Star Equation of State

Wednesday 12 March 2025 17:50 (2 minutes)

In this work, we implement a neural network model introduced by Y. Fujimoto, K. Fukushima, and K. Murase (Phys. Rev. D 98, 023019 (2018)) to infer the neutron star equation of state (EoS) from mass and radius measurements. The Tolman-Oppenheimer-Volkoff equation allows for the derivation of a mass-radius (MR) relationship from a given EoS by solving a system of ordinary differential equations. The inverse problem—determining the EoS from MR data—is considerably more challenging, particularly when accounting for measurement uncertainties. Machine learning, especially neural networks, has proven to be a powerful tool for tackling this problem without imposing strong prior constraints. Here, we reproduce this neural network model and assess its performance using both hadronic and hybrid equations of state from the CompOSE database.

Author: GONÇALVES DA SILVA , André (UFSM)

Co-authors: Mr EFRAIM BRESSAN PASQUALOTTO, Arthur (UFSM); LUCIANO SONEGO FARIAS, RICARDO

Presenter: GONÇALVES DA SILVA , André (UFSM)

Session Classification: Poster session

Contribution ID: **85** Type: **Oral communications**

Minkowski space description of the nucleon and pion

Thursday 13 March 2025 15:00 (15 minutes)

I will review the application of few-body methods to explore the structure of light hadrons in Minkowski space. The description of the nucleon and pion are based on the solution of the Bethe-Salpeter equation in Minkowski space built with phenomenological kernels. For the proton, we will show results obtained with the projection onto the light-front of the Faddeev-Bethe-Salpeter equation, including the valence parton distribution and the image of the valence state on the nullplane. The results for the pion structure observables are computed from the solution of the Bethe-Salpeter equation in Minkowski space using the Nakanishi integral representation. Results for the pion charge form factor, including higher Fock-components will be shown, and compared to the valence one. We found that the charge radius of the higher Fock components is about a half femtometer. The image of the pion valence state onto the null-plane will be presented, as well as resultsvfor the PDF and transverse momentum distributions. Some future prospects of research along these lines will be provided.

Author: Prof. FREDERICO, Tobias (Instituto Tecnologico de Aeronautica)

Presenter: Prof. FREDERICO, Tobias (Instituto Tecnologico de Aeronautica)

Session Classification: Oral communications

Contribution ID: **86** Type: **Poster**

Properties of the hidden strangeness $P_s(2080)$

Monday 10 March 2025 18:08 (2 minutes)

We present a detailed study of the partial decay widths of a spin-parity resonance $J^P = 3/2^-$ N^* with a mass of $\simeq$ 2070 MeV obtained from the coupled channel s wave vector-baryon ρN, ωN, ϕN, $K^*\Lambda$ and $K^*\Sigma$ dynamics. This state, which couples strongly to the $K^*\Sigma$ channel, corresponds to a nucleon with a hidden strange quark content, in analogy to the P_c states discovered by the LHCb collaboration, and we denote it as $P_s(2080)$. A state with such a nature can decay to vector-baryon, pseudoscalar-baryon, and pseudoscalar-baryon resonance channels, involving triangular loops in the latter two cases. As we will show, the partial decay widths to pseudoscalar-baryon resonance channels, like $\pi N^*(1535)$, $\pi N^*(1650)$, $K\Lambda(1405)$, are comparable to those related to ground state baryons in the final state, like πN, ηN, $K\Lambda$. In this way, reactions involving such lighter baryon resonances in the final state can be used as an alternative source of information on the properties of a N^* with hidden strangeness.

Authors: Prof. MARTÍNEZ TORRES, Alberto (Universidade de São Paulo); Mr VERTEL NIETO, Alonso (Universidade de São Paulo); AGATAO GARCIA, Breno (Universidade de São Paulo); Prof. PRADEEPKUMAR KHEMCHANDANI, Kanchan (Universidade Federal de São Paulo); Prof. NAM, Seung-il (Pukyong National University)

Presenter: AGATAO GARCIA, Breno (Universidade de São Paulo)

Session Classification: Poster session

Contribution ID: **87** Type: **Poster**

Decay widths of a $J^P = \frac{3}{2}^- \; N^*$ resonance obtained from pseudoscalar-baryon and vector-baryon dynamics.

Tuesday 11 March 2025 17:50 (2 minutes)

Exotic hadrons are particles that do not fit the traditional classification of hadrons, and their existence is compatible with our present understanding of Quantum Chromodynamics (QCD), the theory that describes how particles interact through the strong interaction, one of the four fundamental forces of Nature. In QCD, quarks and gluons interact via the strong force; quarks are the fundamental constituents of hadrons, while gluons are the force-carrying particles. The traditionally allowed combinations for hadrons are baryons, or three quark systems (e.g., protons and neutrons) and mesons, or quark-antiquark systems (e.g., pions and kaons). On the other hand, exotic hadrons arise from other combinations of quarks that do not fit the traditional structure of baryons and mesons, such as tetraquarks, formed by two quarks and two antiquarks, pentaquarks, composed of four quarks and one antiquark, or "molecules" of two or more hadrons.

Recently, the generation of certain resonances, such as $N^*(2080)$, has been observed through vector-baryon dynamics. This resonance has isospin $I = \frac{1}{2}$ and spin-parity $J^P = \frac{3}{2}^-$. Its decay width is approximately $\frac{\Gamma_{N^*}}{2} = 70$ (MeV) and its mass is $M_{N^*} = 2071$ (MeV). The interest in studying this N^* resonance lies in its hidden strangeness content and the possibility that it may be partner of one of the P_c states discovered by the LHCb collaboration. Although the spin-parity assignments of $P_c^+(4312)$, $P_c^+(4400)$, $P_c^+(4457)$ are still unknown, numerous studies suggest that they could be interpreted as molecular states. Therefore, we aim to investigate the possible states into which $N^*(2080)$, also denoted as, $P_s(2080)$ in analogy to the P_c states, may decay. To do this, we consider certain conservation laws, effective Lagrangians with specific symmetries and computational methods in order to be able to calculate physical observables, such as decay widths and cross-sections, among others, to obtain a better understanding of the properties of the P_s state.

Authors: Dr MARTÍNEZ TORRES, Alberto (IFUSP); DE JESUS VERTEL NIETO, Alonso (IFUSP); AGATÃO, Breno (IFUSP); Dr NAM, Seung-il (PKNU); Dr KHEMCHANDANI, kanchan (UNIFESP)

Presenter: DE JESUS VERTEL NIETO, Alonso (IFUSP)

Session Classification: Poster session

Contribution ID: **88** Type: **Poster**

Interpreting the neutrino signal from core-collapse supernovae using neural networks

Wednesday 12 March 2025 17:46 (2 minutes)

When massive stars (⊠ 10M⊠) reach the end of their life cycle, the instability of their iron core leads to the collapse of the star. This collapse is halted upon reaching extreme densities, as the strong nuclear force prevents further contraction, resulting in the formation of a proto-neutron star (PNS). The collision of the star's outer layers with the PNS generates a shock wave that expels the stellar envelope in an explosion known as a supernova. Core-collapse supernovae have been the subject of theoretical studies for over half a century and observational investigations for even longer. Moreover, decades of simulations suggest that these explosions occur only if the neutrinos emitted by the PNS deposit sufficient energy into the shock wave. Thus, neutrinos play a central role in all phases of the collapse and explosion, being, alongside gravitational waves, the only way to directly access information about the core of stars at the end of their lives. In this work, our aim is to understand how the detection of neutrinos from a supernova can help to interpret the mechanisms that occur within a PNS. To achieve this, we employ artificial neural networks to predict physical properties based on computational simulations of PNSs.
Keywords: supernovae, neutrinos, neural networks.

Author: ESPINDOLA, Isadora (Universidade Federal de Santa Catarina)

Co-author: Dr DA SILVA SCHNEIDER, André (Universidade Federal de Santa Catarina)

Presenter: ESPINDOLA, Isadora (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **89** Type: **Poster**

Transfer learning for efficient emulator training in relativistic heavy-ion collisions

Tuesday 11 March 2025 17:48 (2 minutes)

Bayesian inference is a key tool in relativistic heavy-ion collision studies, enabling probabilistic constraints on model parameters through computational simulations and model-to-data comparison. The information obtained through these simulations, however, is limited to discrete parameter-space points (typically a few hundred to a few thousand design points).

To overcome this bottleneck, the field relies on emulators: surrogate models trained on simulation data. Current approaches use Gaussian Processes (GP) to interpolate simulations, but generating sufficient training data remains expensive. We propose a transfer learning strategy that reduces computational costs by reusing knowledge from simplified simulations.

In relativistic heavy-ion models, approximately 80% of CPU time is spent simulating hadronic transport, where resonance decays (fast to compute) dominate over collisions (slow to compute). By training emulators on a hybrid dataset—combining sparse full simulations (with collisions and decays) and abundant cheap simulations (decays only)—we achieve comparable precision to traditional methods while significantly reducing CPU time. This approach enables more efficient Bayesian analyses without sacrificing accuracy, broadening the scope of feasible studies in heavy-ion phenomenology.

Author: ALVES DE LIMA GUIMARÃES, Gabriel (Universidade de São Paulo)

Co-author: Prof. WILLIAM LUZUM, Matthew (University of São Paulo)

Presenter: ALVES DE LIMA GUIMARÃES, Gabriel (Universidade de São Paulo)

Session Classification: Poster session

Contribution ID: **90** Type: **Poster**

Higher-order QCD corrections to the Higgs decay into hadrons

Tuesday 11 March 2025 17:46 (2 minutes)

In this work we study the higher-order QCD corrections of the Higgs decay into bottom quarks and into a pair of gluons. Our method consists of employing Padé and D-log Padé approximants considering the perturbative coefficients dependence on the number of flavors. We estimate, in a model-independent way, the yet unknown coefficient of order α_s^7 of $\Gamma(H \to gg)$ in the scale-invariant scheme as -312 ± 36 and in the on-shell scheme as -302 ± 35. Moreover, our prediction of the first unknown coefficient of $\Gamma(H \to b\bar{b})$, of $\mathcal{O}(\alpha_s^5)$, is -27 ± 2. Both perturbative series, with the inclusion of these corrections, are almost insensitive to variations on the renormalization scale. The main source of uncertainty for the Higgs decay rate into hadrons remains to be the Standard Model parameters, the strong coupling, the quark masses and the Higgs mass.

Authors: BOITO, Diogo; LONDON, Cristiane Yumi; A. NOGUEIRA, Guilherme (UNICAMP)

Presenter: LONDON, Cristiane Yumi

Session Classification: Poster session

Contribution ID: **91** Type: **Poster**

The Glauber-Gribov theory for dihadron productions in nuclear collisions

Tuesday 11 March 2025 17:44 (2 minutes)

The proposed work aims to investigate dihadron production in ultrarelativistic heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC), focusing on understanding gluon saturation dynamics. To this end, we use Glauber–Gribov theory, which describes nuclear collisions by considering multiple diffraction and coherent effects, enabling us to analyze azimuthal angle correlations and peak suppression in experimental data. We will also compare our results with well-established models in the literature, such as the Quark–Gluon Plasma (QGP) and Color Glass Condensate (CGC). By doing so, we aim to improve our understanding of nuclear shadowing phenomena, as well as the modification of partonic structures in proton–nucleus and nucleus–nucleus collisions.

Author: FERREIRA, Luis

Co-author: DE OLIVEIRA, Emmanuel

Presenter: FERREIRA, Luis

Session Classification: Poster session

Contribution ID: **94** Type: **Poster**

Machine Learning Applied to Quark Stars and Neutron Stars: From Observations to EoS

Wednesday 12 March 2025 17:44 (2 minutes)

In this work, we generate a wide range of equations of state (EoS) for both quark matter and nucleonic matter. For nucleonic matter, we use the metamodeling approach due to its simplicity. The EoS generated using metamodeling must satisfy certain physical constraints: it must be causal, its symmetric properties must fall within experimental values, and it must support approximately 2 solar masses.

The EoS for quark matter is given by the MIT bag model, which here is considered a toy model. The only constraint is the bag value, as it must lie within the stability range for strange matter. The constraint of supporting \(\sim 2\) solar masses was not imposed on strange matter.

By solving the TOV equations for the generated EoSs, we obtained a dataset containing mass (\(M\)), radius (\(R\)), energy density, pressure, and model parameters. This dataset is used to train the model \cite{Krastev2024, Wu2024} and properly solve the inverse problem—i.e., given \(M\) and \(R\), determining the corresponding energy density, pressure, and model parameters. This approach is essential for obtaining information about the microscopic features from the observed M-R relations, such as those for PSR J0030+0451 and PSR J0740+6620.

To validate our trained model, we used the \(M\)-\(R\) relation for the MIT bag model extracted from the literature and verified that the bag value is in good agreement with the value reported in the paper. For nucleonic matter, before training the model, we removed two \(M\)-\(R\) relations —each corresponding to one EoS—from the dataset. These were later used to verify whether key model parameters.

Krastev2024: P.˜G.˜Krastev, A Deep Learning Approach to Extracting Nuclear Matter Properties from Neutron Star Observations," \textit{Symmetry}.
Wu2024: Z.˜Wu and D.˜Wen,From masses and radii of neutron stars to EOS of nuclear matter through neural network," Chin. Phys. C \textbf{48}, no.2, 024101 (2024) [arXiv:2312.15629 [nucl-th]].

Author: Dr KÖPP, Fábio (UFSC)

Co-author: Dr SCHNEIDER, André (UFSC)

Presenter: Dr KÖPP, Fábio (UFSC)

Session Classification: Poster session

Contribution ID: **95** Type: **Poster**

Thermal evolution of quark stars from perturbative QCD

Wednesday 12 March 2025 17:48 (2 minutes)

Since Witten's proposal that symmetric deconfined u, d, and s quark matter might be the true absolute ground state, properties of quark stars have been extensively studied. By choosing an equation of state to describe the matter inside these stars, it is possible to solve the Tolman-Oppenheimer-Volkoff equations to obtain the mass and radius of the star. However, it has become clear that measuring solely the mass and radius will not be sufficient to distinguish between neutron stars, hybrid stars and quark stars. Therefore, it is necessary to take into account other observables that are closely related to microscopic physics.

One possibility is the thermal evolution of these stars. The general relativistic equations of energy balance and energy transport that are solved in a numerical cooling simulation involve both microscopic (neutrino emissivity, heat capacity, thermal conductivity) and macroscopic (metric function, mass, radius) quantities.

In this work, we study the structure and thermal evolution of quark stars employing equations of state from perturbative QCD. We build the framework for acquiring cooling solutions and discuss the consequences arising from the application of different equations of state to describe the properties of quark matter. Additionally, we examine the properties of a thin nuclear crust in quark stars and investigate its impact on the cooling process, comparing our results with available observational data.

Authors: FRAGA, Eduardo (Instituto de Física, Universidade Federal do Rio de Janeiro); FONSECA, Úrsula

Presenter: FONSECA, Úrsula

Session Classification: Poster session

Contribution ID: **96** Type: **Poster**

DATA ANALYSIS IN HIGH ENERGY PHYSICS USING MACHINE LEARNING METHODS

Tuesday 11 March 2025 18:20 (2 minutes)

This scientific initiation project involved the analysis of a Monte Carlo (MC) dataset of relativistic heavy-ion collisions using Machine Learning (ML) methods. The dataset was provided by the Experimental Hadronic Physics Group (HadrEx) in direct collaboration with the ALICE experiment at the Large Hadron Collider (LHC). The research focused specifically on multi-strange baryons—such as Ξ^-, Ξ^+ , and others —and their subsequent decays, a process known as "Cascade Decay." The primary objective was reconstructing these particles through their secondary decays using generative Machine Learning models. By synthesizing realistic data that harmonizes with experimental observations, the project aimed to optimize conventional high-energy physics analyses and enhance data analysis algorithms for the search for rare observables. To address this challenge, the Conditional Tabular Generative Adversarial Network (CTGAN) model was employed. The results demonstrated that CTGAN effectively preserved the physical and intrinsic correlations of the original data while reproducing the variable distributions, reinforcing its potential for improving data-driven studies in high-energy physics.

Author: MIOTTO, Matheus Guilherme

Co-author: Dr TAKAHASHI, Jun (University of Campinas UNICAMP (BR))

Presenter: MIOTTO, Matheus Guilherme

Session Classification: Poster session

Contribution ID: **97** Type: **Poster**

Photon Propagator in Confinement and Deconfinement Phases of Lattice QED

Monday 10 March 2025 17:52 (2 minutes)

Quantum electrodynamics (QED) is the gauge field theory that describes the interactions between photons and charged particles, characterized by gauge invariance under the group U (1) [1]. Understanding how QED works is essential to describe one of the fundamental forces of the universe, eletromagnetism,this can be investigated from various perspectives, including experimental, perturbative [2], and lattice approaches [3]. In this study, we adopt the lattice formulation to simulate and analyze QED, employing Monte Carlo techniques.

The photon propagator, a key object in QED, provides the probability amplitude for a photon to travel from one point in spacetime to another. It also describes how photons transmit their effects through spacetime. Understanding the behavior of the photon propagator is crucial for exploring QED phenomena.

In lattice QED, a unique phenomenon emerges that is not observed in nature: a confinement phase. This divides the lattice QED into two distinct regions—the confinement and deconfinement phases [4]. This phase structure can be attributed to lattice properties and understanding how this phase structure arises and how to deal with it is essencial to improve our data and extract physical meaning.

In this study, we compute the photon propagator in both phases on a lattice of size 204. We utilize the Los Alamos algorithm for gauge fixing and the Heat Bath Monte Carlo algorithm for thermalization and configuration generation.

[1] S. Pokorski, Gauge field theories, vol. 136 (Cambridge University Press, 2000).
[2] M. E. Peskin, An introduction to quantum field theory (CRC press, 2018).
[3] J. Smit, Introduction to quantum fields on a lattice (Cambridge University Press, 2003).
[4] L. C. Loveridge, O. Oliveira, and P. J. Silva, Physical Review D 103, 094519 (2021)

Author: NASCIMENTO MANDELO, Pablo (Universidade de São Paulo - USP)

Co-author: MENDES, Tereza

Presenter: NASCIMENTO MANDELO, Pablo (Universidade de São Paulo - USP)

Session Classification: Poster session

Contribution ID: **99** Type: **Poster**

Pion condensation and chiral symmetry breaking in the early universe

Wednesday 12 March 2025 17:42 (2 minutes)

We discuss how the passage of the universe through a pion condensed phase and a chiral symmetry breaking would affect its cosmic trajectory at the QCD era. A pion condensed phase could be achieved if large lepton asymmetries were reached at this epoch. To describe the QCD sector we employ a quark-meson model at finite temperature and finite baryon and charge chemical potentials. We show that, for large lepton asymmetries, the universe could go through a first-order phase transition while entering the pion condensed phase, followed by a second order phase transition when it exits it.

Authors: FERREIRA, Osvaldo (Universidade Federal do Rio de Janeiro); S. FRAGA, Eduardo (Instituto de Física, Universidade Federal do Rio de Janeiro); HIPPERT, Mauricio (Universidade do Estado do Rio de Janeiro); Prof. SCHAFFNER-BIELICH, Jürgen (Goethe Universität)

Presenter: FERREIRA, Osvaldo (Universidade Federal do Rio de Janeiro)

Session Classification: Poster session

Contribution ID: **100** Type: **Poster**

Total proton-air cross section in a QCD-inspired model

Wednesday 12 March 2025 18:06 (2 minutes)

We describe the total proton-air production cross section based on the inelastic proton-proton cross section derived from a QCD-inspired model. In this approach, the QCD contribution to the total cross section for the inclusive process $A + B \to jets$ is computed at the next-to-leading order.

Author: VENTURA ISER, THOMAS (UFRGS - Universidade Federal do Rio Grande do Sul)

Presenter: VENTURA ISER, THOMAS (UFRGS - Universidade Federal do Rio Grande do Sul)

Session Classification: Poster session

Contribution ID: **101** Type: **Poster**

Meson production by photon-photon interactions in fixed target collisions at the LHC

Tuesday 11 March 2025 18:30 (2 minutes)

The production cross sections and the number of events per year of mesons are estimated by considering photon-photon interactions in fixed-target collisions at the LHC energies of CERN. We consider several mesons with photon-photon partial decay widths well constrained by the experiment, and some mesons that are currently considered candidates for hadronic molecules and glueballs. Our results demonstrate that the experimental analysis of these states is feasible at CERN-LHC.

Author: TACIANNY KAROL DE ARAUJO, Sandra

Co-authors: Dr MOREIRA, Bruno (UDESC); Dr GONÇALVES, Victor (UFPEL)

Presenter: TACIANNY KAROL DE ARAUJO, Sandra

Session Classification: Poster session

Contribution ID: **102** Type: **Oral communications**

Describing the properties of the lightest charmed-axial mesons

Thursday 13 March 2025 16:30 (15 minutes)

In this work, I will present the results of our recent study of the meson-meson interactions with effective Lagrangians. I will show that the consideration of a coupled quark and hadron dynamics is needed to under the properties of the lightest axial mesons with charm.

Author: Prof. KHEMCHANDANI, KANCHAN PRADEEPKUMAR

Co-authors: MARTINEZ TORRES, Alberto (University of Sao Paulo); Prof. MELO ABREU, Luciano

Presenter: Prof. KHEMCHANDANI, KANCHAN PRADEEPKUMAR

Session Classification: Oral communications

Contribution ID: **103** Type: **Poster**

Shock Formation in Relativistic Viscous Fluid Dynamics

Monday 10 March 2025 18:10 (2 minutes)

We use a recently developed explicitly flux conservative formalism for the causal and stable hydrodynamic equations developed by Bemfica, Disconzi, Noronha, and Kovtun (BDNK) with the goal of investigating shock formation in relativistic viscous fluids. It is well known that the relativistic Euler equations can give rise to discontinuous solutions called shock waves, and attempts to show whether or not viscous theories also produce shocks have been made in recent years, including for Müller-Israel-Stewart (MIS) theories and BDNK itself. In order to solve the BDNK equations, we employ the widely used Kurganov-Tadmor scheme coupled with a Total Variation Diminishing Runge-Kutta scheme so as to alleviate oscillations in the solutions. We investigate shock formation in BDNK for large and small viscosities and probe the theory's dependence on the chosen hydrodynamic frame in 1+1 dimensional simulations in flat spacetime.

Authors: OLIVEIRA PINHO, Eduardo (Universidade Federal de Santa Catarina); Prof. LEITE NORONHA, Jorge Jose (University of Illinois at Urbana-Champaign); CLARISSE, Nick

Presenter: OLIVEIRA PINHO, Eduardo (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **104** Type: **Seminar (invitees)**

Proton-deuteron interaction and femtoscopy under the two-body picture

Thursday 13 March 2025 11:00 (30 minutes)

The Lednický-Lyuboshitz formalism was claimed to inadequately describe the proton-deuteron femtoscopy correlation function measured by the ALICE collaboration in high-multiplicity p+p collisions. This result motivated a full three-particle description involving a composite deuteron, leading to a much better agreement with the experimental data. Building on the two-body approach, we solve the complete wave function of the system by solving the Schrödinger equation with both strong and Coulomb potentials, including also higher partial waves beyond the S-wave. Our results show significant differences compared to the Lednický-Lyuboshitz model, providing a better match to the ALICE measurements and also aligning with recent STAR data in Au+Au collisions for the proton-deuteron system.

Authors: TORRES-RINCON, Juan (Universitat de Barcelona); Prof. RAMOS, Àngels (University of Barcelona)

Presenter: TORRES-RINCON, Juan (Universitat de Barcelona)

Session Classification: Morning

Contribution ID: **105** Type: **Oral communications**

Exoticos hadrons with charm and/or strangeness

Thursday 13 March 2025 16:45 (15 minutes)

In this talk I will review some of our results related to the study of the properties of exotic hadrons with explicit/hidden charm and/or strangeness generated from the interaction of three-body systems.

Author: MARTINEZ TORRES, Alberto

Presenter: MARTINEZ TORRES, Alberto

Session Classification: Oral communications

Contribution ID: **106** Type: **Oral communications**

Searching for signatures of the $X(3700)/D\bar{D}$ bound state in femtoscopic correlations

Tuesday 11 March 2025 16:30 (15 minutes)

The femtoscopic $D\bar{D}$ correlations are investigated in order predict the signature of the $X(3700)$ $(D\bar{D})$ bound state in the isoscalar channel. This bound state is generated by solving the coupled-channel Bethe-Salpeter equations with the local hidden-gauge formalism. The momentum correlation functions of the $D^0\bar{D}^0$ and D^+D^- pairs and the low-energy observables are calculated and discussed. I analyze how the features of the $X(3700)$ state might be encoded in the behavior of the correlation functions.

Author: Prof. ABREU, Luciano Melo

Presenter: Prof. ABREU, Luciano Melo

Session Classification: Oral communications

Contribution ID: **107** Type: **Oral communications**

Estimating the intrinsic quark contribution to heavy meson production at forward rapidities in pp collisions at the LHC

Tuesday 11 March 2025 17:15 (2 minutes)

Heavy quark production in hadronic collisions is considered one of the main tools for studying the properties of the strong interactions. In particular, the study of its production at forward rapidities, probes projectile partons with large light cone momentum fractions and target partons carrying a very small momentum fraction. Consequently, it is expected to provide important constraints on the small-x effects expected to be present in the target coming from the non-linear aspects of QCD, and on the large-x effects in the projectile, as e.g. an intrinsic heavy quark component on the proton wave function. In this work, the heavy quark production in proton-proton collisions is studied at the Large Hadron Collider (LHC) energies. In particular, we investigate the D and B meson production at forward rapidities and estimate the impact of an intrinsic quark component in the proton's wave function, considering the hybrid formalism, the solution of the running coupling Balitsky–Kovchegov equation and distinct descriptions for the parton distribution function. The contributions of gluon- and hard quark-initiated processes (charm for D mesons and bottom for B meson) are taken into account, and a comparison with the current LHCb data is performed. Our results indicate that the presence of an intrinsic quark strongly modifies the magnitude of the cross-section at ultra-forward rapidities, as well as, will imply an increase in the prompt neutrino flux at high energies.

Author: DO NASCIMENTO LIMA, Yuri (Universidade de Sao Paulo (BR))

Co-authors: Dr VEIGA GIANNINI, Andre; GONÇALVES, Victor (Universidade Federal de Pelotas)

Presenter: DO NASCIMENTO LIMA, Yuri (Universidade de Sao Paulo (BR))

Session Classification: Oral communications

Contribution ID: **108** Type: **Poster**

The quark anomalous magnetic moment in the NJL model and how to avoid first-order phase transitions induced by regularization issues

Wednesday 12 March 2025 18:08 (2 minutes)

Effective models to the quantum chromodynamics (QCD), like the Nambu–Jona-Lasinio (NJL) model, has been used to describe strong interaction for its simplicity. Regularization procedures can be applied to magnetized quark matter and describe the physics of peripheral heavy ion collisions and magnetars. The quark anomalous magnetic moment is a phenomena that has been calling attention in the last few years, mainly using NJL model, and could lead to the inverse magnetic catalysis phenomena. Some works found first-order phase transitions (1st PT) , even at zero temperature case. Here, we will that these 1st PT are artifacts of the improper regularization procedures. To do so, we explore the vacuum magnetic regularization (VMR) in two cases in respect to the subtraction of the divergences: the mass-dependent (MD) and mass-independent (MI). The MD case leads to a nonmassive minimum at the thermodynamical potential, inducing 1st PT. So, the MI agrees with the present predictions of the Lattice QCD, this case constrains the magnetic field to be smaller than the squared of the vacuum effective quark mass at the VMR scheme. The MI case also get the exactly expression of the one-loop Schwinger–Weisskopf effective Lagrangian adapted to the NJL model.

Authors: LUCIANO SONEGO FARIAS, RICARDO; Mr CARDOSO, Rafael (Universidade Federal de Santa Catarina); AVANCINI, Sidney (universidade federal de santa catarina); TAVARES, William (UERJ)

Presenter: Mr CARDOSO, Rafael (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **109** Type: **Poster**

Effective coupling for the NJL model based on fractals

Wednesday 12 March 2025 18:10 (2 minutes)

The Nambu–Jona-Lasino model is modfied by the inclusion of a running-coupling that was obtained by a fractal approach to QCD. The coupling follows a -exponential function and, in the context of high energy collisions, explains the origin of the Tsallis non-extensive statistics distributions. The parameter is completely determined in terms of the number of colours and the number of quark flavours. We study several
aspects of the extended model and compare our results to the standard NJL model, where a constant coupling is used in combination with a sharp cutoff to regularize the gap equation. We show that the modfied coupling regularizes the model in a smooth cutoff fashion and reproduces the pion mass and decay constant, providing an almost identical GOR relation as in the standard NJL model. In both models the relation is satified in similar cutoff scales. An important novelty of this work is the physical explanation, in terms of the fractal QCD vacuum, for a running coupling that renormalizes the quark condensate.

Author: SALVADOR TIMÓTEO, Varese (University of Campinas - UNICAMP)

Presenter: SALVADOR TIMÓTEO, Varese (University of Campinas - UNICAMP)

Session Classification: Poster session

Contribution ID: **110** Type: **Lecture (invitees)**

Probing Extreme States of QCD Matter in Compact Stars (Part 1)

Monday 10 March 2025 14:30 (1 hour)

The QCD phase diagram still has various unsettled features predicted by theoretical efforts. Experimental data should eventually confirm possible states in extreme environments. Recently, promising data become available from the astrophysical observation of neutron stars. In this lecture, I will summarize expected extreme states at high baryon density and introduce useful constraints on those possibilities imposed by the astrophysical observation.

Author: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Presenter: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Session Classification: Afternoon

Contribution ID: **111** Type: **Seminar (invitees)**

Extraction of the speed of sound in strongly interacting matter using heavy ion collisions at the LHC

Monday 10 March 2025 11:15 (30 minutes)

In this presentation recent extractions of the speed of sound in hot QCD matter are discussed. The measurements are performed using two different analysis techniques, which are applied in PbPb collisions at the LHC with center-of-mass energy per nucleon pair of 2.76 and 5.02 TeV. Special focus to the experimental techniques and prospects for future measurements will be given.

Author: BERNARDES, Cesar (UNESP - Universidade Estadual Paulista (BR))

Presenter: BERNARDES, Cesar (UNESP - Universidade Estadual Paulista (BR))

Session Classification: Morning

Contribution ID: **112** Type: **Poster**

Renormalons in the QCD spectral function, experimental data, and potential implications to the muon g-2

Monday 10 March 2025 17:56 (2 minutes)

The muon anomalous magnetic moment, $g-2$, is one of the most precisely measured quantities in physics. On the theoretical side, however, the Standard Model (SM) prediction does not achieve the same level of precision, primarily due to the uncertainty in the hadronic vacuum polarization (HVP) contribution. At energies between 2 and 3.7 GeV, perturbative QCD (pQCD) is often used for the prediction of the HVP contribution to $g-2$ and this method relies on the determination of the celebrated observable $R(s)$, or, equivalently, the spectral function. Recently, a discrepancy has been observed between the latest and more precise BES-III data and the pQCD prediction for $R(s)$. In order to investigate the origin of this tension, it is essential to analyze the spectral function in detail. In this work, we examine the perturbative series of the spectral function both in the so-called large-β_0 limit and in full QCD at different energy scales. We explore the potential implications of their renormalon structure on the spectral function's behavior, which directly impacts $R(s)$ and, consequently, the HVP contribution to $g-2$ (denoted as a_μ^{HVP}). Additionally, we present our preliminary results for the calculation of a_μ^{HVP} between 2-3GeV using a data-driven approach, along with a comparison to the pQCD prediction.

Authors: CARAM, Marcelle (University of Sao Paulo); Dr BOITO, Diogo (University of Sao Paulo)

Presenter: CARAM, Marcelle (University of Sao Paulo)

Session Classification: Poster session

Contribution ID: **114** Type: **Lecture (invitees)**

The Structure of the Proton (Part 1)

Monday 10 March 2025 09:15 (1 hour)

In these set of lectures we review the modern tools used to compute the quark and gluon distributions within hadrons in general, and the proton in particular. We begin with a review of deep inelastic scattering, and factorization theorems. We then introduce the definitions of parton distribution functions (PDFs), generalized PDFs (GPDs), and transverse-momentum dependent PDFs (TMDPDFs), and how they can be compute from first principles.

Author: Dr STEFFENS, Fernanda (University of Bonn)

Presenter: Dr STEFFENS, Fernanda (University of Bonn)

Session Classification: Morning

Contribution ID: **115** Type: **Poster**

The nonperturbative dynamics of the three and four gluon vertices in the soft kinematics

Monday 10 March 2025 17:54 (2 minutes)

We present a Schwinger-Dyson analysis of the three- and four-gluon vertices in the soft-kinematic configuration, where one external momentum vanishes. The key assumption in our analysis is the validity of a ''planar degeneracy", which states that the leading form factor for each vertex is well described by a single Bose-symmetric variable defining a plane in momentum space. We find that this property leads to significant simplification of the underlying equations and can be verified numerically to a high degree of accuracy. The results obtained with this approach capture the leading non-perturbative features of both vertices and are in good agreement with current lattice simulations.

Author: SANTOS, Leonardo (IFGW - Unicamp)

Presenter: SANTOS, Leonardo (IFGW - Unicamp)

Session Classification: Poster session

Contribution ID: **116** Type: **Poster**

Interplay between symmetry and dynamics in the pole structure of the three-gluon vertex

Monday 10 March 2025 17:48 (2 minutes)

It is well established that the Schwinger mechanism generates a nonperturbative mass for gluons through the emergence of massless poles in the fundamental QCD vertices. In this work, we examine the pole structure of the three-gluon vertex, analyzing its patterns and residues using two complementary approaches: the Slavnov-Taylor identity, which encapsulates the vertex's symmetry properties, and the nonlinear Schwinger-Dyson equation, which dictates its dynamical evolution. Our findings show that both methods produce consistent results, confirming a nonzero residue for the vertex. The model-independent nature of these results underscores the deep interplay between symmetry and dynamics in the theory, offering a nontrivial self-consistency test for this mass-generation mechanism.

Author: SILVEIRA DE OLIVEIRA, Bianca Maria (Universidade de Campinas)

Presenter: SILVEIRA DE OLIVEIRA, Bianca Maria (Universidade de Campinas)

Session Classification: Poster session

Contribution ID: **117** Type: **Poster**

Infrared study of the transversely projected quark-gluon vertex

Monday 10 March 2025 18:18 (2 minutes)

We investigate the quark-gluon vertex in unquenched QCD with two degenerate light dynamical quarks in the Landau gauge. By solving its Schwinger-Dyson equation, derived from the 3PI effective action formalism, we determine the eight form factors of the transversely projected vertex in general kinematics. The analysis incorporates lattice data for key ingredients, including the gluon and quark propagators and the three-gluon vertex. To simplify the numerical treatment, we decouple the system of integral equations: the classical form factor is obtained from a single nonlinear integral equation involving only itself, while the remaining ones are computed through simple integrations. Our results reveal a significant angular dependence, and we establish a clear hierarchy at the level of the dimensionless effective couplings, consistent with previous results. Moreover, the classical form factor exhibits excellent agreement with recent unquenched lattice data in the soft-gluon configuration.

Author: LINHARES, Gustavo (Unicamp)

Presenter: LINHARES, Gustavo (Unicamp)

Session Classification: Poster session

Contribution ID: **118** Type: **Poster**

Constraining the Quark-Gluon Vertex: A Study of Transverse Slavnov-Taylor Identities

Monday 10 March 2025 18:12 (2 minutes)

In this work, we investigate the transverse Slavnov-Taylor identities as a means to constrain the nonperturbative structure of the transverse form factors of the quark-gluon vertex. These identities arise from the interplay between BRST symmetry and Lorentz invariance. While they provide a novel approach to studying the transverse component of the quark-gluon vertex, certain challenges arise, particularly due to the presence of nonlocal terms associated with path-independent Wilson loop contributions. This work represents an initial attempt to develop a general framework for computing these path-independent Wilson loop contributions by analytically evaluating the remaining terms in the transverse identities at the one-loop level and comparing them with well-established perturbative results in the literature. Subsequently, we will extend our analysis to the nonperturbative regime by incorporating dressed propagators and vertices.

Author: SAKAGUTI DÓRIA, Marcelo Antonio (Gleb Wataghin Institute of Physics, University of Campinas)

Presenter: SAKAGUTI DÓRIA, Marcelo Antonio (Gleb Wataghin Institute of Physics, University of Campinas)

Session Classification: Poster session

Contribution ID: **119** Type: **Poster**

Impact of dynamical quarks on the soft kinematics of the three-gluon vertex

Monday 10 March 2025 17:58 (2 minutes)

We perform a detailed analysis of the key features of the transversely projected three-gluon vertex in the presence of two dynamical quarks, focusing on the soft-gluon limit, where one momentum vanishes. Our approach is based on the one-loop dressed Schwinger-Dyson equation derived from the 3PI effective action. A central assumption in our analysis is the validity of planar degeneracy, which states that the form factor of the three-gluon vertex can be accurately described by a single Bose-symmetric variable defining a plane in momentum space. Our preliminary results indicate that, although the overall behavior of the form factor closely resembles that observed in the quenched case, the presence of dynamical quarks significantly mitigates its infrared suppression. This effect shifts the zero crossing even deeper into the infrared region, in agreement with previous findings from lattice simulations.

Author: ALMEIDA WENDLAND, Lais

Presenter: ALMEIDA WENDLAND, Lais

Session Classification: Poster session

Contribution ID: **120** Type: **Seminar (invitees)**

Extreme magnetic fields during pre-equilibrium in heavy-ion collisions

Tuesday 11 March 2025 11:00 (30 minutes)

The quark-gluon plasma produced in heavy-ion collisions is a state of matter where quarks and gluons are, for a few instants, in a deconfined state, not bound inside hadrons. The deconfinement is driven by an extremely high temperature produced in the collisions. Besides the high temperature, it is expected that non-central collisions produce the highest magnetic fields we know in nature or in the laboratory. Although the intensity drops down fast and, moreover, it is not clear whether the fields last long enough to induce a magnetization during the quark-gluon plasma phase, most of the models and simulations predict a significant intensity that lasts up to proper times of order 1 fm after the beginning of the reaction. In this seminar, I will discuss possible effects these extreme fields can induce during the first stage after the collision, period when the field is at its maximum. I will also discuss perspectives to define observables for these fields.

Author: MIZHER, Ana (UNICID/IFT-Unesp)

Co-author: Prof. AYALA, Alejandro (Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico)

Presenter: MIZHER, Ana (UNICID/IFT-Unesp)

Session Classification: Morning

Contribution ID: **121** Type: **Oral communications**

Impact of rotational effects on the QCD phase diagram: chiral vortical catalysis constrained by Lattice QCD

Thursday 13 March 2025 15:15 (15 minutes)

Vortical effects in quantum chromodynamics (QCD) have been widely explored in the past few years due to the observation of global polarization of Λ and $\bar{\Lambda}$ baryons in peripheral heavy-ion collisions by the STAR collaboration. Subsequently, the global spin-alignment pattern has been observed for K^{0*} and ϕ vector mesons by the ALICE and STAR collaborations; however, the measurements of the spin density matrix element ρ_{00} differ in both groups, indicating that the underlying physical mechanisms remain unclear. Based on some of these evidences, it is natural to believe that intricate and interesting new phenomena associated with rotations could potentially change different quantities of the QCD phase transitions.

Recent lattice QCD results indicate that the chiral and deconfinement pseudocritical temperatures increase as a function of the real angular velocity, a behavior that is not naturally reproduced in most effective approaches. This effect can be understood by separating the contributions of quarks and gluons in the action. As a result, it is observed that the pseudocritical temperatures decrease when only quarks are considered, but increase when gluons or both degrees of freedom are included simultaneously. This analysis shows that gluonic interactions are indeed fundamental pieces to describe appropriately the QCD phase diagram with rotations.

In order to explore the effects of rotations in QCD phase transitions within an effective chiral model, we consider the two-flavor Nambu–Jona-Lasinio model under the mean field approximation in a rotating rigid cylinder with constant angular velocity. To circumvent the absence of gluons in the model, we adopt a coupling fitted to describe the pseudocritical temperature of chiral phase transition obtained from lattice QCD. Considering this environment, we reproduce the previously dubbed chiral vortical catalysis effect, which is the increase in the chiral condensate as a function of the angular velocity, in contrast to what is observed in the constant coupling case. We also explore the chiral susceptibilities, effective quark masses and the phase diagram. In the last case, we observe first- and second-order phase transitions that become more pronounced as we increase the values of angular velocity, in disagreement with results obtained using constant coupling and different effective approaches.

Author: TAVARES, William (UERJ)

Co-authors: Dr FARIAS, Ricardo (UFSM); Mr MENDEZ NUNES, Rodrigo (UFSM); Dr SALVADOR TIMÓTEO, Varese (UNICAMP)

Presenter: TAVARES, William (UERJ)

Session Classification: Oral communications

Contribution ID: **122** Type: **Oral communications**

Hadronic rescattering to solve helicity puzzle in $B^+ \to p\bar{p}\pi^+(K^+)$ decays

Tuesday 11 March 2025 17:00 (15 minutes)

Experimental results indicate opposite helicity angle θ_p distributions in $B^+ \to p\bar{p}\pi^+$ and $B^+ \to p\bar{p}K^+$ decays with the difference presenting a remarkable linear dependence on $\cos\theta_p$.
We assume the production mechanism is driven by $B^+ \to xy\,m^+ \to p\bar{p}m^+$, where $m = \pi$ or K, and xy represents favorable mesonic decay channels producing $p\bar{p}$.
From that, I will present a model that includes three-body final state interaction between the p , $\bar{p}$ and π^+ or K^+ considering the dominance of elastic channels π^+p and $K^+\bar{p}$ interactions below 2\,GeV/c^2.
I will show that our three-body framework with FSI explains qualitatively the observed opposite behavior of the helicity distributions and the observed linearity.

Author: MAGALHAES, Patricia (CBPF - Brazilian Center for Physics Research (BR))

Co-authors: Prof. DE BEDIAGA HICKMAN, Ignacio (CBPF - Brazilian Center for Physics Research (BR)); Prof. FREDERICO, Tobias (Instituto Tecnologico de Aeronautica)

Presenter: MAGALHAES, Patricia (CBPF - Brazilian Center for Physics Research (BR))

Session Classification: Oral communications

Contribution ID: **123** Type: **Seminar (invitees)**

Heavy flavour probes: a key to understanding the Quark-Gluon Plasma

Monday 10 March 2025 10:15 (30 minutes)

The formation of the QGP occurs at extremely high temperatures and/or high densities, which can be reached in ultra-relativistic heavy-ion collisions as provided by the Large Hadron Collider (LHC) at CERN (Organization Européenne pour la Recherches Nucléaires). Collisions of heavy nuclei at the LHC provide abundant production of heavy flavour probes, which can be used to answer some critical open questions in the field. ALICE (A Large Ion Collider Experiment) is one of the LHC detectors built to study the QGP. The ALICE physics program includes understanding the nature of high-energy quark-gluon interactions in QGP; how quarks of different masses reach thermal equilibrium within QGP; and what are the mechanisms of hadronisation within QGP. In this seminar, recent results from ALICE will be discussed, and how heavy flavour probes are used to characterise this highly interactive medium. In particular, new results from Run-3 on quarkonia and open heavy flavour in Pb-Pb at 5.36 TeV will be discussed.

Author: Dr JAHNKE, Cristiane (University of Campinas UNICAMP (BR))

Presenter: Dr JAHNKE, Cristiane (University of Campinas UNICAMP (BR))

Session Classification: Morning

Contribution ID: **124** Type: **Lecture (invitees)**

Collective dynamics in Relativistic Heavy-ion Collisions (Part 1)

Monday 10 March 2025 11:45 (1 hour)

I will give a series lectures that covers the fundamentals and current frontier of studying the collective behavior of the Quark Gluon Plasma (QGP) produced in relativistic heavy-ion collisions.

Author: SHEN, Chun (Wayne State University)

Presenter: SHEN, Chun (Wayne State University)

Session Classification: Morning

Contribution ID: **125** Type: **Poster**

Interactions of the deuteron with a hadronic medium

Wednesday 12 March 2025 18:00 (2 minutes)

We investigate the interactions of the deuteron with light mesons during the hadronic phase in heavy-ion collisions. For this purpose, we treat the deuteron as a bound state of two nucleons and analyze the evolution of the cross-sections in interactions between the deuteron and pions. We begin by using effective Lagrangians obtained through chiral perturbation theory to estimate the vacuum and thermally-averaged cross-sections for elastic processes $N+\pi \to N+\pi$ and $N'+\pi \to N'+\pi$. These processes are employed in the quasi-free approximation approach to calculate the vacuum and thermally-averaged cross-sections for deuteron dissociation and production, namely, $d+\pi \to N+N'+\pi$ and the corresponding inverse reaction. Finally, we use these processes in a rate equation to estimate the time evolution of the deuteron multiplicity under two initial condition scenarios: the statistical hadronization model and the coalescence model, where the deuteron is treated as a hadronic molecule.

Authors: OLIVEIRA MAGALHÃES, Rodrigo (Universidade Federal da Bahia (UFBA)); Prof. ABREU, Luciano Melo (Universidade Federal da Bahia (UFBA)); HIGA, Renato (University of São Paulo); SILVEIRA NAVARRA, Fernando (Universidade de São Paulo)

Presenter: OLIVEIRA MAGALHÃES, Rodrigo (Universidade Federal da Bahia (UFBA))

Session Classification: Poster session

Contribution ID: **126** Type: **Seminar (invitees)**

Recent results on hadron physics from LHCb

Tuesday 11 March 2025 10:00 (30 minutes)

The LHCb experiment at CERN has collected a large, high-quality dataset of proton-proton collisions during run 1 and run2. It has proven to be a very prolific player in the field of hadron physics, with important contribution on the production and properties of both conventional and exotic QCD states. Here we present some of the most recent and important results from LHCb in this area.

Authors: GOBEL BURLAMAQUI DE MELLO, Carla (Pontifical Catholic University of Rio de Janeiro (BR)); GOBEL BURLAMAQUI DE MELLO, Carla (Pontificia Universidade Catolica (BR))

Presenter: GOBEL BURLAMAQUI DE MELLO, Carla (Pontifical Catholic University of Rio de Janeiro (BR))

Session Classification: Morning

Contribution ID: **127** Type: **Seminar (invitees)**

Dark matter effects in hadronic and strange stars

Friday 14 March 2025 11:00 (30 minutes)

An important component that can directly affect the description of astrophysical and cosmological systems is dark matter (DM), whose fundamental nature is not completely understood at the moment. The current understanding predicts that 27% of the Universe is made of dark matter, 68% of dark energy (the main component that explains the accelerated expansion of the Universe), and only 5% of luminous matter. Recently, some studies were performed in which DM is coupled to hadronic and/or quark models and used to describe astrophysical systems, such as compact stars. In this talk, we show the effects of including DM content in hadronic relativistic mean-field models, as well as in a particular effective quark model, in which the respective constituent quark masses are density dependent functions (in-medium effects taken into account).

Author: Prof. LOURENÇO, Odilon (Instituto Tecnológico de Aeronáutica)

Co-authors: Dr F. COELHO, Anderson (Instituto Tecnológico de Aeronáutica); Dr H. RODRIGUES, Everson; Dr MARZOLA, Isabella; DUTRA, Mariana (Instituto Tecnológico de Aeronáutica)

Presenter: Prof. LOURENÇO, Odilon (Instituto Tecnológico de Aeronáutica)

Session Classification: Morning

Contribution ID: **128** Type: **Poster**

Critical Phenomena and Renormalization Group

Monday 10 March 2025 17:44 (2 minutes)

The interest in systems with many correlated degrees of freedom is a central aspect of Quantum Field Theory (QFT) and Statistical Mechanics. These conditions mean that the effective long-range interactions between the particles in the system become highly non-trivial, and we therefore use the Renormalization-Group method to analyze the behavior around the critical point. This process is arguably not so intuitive in QFT, since it relates to divergences that may not be directly observable. Another interesting aspect of the Renormalization Group is related to how the volume of the system transforms around the critical point. This aspect is the foundation of the Finite-Size-Scaling process, used to study numerically the behavior of systems around said point. To create a better sense of understanding, we explore the theory for Spin Models, where renormalization-group ideas and critical phenomena show up as something more natural. Starting from symmetries and important scales that define a physical system, we highlight the principles behind the nonperturbative, multiscale study of such systems, noticing that, most of the time, analytical solutions are not possible. To deal with these problems, we also introduce the Monte Carlo method, which allows us to sample configurations of the system based on a probability measure. With these tools at hand, we explore the similarities of numerical simulation (via the Metropolis algorithm) for the Ising and XY spin models compared to lattice QCD, comparing the symmetries of these systems. The calculation of observables for each system is directly related to the symmetry group that defines the interaction, making each system unique, while the process itself is universal. In this work, developed during an undergraduate research project and the first months of PhD, we show the parallels between QFT and Statistical Mechanics, by highlighting the importance of critical phenomena to Lattice QFT and applying the methods to simpler systems.

Author: Mr SOARES RODRIGUES, Artur (Universidade de São Paulo)

Co-author: MENDES, Tereza

Presenter: Mr SOARES RODRIGUES, Artur (Universidade de São Paulo)

Session Classification: Poster session

Contribution ID: **129** Type: **Seminar (invitees)**

Surface tension of neutron star matter

Thursday 13 March 2025 10:00 (30 minutes)

The phase transition from hadronic to quark matter may take place already during the early post-bounce stage of core collapse supernovae and in neutron star mergers. If the phase transition is of first order, the formation of the quark matter phase occurs via the nucleation of droplets. The timescales relevant for the phase conversion dynamics, as well as the possibility of mixed phases, are very sensitive to the value of the surface tension in this dense environment. We discuss the computation of the surface tension from the initial purely chiral models to a nucleon-meson model that describes nuclear matter in the low-density sector, with fully broken chiral symmetry, and the approximately chirally restored phase at high density within a unified effective potential. Finally, we incorporate parity doubling, which allows for stable static configurations of stars with a metastable matter core, enabling stars with masses higher than the expected minimum mass of a neutron star formed via core collapse supernova and around the value of the less massive observed neutron star which makes metastability related phenomena particularly relevant. In all cases, we find values of the surface tension that favor the nucleation of quark matter.

Author: FRAGA, Eduardo (Instituto de Física, Universidade Federal do Rio de Janeiro)

Presenter: FRAGA, Eduardo (Instituto de Física, Universidade Federal do Rio de Janeiro)

Session Classification: Morning

Contribution ID: **130** Type: **Poster**

A comparative study between UrQMD and SMASH: Numerical implementations associated with hadronic transport in the context of heavy ion collisions

Monday 10 March 2025 18:16 (2 minutes)

The quark-gluon plasma is a state of matter where quarks and gluons, the fundamental components of protons and neutrons, are free and constantly interacting due to the properties of quantum chromodynamics, such as confinement and asymptotic freedom. This state can only be produced under extreme energy conditions, such as those that existed in the early universe after the Big Bang or in the core of neutron stars. To
study the QGP, these extreme conditions are recreated in laboratories by colliding heavy ions accelerated to relativistic speeds.
The QGP resulting from these collisions has a dimension on the order of 10^{-4} meters and survives for approximately 10^{-23} seconds. Due to its small scale and brevity, direct observation is not feasible, requiring indirect measurements such as the final particle spectrum detected. Thus, studying the QGP requires a series of simulations describing each stage of the collision, connecting theories with experimental data to refine our understanding of the fundamental forces governing subatomic particles.
A crucial stage in this process is hadronic transport, which occurs after the QGP expands and cools, when quarks and gluons reconfine into hadrons. At this stage, the system is described as a gas whose temporal evolution is governed by the Boltzmann equation, considering collisions and decays of hadrons. Several computational models describe this stage. A comparative study of different implementations is essential to identify discrepancies and improve the models'approximation to experimental data.
UrQMD (Ultra-relativistic Quantum Molecular Dynamics) is a numerical implementation that solves the Boltzmann equation for all hadrons, simplifying by considering binary collisions, elastic, and inelastic, as well as decays. It is available as open-source code in Fortran. Similarly, SMASH (Simulating Many Accelerated Strongly-interacting
Hadrons) is a solution for the non-equilibrium dynamics of hadrons, considering inelastic collisions as resonance excitations that decay with vacuum properties. It is also available as open-source code, in C++.
This work compares the UrQMD and SMASH programs, evaluating the considerations made in the construction of each model and the relationship between their final results, using the same input data.

Author: GEMMI DOS SANTOS, Sofia (Universidade Federal de Santa Catarina)

Co-author: JOSÉ NUNES DA SILVA, Tiago (UFSC)

Presenter: GEMMI DOS SANTOS, Sofia (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **131** Type: **Poster**

Studying gauge-space geometry via lattice QCD

Wednesday 12 March 2025 17:58 (2 minutes)

Quantum chromodynamics (QCD) is the theory that describes the nuclear strong interaction between quarks, mediated by gauge fields carrying color charge, the gluons. QCD has a very important and unsolved problem, which is finding a mechanism to explain why quarks are never seen alone in nature, but only forming bound states, such as protons and neutrons. This constitutes the color confinement problem, which may be studied in the framework of quantum field theory. It is a hard task because of the non-Abelian character of the theory: the gluons themselves interact with each other and, in the low-energy regime, this forbids us to treat the theory perturbatively, as done in quantum electrodynamics (QED).

Consequently, the quantization of non-Abelian gauge fields presents several issues. From the technical point of view, integrating the gauge field over all its possible configurations in the path integral involves the inversion of operators in the Yang-Mills Lagrangian with null eigenvalues, leading to divergences. Using the Faddeev-Popov method, we impose a gauge condition for the gluon field, adding new integration variables in gauge space. The curves that connect physically equivalent fields through gauge transformations in this space are called gauge orbits and, in principle, the resulting formulation solves the divergences by factorization.

Ideally, the gauge-fixing method just described causes a gauge orbit to intersect the region specified by the gauge condition only once. But this is not guaranteed for a general Yang-Mills theory, and hence there are still ambiguities coming from equivalent configurations in gauge space, called Gribov copies. For a gauge transformation, the existence of Gribov copies is directly related to the fact that there are non-trivial eigenstates of the Faddeev-Popov operator with null eigenvalues.

Among the proposed confinement scenarios, the one due to Gribov and Zwanziger associates color confinement to infrared properties of propagators of (gauge-fixed) fields around null eigenvalues of the Faddeev-Popov operator in gauge space. Our main objective is to explore and test the Gribov-Zwanziger confinement scenario, comparing analytical predictions with numerical results from lattice QCD. As a preliminary result of our lattice data, we calculate the static quark-antiquark potential. In addition, we show our results for the Landau gauge fixing procedure using different algorithms and the measurement of the gluon propagator.

Authors: KÜL, João Octavio (Universidade de São Paulo); MENDES, Tereza

Presenter: KÜL, João Octavio (Universidade de São Paulo)

Session Classification: Poster session

Contribution ID: **132** Type: **Poster**

Effects of the Medium Separation Scheme on Cold, Magnetized Two-Flavor Color Superconducting Quark Matter

Wednesday 12 March 2025 18:02 (2 minutes)

In this study, we investigate the interplay between chiral and diquark order parameters in cold, dense quark matter subjected to an external magnetic field, using an SU(2) version of the Nambu–Jona-Lasinio (NJL) model. We analyze the impact of the magnetic field on the phase diagram, addressing model divergences through various regularization strategies. These include the combined application of the Magnetic Field Independent Regularization (MFIR) method and the Medium Separation Scheme (MSS), as well as the conventional approach using form factors. This approach ensures a clear separation between finite magnetic contributions and model divergences. Additionally, we examine the effect of the MSS on two-flavor color superconducting (2SC) dense quark matter in the presence of a finite external magnetic field. Within this framework, we investigate how the external magnetic field and density influence the quark Bardeen-Cooper-Schrieffer (BCS) gap and the dynamically generated quark mass. Our findings highlight the importance of separating medium effects from vacuum contributions, which suppresses artificial oscillatory behavior often misinterpreted in the literature as the van Alphen–de Haas (vA-dH) effect.

Authors: CRISTINE DUARTE, DYANA (Universidade Federal de Santa Maria); XAVIER AZEREDO, Francisco (Universidade Federal de Santa Maria); LUCIANO SONEGO FARIAS, RICARDO

Presenter: XAVIER AZEREDO, Francisco (Universidade Federal de Santa Maria)

Session Classification: Poster session

Contribution ID: **133** Type: **Oral communications**

Light pseudo-scalar meson mass: effect of temperature and magnetic field

Monday 10 March 2025 17:00 (15 minutes)

The effect of strong magnetic fields and temperature on the light pseudo-scalar mesons is calculated. The three-flavor effective Nambu-Jona-Lasinio model is used for the calculations since this effective model incorporates some important features of quantum chromodynamic theory (QCD), as the chiral symmetry-breaking mechanism and the Kobayashi-Maskawa-'t Hooft interaction and is a computationally viable model to treat QCD in the non-perturbative regime. The meson masses may be calculated by using different approaches. The most used ones are the pole and screening mass. This work will discuss meson mass calculations and consider the effect of finite temperature and strong magnetic fields. Some comparisons with lattice QCD results are presented in some cases.

Author: AVANCINI, sidney (Universidade Federal de Santa Catarina)

Presenter: AVANCINI, sidney (Universidade Federal de Santa Catarina)

Session Classification: Oral communications

Contribution ID: **134** Type: **Poster**

Speed of sound, compressibility and adiabatic index in the Many-Body Forces Model for nuclear matter at finite temperature

Wednesday 12 March 2025 17:56 (2 minutes)

We present the extension for finite temperature of the Many-Body Forces Model (MBF Model) for the first time. The MBF Model describes nuclear matter in a relativistic quantum hadrodynamics formalism that takes many-body forces into account, by means of a field dependence of the nuclear interaction coupling constants in an adjustable derivative coupling framework. Assuming nuclear matter to be charge neutral, beta-equilibrated and populated by the baryon octet, electrons and muons, we explore the parameters of the model, different hyperonic coupling schemes (also for the first time) and temperature effects to describe basic properties of nuclear matter, including speed of sound, compressibility and adiabatic index. Our first hand results at finite temperature open the path to a new description of proto-neutron stars using the MBF Model.

Authors: JACOBSEN, Rafael (Universidade Federal de Santa Maria (UFSM)); Prof. FARIAS, Ricardo (Universidade Federal de Santa Maria (UFSM)); Prof. DEXHEIMER, Veronica (Kent State University (KSU))

Presenter: JACOBSEN, Rafael (Universidade Federal de Santa Maria (UFSM))

Session Classification: Poster session

Contribution ID: **135** Type: **Poster**

Thermomagnetic effects on light pseudoscalar meson masses within the SU(3) Nambu–Jona-Lasinio model

Wednesday 12 March 2025 18:14 (2 minutes)

In this work we use the Nambu–Jona-Lasinio model in its $SU(3)$ formulation, with the introduction of a six-point interaction given by the 't Hooft determinant to reproduce the breaking of the $U_A(1)$ symmetry.
Then, we apply the mean field approximation to obtain the effective quark masses and the stationary phase approximation in the bosonized NJL model to obtain the meson masses.
The inclusion of constant external magnetic fields is obtained in the Schwinger proper-time method, while the temperatures are included by the imaginary-time formalism in terms of the Matsubara frequencies.
These methods can be directly applied in the polarization functions of neutral meson mesons, and in the Ritus basis to the charged mesons.
Finally, for the regularization, we use the Magnetic Field Independent Regularization (MFIR) scheme, by separating the magnetic and thermal contributions to the vacuum ones, which avoids nonphysical oscillations in the quark condensates.
In order to obtain inverse magnetic catalysis we employ a magnetic field dependent coupling, fitted with LQCD data.

As a consequence of adding an external magnetic field, the screening masses of the neutral mesons are split in two: the perpendicular and the parallel ones, with $m_{scr,\perp} > m_{scr,\parallel}$.
We find that, for the parallel masses, they increase with the temperature when we consider a coupling depending on the magnetic field; and they decrease when we consider a constant coupling.
For the perpendicular mass, considering a constant coupling they exhibit a nonmonotonical magnetic behaviour until they reach temperatures {\color{red}below} T
$lesssim$500 MeV, and after this they increase.
For a coupling depending on eB, they always increase with the magnetic field.
We only find the parallel masses for the charged mesons, that always increase with eB.
Also is important to emphasize that when we use a coupling depending on the magnetic field we are able to reproduce the effect of IMC, where the critical temperatures decreases with eB, a result that we cannot reproduce if the coupling is constant.
On the other hand, the MC effect is reproduced regardless of whether we use a coupling depending on the magnetic field or not.

Authors: SODRÉ, Joana Carolina; COPPOLA, Máximo; SCOCCOLA, Norberto (Comision nacional energia atomica); Dr TAVARES, William (UERJ); AVANCINI, sidney (Universidade Federal de Santa Catarina)

Presenter: SODRÉ, Joana Carolina

Session Classification: Poster session

Contribution ID: **136** Type: **Poster**

Effective models of QCD with an infrared confinement

Wednesday 12 March 2025 17:54 (2 minutes)

Quantum chromodynamics (QCD) is the fundamental theory of the strong interaction. Its equation of state at finite temperatures has been computed from first principles using lattice QCD simulations with Monte Carlo methods. At finite baryon densities, however, the known fermion sign problem prevents the application of these methods. In order to obtain results in this regime, which is relevant for astrophysical applications involving neutron stars and gravitational wave phenomenology, it is necessary to develop alternative theoretical approaches. Therefore, we focus on a description based on effective models of QCD. One of the theory's fundamental properties is asymptotic freedom, where the coupling strength decreases with increasing energy scale. Consequently, at sufficiently high energies QCD matter is expected to undergo a phase transition from a state of confined hadrons to the quark-gluon plasma, observed in heavy-ion collisions. As such, the deconfinement phase transition is a critical aspect of QCD, yet it is often absent in traditional treatments utilizing effective models such as the Nambu–Jona-Lasinio (NJL) model and linear sigma model with quarks (LSMq). These models, for instance, predict timelike quark mass poles and hadronic decays into quarks, unphysical features that contradict the confining nature of QCD. Therefore, in this work we set to explore the consequences of the introduction of an infrared regulator in proper-time regularization, eliminating unphysical quark production thresholds. In this way, we can investigate the deconfinement phase transition through the dynamics of this regulator. Our findings indicate that chiral symmetry restoration occurs as a smooth crossover, consistent with results from lattice QCD, and that the deconfinement phase transition is sharper and happens at higher temperatures.

Author: LOPES, Bruno (Universidade Federal de Santa Maria)

Co-authors: Dr KREIN, Gastão (Instituto de Física Teórica - Universidade Estadual Paulista); Dr L. S. FARIAS, Ricardo (Universidade Federal de Santa Maria)

Presenter: LOPES, Bruno (Universidade Federal de Santa Maria)

Session Classification: Poster session

Contribution ID: **137** Type: **Poster**

Exploring the QCD Phase Structure at Finite T, μB, and μI within the NJL Model

Wednesday 12 March 2025 18:12 (2 minutes)

Recent developments in lattice calculations of thermodynamical properties of the QCD equation of state along the isospin axis at finite temperature and low baryon chemical potential have been successfully implemented (B. B. Brandt, F. Cuteri and G. Endrődi, JHEP 07 (2023) 055 [2212.14016]). Lattice calculations provide reliable physical data on the thermodynamics of gauge theories such as QCD, though the sign problem restricts this approach to low baryonic densities at high temperatures.

Effective models are valuable tools for exploring the QCD equation of state in the non-perturbative regime. These models extend our understanding beyond the regions currently accessible through lattice QCD calculations. The Nambu—Jona-Lasinio (NJL) model for quarks has been widely used due to its ability to qualitatively reproduce dynamical chiral symmetry breaking and restoration properties. As a non-renormalizable model, the NJL model requires careful consideration of regularization procedures, which play a crucial role in determining the qualitative behavior of its results.

In this work, we explore the QCD phase structure and properties using the SU(3) flavor version of the NJL model at finite temperature, baryon chemical potential, and isospin chemical potential. We pay special attention to medium-dependent terms in two different regularization procedures.

Author: PASQUALOTTO, Arthur (UFSM)

Co-authors: BANDYOPADHYAY, Aritra; LOPES, Bruno; LUCIANO SONEGO FARIAS, RICARDO

Presenter: PASQUALOTTO, Arthur (UFSM)

Session Classification: Poster session

Contribution ID: **138** Type: **Oral communications**

Quark and proton anomalous magnetic moments in confining models

Monday 10 March 2025 16:45 (15 minutes)

We present one-loop results for corrections from Strong Interactions to the quark-photon vertex using different confining models for the exchanged gluon. This calculation allows for the prediction of confinement effects in form factors and observables like the proton anomalous magnetic moment. We show that a range of confining models with dynamical gluon masses and even complex-conjugated poles present predictions that are fully compatible with observables and discuss to what extent model parameters may be constrained by this comparison.

Authors: MENA, Carlos (UERJ); PALHARES, Leticia

Presenter: PALHARES, Leticia

Session Classification: Oral communications

Contribution ID: **139** Type: **Poster**

A Study on the Tidal Deformability of Compact Objects

Wednesday 12 March 2025 17:40 (2 minutes)

Neutron stars act as natural laboratories for probing nuclear matter under extreme densities, with their inner layers reaching values several times greater than those found in atomic nuclei. The detection of gravitational waves from neutron star mergers has provided unprecedented experimental data on tidal deformability during the final coalescence phase of binary systems. In this work, we employ the mathematical framework of general relativity to calculate the tidal deformability of a neutron star immediately before merging with its companion. Our goal is to compute key parameters governing nuclear matter behavior under such extreme conditions, employing diverse equations of state (EoS), and compare these results with existing literature. This comparative analysis tests the robustness of current EoS models in describing dense nuclear matter.

Author: DO CARMO DA SILVA, Eduardo (Universidade Federal de Santa Maria)

Co-author: LUCIANO SONEGO FARIAS, Ricardo (Universidade Federal de Santa Maria)

Presenter: DO CARMO DA SILVA, Eduardo (Universidade Federal de Santa Maria)

Session Classification: Poster session

Contribution ID: **141** Type: **Lecture (invitees)**

Three ways to decipher the nature of hadronic molecules (Part 1)

Wednesday 12 March 2025 14:30 (1 hour)

In the past two decades, a plethora of hadronic states beyond the conventional quark model of qqbar mesons and qqq baryons have been observed experimentally, which motivated extensive studies to understand their nature and the non-perturbative strong interaction. Since most of these exotic states are located near the mass thresholds of pairs of conventional hadrons, the prevailing picture is that they are primarily hadronic molecules. In principle, one can verify the molecular nature of these states by thoroughly comparing their masses, decay widths, and production rates in a particular picture with experimental data. However, this is difficult or impossible. First, quantum mechanics allows for mixing configurations permitted by symmetries and quantum numbers. Second, data are relatively scarce because of their small production rates and the many difficulties in the experimental measurements. As a result, other alternatives need to be explored. In these three lectures, I introduce three approaches that can help disentangle the nature of the many exotic hadrons discovered.

In the first approach, based on the molecular interpretations for some exotic states, we study the likely existence of multiplets of hadronic molecules related by various symmetries, such as isospin symmetry, SU(3)-flavor symmetry, heavy quark spin/flavor symmetry, and heavy antiquark diquark symmetry, which are known to be approximately satisfied and can be employed to relate the underlying hadron–hadron interactions responsible for the formation of hadronic molecules. The masses of these multiplets of hadronic molecules can then be obtained by solving the Lippmann–Schwinger equation. Their decay and production patterns are also related. As a result, experimental discoveries of such multiplets and confirmations of the predicted patterns will be invaluable to understanding the nature of these hadronic molecular states.

In the second approach, starting from some hadronic molecular candidates, one can derive the underlying hadron–hadron interactions. With these interactions, one can study related three-body systems and check whether three-body bound states/resonances exist. The existence of such three-body molecules can directly verify the molecular nature of exotic hadrons of interest.

In the third approach, one can turn to the femtoscopy technique to derive the hadron–hadron interactions, hence inaccessible. This technique provided an unprecedented opportunity to understand the interactions between unstable hadrons. Although the past focus was mainly on the light quark sector, we have seen increasing theoretical activities in the heavy quark sector in recent years. We review relevant studies and point out future directions where more effort is needed.

Author: GENG, Li-Sheng (Beihang University)

Presenter: GENG, Li-Sheng (Beihang University)

Session Classification: Afternoon

Contribution ID: **142** Type: **Seminar (invitees)**

Overview of (Brazilian) Lattice QCD

Friday 14 March 2025 10:00 (30 minutes)

The lattice formulation allows a first principles nonperturbative study of Yang-Mills theories (and, in particular, QCD) via statistical mechanics methods, at the price of a very high computational investment. Today, lattice simulations have become a key input in precision tests of standard model phenomenology, including the determination of the muon g-2 factor. At the same time, some lesser explored features of the simulations allow the investigation of fundamental properties of QCD, such as the mechanism behind color confinement. We briefly describe general aspects of the lattice formulation and present some unconventional ideas to investigate confinement from infrared propagators on the lattice.

Author: MENDES, Tereza

Presenter: MENDES, Tereza

Session Classification: Morning

Contribution ID: **143** Type: **Seminar (invitees)**

g-2 of the muon in the Standard Model: status and challenges

Monday 10 March 2025 15:30 (30 minutes)

The anomalous magnetic moment of the muon, or g-2, is now known experimentally with an astonishing precision of 0.19 parts per
million and final results from the g-2 experiment at Fermilab are
expected to be released in 2025. It is, therefore, crucial to
scrutinize the Standard Model (SM) determination of g-2 in order to
assess whether or not there is room for beyond-the-SM physics. The main issue is the hadronic vacuum polarization (HVP) contribution
which dominates the theory error. The SM g-2 result based on the HVP
contribution obtained using input from e+e- hadronic cross-section
data shows a larger-than-5-sigma tension with the experimental result,
while using new results for the HVP from lattice QCD the SM
determination of g-2 becomes compatible with experiment. Understanding
the discrepancies between experiment and theory, and between the
data-driven and lattice computations of the HVP contribution, are
critical tasks. In this talk, I will discuss the present status of g-2
in the SM and our recent data-driven computation of specific diagrams
contributing to the HVP in g-2, which provide new benchmarks for the
comparison with present and future lattice-QCD results. I will also
discuss the potential role of recent CMD-3 2pi cross-section data and
new sum rules introduced for scrutinizing the SM calculation of g-2,
comparing data-driven and lattice approaches.

Authors: BOITO, Diogo (Universidade de São Paulo); BOITO, Diogo

Presenter: BOITO, Diogo

Session Classification: Afternoon

Contribution ID: **144** Type: **Oral communications**

Finite Temperature Description of Fermi Gases with In-medium Effective Mass

Thursday 13 March 2025 15:45 (15 minutes)

We investigate Fermi gases at nite temperature for which the in-medium effective mass may not be constant as a function of the density, the temperature, or the chemical potential. We suggest a formalism that separates the terms for which the mass is constant from the terms that explicitly treat the correction due to the in-medium effective
mass. We employ the ensemble equivalence in in nite matter to treat these different terms. Our formalism is applied in nuclear matter and we show its goodness by comparing it to an exact treatment based on the numerical
calculation of the Fermi integrals.

Authors: MARGUERON, Jérôme (Institut de Physique Nucléaire de Lyon); DUTRA DA ROSA LOURENÇO, Mariana (Instituto Tecnológico de Aeronáutica); Prof. LOURENÇO, Odilon (Instituto Tecnológico de Aeronáutica)

Presenter: DUTRA DA ROSA LOURENÇO, Mariana (Instituto Tecnológico de Aeronáutica)

Session Classification: Oral communications

Contribution ID: **145** Type: **Seminar (invitees)**

Medium Separation Scheme and the Proper Description of Extreme Environments

Tuesday 11 March 2025 15:30 (30 minutes)

This talk explores the challenges of studying strongly interacting systems at finite density, with a focus on the effects of external magnetic fields. The Medium Separation Scheme (MSS) plays a key role in the proper separation of medium effects, avoiding misleading interpretations and ensuring reliable behavior of the physical quantities. Finally, possible approaches to applying MSS in the study of quarkyonic matter in the presence of a finite magnetic field are explored.

Authors: CRISTINE DUARTE, DYANA (Universidade Federal de Santa Maria); DUARTE, Dyana

Presenter: CRISTINE DUARTE, DYANA (Universidade Federal de Santa Maria)

Session Classification: Afternoon

Contribution ID: **146** Type: **Poster**

New Tool to Detect Inhomogeneous Chiral Symmetry Breaking

Wednesday 12 March 2025 18:04 (2 minutes)

The structure of the QCD phase diagram is a fundamental question in nuclear and particle physics. Recent works suggest the possibility of inhomogeneous phases, where key properties of quark matter such as the chiral condensate or number density adopt periodic spatial patterns. Although progress has been made in studying these phases within QCD-inspired models, direct analysis in full QCD remains challenging. In the past few years, we have adapted the standard technique of stability analysis to be used in QCD, via Dyson-Schwinger equations [PRD 110 (2024) 7, 074014]. However, in this talk, I will introduce a completely new method for stability analysis, which is based on an extension of the concept of chiral susceptibility to encompass inhomogeneous phases [arXiv:2411.02285]. As opposed to previous approaches, this method does not depend on any external input, providing a more conclusive analysis. I will demonstrate how this technique reproduces established results from the NJL model and present findings for QCD under a simple truncation.

Author: MOTTA, Theo (Justus Leibig University Gießen)

Presenter: MOTTA, Theo (Justus Leibig University Gießen)

Session Classification: Poster session

Contribution ID: **149** Type: **Lecture (invitees)**

The Structure of the Proton (Part 2)

Tuesday 11 March 2025 09:00 (1 hour)

In these set of lectures we review the modern tools used to compute the quark and gluon distributions within hadrons in general, and the proton in particular. We begin with a review of deep inelastic scattering, and factorization theorems. We then introduce the definitions of parton distribution functions (PDFs), generalized PDFs (GPDs), and transverse-momentum dependent PDFs (TMDPDFs), and how they can be compute from first principles.

Author: Dr STEFFENS, Fernanda (University of Bonn)

Presenter: Dr STEFFENS, Fernanda (University of Bonn)

Session Classification: Morning

Contribution ID: **150** Type: **Lecture (invitees)**

The Structure of the Proton (Part 3)

Wednesday 12 March 2025 09:00 (1 hour)

In these set of lectures we review the modern tools used to compute the quark and gluon distributions within hadrons in general, and the proton in particular. We begin with a review of deep inelastic scattering, and factorization theorems. We then introduce the definitions of parton distribution functions (PDFs), generalized PDFs (GPDs), and transverse-momentum dependent PDFs (TMDPDFs), and how they can be compute from first principles.

Author: Dr STEFFENS, Fernanda (University of Bonn)

Presenter: Dr STEFFENS, Fernanda (University of Bonn)

Session Classification: Morning

Contribution ID: **151** Type: **Lecture (invitees)**

Collective dynamics in Relativistic Heavy-ion Collisions (Part 2)

Tuesday 11 March 2025 11:30 (1 hour)

I will give a series lectures that covers the fundamentals and current frontier of studying the collective behavior of the Quark Gluon Plasma (QGP) produced in relativistic heavy-ion collisions.

Author: SHEN, Chun (Wayne State University)

Presenter: SHEN, Chun (Wayne State University)

Session Classification: Morning

Contribution ID: **152** Type: **Lecture (invitees)**

Collective dynamics in Relativistic Heavy-ion Collisions (Part 3)

Wednesday 12 March 2025 11:30 (1 hour)

I will give a series lectures that covers the fundamentals and current frontier of studying the collective behavior of the Quark Gluon Plasma (QGP) produced in relativistic heavy-ion collisions.

Author: SHEN, Chun (Wayne State University)

Presenter: SHEN, Chun (Wayne State University)

Session Classification: Morning

Contribution ID: **153** Type: **not specified**

Closing session

Presenter: GONCALVES, Victor

Session Classification: Morning

Contribution ID: **154** Type: **Lecture (invitees)**

Probing Extreme States of QCD Matter in Compact Stars (Part 2)

Tuesday 11 March 2025 14:30 (1 hour)

The QCD phase diagram still has various unsettled features predicted by theoretical efforts. Experimental data should eventually confirm possible states in extreme environments. Recently, promising data become available from the astrophysical observation of neutron stars. In this lecture, I will summarize expected extreme states at high baryon density and introduce useful constraints on those possibilities imposed by the astrophysical observation.

Author: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Presenter: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Session Classification: Afternoon

Contribution ID: **155** Type: **Lecture (invitees)**

Probing Extreme States of QCD Matter in Compact Stars (Part 3)

Thursday 13 March 2025 09:00 (1 hour)

The QCD phase diagram still has various unsettled features predicted by theoretical efforts. Experimental data should eventually confirm possible states in extreme environments. Recently, promising data become available from the astrophysical observation of neutron stars. In this lecture, I will summarize expected extreme states at high baryon density and introduce useful constraints on those possibilities imposed by the astrophysical observation.

Author: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Presenter: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Session Classification: Morning

Contribution ID: **156** Type: **Lecture (invitees)**

Three ways to decipher the nature of hadronic molecules (Part 2)

Thursday 13 March 2025 11:30 (1 hour)

In the past two decades, a plethora of hadronic states beyond the conventional quark model of qqbar mesons and qqq baryons have been observed experimentally, which motivated extensive studies to understand their nature and the non-perturbative strong interaction. Since most of these exotic states are located near the mass thresholds of pairs of conventional hadrons, the prevailing picture is that they are primarily hadronic molecules. In principle, one can verify the molecular nature of these states by thoroughly comparing their masses, decay widths, and production rates in a particular picture with experimental data. However, this is difficult or impossible. First, quantum mechanics allows for mixing configurations permitted by symmetries and quantum numbers. Second, data are relatively scarce because of their small production rates and the many difficulties in the experimental measurements. As a result, other alternatives need to be explored. In these three lectures, I introduce three approaches that can help disentangle the nature of the many exotic hadrons discovered.

In the first approach, based on the molecular interpretations for some exotic states, we study the likely existence of multiplets of hadronic molecules related by various symmetries, such as isospin symmetry, SU(3)-flavor symmetry, heavy quark spin/flavor symmetry, and heavy antiquark diquark symmetry, which are known to be approximately satisfied and can be employed to relate the underlying hadron–hadron interactions responsible for the formation of hadronic molecules. The masses of these multiplets of hadronic molecules can then be obtained by solving the Lippmann–Schwinger equation. Their decay and production patterns are also related. As a result, experimental discoveries of such multiplets and confirmations of the predicted patterns will be invaluable to understanding the nature of these hadronic molecular states.

In the second approach, starting from some hadronic molecular candidates, one can derive the underlying hadron–hadron interactions. With these interactions, one can study related three-body systems and check whether three-body bound states/resonances exist. The existence of such three-body molecules can directly verify the molecular nature of exotic hadrons of interest.

In the third approach, one can turn to the femtoscopy technique to derive the hadron–hadron interactions, hence inaccessible. This technique provided an unprecedented opportunity to understand the interactions between unstable hadrons. Although the past focus was mainly on the light quark sector, we have seen increasing theoretical activities in the heavy quark sector in recent years. We review relevant studies and point out future directions where more effort is needed.

Author: GENG, Li-Sheng (Beihang University)

Presenter: GENG, Li-Sheng (Beihang University)

Session Classification: Morning

Contribution ID: **157** Type: **Lecture (invitees)**

Three ways to decipher the nature of hadronic molecules (Part 3)

Friday 14 March 2025 09:00 (1 hour)

In the past two decades, a plethora of hadronic states beyond the conventional quark model of qqbar mesons and qqq baryons have been observed experimentally, which motivated extensive studies to understand their nature and the non-perturbative strong interaction. Since most of these exotic states are located near the mass thresholds of pairs of conventional hadrons, the prevailing picture is that they are primarily hadronic molecules. In principle, one can verify the molecular nature of these states by thoroughly comparing their masses, decay widths, and production rates in a particular picture with experimental data. However, this is difficult or impossible. First, quantum mechanics allows for mixing configurations permitted by symmetries and quantum numbers. Second, data are relatively scarce because of their small production rates and the many difficulties in the experimental measurements. As a result, other alternatives need to be explored. In these three lectures, I introduce three approaches that can help disentangle the nature of the many exotic hadrons discovered.

In the first approach, based on the molecular interpretations for some exotic states, we study the likely existence of multiplets of hadronic molecules related by various symmetries, such as isospin symmetry, SU(3)-flavor symmetry, heavy quark spin/flavor symmetry, and heavy antiquark diquark symmetry, which are known to be approximately satisfied and can be employed to relate the underlying hadron–hadron interactions responsible for the formation of hadronic molecules. The masses of these multiplets of hadronic molecules can then be obtained by solving the Lippmann–Schwinger equation. Their decay and production patterns are also related. As a result, experimental discoveries of such multiplets and confirmations of the predicted patterns will be invaluable to understanding the nature of these hadronic molecular states.

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In the third approach, one can turn to the femtoscopy technique to derive the hadron–hadron interactions, hence inaccessible. This technique provided an unprecedented opportunity to understand the interactions between unstable hadrons. Although the past focus was mainly on the light quark sector, we have seen increasing theoretical activities in the heavy quark sector in recent years. We review relevant studies and point out future directions where more effort is needed.

Author: GENG, Li-Sheng (Beihang University)

Presenter: GENG, Li-Sheng (Beihang University)

Session Classification: Morning

Contribution ID: **158** Type: **Poster**

The infrared-safe Minkowskian Curci-Ferrari model

Monday 10 March 2025 18:22 (2 minutes)

We discuss the existence of Landau-pole-free renormalization group trajectories in the Minkowskian version of the Curci-Ferrari model as a function of a running parameter q^2 associated to the four-vector q at which renormalization conditions are imposed, and which can take both spacelike (q^2 < 0) and timelike (q^2 > 0) values. We discuss two possible extensions of the infrared-safe scheme defined in a previous work for the Euclidean version of the model, which coincide with the latterin the space-like region upon identifying Q^2 ≡ −q^2 with the square of the renormalization scale in that reference. The first extension uses real-valued renormalization factors and leads to a flow in the timelike region with a similar structure as the flow in the spacelike region (or in the Euclidean model), including a non-trivial fixed point as well as a family of trajectories bounded at all scales by the value of the coupling at this fixed point. Interestingly, the fixed point in the timelike region has a much smaller value of λ ≡ g^2 N/16π^2 than the corresponding one in the spacelike region, a value close to the perturbative region λ ≤ 1. In this real-valued infrared-safe scheme, however, the flow cannot connect the timelike and spacelike regions. It is thus not possible to deduce what is the relevant timelike flow trajectory from the sole knowledge of a spacelike flow trajectory. To try to cure this problem, we investigate a second extension of the Euclidean IR-safe scheme which allows for complex-valued renormalization factors. We discuss under which conditions these schemes can make sense and study their ability to connect spacelike and timelike flow trajectories. In particular, we investigate to which types of timelike trajectories the perturbative spacelike trajectories are mapped into.

Author: Mr ORIBE, Santiago (Universidad de la República)

Presenter: Mr ORIBE, Santiago (Universidad de la República)

Session Classification: Poster session

Contribution ID: **159** Type: **not specified**

Tribute to Yogiro Hama

Authors: Prof. NAVARRA, Fernando (USP); GONCALVES, Victor

Presenters: Prof. NAVARRA, Fernando (USP); GONCALVES, Victor

Session Classification: Workshop

Contribution ID: **160** Type: **not specified**

Discussions

Author: GONCALVES, Victor

Presenter: GONCALVES, Victor

Session Classification: Workshop

Contribution ID: **161** Type: **Lecture (invitees)**

Tribute to Yogiro Hama

Thursday 13 March 2025 17:15 (15 minutes)

Author: Prof. NAVARRA, Fernando (USP)

Presenter: Prof. NAVARRA, Fernando (USP)

Contribution ID: **162** Type: **not specified**

Workshop dinner

Session Classification: Workshop

Contribution ID: **163** Type: **not specified**

Opening session

Presenter: GONCALVES, Victor

Session Classification: Morning

Contribution ID: **164** Type: **not specified**

Tribute to Kau Dalfovo Marquez

Thursday 13 March 2025 17:30 (15 minutes)

Presenter: MENEZES, Débora

Contribution ID: **165** Type: **not specified**

Mundo QCD, o que os quarks e glúons têm a ver comigo?

Friday 14 March 2025 14:00 (2 hours)

Nesta palestra, vamos conversar sobre a Física de Partículas, especialmente a Cromodinâmica Quântica ou QCD, que explica a força nuclear forte (que mantém os prótons ligados no núcleo atômico) como resultado da interação entre os quarks, através da troca de glúons. Venha conferir!

Presenter: MENDES, Tereza

Session Classification: Outreach

Contribution ID: **166** Type: **not specified**

Workshop Photo

Session Classification: Workshop

Contribution ID: **167** Type: **not specified**

Workshop Photo

Session Classification: Workshop