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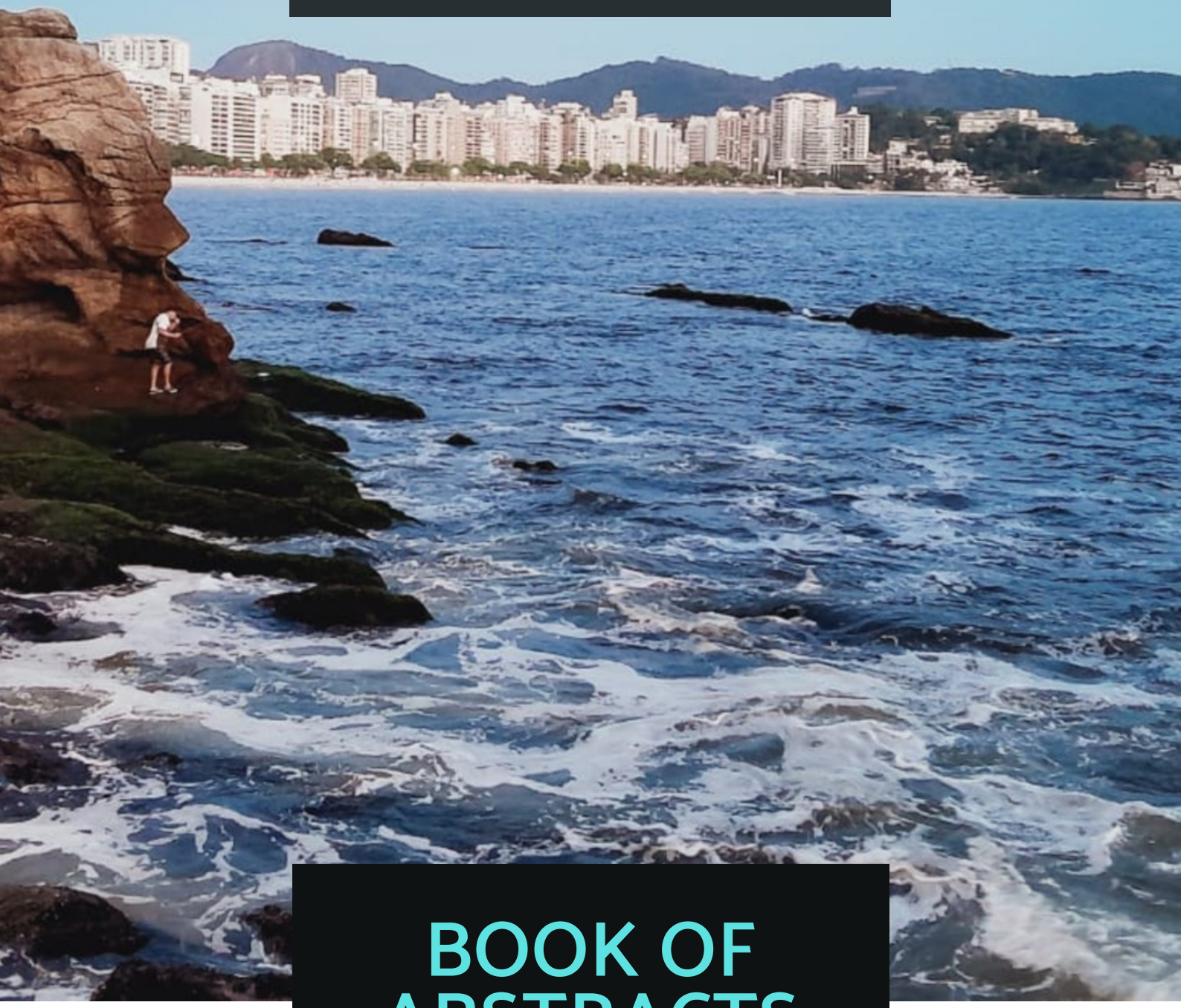
INSTITUTO NACIONAL DE CIÊNCIA E TECNOLOGIA
FÍSICA NUCLEAR E APLICAÇÕES

IV INCT-FNA SYMPOSIUM 2024



BOOK OF ABSTRACTS

INCT-FNA
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IV INCT-FNA SYMPOSIUM
APRIL, 23-26, 2024

PROC. NO. 464898/2014-5

PROJETO PROF. PAULO ROBERTO SILVEIRA GOMES
(1950 - 1916)

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Greetings from Niterói!

A warm welcome to the 4th edition of the INCT-FNA Symposium, set against the backdrop of the vibrant city of Niterói! This local event brings together researchers, professionals, and students, creating a unique space for the exchange of knowledge and ideas within our community.

As we gather for this symposium, we celebrate the diversity of research and the collaborative spirit that defines our local scientific community. The absence of a specific theme underscores the inclusive nature of this event, allowing for a wide-ranging exploration of topics and fostering a dynamic exchange of insights.

Within the pages of this book, you will find abstracts that offer a glimpse into the varied research projects that will be presented during the symposium. Each contribution reflects the passion and dedication of our local contributors, highlighting the richness of our shared intellectual pursuits.

Our sincere thanks go out to everyone who has played a role in bringing this symposium to fruition. Your commitment to the advancement of knowledge within our community is truly commendable.

May the 4th INCT-FNA Symposium be a source of inspiration and collaboration for all participants, fostering connections and discussions that contribute to the ongoing growth of our local research landscape.

Welcome to Niterói, and welcome to a symposium that embraces the diversity of our collective intellectual journey.

Best Regards,

The Committee

CNPq

Universidade Federal Fluminense

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PROGRAM

IV INCT-FNA Symposium				
	23/04 – Tuesday	24/04 – Wednesday	25/04 – Thursday	26/04 – Friday
08:00 - 09:00	Registration			
09:00 – 09:50	Tiago Fiorini chair: Lucas Sigaud	Andreas Karydas chair: Carlos R. Appoloni	Maria Zucchi chair: Dyana Duarte	Tobias Frederico chair: Emmanuel de Oliveira
09:50 – 10:40	Tereza Mendes chair: Lucas Sigaud	Kelly Pires chair: Carlos R. Appoloni	Leonid Glozman chair: Dyana Duarte	Sidney Avancini chair: Emmanuel de Oliveira
10:40 – 11:10	Coffee - Break			
11:10 – 12:00	Valdir Guimarães chair: Jeannie Rangel	Jun Takahashi chair: Gabriel Denicol	Carla Carvalho chair: Fabiana Monteiro	Alessia di Pietro chair: Vinicius Zagatto
12:00 – 14:00	Lunch			
14:00 – 14:20	Parallel sessions	Giorgio Torrieri chair: Roberto Linares	Free Afternoon	Cristian Villavicencio chair: Lucas Sigaud
14:20 – 14:40		Leandro Gasques chair: Roberto Linares		José Roberto Oliveira chair: Lucas Sigaud
14:40 – 15:00		Avacir Andrello chair: Roberto Linares		Manfredo Tabacniks chair: Lucas Sigaud
15:00 – 15:20		Débora Menezes chair: Roberto Linares		Fabio Braghin chair: Lucas Sigaud
15:20– 15:50	Coffee - Break			Closure session
15:50– 17:30	Parallel sessions	Poster Session		

	Parallel sessions		
	Applied Physics (Institute of Computing)	Hadrons & High Energy (Paulo Gomes Auditorium)	Reactions & Strucuture (AGIR Auditorium)
14:00 – 14:20	Fábio Nóbrega chair: Fabiana Monteiro	Ricardo Sonego Farias chair: Gabriel Denicol	Jonas Ferreira chair: Kelly Pires
14:20 – 14:40	Bruna Netto chair: Fabiana Monteiro	Adamu Issifu chair: Gabriel Denicol	Uiran Silva chair: Kelly Pires
14:40 – 15:00	Marcia Rizzutto chair: Fabiana Monteiro	Maurício Hippert Teixeira chair: Gabriel Denicol	Juan Pablo García chair: Kelly Pires
15:00 – 15:20	Edher Herrera chair: Fabiana Monteiro	Willian Serenone chair: Gabriel Denicol	Andrés Arazi chair: Kelly Pires
15:20– 15:50	Coffee - Break		
15:50 – 16:10	João Marcos Lopes chair: Fábio Melquiades	Patrícia Magalhães chair: Dyana Duarte	Arturo Samana chair: Jeannie Rangel
16:10 – 16:30	Renata Jou chair: Fábio Melquiades	Andre Nepomuceno chair: Dyana Duarte	Olorunfunmi Sunday chair: Jeannie Rangel
16:30 – 16:50	Felipe Santos chair: Fábio Melquiades	Kauan Marquez chair: Dyana Duarte	Barbara Paes chair: Jeannie Rangel
16:50 – 17:10	Kita Macario chair: Fábio Melquiades	Joao Pacheco Melo chair: Dyana Duarte	Erica Cardoso chair: Jeannie Rangel
17:10 – 17:30	Cheila Sumenssi chair: Fábio Melquiades	William Tavares chair: Dyana Duarte	Valdir Scarduelli chair: Jeannie Rangel

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LECTURE

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Expanding applications of machine learning in ion beam analysis

Tiago F. Silva

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We are surrounded by systems employing machine learning algorithms with various purposes, from tailored advertisements based on our experience online to massive information processing for complex text composition.

The reason is that machine learning systems can identify patterns, make accurate predictions, and automate repetitive tasks by leveraging vast amounts of data. This technology enables optimizing processes, streamlining workflows, and reducing human error, ultimately enhancing efficiency. Machine learning can extract valuable insights, make data-driven decisions, and improve overall productivity, making it a vital tool in today's rapidly evolving science.

However, its uses in ion beam analysis still need improvement. One concept spread in the community is the multi-objective optimization applied in data fusion of different ion beam techniques [1,2]. Furthermore, some other works of a few groups show great potential, but artificial intelligence is mainly restricted to simple artificial neural network models to fit experimental data [3–5].

We apply different techniques in our lab to process our data qualitatively and quantitatively. We succeed in implementing unsupervised machine learning algorithms to feature extraction in semi-automatic processing of wide-field PIXE mapping [6], with the advantage of enabling the disentanglement of pigment composition even in mixtures or layered structures. The algorithm extracts meaningful insights easily overlooked in the conventional data processing.

We also used convolutional neural networks to process tomographic data to obtain information on laterally inhomogeneous samples [7]. Even with the most sophisticated simulation software available, this task is arduous for a human but simple to the algorithm.

Additionally, we use generative models to replace computationally demanding simulations in uncertainty determination procedures [8]. Instead of focusing solely on predicting outcomes or classifying data, generative models seek to learn the underlying patterns and structure of the data, enabling them to create new instances similar to the training examples.

Our last development focuses on increasing the interpretability of neural network predictions when analyzing experimental data [9]. With our method, we can figure out what regions in the spectra contribute the most to the results by the neural network. Methods like this are vital in a material analysis laboratory, mainly if some uncertainty traceability is requested.

In this presentation, we will summarize our experience on the subject and demonstrate what kind of benefits we may have by embracing this technology.

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[8] To be published.

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Overview of (Brazilian) Lattice QCD

Tereza Mendes
Instituto de Física de São Carlos, Universidade de São Paulo

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 describe general aspects of the lattice formulation and current trends in the field. We also present some unconventional ideas to investigate confinement from infrared propagators on the lattice.

Investigation of cluster structure in light nuclei using elastic and resonant scattering.

Valdir Guimarães
Instituto de Física da Universidade de São Paulo

Cluster structures in weakly bound light nuclei have been of great interest in the investigation of nuclear structure and reactions, as well as in nuclear astrophysics. Such halo or cluster states often appear near the boundaries of nuclear stability and can be considered as OQS (Open Quantum Systems). Some of these light nuclei (proton or neutron rich) can exhibit exotic configurations such as halo or Borromean structures, where the weakly-bound valence particles orbit a core. The strong synergy between reaction mechanisms and structure has helped us in the investigations of these configurations. In elastic scattering, the correlations of the valence particles and the strong coupling with the continuum can significantly affect the angular distributions. By its turn resonant scattering can be used to obtain information on the total spins of the resonances. In this talk I will present a discussion on the static and dynamic effects, due to cluster configuration, on the angular distributions for the elastic scattering of proton-rich nuclei such as $^{10}C+^{208}Pb$ and $^{12}N+^{197}Au$. I will also present some results on resonant scattering of ^{10}B and $^{11}B+p$ for the investigation of the cluster structure of the corresponding compound nucleus, ^{11}C and ^{12}C. I will also present the scientific program being developed by the NEAN (Exotic Nuclei and Nuclear Astrophysics) group related to cluster investigations in light nuclei.

Visualizing the dissipated polychromy of Greek Antiquities using MA-XRF imaging

Andreas G. Karydas[1, 2]

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[2]*CNR, Istituto di Scienze del Patrimonio culturale (ISPC), Via Biblioteca 4, 95124, Catania, Italy*

Abstract

Macroscopic X-ray Fluorescence imaging (MA-XRF) has emerged during the last decade as an indispensable analytical tool for the non-invasive elemental imaging of historical and/or contemporary paintings. The ability of the technique to allow for simultaneous mapping of different chemical elements on a large-dimension pictorial surface offers- through the produced elemental images- an immediate visual impression of how the different elements are distributed in close conjunction with the iconographic elements, thus, unravelling their possible associations. In this way, a more comprehensive interpretation can be achieved regarding the nature of materials employed and their application techniques, the technological and artistic choices, aesthetics, the artists' skills and likely overpainting. To date, the application of MA-XRF on archaeological artefacts is rather limited, since ancient polychromy is either poorly preserved or has entirely vanished [1].

In the present contribution, recent developments and results from the first applications of MAXRF imaging on Greek antiquities will be presented and discussed. All the measurements have been carried out in-situ, at different Greek museums and archaeological sites, using real-time technology optimized MA-XRF spectrometers developed by ISPC-CNR and INFN-LNS in Catania, Italy [2] and a modular one developed by the XRF laboratory of NCSR "Demokritos" in Greece. The obtained results have demonstrated undoubtedly the enhanced capabilities of the MA-XRF technique to analyze archaeological materials quite different in nature (gold alloy/pigments) or those composed of the same materials (pigments) on different substrate media and highlight the perspectives and future contribution of this groundbreaking technique to archaeological research and History of Art [3, 4].

References

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An overview of exotic nuclei studies using the "Radioactive Ion Beams in Brasil" (RIBRAS) facility.

K. C. C. Pires, R. Lichtenthäler Filho, A. Lépine-Szily, O. C. B. dos Santos,
U. Umbelino, A. S. Serra, B. P. Monteiro, H. F. G. Arruda,
D. A. Santana, F. R. Loureiro and RIBRAS Collaboration

Departamento de Física Nuclear, Instituto de Física,
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Abstract

Investigations of nuclear reactions involving nuclei out of the stability valley is one of the most interesting areas in low-energy nuclear physics today. The RIBRAS facility is in operation since 2004 at the "Open Laboratory for Nuclear Physics and Applications" (LAFNA), which is the sole laboratory in Brazil dedicated to research in nuclear physics, covering both fundamental and applied aspects. The RIBRAS system consists of two superconducting solenoids with a maximum magnetic field of B=6.5 T, coupled to the 8UD-Pelletron tandem Accelerator installed at the Institute of Physics of the University of São Paulo (IFUSP), Brazil [1, 2, 3, 4]. The production mechanism of the radioactive ions is by transfer reactions, using ^{9}Be, ^{3}He, LiF, and other production targets. Particles of interest arising from the production reaction are selected and focused by solenoids into a scattering chamber. RIBRAS delivers light radioactive ion beams of ^{6}He, ^{8}Li, ^{7,10}Be, ^{8,12}B, with intensities ranging from 10^4 to 10^6 pps, which were used to study elastic, inelastic, and transfer reactions on a variety of light (^{9}Be, ^{12}C) medium (^{27}Al, ^{51}V, ^{58}Ni) and heavy (^{nat}Zr, ^{120}Sn) secondary targets. In all cases, the measured cross sections have shown good agreement with sophisticated theoretical calculations. Furthermore, we have identified a substantial production of alpha particles during collisions induced by the neutron-rich ^{6}He with several targets at low energies. These alpha particles can originate from the breakup of the ^{6}He nucleus in the presence of the target nucleus, as well as from transfer reactions. A review of the research program carried out along the last years using the RIBRAS facility will be presented.

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Nuclear collisions in high energies, overview and future perspectives

Jun Takahashi

Unicamp

Through the collision of nuclei in relativistic energies we study the behavior of matter under extreme conditions. More than 20 year ago, when collisions of the Relativistic Heavy Ion Collider (RHIC) started, we were searching for evidence that nuclear matter would undergo a phase transition from the color confined hadronic state to a deconfinned new state of matter called the Quark Gluon Plasma (QGP). At almost exactly 20 years, the four RHIC experiments released a set of white papers compiling all the data measured then demonstrating without a doubt that indeed the QGP was formed and that despite the complexity of the many phases involved in such collisions signatures of the QGP were confirmed in the data. Since then, we have shifted from discovery mode to a precision physics mode, and today we have a much better understanding of the different phases in the collision. Moreover, many new experimental observables have been proposed and measured, connecting the different physics processes with the measured data. New and unexpected results have also been observed, that requires new ideas and new approaches to the models we use. In this talk, we will discuss some of the current interests and developments, with a special focus on the contributions from Brazilian groups and also discuss future perspectives.

"Status Report of Carbon-14 Sample Preparation Laboratory (LAPAC-UFBA) in Collaboration with the Carbon-14 Laboratory (LAC-UFF)"

Maria do Rosário Zucchi - UFBA

This presentation shows the first results of sample preparation and graphite produced for carbon-14 dating at UFBA in and ours collaboration with LAC-UFF using the technique of Accelerator Mass Spectrometry (AMS). This technique should be applied in paleoenvironmental, archaeological studies, etc. In order to verify the no-contamination process, initially, swipe samples were collected at UFBA and the graphites were produced at LAC-UFF. Several reference materials (C1, C2, C6, C9, and OXII standards) were prepared and converted into graphite and partially prepared at UFF and UFBA were analyzed in the AMS system at LAC-UFF. Replicas were made for measurements of $\delta^{13}C$ in the Elementary Analyzer coupled to the Isotope Ratio Mass Spectrometer (EA-IRMS) in the LFNA-UFBA to study the isotopic fractionation and yield of the graphitization reaction. Regarding the errors associated with the measurements, the relative discrepancy and the relative deviation were less than one percent. Several sample matrices will be prepared at LAPAC-UFBA, focusing particularly on dissolved inorganic carbon in groundwater and organic matter in sediments.

Symmetries and QCD phase diagram

Leonid Glozman – University of Graz

I will introduce new symmetry of electrodynamics and of quantum chromodynamics, called chiral spin symmetry, which is a symmetry of the electric (confining) part of the theory. This symmetry allows one to distinguish regimes and phases of QCD. Then I will discuss three regimes of QCD upon heating in the real world N_c=3 and with small but nonzero quark mass, that are separated by smooth crossovers: hadron gas at low temperatures, stringy fluid at RHIC and LHC temperatures and quark-gluon plasma at very high temperatures. In the large Nc world and with vanishing quark masses these three regimes become distinct phases separated by phase transitions.

LAC-UFF - The first radiocarbon laboratory installed in Latin America: History and Status Report

Carla Carvalho, Kita Macario & Fabiana Oliveira
Radiocarbon Laboratory - Fluminense Federal University

Since the 1970s, when the 14C-AMS technique was established, many facilities were installed, especially in Europe and in the US. The first sample preparation laboratory for 14C-AMS analysis in Latin America was installed only in 2009. Sample preparation is one of the critical steps in the 14C-AMS technique. The procedures aim to isolate the pristine carbon from the time/context until carbon exchanges in the system cease. Methods for sample preparation strongly depend on the sample matrix and can vary among different laboratories. The LAC-UFF, Radiocarbon Laboratory of UFF, became a complete facility in 2012 with the installation of a 250 kV SSAMS system built by the NEC Corporation. Since then, the laboratory became a reference center and thousands of samples of several kinds have been both prepared and measured, mostly through collaborative scientific research. Over the years we have applied pretreatment protocols for a variety of materials received on a national research scale. Intending to expand the range of materials to be analyzed, we established new protocols. LAC-UFF main research fields are Brazilian archaeology, the 14C marine reservoir effect, palaeovegetation, and climate change. We have also worked with biopolymers, anthropic contamination, and historical objects. A status report on the scientific interdisciplinary research, technical development of pretreatments, graphitization, and the SSAMS system will be presented.

Few-body physics: hadrons, CP violation, halo nuclei and cold atoms.

Tobias Frederico

Instituto Tecnológico de Aeronáutica, São José dos Campos, Brazil

I will review the application of few-body methods to explore the structure of light hadrons in Minkowski space, the effect of final state interaction in CP violation of heavy meson decays, the structure of light nuclei two-neutron halo and beyond, and the discrete and continuous scaling symmetry in few-atom systems. Future prospects of research in these problems will be also discussed.

Matter under extreme external electromagnetic fields

Sidney S Avancini - Depto deFísica - UFSC

We discuss recent developments aiming to understand the matter under extreme electromagnetic fields. In non-central relativistic heavy ions collisions, huge electromagnetic fields are expected to be generated due to the motion of the charged spectator particles. Also, in a certain class of neutron stars named magnetars, very strong magnetic fields are present, and interesting phenomena are possibly related to the existence of these fields, for instance, the very slow spin of these objects. In this talk, emphasis will be given to the use of effective models, which incorporate the basic symmetries and properties of the fundamental theory of hadrons, the quantum chromodynamics, (QCD), and are appropriate for the description of the QCD phase diagram in both the non-perturbative and the perturbative regime and, specially, are computationally viable.

Interplay between reaction dynamics and nuclear structure of light exotic beams

Alessia Di Pietro

INFN-Laboratori Nazionali del Sud

The region of the nuclear chart corresponding to light radioactive nuclei has, over the years, yielded many surprising results, among others the discovery of the halo structure in neutron and proton dripline nuclei. This region of the nuclear chart is also rich of many other phenomena like the appearance of molecular-like structures where }particle-clusters are bound together by the exchange of neutrons or the existence of cluster configurations where at least one of the clusters is a weakly bound nucleus.

The availability of post-accelerated radioactive ion beams has opened the opportunity to study nuclear structure and reactions of such peculiar nuclei. Moreover, to be able to describe the physics observables extracted from experiments, state-of-the-art theory has to be used to advance our understanding of the nuclear structure and reaction dynamics. In this talk an overview of some of the new phenomena involving light exotic RIBs will be given and future perspectives discussed.

VIth Topical Workshop on Modern Aspects in Nuclear Structure
The Many Facets of Nuclear Structure
BORMIO 6-11 February 2023

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Investigating anisotropic neutron stars with non-linear walecka models

Fábio Köpp[1] (fabiokopp@proton.me), Marcelo Alloy[2] (marcelo.alloy@ufsc.br)
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We utilize two key observations, specifically the mass-radius (mxr) relations derived from NICER, to impose constraints on the anisotropy parameter for each investigated model. The anisotropic pressure models under consideration include those proposed by Bowers and Liang (BL), Horvat (H), and Cosenza (C). The anisotropic pressure may arise from factors such as magnetic fields, turbulence, convection, and phase transitions.

Our focus centers on equations of state (EoS) incorporating hyperons, featuring phase transitions. This interest stems from the fact that such EoS typically fail to reach the two solar masses required by NICER measurements. Additionally, the physically plausible solutions derived from the three anisotropy models yield a stellar sequence capable of supporting significant higher solar mass than the isotropic stars.

We argue against assigning large values to the anisotropic parameters, as recent EoSs without hyperons align with NICER observations. To explore this further, we select two parametrizations for the Non-linear Walecka Model (NLWM), known as el3_omega_rho and nl3_omega_rho. These parametrizations account for recent the astrophysical observations as well the incorporation of current measurements of symmetry energy and its slope.

A HIPÓTESE DE BIOINVASÃO DO MOLUSCO *PERNA PERNA* NO BRASIL

Netto, B.M[1,2]; Macario, K.D.[1,2]; Alves, E.Q.[1,2]; Carvalho, C.[1,2]; Silva, E.P.[3]; Souza, R.C.C.L.[3]; Aguilera, O.[2]; Lima, T.A.[4];Fernandes, F.C.[5]; Duarte, M.R.[3]

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RESUMO: Em estudos de ambientes antigos e da ocupação humana, técnicas de cronologia são fundamentais. Uma delas é a datação por carbono 14 associada à espectrometria de massa com aceleradores (AMS), que permite datar eventos que tenham ocorrido até cinquenta mil anos atrás. Utilizando essa técnica, muitos estudos de paleoambiente ao longo do Holoceno, período de importante ocupação humana da costa brasileira, vêm sendo executados. Dentre os muitos locais de estudo, um tipo de sítio arqueológico que merece destaque são os sambaquis, formações encontradas em diversos locais do mundo e que foram deixados na costa brasileira por povos que viveram aqui antes da chegada dos portugueses. Nos sambaquis estão vestígios arqueológicos como carvões, artefatos do cotidiano do povo e ossos humanos e de animais. Entretanto, o principal vestígio são as conchas, marinhas e terrestres, que ajudam a compreender a cultura e os hábitos do povo, e a dieta que ele seguia, além de representarem parte da diversidade biológica do local naquele contexto. Por serem patrimônio arqueológico, os sambaquis são protegidos por lei federal, e é feito um registro do que foi encontrado em cada um deles. O molusco *Perna perna* (Linnaeus, 1758), bivalve com grande destaque econômico e alimentício, conhecido por ter hábito de invasor biológico, tem sua presença sendo amplamente discutida nos sambaquis brasileiros. Um levantamento dos vestígios dos sítios brasileiros mostra que nas poucas vezes em que ele é encontrado, está em camadas superiores, mais recentes que a ocupação sambaquieira, e na maior parte dos sítios ele nem chega a ser citado. Essas informações, juntamente com o enorme número de registros arqueológicos de *Perna perna* em países da África, corroboram uma hipótese de bioinvasão, que pode ter ocorrido durante o tráfego negreiro durante a colonização do Brasil, quando a espécie pode ter chegado ao país incrustrada nos navios. O presente trabalho tem por objetivo trazer resultados de datações por ^{14}C para o Sambaqui de Saquarema, sítio da Região dos Lagos do Rio de Janeiro, um dos poucos onde *Perna perna* foi encontrado. Além disso, revisitamos um trabalho que indica a espécie como nativa do Brasil, apontamos o erro cometido e mostramos, mais uma vez, um caso de indivíduo bioinvasor.

PALAVRAS-CHAVE: Sambaqui, Cronologia, Bioinvasor.

Avanços tecnológicos na área de Ciência do Patrimônio: Inovações instrumentais e uso de muti-técnicas

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Resumo

Novos instrumentos e estudos com uso de muti-técnicas, tem crescido nos últimos anos para estudo e caracterização de objetos do patrimônio histórico-cultural.

A motivação de uso de várias técnicas analíticas é para melhor compreender os materiais dos objetos do patrimônio cultural e os processos criativos dos artistas e assim contribuir para as discussões relacionadas a preservação e conservação destes objetos. Dentro destes objetivos será apresentado o novo Centro de Ciência do Patrimônio que está sendo construído no Museu de Arte Contemporânea. Este centro contará com o primeiro laboratório do Brasil com multi facilidades analíticas dentro de um museu.

A equipe que esta envolvida neste projeto é composta por diferentes profissionais de diferentes áreas como Física, Engenharia, História, História da Arte, Museologia, Conservadores e Restauradores, etc.

Vários objetos com diferentes suportes poderão ser analisados tanto com técnicas de imageamento com espectroscópicas que pode fornecer informações importantes tanto do processo criativo dos artistas como dos materiais existentes.

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Paleometry: Physicochemical Characterization of Fossil Remains from Paraguay

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Abstract:

The studies conducted on the fossil remains collected in Neuland and Colonia Paratodo, Chaco Paraguayo, involved detailed analysis using various analytical techniques such as Energy-Dispersive X-ray Fluorescence Spectrometry (EDXRF), Infrared (IR) and Raman Spectroscopy, and X-ray Diffraction (XRD). These techniques have been crucial in identifying and quantifying the elements present in the original material, as well as obtaining vibrational responses and mineralogical data. The results have enabled a correlation to be established between the mineralogical and chemical characteristics of the samples and the geological environment of the deposit, providing essential insights into the potential diagenetic processes that have affected the preservation of these fossil remains.

Keywords: Fossil, EDXRF, IR and Raman Spectroscopies, XRD, Diagenetic.

Spectral Deconvolution Approach for Beryllium-7 Detection: Evaluating Soil Redistribution with NaI(Tl) Detectors

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Beryllium-7 is a cosmogenic radionuclide produced in the upper atmosphere through the spallation of cosmic rays and falls to Earth mainly by wet deposition. Given its short half-life (53 days) and strong adsorption to the clay present in soil, ^{7}Be inventory may be evaluated to obtain information about soil redistribution for periods of up to 6 months. By performing these measurements, one may infer about the employed soil management and conservation procedures efficiency. The isotope presence is measured by performing Gamma-Rays Spectrometry to detect its decay emission, a photon with energy of 477 keV. Since other isotopes found in soil emits photons with similar energies, it is common to perform such measurements using High Purity Germanium Detectors (HPGe) due to its energy resolution. Although reliable, this kind of detector is expensive and demands cryogenic cooling while being operated. A different type of detector that does not require cryogenic cooling and has a lower cost, but has a poorer resolution, is Thallium Activated Sodium Iodide (NaI(Tl)) detectors. Particularly, the detector is unable to separate the emission from ^{228}Ac (436 keV), ^{7}Be and ^{208}Tl (509 keV). This work aims to apply spectral deconvolution to quantify ^{7}Be in soil samples collected in an agricultural mega-parcel situated on a hill slope and evaluate the soil redistribution experienced within. The activities of the interfering isotopes were quantified using other emissions and the results were employed to calculate the corresponding area in the desired region of the spectra. From this, ^{7}Be activities were calculated and compared with the HPGe results to validate the deconvolution technique applied. The calculated activities for the three radioisotopes showed similar correspondence between the two detectors, which shows that the applied method is adequate to evaluate soil redistribution at lower costs. The calculated changes in inventory showed no significant redistribution during the current rotation. Moreover, these results suggest that similar treatment can be applied to quantify other isotopes using NaI(Tl) detectors as an alternative for HPGe detectors.

METHODOLOGY TESTS USING AMAZONIAN SOIL SAMPLES FOR 14C-AMS DATING AT LAC-UFF

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Abstract:

Although ^{14}C-AMS (Accelerator Mass Spectrometry) is an important tool for the establishment of soil chronology, its application is challenging due to the complex nature of soil samples. In the present study, chemical extraction methodologies were tested to obtain the most representative age of Amazonian soil deposition by ^{14}C-AMS. We performed acid hydrolysis with different numbers of extractions, as well as treatments combining acid and bases and quartered and non-quartered samples. The ages of the SOM fractions were compared to the ages of naturally buried charcoal samples at similar depths. The results show that the age of the non-hydrolyzable inert fraction of soil was closer to the age of charcoal and older than the ages of humin. It was also observed that the quartering process can influence the results, since the dating of the humin fraction showed variability in the results. Our results are important to provide information about the most suitable method for the ^{14}C-AMS dating of soil samples for paleoenvironment reconstruction studies.

Soybean protein determination using X-ray fluorescence: optimization of instrumental conditions

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Abstract

X-ray fluorescence (XRF) is an analytical method that enables environmentally friendly analysis of a wide element variety with minimal or no sample preparation and low operating costs. Traditionally, XRF is used for qualitative and quantitative analysis of elements from Mg to U in several types of samples. In more recent decades, numerous studies have demonstrated that XRF data correlate well with other parameters, such as sugar cane quality parameters (i.e., sucrose and fiber content) [1]; sucrose content and fixed acidity of juices [2]; paint thickness [3]; soil fertility attributes [4]; H, C, and N in different matrices [5], among others. A study conducted by Camargo et al. (2023) developed a logistic regression model using XRF spectra for classifying soybean as high- or low-protein [6]. They found that S Kα was the main variable responsible for soybean sorting based on protein content. The relationship between protein content and the sulfur should be related to the presence of the element in the structure of cysteine and methionine amino acids. It is important to mention that similar reasoning is used in the traditional Kjeldahl and Dumas methods, which estimate the concentration of protein based on the total N content. However, these techniques are time-consuming, require hazardous and costly chemical reagents, and do not comply with green chemistry practices. In light of the previous work, the present study aimed to answer the following questions: (i) Is it possible to determine soybean protein content using XRF spectra? (ii) what is the best XRF instrumental condition to obtain accurate prediction? One hundred and twenty-five soybean samples of different cultivars and locations were used in this study. The grains were ground into flour using a coffee grinder and the protein content was determined by Dumas method. About 4 g of flour soybean samples were measured in a portable XRF spectrometer (Bruker AXS, Madison, WI, USA). This spectrometer has an Rh X-ray tube and an X-Flash® Peltier-cooled Silicon Drift Detector. Three operation conditions were tested: (i) 15 kV and 55 μA; (ii) 35 kV and 7 μA; and (iii) 40 kV and 30 μA. Three scenarios of dwell time for each operation condition were evaluated: (i) 10 s; (ii) 30 s; and (iii) 60 s. The partial least square (PLS) method was employed to build the prediction models using XRF spectral data as explanatory variables (**X**) and protein content determined by the conventional method as predictor variables (**y**). For that, the dataset was divided into calibration (88 samples) and prediction (37 samples) subsets following the Kennard-Stone algorithm. The square correlation coefficients (r^2) of prediction ranged from 0.73 to 0.82 and the root mean square error of prediction (RMSEP) ranged from 1.24 % a 1.04 %, indicating that the instrumental condition had no significant influence on the protein content prediction. The best condition was 35 kV and 7 μA with 30 s of dwell time (r^2 = 0.82 and RMSEP = 1.04%). Using this model, the recovery of the validation dataset ranged from 95 % to 105 %, demonstrating the feasibility of determining soybean protein content using XRF spectral data. Finally, the findings of this research open doors for further investigations, creating the possibility of developing a rapid, cost-effective, and environmentally friendly method for the evaluation of soybean protein content.

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Study of ceramics sherds from the Ventarrón-Collud archaeological complex - Lambayeque, Peru by EDXRF, XRD, FTIR and exploratory multivariate analysis

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Abstract

The archaeological ceramic fragments studied in this work come from the Ventarrón-Collud archaeological complex, located in the Lambayeque region, at the North Coast of the Central Andes – Peru. This archaeological complex is an area marked by the presence of an extensive set of archaeological material, whose temporal depth is greater than 4000 years, in addition to being a region susceptible to ENSOs (El Niño Southern Oscillation). This scenario challenges archeology due to the breadth of the temporal scale, requiring an archaeometric analysis to better understand the social dynamics of this place. Therefore, the possibility of obtaining specific information from these artifacts is extremely important for understanding complex organizational systems on the Peruvian North Coast. The analyzed set was composed of 193 ceramic shards from four archaeological sites: Zarpán, Collud, Arenal and Huaca Ventarrón. The ceramic fragments were analyzed by Energy Dispersive X-ray Fluorescence (EDXRF) with the aid of multivariate statistical analysis (PCA and HCA), X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and photomicrographs using a digital microscope to carry out petrographic analysis. PCA and HCA analyzes were performed with ceramic paste data from the fragment obtained with EDXRF. The results shows that the ceramic fragments from the four archaeological sites are statistically similar to each other, which indicates that over the years similar clay sources were used to manufacture the ceramics. Based on the PCA data, a selection of samples was made to perform the XRD and FTIR techniques due to the need to remove a small quantity of powder from the ceramic fragment paste. Both XRD and FTIR techniques provide information on mineralogical composition, burning temperature and burning atmosphere. Photomicrographs, XRD and FTIR results indicated the presence of hematite, orthoclase, anorthite and quartz. The hematite confirms the oxidizing atmosphere adopted by the artisans during the firing of the ceramics and the anorthite indicates that the temperature range reached by this stage was approximately 850ºC. Using the FTIR technique, traces of calcite were found in some samples, which indicates the use of calcareous clay as raw material.

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14C-AMS applications: Science and Society

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Applied Nuclear Physics is a transdisciplinary approach where concepts and/or instrumentation borrowed from Nuclear Physics are the main tools to disclose important aspects of several other disciplines. Many of such disciplines are directedly connected to the Society, either by cultural and historical aspects or by being part of everyday life, affecting economy, politics and the environment. In such context, among the many applications of Nuclear Physics, the Radiocarbon Accelerator Mass Spectrometry Technique (14C-AMS) stands out for the wide range of disciplines it can influence, most of them impacting society in some way. Encompassing forensic studies, cultural heritage protection, global climate changes, as well as the development and certification of renewable materials such as biomedicines, bioplastics and biofuels, a wide range of research fields can benefit from the study of carbon isotopes, especially radiocarbon. Here I focus on examples of use of radiocarbon that are directedly related to society, where knowledge of its concepts can help stopping art traffic, expanding green fuel sources or avoiding the destruction of heritage of humankind. By highlighting these diverse applications of 14C-AMS, I aim to stress the role of applied physics in addressing societal challenges and advancing knowledge across interdisciplinary boundaries. Through science dissemination and outreach efforts, we can bridge the gap between academic research and public awareness, fostering informed decision-making and collective action for a sustainable future.

The speed of sound peak of isospin-asymmetric QCD

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The main quantity to obtain a better understanding of equilibrium Quantum Chromodynamics QCD is the equation of state (EOS), that provides the relationship between thermodynamic quantities. A quantity related to EoS that has attracted a lot of attention nowadays, specially at finite density, is the speed of sound (C_s). Recent first principles calculations implemented in recent lattice QCD simulations for isospin imbalanced strongly interacting matter, show for the first time a violation of the conformal limit ($C_s^2 > 1/3$) which is a general limit expected from holography.

This non-monotonic behavior of the speed of sound, found by recent lattice QCD simulations, can be reproduced within the Nambu-Jona-Lasinio model and Linear Sigma Model with quarks when the couplings become isospin chemical potential-dependent. The introduction of medium-dependent couplings can potentially affect the equivalence between the thermodynamic relations and their definitions from statistical mechanics. We describe the procedure to compensate for the introduction of medium-dependent couplings to preserve the correct thermodynamic identities. We find the isospin chemical potential dependence for the couplings from the isospin density LQCD data and, after finding the compensating function to correctly describe the pressure, we show that the description of the square of the speed of sound reported by LQCD is well reproduced when using the found medium-dependent couplings in both effective models.

Hot quark matter and binary merger remnants

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I. ABSTRACT

This paper investigates hot quark matter under thermodynamic conditions characteristic of a binary neutron star (BNS) merger remnants from the nuclear microscopic equation of state (EoS). We use the density-dependent quark mass model (DDQM) and investigate a strange quark matter (SQM) at finite temperature and entropy in the presence of electrons and muons and their neutrinos to simulate the BNS merger conditions. We observe that as the entropy of the SQM increases, the merger remnant becomes more massive, and increases in size whereas the neutrino population also increases. We determine the particle distribution in the remnants' core, the remnant's structure, the temperature profile, sound velocity, and the polytropic index and discuss their effects. The strange quark (SQ) remnants satisfy the $2\,M_\odot$ mass constraint associated with neutron stars (NS).

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Location of the QCD critical point predicted by holographic Bayesian analysis

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Abstract: We present results for a Bayesian analysis of the location of the QCD critical point constrained by first-principles lattice QCD results at zero baryon density. We employ a holographic Einstein-Maxwell-dilaton model of the QCD equation of state, capable of reproducing the latest lattice QCD results at zero and finite baryon chemical potential. Our analysis is carried out for two different parametrizations of this model, resulting in confidence intervals for the critical point location that overlap at one sigma. While samples of the prior distribution may not even predict a critical point, or produce critical points spread around a large region of the phase diagram, posterior samples nearly always present a critical point at chemical potentials of $\mu_{Bc} \sim 550 - 630$ MeV.

Accelerating a (3+1)D Viscous Hydrodynamic Code for Heavy-Ion Collisions with Cabana+Kokkos

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The study of Quantum Chromodynamics (QCD) at extreme conditions poses experimental challenges. This is evident when considering the small spatial and time scales of heavy-ion collisions or the vast distances separating us from neutron stars. Due to these reasons, physicists often resort to phenomenological models, relying on relativistic hydrodynamic simulations that incorporate QCD properties through the equation of state and transport coefficients. For heavy-ion collisions at LHC energies, one can use the boost-invariant approximation for the simulations. However, for lower energies, full (3+1)D relativistic viscous hydrodynamic simulations are crucial, albeit computationally more expensive. In this work, we demonstrate the acceleration of a Smoothed Particle Hydrodynamics (SPH) viscous hydrodynamic simulation (CCAKE) using Cabana and Kokkos libraries. The use of SPH, coupled to a Lattice-QCD based equation of state that consider baryon, strangeness and electric chemical potential, allow us to easily incorporate these quantum numbers as conserved quantities. Our approach facilitates seamless compiling of the simulation to multicore systems and GPUs, ensuring optimal performance across various computing platforms — from small laptops to clusters with powerful GPUs. We present results showcasing preliminary results for the effects of fluctuation of Baryon, Strangeness and Electric charges at LHC energies as well showing the performance speed-up in our approach.

Dispersive $\pi\pi \to K\bar{K}$ amplitude and giant CP violation in B to three light-meson decays at LHCb

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Abstract

The LHCb collaboration has recently reported the largest CP violation effect from a single amplitude, as well as other giant CP asymmetries in several B-meson decays into three charmless light mesons. It is also claimed that this is predominantly due to $\pi\pi \to K\bar{K}$ rescattering in the final state, particularly in the 1 to 1.5 GeV region. In these analyses the $\pi\pi \to K\bar{K}$ amplitude is by default estimated from the $\pi\pi$ elastic scattering amplitude and does not describe the existing $\pi\pi \to K\bar{K}$ scattering data. Here we show how the recent model-independent dispersive analysis of $\pi\pi \to K\bar{K}$ data can be easily implemented in the LHCb formalism. This leads to a more accurate description of the asymmetry, while being consistent with the measured scattering amplitude and confirming the prominent role of hadronic final state interactions, paving the way for more elaborated analyses.

Looking for Baryon Number Violation with HIBEAM/NNBAR Experiment

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The baryon number violation is an essential ingredient for the preferential creation of matter over antimatter needed to account for the observed baryon asymmetry in the Universe. However, such a process has yet to be experimentally observed. The HIBEAM/NNBAR program is a proposed two-stage experiment at the European Spallation Source (ESS) to search for baryon number violation. The program will include high-sensitivity searches for processes that violate baryon number by one or two units: free neutron–antineutron oscillation, neutron–antineutron oscillation via regeneration from a sterile neutron state and neutron disappearance. The search for free neutrons converting to antineutrons will have a sensitivity improvement of three orders of magnitude compared to the last searches. We will present the progress towards a conceptual design report, including design studies for the annihilation detector, particle identification and backgrounds rejection.

Oscilações em estrelas híbridas: efeitos da transição hádron-quark

Kauan Marquez

Neste trabalho estudamos as oscilações radiais de estrelas de nêutrons híbridas compostas por camadas externas hadrônicas seguidas por um núcleo de matéria de quarks. Utilizamos um modelo de campo médio relativístico dependente da densidade, incluindo hiperons e bárions, para descrever a matéria hadrônica, e um modelo de quarks dependente da densidade para a matéria de quarks. Obtemos as dez frequências próprias mais baixas e as correspondentes funções de oscilação das equações de estado N, N+, N+H e N+H+D com uma transição de fase para a matéria de quarks em 1.4 e 1.8, focando nos efeitos de uma transição de fase lenta na interface hádron-quark. Observamos que a massa máxima é alcançada antes que a frequência do modo fundamental se anule para transições de fase lentas, sugerindo que algumas configurações estelares com densidades centrais mais altas do que a massa máxima permaneçam estáveis mesmo quando sofrem pequenas perturbações radiais.

Exploring the covariant form factor for spin-1 particles

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Abstract

The spin-1 particles is an admirable two quarks bound state system to understand electromagnetic properties from hadronic states. These systems are generally relativistic, and therefore, need an approach using quantum field theory. In the present work, we will use both the quantum field theory at the instant form, as well, quantum field theory on the light-front (LFQFT). In general, it is used to calculate the electromagnetic properties of spin-1 vector particles in the LFQFT formalism, with the plus component of the electromagnetic current. In the present work, we used, in addition to the plus component of the electromagnetic current; the minus component of the current, and we use that components o the current, to extract the covariant form factors; showing that to have an equivalence between these we need to add non-valence terms to the electromagnetic current, in order to restore the covariance, and obtain exactly the same results when using the instant form quantum field theory.

The effect of quark anomalous magnetic moment on magnetized strongly interacting matter

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The inclusion of the quark anomalous magnetic moment (AMM) in effective descriptions of quantum chromidynamics (QCD) can be useful to explore extensions and unsolved questions related to the QCD phase diagram. In recent literature, the quark AMM is considered to have different constant values for both light flavors, defined by phenomenological relations between the magnetic moments of nucleons and quarks. When applied to the SU(2) Nambu–Jona-Lasinio model with a constant external magnetic field, it predicts effects that are not reported by lattice QCD. At low temperatures, such effects lie between inverse magnetic catalysis and first-order phase transitions depending on the value of quark AMM. In this talk, we will show that these predictions result from applying regularization techniques that entangle the magnetic field and vacuum contributions in the thermodynamic potential and how to circumvent it by using the vacuum magnetic regularization scheme (VMR).

Fusion processes in collisions of weakly bound stable and halo beams on heavy targets

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Recently, we develop a model to evaluate complete and incomplete fusion in collisions of weakly bound nuclei such as ^{6,7}Li. We propose a modification of the imaginary potential to deal with cross sections at energies well below the Coulomb barrier, and discuss the relation between the cross sections provided by a continuum discretized coupled-channel calculation and the ones measured in actual experiments. Then, the present method was used to investigate fusion reactions in collisions of neutron-halo projectiles with heavy targets. For this purpose, we calculate cross sections for fusion processes in ^{6}He + ^{209}Bi and ^{6}He + ^{238}U collisions and compare the results with the available data. In this work, we present the recent published results of complete and incomplete fusion for these systems.

Halo and weakly bound isotopes interaction with light targets

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Abstract

In this work, preliminary results of the scattering of the interesting radioactive isotopes, ^{7}Be and ^{8}B, in light targets will be presented. The experiment was performed at the RIBRAS system (Radioactive Ion Beam in Brasil), that operates with the 8UD Pelletron accelerator. The ^{6}Li primary beam was impinged in a ^{3}He gaseous target and the products of this collision are selected and focused by the superconducting solenoid. The central scattering chamber was used to mount scattering targets and the detection system, composed by five telescopes (dE-E). A set of Silicon barrier surface detectors was mounted in a recently implemented detection setup. This new setup provides a full electrical insulation of the detectors, which reduced the noise-signal ratio to less than 1%, when tested with a ^{241}Am alpha source (5,486 MeV). Future perspectives and improvements of the detection setup of the central scattering chamber will also be presented. The experimental data of the elastic scattering and the angular distributions, compared with a preliminary Optical Model and Coupled Channels calculations, will be presented.

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Study of ^{9,11}Li+^{64}Zn reactions at 22 MeV

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We present new data for the 9,11Li+64Zn reactions, recently measured at the radioactive nuclear beam facility in TRIUMF (Vancouver, Canada) at energy above the Coulomb barrier (Elab = 22.5 MeV). The halo nucleus of 11Li is composed by a core nucleus of 9Li and two loosely bound neutrons. Due to the weakly bound structure, this nucleus is easily polarizable and, therefore, easily to break up.

In this contribution we present preliminary experimental data on the elastic scattering angular distributions of 9,11Li+64Zn reactions and the breakup probability of 11Li. These distributions are compared with Continuum-Discretized Coupled-Channels calculations. We find that the strong reduction of the elastic cross section with respect to the Rutherford prediction is mostly due to couplings to the breakup channels. Although CDCC calculations reproduce the elastic scattering, it underestimates the breakup probability angular distribution suggesting the presence of other mechanisms rather than the direct breakup.

Experiments on the d + ^{197}Au reaction channels at near-barrier energies

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In spite of its simplicity, the deuteron has many possible reaction channels, such as elastic and inelastic scattering, neutron pickup (leading to t + ^{196}Au), neutron stripping (leading to p + ^{198}Au), non-capture breakup (yielding n + p + ^{197}Au), complete fusion (producing the compound nucleus ^{199}Hg, which yields several evaporation residues). In this contribution, we will focus on the experimental techniques, results, and how they compare to the theoretical calculations, for all these channels.

The elastic scattered deuterons and protons stemming from breakup were online identified using two fourfold-ΔE silicon telescopes. The elastic scattering was analyzed with the Sao Paulo Potential, from which a reaction cross section was derived. The breakup cross section was compared to calculations based on the Ichimura-Austern-Vicent (IAV) formalism. The evaporation residues were identified by the offline detection of their respective β-delayed γ-rays with a HPGe detector, showing a 45% suppression of the complete fusion with respect to the one-channel calculations. The pickup and stripping processes were studied both with the online and offline methods. The integration of the angular distribution of protons and tritons is compatible with the integral cross section derived from the ^{196}Au and ^{198}Au offline identification, and were well reproduced by Coupled Reaction Calculations (for more details on these calculations, see B. Paes et al., this conference). Moreover, the sum of the cross sections of these reaction channels turned to be compatible with the reaction cross section derived from the elastic scattering data.

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Neutrino and Antineutrino captures on ^{18}O and ^{40}Ar

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In this work we have evaluated the neutrino (NS) and antineutrino (AS) scattering cross sections on ^{18}O and ^{40}Ar the inclusive muon capture (MC) rates at low energies within the Quasiparticle Random Phase Approximation (QRPA) and Projected QRPA (PQRPA) models. We present the first study of $^{18}\mathrm{O}(\nu_e, e^-)^{18}\mathrm{F}$ and $^{18}\mathrm{O}(\bar{\nu}_e, e^+)^{18}\mathrm{N}$ cross sections that are an important nuclear input for astrophysical calculations such as the CNO cycle [1] . As well the allowed and forbidden contributions for $^{40}\mathrm{Ar}(\nu_e, e^-)^{40}$ K, important for DUNE experiment. We have employed the weak formalism developed in Ref. [2] to analyze neutrino/antineutrino-nucleus scattering. Within this formalism, the nuclear residual interaction is described by δ-force previously employed to evaluate single and double beta decays in QRPA models. We compared our results for the NS and AS cross sections on ^{18}O and ^{40}Ar with other theoretical evaluations . For NS and AS we observed that the PQRPA procedure yields cross sections smaller than QRPA. We show that the Pauli blocking has an important role in the distribution of the partial contributions.

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Systematic Analysis of ^{10}B Elastic Scattering Using Double Folding Optical Model

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This study presents a comprehensive analysis of the elastic scattering cross section for ^{10}B projectiles incident on various target nuclei across a range of energies, employing the double folding optical model. The model used in this analysis is based on the Michigan-3 Yukawa (M3Y) effective nucleon-nucleon (NN) interaction. Two distinct forms of nuclear potentials are considered to construct the total optical potential. The first form incorporates a real part generated by folding the M3Y interaction over the densities of the interacting nuclei, complemented by an imaginary part modeled by a phenomenological Woods-Saxon (WS) form. In the second form, both the real and imaginary components of the nuclear potential are derived from the double folding model. The study calculates and presents the elastic scattering cross sections along with the volume integrals (real and imaginary) for all investigated nuclear systems. Results demonstrate that the double folding optical model effectively predicts experimental data. Additionally, a novel expression for the depth of the imaginary potential is derived and proposed. This research contributes to a deeper understanding of nuclear interactions and provides valuable insights into the dynamics of elastic scattering processes involving ^{10}B projectiles across diverse target nuclei and energy regimes.

Theoretical analysis on the ^{9}Be + ^{197}Au and d + ^{197}Au systems at near-barrier energies

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In recent years, our group's research activities have been significantly focused on weakly bound nuclei at energies around the Coulomb barrier. These investigations covered both experimental and theoretical aspects. All theoretical analyses employed the parameter-free São Paulo potential (SPP) as the optical potential. Consistent treatment of the elastic, inelastic, transfer, and fusion channels was undertaken with the optical potential energy dependence near the Coulomb barrier.

For the ^{9}Be + ^{197}Au system, the one-neutron transfer (pickup and stripping), complete and incomplete fusion cross sections were measured in energies around the Coulomb barrier. Coupled reaction channel (CRC) calculations were performed to derive the total cross sections for one-neutron stripping and pickup. It was found that the reduced complete and total fusion was hindered above and enhanced below the Coulomb barrier compared to the universal fusion function (UFF) due to breakup plus transfer effects.

Elastic scattering for the d + ^{197}Au system was analyzed using the SPP. The integrated cross sections for the one-neutron pickup and stripping processes were obtained online and offline and investigated using the CRC method. Also, the angular distributions cross section was obtained using the online method for energies above and below the Coulomb barrier and investigated using the same methodology. The complete fusion cross-section was also measured and analyzed using a short-range imaginary potential. Also, the angular distributions for one-neutron stripping and pickup reactions were obtained using the online method for energies above and below the Coulomb barrier and investigated using the same methodology.

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Study of pair-correlation in two-nucleon transfer reaction

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In recent years, the study involving transfer reactions of multiple nucleons without the use of scaling factors in the transfer cross section has been intensifying. Different reaction mechanisms, such as direct (one-step) and sequential (two-step) transfer, allow us to analyze whether the transferred nucleons are sensitive to short and long-range interactions. It has been observed that when the nucleus that receives the transferred nucleons presents a high degree of collectivity, such as vibrations or rotations, there is a competition between the direct and sequential mechanisms in the elastic cross sections. However, for cross sections of the excited states, the sequential mechanism is dominant, breaking the pairing correlation of the transferred nucleons.

Advances in nuclear instrumentation for exclusive measurements at LAFNA

Valdir B. Scarduelli – USP

In 1911, Ernest Rutherford demonstrated the existence of the atomic nucleus by studying the elastic scattering of stable nuclei below the Coulomb barrier. This revealed that the majority of the mass of the atom must be concentrated in a very small space in the interior of the atom, which he named the nucleus. This discovery marked the beginning of a new era in which nuclear collisions were used to study the structure of the nucleus. The study of nuclear reactions involving weakly bound nuclei is particularly fascinating in this context. These nuclei have an increased probability of undergoing a process called breakup, which results in a complex problem with three or more bodies. The breakup channel affects all other reaction channels and provides additional information about the characteristics of these systems. In recent years, we have developed new detectors and versatile experimental arrangements to perform exclusive measurements, in which the breakup products of a weakly bound projectile are detected in temporal coincidence, contributing to the understanding of the reaction mechanisms related to the breakup process. This seminar will present the latest advances in nuclear instrumentation used to perform exclusive measurements at the 30B beamline of the Open Laboratory for Nuclear Physics and Applications (LAFNA).

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TALK

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A Gibbsian approach to hydrodynamics

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We show that volume-preserving diffeomorphisms and the chemical shift symmetry defining relativistic lagrangian ideal fluid dynamics can be derived as an emerging symmetry when ergodicity is assumed to apply locally in a way that is invariant under smooth spacetime foliations. This can be used as a way to derive the ideal hydrodynamic limit in a strongly coupled but strongly fluctuating medium. We comment on the connection with thermalization in small systems, the Eigenstate thermalization hypothesis and deviations from the ideal limit.

Nuclear reactions with weakly bound projectiles

Leandro Romero Gasques - USP

Nuclear reactions with weakly bound projectiles have been extensively studied over the last decades. In this talk, an overview of the experimental program carried out at the Institute of Physics of the University of Sao Paulo (USP), using the 8 MV Pelletron accelerator installed in the Open Laboratory of Nuclear Physics, will be presented.

LFNA/UEL – 47 Years and beyond

Andrello, A. C, Head In Chief of Applied Nuclear Physics Laboratory (LFNA in Portuguese)

Physics Department of State University of Londrina

LFNA was create in 1977 by Professors Carlos Roberto Appoloni, Antonio Tannous and Roberto Vicençotto Ribas. At the beginning, only gamma ray transmission and gamma ray spectrometry using a NaI(Tl) detector were realized. From the years were passing, other techniques were implanted. Today are eight techniques used in LFNA: gamma ray transmission, gamma ray spectrometry with HPGe, NaI(Tl) and CZT detectors, X-Ray Fluorescence (portable made in home system, EDXRF, WDXRF and TXRF), Raman Spectroscopy, X-Ray Micro CT and Mercury Porosimeter. After the start of the INCT-FNA program, LFNA managed to acquire new equipment and maintain others that made it possible to maintain and improve the number and quality of work carried out in all lines of research and in master's and doctoral projects. In this way, being part of the INCT-FNA contributed a lot to the history of the LFNA.

Axial coupling in dense magnetized nuclear matter

Cristian Villavicencio

Universidad del Bío-Bío

The axial coupling constant of the nucleon is obtained in dense nuclear matter in the presence of a constant and uniform external magnetic field. Axial coupling of nucleons is directly related to beta decay and the Urca process, which is one of the main cooling mechanisms in compact stars. The presence of a strong magnetic field is considered in order to explore the magnetar environment. Finite energy summation rules (FESR) are used in this work, which implement quark-hadron duality, in conjunction with the operator product expansion to explore the non-perturbative sector of quantum chromodynamics.

In-beam test of the G-NUMEN Demonstrator at high reaction rates from a fusion-evaporation reaction

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Abstract

We proposed an in-beam test of the *G-NUMEN gamma array Demonstrator* at the IJCLab ALTO Tandem at Orsay, France. We delivered an intensity in the 1-10 pnA range of 83.5 MeV ^{16}O pulsed beam (2.5 MHz) onto natural Ti (6.6 mg/cm^2), in order to produce abundant gamma and neutron radiation background, followed by a separate target consisting of natural Ta (^{181}Ta 99.99%, 2.5mg/cm2), which was be Coulomb excited by the beam after the energy loss of about 20 MeV in the first target. The gamma ray decay from the Coulomb excited states of ^{181}Ta was efficiently separated from the background by requiring time coincidence with the scattered ^{16}O particles detected by Si solid state detector (SSD) mounted around 120 degrees from the beam direction inside the D-shaped (Demi-Camenber) scattering chamber. The Demonstrator array, consisting of 15 $LaBr_3$(Ce) scintillators, was mounted outside the chamber with the detector axes directed towards the Ta target. We produced a high random coincidence event probability comparable to that of a typical NUMEN experiment, which should validate in practice the limiting signal to background ratios predicted by GEANT4 simulations [1] for the coincidence measurements. The experiment allowed for a complete test of the system, including the array geometrical distribution, scintillator detector performance, electronics, and data acquisition and analysis under real conditions.

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30 years of ion beam analysis at LAMFI-USP: past experiences, social impacts, and insights for the future

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Science and its socioeconomic impacts helps shaping the economy and the social well-being of civilizations. In the specific case of Ion Beam Analysis using small ion accelerators, the LAMFI-USP (acronym for the Laboratory of Material Analysis with Ion Beams of the University of São Paulo) is a dedicated facility of the |University of São Paulo, with a 1.7 MV tandem electrostatic accelerator, that has been providing high-standard ion beam and material analysis to Brazilian scientists, for over 30 years.

Initially, the PIXE technology was introduced at USP in 1975, to support research on air pollution based on the elemental analysis of atmospheric aerosols [1]. LAMFI-USP was installed in 1990. Since then, several materials have been analyzed at LAMFI-USP, aiming to support environmental, archaeological and cultural-based research: e.g. tree rings of a 166 years old Amazonian tree [2], genetically modified soya seeds [3], baby teeth [4], elemental analysis of blood-plasma as a conceptual test for cancer diagnosis [5], and archaeological ceramic pieces of the Chimu Culture [6]. High-tech materials are also frequently analyzed: thin films in general, tiles of the internal walls of a proto fusion reactor [8], solar cells, etc. Irradiating micro-circuits [9], opened a new frontier testing COTS circuits in ionizing environments for space applications in Brazil.

An Ion Beam Analysis laboratory can also be a valuable teaching tool and inspiration for students. LAMFI-USP has been used to teach undergraduate modern physics, e.g. reproducing the Cockcroft-Walton experiment to demonstrate the mass-energy equivalence, or as a showcase to high school students, while visiting the laboratory, eventually sparking scientific curiosity and/or interest in a science career.

Applied science produces an additional benefit by generating problems that may drive basic science investigations. The increasing need for better results, drives advances in analytical setups, better detectors, time-resolved analysis, and new instruments for complementary measurements. There is a growing need for more and improved data on radiation effects in solid materials and on stopping powers near the Bragg peak. Additionally, the analysis of trace elements focusing on microplastics and flame retardants in biological systems is a recent trend to be explored. Facilitating access to IBA facilities for students and researchers, and sponsoring hands-on training courses by IAEA, can help promoting a more inclusive scientific community and solutions to relevant and contemporary scientific questions.

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Weak magnetic field corrections to the pion exchange potential

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The pion exchange potential (Yukawa) is calculated in a weak magnetic field by considering the framework of the constituent quark model. The magnetic field is weak with respect to the constituent quark effective mass. In particular the role of the magnetic field dependent pion and quark masses and in the pion-constituent quark coupling is investigated.

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OU-01	Fábio Lunelli da Silva Brum	Estudo Computacional do Efeito da Focalização na Radioterapia VHEE
AP-01	Gabriela Ferraz de Lima	Natural Radiation Analysis of Banana Heart Samples: Assessing Radionuclide Composition and Annual Ingestion Dose
AP-02	Isabela Gil	Multi-element analysis of Brazilian processed dark chocolates
AP-03	Anna Carolinne Braz Silva	Study of ceramic fragments from the Huaca Ventarrón and Arenal sites by EDXRF
AP-04	Matheus Dos Santos Guerra	Degradation of Highly Oriented Pyrolytic Graphite Properties Due to Ionizing Radiation Effects
AP-05	Paulo Roberto Garcia Junior	Exploring Ionizing Radiation Tolerance of Rectangular and ELT Power Transistors
AP-06	Gabriela Dantas Santos	Um arranjo experimental para medidas de seção de choque de espalhamento nuclear no LAMFI-USP
AP-07	Victor Pires	Otimizações de medições de poder de freamento usando o método de retroespalhamento
AP-08	Thomas Hirata Pschera	Total Ionizing Dose Effects on NMOS Power Transistors for Advanced Electronics in Harsh Environments
AP-09	Caio de Sousa Ribeiro	Implementação de escaneamento óptico de folhas GEM
AP-10	Igor Marques Nogueira	Soil analysis by EDXRF in agricultural area of Toledo
AP-11	Enzo Gabriel Avelar Correa	Influence of the format of archaeological ceramic fragments on the morphological results obtained by micro-CT
AP-12	Kaliane dos Santos Barreto	THE USE OF ACCELERATOR MASS SPECTROMETRY FOR CARBON-14 DATING OF WATER SAMPLES
AP-13	Larissa Yumi Tabuti Sibuya	ANALYSIS OF SOILS AND PLANTS CULTIVATED IN AN ORGANIC GARDEN AT FEI UNIVERSITY CENTER
AP-14	Marcos Vinícius Rodrigues Ribeiro	Melhorias para o sistema de detecção do RIBRAS
AP-15	Rayssa Prazeres de Jesus Santos	AVALIAÇÃO DO IMPACTO AMBIENTAL EM AMBIENTES DE MANGUEZAIS DEVIDO A UM DERRAMAMENTO DE ÓLEO A PARTIR DE ANÁLISES GEOQUÍMICAS E ISOTÓPICAS

AP-16	Maria Clara de Oliveira Flores	Data Processing: A Closer Look at Cultural Heritage Material
AP-17	Giovana Estrelado Fernandes Santos	AVALIAÇÃO DA BIORREMEDIAÇÃO EM COMPOSTOS SATURADOS APLICANDO ANÁLISE MOLECULAR E ISOTÓPICA DE 13C
AP-18	André Fellipe Vieira dos Santos	PIGMENTOS EM PÓ ANALISADOS POR TÉCNICAS DE FLUORESCÊNCIA DE RAIOS X E RAMAN E SUAS APLICAÇÕES PARA ESTUDO DE PINTURAS DE CAVALETE
AP-19	Luiza Monticelli Queiroz	Pigmentos em pó analisados por técnicas de fluorescência de Raios-X
AP-20	Juliana Galvão Maia de Camargo Mello	Morphological Diversity and Inorganic Element Distribution in the Tapajós River: Insights from Gamma Ray Spectrometry Analysis
AP-21	Erick Gomes	Dendocrinologia e a técnica pixe como ferramentes de análise ambiental
AP-22	Rafael Molari	Pigment determination in paintings by Vincent van Gogh from MASP collection by portable X-ray fluorescence (pXRF)
AP-23	Fábio Luiz Melquiades	Gamma-ray Spectrometry combined with multivariate regression to predict soil fertility attributes: a case of study with Xanthic Hapludox.
AP-24	Cleber Lima Rodrigues	NEW INTEGRATED ARCHITECTURE FOR DATA ACQUISITION AND SAMPLE POSITIONING OF THE LAMFI-USP FACILITY
AP-25	Letícia Martins Birelo	Characterizing the materials present in Drinkstone Park (1747) of Thomas Gainsborough applying spectroscopy and imaging techniques
AP-26	Mateus Gruener Lima	Factorial planning in evaluating the influence of experimental parameters on X-ray micro-computed tomography imaging
AP-27	Vitor de Andrade Mirwald	Uso de algoritmos de aprendizado de máquina no processamento de dados de espectroscopia de raios-x
AP-28	Edher Herrera	Paleometry: Physicochemical Characterization of Fossil Remains from Paraguay
AP-29	Yuri Idalgo de Matos da Silva	Estudo de Padrões de Deposição de Resíduos de Pólvora em Disparos de Armas de Fogo pela Técnica PIXE
AP-30	Júlia Schenatto	Caracterizando Oscar Pereira da Silva: uma abordagem multi-técnicas

AP-31	Maíra Cesário Alvim Lobo	Thorium as nucelar fuel in Brazil.
AP-32	Naiana Dias dos Ssntos	Análise de Radioisótopos Naturais em Matrizes Ambientais
AP-33	José Vinícius Ribeiro	Comparison of machine learning tools in systematic study of training samples set reduction for soil organic carbon determination through EDXRF spectrum
AP-34	CAUÊ GOMES FERREIRA	Otimização de instrumentações analíticas para o estudo de objetos do patrimônio histórico e cultural
AP-35	Jéssica da Silva Sarpa	Áreas Úmidas no Litoral Norte do Estado da Bahia: Caracterização
AP-36	Vitória Dias de Sousa	DETERMINING THE SENSITIVITY CURVE OF AN ENERGY DISPERSIVE X RAY FLUORESCENCE AND PIXE SYSTEMS
AP-37	Arilson da Silva	Medidas de alta acurácia de poder de freamento para prótons com energia de alguns MeV
AP-38	Ana Beatriz	Direct O2+ production from CO2 ionization
AP-39	Marcos Felipe C. Silva	Determination of biogenic fraction in aviation kerosene samples using carbon-14
AP-40	Mateus Massolar Freitas	Evaluation of CO2 in the atmosphere by 14C measured on tree rings

RS-01	José Montenegro Brandão Neto	Elastic scattering studies for 12-Carbone reactions with Sao Paulo Potential
RS-02	Gabriel de Souza Gonçalves	Di-neutron potential in the 6He+58Ni interaction
RS-03	Fernando Lock Miletto	Elastic scattering and transfer reaction induced by 13C beam in the 9Be target
Rs-04	Caio Eduardo Cabral de Vasconcellos	Tests of the new "Nossa Caixa" gamma-ray spectrometer
RS-05	Pedro Luiz Domingues Magro	Elastic and inelastic scattering measurement for the 13C+208Pb system at energies close to the barrier
Rs-06	William Akira Yoshida Hatano	Study of (10,11)B+119Sn reactions at energies around Coulomb barrier
Rs-07	Higor Felipe Gonçalves de Arruda	Influence of 6He breakup on the 6He+27Al collision
RS-08	Mariane Rodrigues Cortes	Fusion reactions in 6Li + 90Zr scattering
RS-09	Hideaki Miyake	α + core structure described with an alternative NN

		effective interaction
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Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro

ESTUDO COMPUTACIONAL DO EFEITO DA FOCALIZAÇÃO NA RADIOTERAPIA VHEE

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A radioterapia, uma das principais modalidades de tratamento do câncer, consiste no uso de radiação ionizante para eliminar células tumorais. Dependendo da profundidade e das características do tumor, diferentes fontes de radiação e técnicas de planejamento podem ser adotadas para modular a deposição de dose no paciente, maximizando-a na região tumoral e minimizando-a nos tecidos saudáveis. O desenvolvimento de novas técnicas de aceleração de elétrons (TOMAS, 2010) (ESAREY; SCHROEDER; LEEMANS, 2009) renovou o interesse na radioterapia com elétrons de energias muito altas (very high energy electrons, ou VHEE), que faz uso de feixes com energias entre 50 e 250 MeV para o tratamento de tumores profundos. Resultados recentes (WHITMORE et al., 2021) mostraram que combinando feixes VHEE com focalizações distintas, é possível obter-se curvas de porcentagem de dose em profundidade (PDP) semelhantes às obtidas na protonterapia, a um custo possivelmente menor após o desenvolvimento dessa tecnologia (KRIM et al, 2020). Este estudo propõe uma investigação por simulações de Monte Carlo do efeito da focalização de um feixe VHEE na dose depositada pelo mesmo em um objeto simulador de água. Utilizando-se o código TOPAS, foram realizadas simulações com feixes simétrica e assimetricamente focalizados por conjuntos de quadrupolos magnéticos. Com relação à fonte de radiação, utilizou-se feixes Gaussianos de elétrons, com desvios padrão transversais σ_x = 4 mm e σ_y = 4 mm, e com energia média de 250 MeV e desvio padrão σ_E = 0,75%, e com divergência inicial de 3,2 mrad. Esses parâmetros foram obtidos a partir do artigo de referência (WHITMORE et al., 2021), e os resultados das simulações foram compatíveis com os resultados apresentados em tal artigo. Com a validação das simulações computacionais desenvolvidas, pretende-se em trabalhos futuros simular aplicações da VHEE focalizada, comparando seus resultados com simulações de outras modalidades de radioterapia para avaliar o seu potencial.

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Natural Radiation Analysis of Banana Heart Samples: Assessing Radionuclide Composition and Annual Ingestion Dose

Gabriela Ferraz[1], Nilberto H. Medina[1], W. Sciani[1], Jéssica F.Curado[1], Marcilei A. Guazzelli[1]
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Bananas are a staple in the Brazilian diet and are widely consumed around the world. However, it is important to recognize that bananas are among the fruits with the highest radiation dose levels from potassium-40 . This undergraduate research project aims to analyze the radioactivity levels in different species of banana plants, with a specific focus on banana hearts, which are often discarded despite their rich nutrient content. The Brazilian industry lacks substantial information regarding the composition of banana hearts, and it is challenging to find research data related to this potential nutrient source. Through this project, we aim to assess the potential of banana hearts, determine the radiation dose resulting from the concentration of potassium-40 (^{40}K), and develop highly nutritious products that can be processed and manufactured [1].
This study is part of a larger research project focused on the study of Natural Radiation, complementing the assessment of natural radiation primarily attributed to the presence of ^{40}K in bananas due to its high potassium content. Previous studies have explored the macro and micronutrient profiles of various banana components, and the analysis of natural radiation will provide valuable supplementary information. The Natural Radiation research program encompasses the study of Naturally Occurring Radioactive Materials (NORM) with the objective to establish Gamma Ray Spectrometry analysis techniques at Centro Universitário FEI, fostering interdisciplinary research capabilities across different engineering fields [2]. Gamma radiation measurements emitted by natural radionuclides were conducted using gamma-ray spectrometry techniques at the Laboratory of Radiation Physics (LERI) at Centro Universitário FEI. By estimating natural radiation doses and intake doses for various species of banana trees, variations in the levels of radioisotopes among the samples were identified, with potassium levels surpassing those of uranium-238 and thorium-232, reaffirming the remarkable potential of banana hearts as a valuable food supplement.

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Multi-element analysis of Brazilian processed dark chocolates

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Chocolate is one of the most beloved foods worldwide and is consumed in various ways across different cultures. However, like all organic foods, chocolate is composed of elements such as iron, zinc, potassium, phosphorus, calcium, codium, magnesium, and copper. Heavy metals are also present in the composition, and it is crucial to adhere to a healthy limit for consumption [1]. Recent studies have reported instances of detecting heavy elements in higher-than-expected quantities in various international chocolate brands, raising concerns about the safety and quality of these products. Elements such as lead, cadmium, and mercury can pose risks to human health, especially when consumed in quantities exceeding established limits [2]. This scientific initiation project aims to analyze samples of dark and semi-sweet chocolates of both national and imported origin. The selection of chocolates with these characteristics is due to the higher concentration of cocoa mass, an ingredient that can potentially concentrate contamination by heavy metals like cadmium and lead. For the elemental characterization of the samples, the Energy Dispersive X-ray Fluorescence (EDXRF) technique will be employed. This technique is based on measuring the intensities of the characteristic X-rays emitted by the chemical elements constituting the sample when properly excited.

To carry out the project, the non-destructive physical methods available at the Radiation Physics Laboratory (LERI) located on the FEI Campus in São Bernardo do Campo will be utilized.

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Study of ceramic fragments from the Huaca Ventarrón and Arenal sites by EDXRF

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Abstract

The archaeological ceramic fragments under analysis in this study are derived from the Ventarrón-Collud archaeological complex, which is divided into four primary sites; Zarpan, Collud, Huaca Ventarrón and Arenal. Although, the artifacts in question were acquired from the Huaca Ventarrón and Arenal sites. This complex is situated on a desertic strip by the Lambayeque Valley, situated approximately to Cerro Ventarrón on the Andean North Coast. This complex is distinguished by an extensive assemblage of archaeological materials, spanning a chronological depth exceeding 4000 years. Furthermore, the region is prone to the influence of El Niño Southern Oscillations (ENSOs) and is considered one of the areas with the greatest environmental stress on the planet. The confluence of a protracted temporal scale and vulnerability to ENSOs poses a challenge for archaeological inquiry, requiring an archaeometric approach to comprehensively elucidate the intricate social dynamics prevalent in this region. Consequently, the acquisition of specific information from these ceramic artifacts assumes paramount importance in elucidating the nuanced organizational systems on the Peruvian North Coast. The dataset under examination comprised 50 ceramic fragments, evenly distributed between the Huaca Ventarron and Arenal archaeological sites. Energy Dispersive X-ray Fluorescence (EDXRF) was employed to analyze the ceramic shards, aided by multivariate statistical techniques, these being Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA). In the exploratory multivariate analysis of PCAs and HCAs, the element's net area was examined employing the Autoscale pre-processing technique on the ceramic paste data acquired via EDXRF. The elemental components found by the EDXRF analysis include Si, Al, Fe, Ca, K, P, Ti, S, Mn, Sr, V, Zr, Cu, Zn, Y and Rb. The outcomes presented a statistical similarity between the ceramic fragments from the two archaeological sites, as shown by the superimposing of the samples of the different complexes. This concurrence suggests a consistent utilization of similar clay sources in the ceramic manufacturing process over the course of time.

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Degradation of Highly Oriented Pyrolytic Graphite Properties Due to Ionizing Radiation Effects

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The primary goal of the NUMEN project (Nuclear Matrix Elements in Neutrinoless Double Beta Decay) is to investigate charge-exchange reactions, as well as elastic, inelastic, and single-charge-transfer channels [1]. In the midst of this challenge, the characterization of the Highly Oriented Pyrolytic Graphite substrate (HOPG) plays a crucial role, as this material is used adjacent to the target of the nuclear reaction for thermal dissipation [2]. With the aim of examining and describing the properties of pyrolytic graphite, both before and after exposure to various sources of ionizing radiation, in order to identify changes in mechanical, thermal, and crystalline structure properties that may compromise essential characteristics for its use in the context of the NUMEN project, this research seeks to simulate the effects of heavy ion interaction with pyrolytic graphite. Different particles will be applied to HOPG samples to assess the effects of this interaction. To investigate the defects caused by ionizing radiation in the material, the SRIM/TRIM software plays a fundamental and complementary role in this study. By utilizing the semi-empirical parameterizations of Zigler, Biersack, and Littmark for electronic stopping calculations and the Monte Carlo method for scattering calculations, the software is suitable for calculating the energy loss that the particle undergoes when penetrating the target. Thus, the program determines the formation of gaps - defects in the material - generated during the exposure of the target to an ion beam. The software allows for the input of key research parameters, such as beam energy (ranging from keV to MeV), the atomic nature of the incident ion, the number of ions from the beam, the target thickness, and its chemical composition. Additionally, there is the possibility of adding subsequent substrates to the target. In this way, it becomes feasible to conduct simulations aligned with the experimental parameters of the NUMEN project.

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Exploring Ionizing Radiation Tolerance of Rectangular and ELT Power Transistors

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Transistors are of immense importance for the development of advanced electronics and form the foundation of technologies used daily. They were introduced to the world in the 1950s and are now present in the majority of electronic devices, including aerospace applications, particle accelerators, and other systems requiring tolerance to the effects of ionizing radiation. In light of this, new techniques are being employed to mitigate the effects of radiation on power transistors, such as the Closed-Structure ELT transistor, which utilizes polysilicon around the drain and source terminals to enhance insulation in these areas [1]. Therefore, this study explores the effects of Total Ionization Dose (TID) on a PPTLEXT06SOID40 integrated circuit with five transistors, three of which are conventional rectangular transistors, and the others are ELT transistors. The ICs were designed by the CTI Renato Archer for space applications and were characterized before, during, and after exposure to a 10 keV X-ray beam. The devices were analyzed in two modes of operation: ON MODE and OFF MODE. During the ON MODE, the gate terminal was biased, and the other terminals were grounded. In the OFF MODE, all terminals were grounded. The radiation dose rate was set to 100 krad(Si)/h, accumulating a total dose of 300 krad(Si) on the Device Under Test (DUT). The $IDSxVGS$ and $IDSxVDS$ characteristic curves were analyzed, and several electrical parameters were determined to assess the DUT's tolerance to charge trapping during radiation exposure. The results indicate significant changes in the devices' electrical parameters. However, it was not possible to observe relevant differences arising from the ELT layout change [2, 3].

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Um arranjo experimental para medidas de seção de choque de espalhamento nuclear no LAMFI-USP

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Objetivo

Medidas de seção de choque são importantes para a física nuclear pois oferecem informações sobre potenciais de interação nuclear e sobre a estrutura interna dos núcleos. Para o caso específico de análise de materiais com técnicas nucleares, o conhecimento acurado das seções de choque de espalhamento são essenciais para uma análise de qualidade. Tabelas de seções de choque são usadas como parâmetros de entrada nos programas de simulação utilizados na deconvolução dos dados e elaboração de resultados finais de caracterização.

O objetivo deste trabalho é adaptar a câmara multipropósito do Laboratório de Análises de Materiais com Feixes Iônicos da Universidade de São Paulo (LAMFI-USP) para realização de medidas acuradas de seção de choque de espalhamento nuclear elástico. Este trabalho se insere num projeto de pesquisa apoiado pelo CNPq visando o aperfeiçoamento das técnicas nucleares para análise de materiais relevantes para a fusão nuclear.

Métodos e Procedimentos

A câmara multi-propósito do LAMFI-USP é utilizada para a realização de irradiação de amostras e análises de materiais, normalmente pelas técnicas RBS (*Rutherford Backscattering Spectrometry*), PIXE (*Particle Induced X-ray Emission*), NRA (*Nuclear Reaction Analysis*) e FRS (*Forward Recoil Spectrometry*) [1,2]. Ela possui, entre outros dispositivos, um porta amostras de 5 eixos para controle de posição e ângulo de incidência do feixe na amostra e dois detectores de tecnologia de silício para medidas de energia de partículas do feixe espalhamento (um em ângulo fixo de 170°, e outro móvel entre 90 e 160°).

Normalmente, a carga total de feixe depositada na amostra é medida com o auxílio de um nanoamperímetro com integrador de carga conectado no porta amostras. Esse é um parâmetro importante para normalização dos dados. Nas medidas de seção de choque, as amostras são compostas por filmes finos autoportantes, o que significa que a totalidade do feixe atravessa a amostra tornando impraticável essa metodologia. Para isso, instalamos um dispositivo medidor de feixe total (copo de Faraday) na extensão da câmara multi-propósito. A distância da entrada do copo de Faraday para a amostra é de 180 mm, e a abertura do copo é de 45 mm.

Com a ajuda do programa SRIM [3] conseguimos calcular a espessura máxima de alvo tal que não prejudique a coleta de carga no copo de Faraday (assumindo um alvo de ouro). Essas simulações foram realizadas admitindo-se feixes de prótons de 500 keV de energia, sendo este o limite inferior do intervalo de medida e, consequentemente, a energia que deve apresentar a maior sensibilidade na coleta de carga em relação à espessura da amostra.

Para calibração de ângulo sólido dos detectores, realizamos medidas de seção de choque de espalhamento de prótons em ouro. Esta combinação de íon e alvo apresenta interação puramente Coulombiana no intervalo de energias dos LAMFI-USP, viabilizando a

comparação com a predição teórica da seção de choque Rutherford, e assim, a determinação dos ângulos sólidos dos detectores.

Resultados

No gráfico da fig. 1 mostramos os resultados de simulação da eficiência de coleta de partículas no copo de Faraday em função da espessura do filme

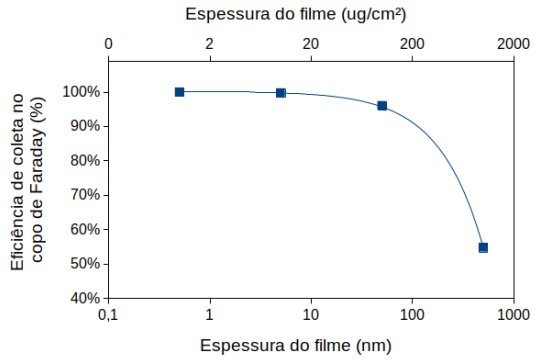

Fig. 1 - Cálculo de simulação realizado com o programa SRIM da eficiência de coleta de carga pelo copo de Faraday em função da espessura do filme.

No gráfico da fig. 2 estão representados os dados das seções de choque do ouro para cada ângulo medido, onde as curvas contínuas são os dados encontrados teoricamente e as curvas pontilhadas os dados encontrados experimentalmente. Essa comparação é feita, a fim de alinharmos ambos espectros.

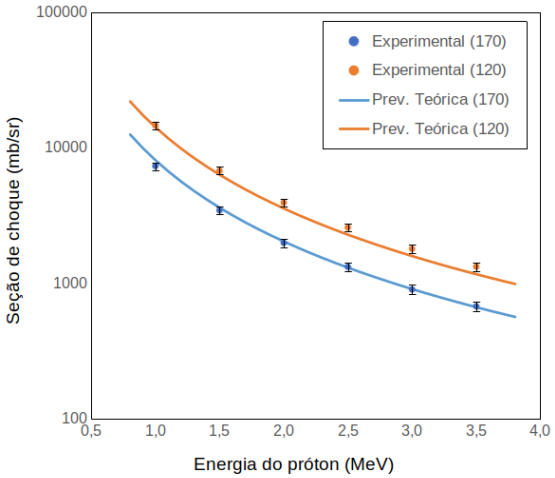

Fig. 2: Comparação entre as seções de choque do ouro teórico e experimental.

Conclusão

Os resultados preliminares obtidos até aqui nos permitem avaliar que a espessura máxima dos alvos a serem utilizados em medidas de seção de choque de espalhamento elástico não devem exceder 20 nm (ou 40 μg/cm2). Caso contrário, uma correção de eficiência de coleta de carga no copo de Faraday deve ser implementada.
Além disso, medidas de seção de choque de espalhamento em alvos de ouro indicam que boa concordância com previsões teóricas.
O trabalho se encontra em andamento e mais testes devem ser realizados.

Agradecimentos

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INCT-FNA INSTITUTO NACIONAL DE CIÊNCIA E TECNOLOGIA FÍSICA NUCLEAR E APLICAÇÕES

Otimizações de medições de poder de freamento usando o método de retroespalhamento

Resumo

O poder de freamento eletrônico (ou nuclear) é uma quantidade física com amplas implicações em diversos campos, incluindo engenharia e medicina. Portanto, neste trabalho, projetamos um código para estimar o erro de uma medida de poder de freamento pelo método de retroespalhamento e também planejar qual a configuração geométrica ideal para medição que apresenta a menor incerteza. Para isso, assumimos duas medidas em configurações de ângulos diferentes, ao se definir um ângulo de entrada de um arranjo, igual ao de saída do outro e vice-versa colocamos os dois arranjos em termos de apenas dois ângulos A e B. O código calcula incertezas estatísticas e sistemáticas. A primeira incerteza é calculada por uma análise do comportamento do mínimo múltiplo quadrado, enquanto a última é calculada através de uma simulação computacional, integrada às aproximações do programa SRIM. Feito os cálculos do programa, podemos enquadrar essas incertezas em um mapa de calor, assim discernindo a geometria ideal para medição e qual é seu respectivo erro.

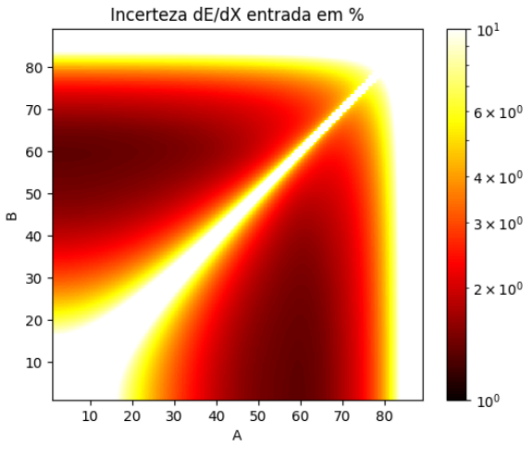

Figura 1 - Incerteza do poder de freamento no caminho de entrada de um filme de tungstênio para um feixe de hélio de 700 keV, com ângulos de entrada e saída A e B.

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Total Ionizing Dose Effects on NMOS Power Transistors for Advanced Electronics in Harsh Environments

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Abstract

Transistors, pivotal devices in modern electronics, play a critical role in amplifying and regulating electrical signals. Developed primarily in technologies like MOS (Metal-Oxide-Semiconductor), these semiconductor components form the foundation of electronics, facilitating the creation of oscillators, digital circuits, and more. With their unique ability to modulate current flow based on input signals, transistors drive continuous innovation in electronics and are instrumental in technology's ongoing evolution across various scientific fields. This study investigates the impact of ionizing radiation on power NMOSFET devices, specifically the IRLZ34NPbF devices [1]. Initially, transconductance and threshold voltage values were quantitatively extracted to assess the influence of epoxy protection on intrinsic device values. Subsequently, the epoxy layer was removed, and the transistor was irradiated with a 10 keV beam at a rate of 100 krad/h, accumulating a total of 300 krad in the device. The device characteristics were evaluated before, during, and after radiation exposure [2]. Despite being of the same model, minor parameter variations were observed after the removal of the protective layer, possibly due to the removal process itself. Following irradiation, significant changes in threshold voltage and saturation current values were noted, potentially compromising device functionality. In conclusion, comparing parameters before and after the experiment revealed a high sensitivity to radiation, suggesting that the IRLZ34NPbF transistor may not be suitable for applications in hostile environments with increased susceptibility to radiation. Future steps involve analyzing more components of the same model with different dose rates and allowing for transistor annealing, a process aimed at minimizing damage caused by X-rays through controlled temperature and time conditions, without emitting radiation.

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Implementação de escaneamento óptico de folhas GEM

Participantes:

Nome	Função	Vínculo Principal
Caio de Sousa Ribeiro Tiago Fiorini da Silva	Bolsista Orientador	Instituto de Física da Universidade de São Paulo

Resumo:

A inspeção das folhas GEM é crucial para a garantia de qualidade do processo e dos métodos de fabricação. Para além disso, pretende-se obter medidas quantitativas que permitam verificar se as tolerâncias mecânicas definidas por simulação foram cumpridas experimentalmente. Para tal, a implementação de um escaneamento ótico de alta resolução é utilizada para obter uma imagem de campo amplo e de alta resolução da folha metálica, permitindo a identificação de padrões para determinar a forma dos furos e as suas distâncias. O escaneador ótico será implementado utilizando uma plataforma de três eixos, acionada por motores de passo e controlada por uma placa Arduino. Este permitirá que uma câmara USB com uma lente de amplificação digitalize a superfície da folha, guardando imagens que serão utilizadas para formar a imagem de campo amplo da folha, e posteriormente processadas. Há um desafio nesta configuração experimental no que diz respeito à otimização do número de imagens guardadas para gerar uma imagem de campo amplo com pouca deformação. É também necessária a implementação de algoritmos para correção gama dinâmica. O aluno envolvido neste projeto aprenderá as noções básicas de programação, sistemas de controle, processamento de imagem e reconhecimento de padrões.

Soil analysis by EDXRF in agricultural area of Toledo, Paraná: A quantification study

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The problem addressed is the need to assess soil fertility accurately, quickly, and efficiently. The study aims to establish an alternative and efficient method for determining inorganic soil nutrients, reducing costs and analysis time. It will enable precise and rapid monitoring of soil fertility attributes, contributing to sustainable management of agricultural soils. The objective of the study was to analyze agricultural soils using Energy Dispersive X-Ray Fluorescence (EDXRF) technique to determine fertility attributes and total contents of macro and micronutrients. A set of 212 samples were analyzed at four soil depths in the Southwest region of Paraná. The samples were analyzed by the conventional method and measured by benchtop EDXRF equipment. The soil fertility parameters determination were performed indirectly. The multiple linear regression method was applied to elements quantified by EDXRF correlating with the fertility parameter of interest. The following elements were quantified by EDXRF: Al, Si, P, S, K, Ca, Ti, Mn, Fe, Cu, Zn, and Sr. The soil fertility parameters studied were: pH, K, P, H+Al, Ca, Mg, SB, CTC, and V%. Performance parameters calculated for the models were the correlation coefficients between conventional method values and those determined by RLM with EDXRF data. Additionally, the Ratio Performance to Deviation (RPD) was calculated. The values of R^2Cal, R^2Pred, and RPD for each parameter are, respectively, pH (0.68, 0.42, 1.3), K^2+ (0.87, 0.55, 1.34), Pm (0.57, 0.28, 0.72), C (0.67, 0.28, 1.12), H+Al (0.55, 0.22, 1.07), Ca2+(0.79, 0.76, 2.03), Mg2+ (0.78, 0.64, 1.66), SB(0.82, 0.77, 2.08), CTC(0.70, 0.34, 1.19), V%. The RPD values were good for Ca and SB, with respective values: 2.03 and 2.08. The RLM method was not sufficient to obtain robust models, indicating that other multivariate calibration methods need to be explored. The literature indicates the use of PLS and other machine learning methods, which will be the subject of future studies.

Influence of the format of archaeological ceramic fragments on the morphological results obtained by micro-CT

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X-ray Computed Microtomography (micro-CT) is a non-destructive three-dimensional imaging technique capable of providing morphological data and reconstructing virtual models of various samples. In this study, a micro-CT scanner (SkyScan 1173, BRUKER™) was used to analyze the influence of the format and measurement orientation of ceramic samples on the morphological results obtained. Seven ceramic fragments were selected and measured in three different rotation positions (horizontal, vertical 1, vertical 2). Measurements were performed at 100 kV, 80 µA with an exposure time of 1100s, and image resolution was 26 µm. The evaluated morphological parameters were the percentage of clay phase, porosity and aggregate, and the distribution of pores and aggregates. The results indicate a variation in phase classification for the same ceramic fragment across rotation positions, averaging 3.81% for the ceramic paste, with a minimum of 0.48%, indicating the least variability within this phase. Additionally, it is observed that both pore and aggregate phases exhibit fluctuations that appear to compensate for each other. When considering pore and aggregate size distribution based on mid-range diameter, there is a discernible trend in the classification of pores larger than 0.85 mm and aggregates larger than 1.04 mm for the horizontal rotation position, compared to the other two positions. Hence, it can be concluded that there exists a correlation between the shape and measurement orientation of ceramic fragments with the morphological results obtained by micro-CT.

THE USE OF ACCELERATOR MASS SPECTROMETRY FOR CARBON-14 DATING OF WATER SAMPLES

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Accelerator mass spectrometry is a sophisticated technique used to analyze the isotopic composition of samples, allowing the determination of specific elements and their relative quantities. In the context of carbon-14 (^{14}C) dating, this method has become widely used. Carbon-14 is a radioactive isotope that is produced naturally in the atmosphere by the interaction of cosmic rays with atmospheric nitrogen. This process creates a constant proportion of carbon-14 in the atmosphere, which is then absorbed by living organisms. When organisms die, the radioactive decay rate of carbon-14 can be used to determine the age of biological samples. In research related to hydrology and hydrogeology, carbon-14 dating has been employed as a tool to determine the origin, measure recharge, and determine the age of the aquifer. The basic principle of ^{14}C dating is that the mass of this element's atoms reduces by half over 5,730 years, due to radioactive decay. In this context, this work aims to present two methodologies tested for the preparation of water samples for ^{14}C dating using AMS at the Sample Preparation Laboratory for ^{14}C Dating at UFBA (LAPAC - UFBA), as well as preliminary results. The methodologies are: the headspace technique - which uses a system with a double needle with a controlled flow of nitrogen as a carrier gas to extract dissolved carbon dioxide; and the precipitation technique - given by the addition of a saturated solution of barium hydroxide ($Ba(OH)_2$) to a solution of sodium carbonate (Na_2CO_3), which reacts to form barium carbonate ($BaCO_3$); then this precipitate is filtered and acid is added for purification in the vacuum line. Finally, this work will be used in the project to characterize the São Sebastião aquifer (state of Bahia), aiming to contribute to the region's hydrological cycle.

ANALYSIS OF SOILS AND PLANTS CULTIVATED IN AN ORGANIC GARDEN AT FEI UNIVERSITY CENTER

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Summary: This project aims to quantify the presence of macro and micronutrients in soils and vegetables planted in the FEI organic garden using the Energy Dispersive X-Ray Fluorescence (EDXRF) technique.

1. Introduction

Urban organic gardens have emerged as a growing initiative in cities around the world, including in Brazil, contributing to making cities more sustainable, improving quality of life, and encouraging healthy eating habits. However, the presence of pollution in urban areas poses a risk to crop cultivation, as it can lead to contamination by heavy metals, primarily from vehicle emissions [1].

Based on this, there is a need to evaluate the risk factors that cultivation in urban gardens can bring to human health. Therefore, this project aims to highlight a study on the presence of macro and micronutrients in soil and vegetables planted in the FEI organic garden over two months. Furthermore, the project evaluated lettuce, the agricultural crop chosen for the study, in three different groups: in the presence of manure, NPK, and without anything, to demonstrate the most effective and beneficial means of its cultivation.

2. Methodology

2.1 Sample preparation

To prepare the samples in powder form, it is necessary first to dry the lettuce and soil and then grind them. For this, an oven made available by the FEI Chemistry laboratory was used, in which the machine in question was programmed for a temperature of 60 °C to 100 °C, for 24 hours. Then, after drought, a pistil was used to grind the vegetables and, for the soil, only a sieve was used, to separate small twigs and stones present in its composition.

Subsequently, in individual bags, the samples were cataloged. With this, the samples are ready for data acquisition.

2.2 X-ray fluorescence

To acquire data using the X-ray fluorescence method, portable equipment was used, consisting of a MINI-X spectrometer and a Silicon detector. During data capture, it was decided to operate it under a voltage of 30 kV and an electric current of 5 μA.

The samples were all analyzed at the Radiation Physics Laboratory (LAFIR), located on the FEI Campus, in São Bernardo do Campo. For every measurement carried out, it is necessary to calibrate the equipment, first measuring the air and then the lead. This is used to then relate the acquisition channels with their corresponding energies in WinQxas [2]. In this case, the Argon (Ar) and Lead (Pb) peaks were used in the energy calibration.

It is worth highlighting the importance of this step in data acquisition, since the equipment, as it is sensitive to external factors, requires that the calibration be redone for every measurement carried out. Thus, preventing any false analysis from occurring in the future.

Furthermore, to be able to evaluate the samples quantitatively, it is necessary to use standards. In the study, Tomato Leaves and Buffalo River Sediment were used to determine the concentration of components in lettuce and soil samples, respectively. The importance of using standards in the EDXRF method is because they increase the precision of research data, as they have a certification for the concentrations of elements in their composition [3].

After this step, with the help of the WINQXAS software, the samples were analyzed, one by one. An example of how this part was done will be shown below, in which test samples were used to study the system in question.

3. Results

As previously stated, using the EDXRF technique, the concentrations of elements present in lettuce and soil samples can be calculated. Thus, this section will showcase those outcomes that were achieved.

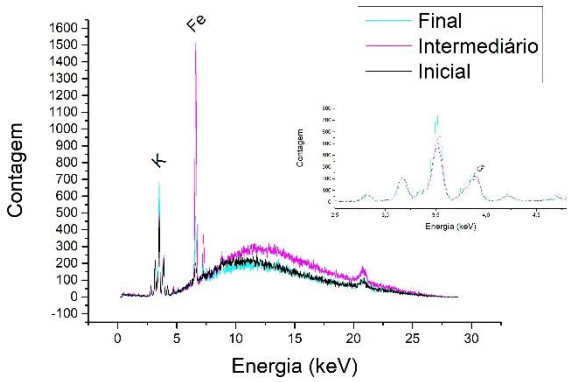

Figure 1 – Chart of lettuce without fertilizers.

By analyzing concentration calculations and charts, one can identify the most prevalent elements, including Fe, K, Ca, Cl, and Al. It is worth noting that vegetables grown with manure and NPK demonstrate a higher nutrient concentration when compared to lettuce planted without any fertilizer, as expected.

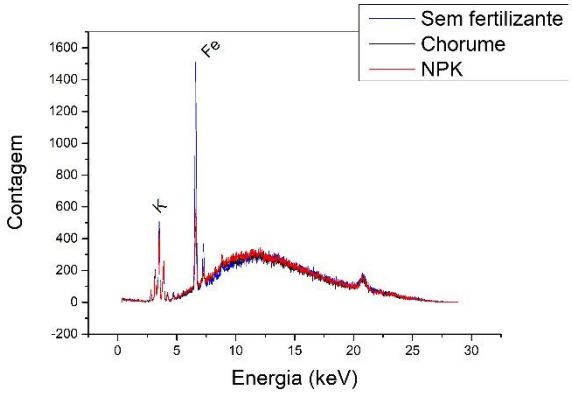

Figure 2 – Chart of intermedium lettuces.

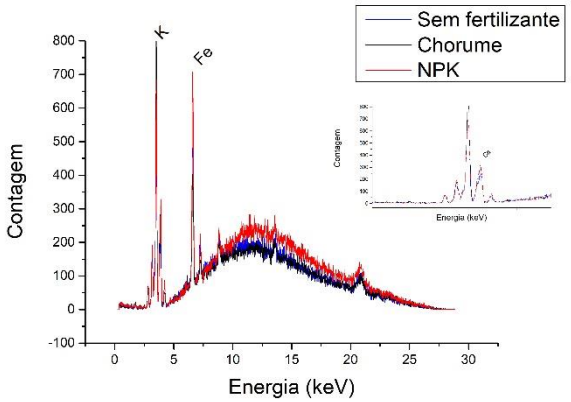

Figure 3 – Chart of final lettuces.

Therefore, in general, it can be seen, through calculations and graphs, that over two months the three crops, without fertilizers, with manure, and with NPK, developed and grew. This fact is represented by the increase in the potassium peak from figures 2 and 3. Furthermore, from a brief analysis of these, it can be concluded that in the intermediate samples, there was almost no effect of fertilizers on the concentration of nutrients in vegetables. In contrast, in the final samples, the lettuces showed a higher concentration of nutrients, under the presence of NPK.

In order to determine the concentrations, a straightforward correlation was employed between the energy peak area of a particular element in the spectrum and its concentration in the standard. Essentially, we can establish a connection between the area obtained for a specific element in the standard spectrum and its concentration in the standard. By applying this same relationship to the spectrum of the sample being analyzed, we can then calculate the concentration of that element. The following equation is used in these calculations:

$$C_{Sample} = \frac{S_{Sample} * C_{standards}}{S_{Standards}} \quad (1)$$

C_{Sample}: Concentration of the element in the sample.
S_{Sample}: Area of the energy peak of the element in the sample.
$C_{standards}$: Concentration of the element in the standard.
$S_{standards}$: Area of the energy peak of the element in the standard.

Below there is a demonstration of the elements found, as well as their respective concentrations in ppm, for lettuce seedlings.

Alface Inicial	
Componente	**Concentração**
Al	(37±26).10 ppm
Cl	(33±13).10^2 ppm
K	(260±37).10^2 ppm
Ca	(496±74).10 ppm
Mn	(132±23) ppm
Fe	(301±45) ppm
Ni	(1,96±0,49) ppm
Cu	(10,04±2,2) ppm
Zn	(49,6±8,6) ppm
Rb	(75±28) ppm
Sr	(39±15) ppm
Ba	(40±14).10 ppm

Table 1 – Concentrations in the lettuce seedling.

4. Conclusion

Thus, it can be concluded that the objectives of evaluating the presence of macro and micronutrients in the FEI garden were achieved. Furthermore, through the analysis of the calculations carried out on the concentrations of the three crops, it can be said that both the use of NPK and the use of slurry had satisfactory results.

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Melhorias para o sistema de detecção do RIBRAS

Marcos Vinícius R. Ribeiro - IFUSP

Orientador: Uiran Umbelino da Silva - IFUSP

O RIBRAS (Radioactive Ions Beams in Brasil) [1–3] é um sistema de duplo solenoide empregado na produção, seleção e focalização de feixes radioativos. Localiza-se na canalização a 45 graus da sala experimental B do Laboratório Aberto de Física Nuclear e opera em conjunto com o acelerador eletrostático Pelletron [4]. A produção do feixe secundário ocorre por meio de uma reação nuclear na câmara de produção e, consequentemente, são menos intensos que os feixes primários (10^{-8} a 10^{-7}). Os isótopos de interesse são focalizados pelo campo magnético do primeiro solenoide no interior da câmara central, onde está localizado o alvo secundário e o sistema de detecção. A câmara central é do tipo ISO-250, com um prato giratório e trilhos para suportes de detecção.

Para obter um feixe de alta pureza, o segundo solenoide pode ser utilizado, focalizando o feixe de interesse na câmara de espalhamento traseira, que possui 750 mm de diâmetro. Esta câmara possui dois pratos giratórios concêntricos com perfurações espaçadas em 15° para fixação de suportes. A obtenção de dados de alta precisão é um processo demorado, e interferências eletrônicas impactam na qualidade dos resultados. Portanto, um sistema de detecção eficiente e limpo de ruídos é essencial para ocupar as câmaras, garantindo o isolamento elétrico e permitindo a completa distinção entre eventos físicos de interesse e ruído eletrônico.

O desenvolvimento de um novo conjunto de suportes para a câmara de espalhamento central, possibilitou o posicionamento de mais torres de forma simultânea e isolou eletricamente os detectores por meio de uma peça de poliacetal. Além disso, os cabos conectados aos detectores são conectados à eletrônica de aquisição via passadores acoplados a uma flange. A substituição da flange de alumínio por uma de acrílico (material isolante) produziu uma redução média de 40(1)% entre os detectores testados, exibindo a importância do isolamento elétrico dos componentes que integram o sistema de detecção.

Este trabalho mostrará as melhorias propostas para a câmara traseira que pre-

tendem atenuar o problema de ruído. Planeja-se implementar suportes isolantes, que sejam compatíveis com os novos suportes da câmara central. Além disso, será alvo de aprimoramento a flange de alumínio atual da câmara traseira, que suportam os passadores de cabo. Simultaneamente, na câmara central, serão realizadas melhorias com o desenvolvimento de suportes fixos isolados eletricamente, posicionados na parte superior da câmara.

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AVALIAÇÃO DO IMPACTO AMBIENTAL EM AMBIENTES DE MANGUEZAIS DEVIDO A UM DERRAMAMENTO DE ÓLEO A PARTIR DE ANÁLISES GEOQUÍMICAS E ISOTÓPICAS

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**Autor palestrante*

RESUMO: A importância do petróleo para a economia mundial está condicionada ao rápido desenvolvimento global, devido à sua exploração e comércio. Seu uso desenfreado vem impulsionando, no entanto, desastres ambientais, como o ocorrido na costa do nordeste brasileiro em 2019, que acarretou a retirada de mais de duzentas toneladas de material oleoso em cerca de 2.880 Km de extensão da costa brasileira. As análises geoquímicas e isotópicas são importantes ferramentas para o estudo dos efeitos da contaminação por petróleo em um ecossistema como o manguezal. As características qualitativas e quantitativas da matéria orgânica presentes no ambiente de mangue permitem rastrear a origem e a trajetória do petróleo e seus subprodutos, além de avaliar seu impacto sobre o meio ambiente. O presente trabalho tem como objetivo a avaliação da matriz sedimentar de amostras de manguezal coletadas no território da Área de Proteção Ambiental (APA) do Pratigi no município de Ituberá no baixo sul da Bahia. Parte dos ensaios foram feitos no Laboratório de Estudos do Petróleo (Lepetro) da Universidade Federal da Bahia (UFBA) dada a sequência de processos analíticos de granulometria, extração da fração orgânica pelo sistema Dionex ASE 300 e cromatografia com hidrocarbonetos totais de petróleo (HTPs), em ordem de estabelecer parâmetros físico-químicos das frações do substrato. Outra parte do estudo será conduzida no Laboratório de Física Nuclear Aplicada do (LFNA) da UFBA e os resultados obtidos a partir da espectrometria de massas de razão isotópica e determinação do Δ14C. Logo, sendo um trabalho em andamento, esse conjunto de dados serão avaliados estatisticamente através de perfis isotópicos e geoquímicos do modelo simulado de manguezal contaminado com a pretensão de verificar o impacto na degradação ambiental do sistema oriundo.

Palavras-chaves: petróleo, manguezal, análises geoquímicas, perfis isotópicos.

Data Processing: A Closer Look at Cultural Heritage Material

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Abstract

The scientific foundation of cultural heritage lies in the characterization of materials through molecular and elementary identification of objects. To accomplish this task, spectrometric techniques capable of revealing certain characteristics based on the incident energy on the sample are necessary. In this study, the focus is on powder pigments and an oil-based ink. To determine the elemental composition of the samples, i.e., to identify the chemical elements present, Energy Dispersive X-Ray Fluorescence Spectroscopy technique (ED-XRF) was utilized, which complements Fourier-Transformed Infrared Spectroscopy (FTIR). The latter method reveals the chemical compounds found in the samples through the characterization of spectral bands located in the mid-infrared region. The ED-XRF Amptek and FTIR Alpha Bruker equipments are located in Laboratory of Archaeometry and Applied Science to Cultural Heritage (LACAPC) at IFUSP. The ED-XRF system is composed of an X-ray tube and a Silicon Drift Detector (SDD). The FTIR system offers two diferent analytical methods: Frontal reflection (RF) and Attenuation Total Reflection.(ATR). The difference between them lies in the interaction of incident IR beam with the sample. The bands to be characterized are related to ATR; therefore, the study will delve into a possible correlation between ATR-FTIR and RF-FTIR, as there is limited literature on this last method.

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AVALIAÇÃO DA BIORREMEDIAÇÃO EM COMPOSTOS SATURADOS APLICANDO ANÁLISE MOLECULAR E ISOTÓPICA DE 13C

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O derramamento de petróleo em ambientes marinhos tem se tornado cada vez mais foco de interesse da comunidade científica, devido aos efeitos deletérios causados por esse contaminante. A atenuação natural é um processo no qual o próprio meio ambiente, através de mecanismos físico-químicos atua na intenção de reduzir os impactos da contaminação por hidrocarbonetos em compartimentos ambientais. Nesse sentido, o objetivo da pesquisa diz respeito à análise da fração saturada do petróleo da Bacia do Recôncavo(BA), Campos(RJ) e da Bacia de Sergipe. Foram realizados testes de biorremediação natural em tanques com água salinizada que simulou o ambiente de manguezal contaminado por óleo. A amostragem foi efetuada em 30, 60 e 90 dias de experimentação. Os compostos foram analisados por análise do δ 13C por GC-IRMS. As primeiras amostras das frações saturadas do petróleo analisadas que no decorrer do experimento o óleo modificações nos perfis cromatográficos indicando uma redução da concentração dos compostos saturados de forma significativa nos primeiros meses.Isso pode indicar que ao final do tratamento ocorreu uma diminuição da comunidade microbiana. .Com a formulação de todos os dados, pretende-se determinar o nível de biodegradação do petróleo por meio do fracionamento de isótopos de carbono. A partir dos dados obtidos até o momento e das perspectivas do andamento da pesquisa ,pode-se concluir que a análise isotópica de composto específico pode ser uma ferramenta importante para analisar a magnitude e direção do fracionamento de isótopos de carbono em regimes que simularam fatores físico-químicos e biológicos por processos de biorremediação de compostos do petróleo.

Palavras-chave: Isótopos, petróleo, contaminação, degradação, GC-MS.

PIGMENTOS EM PÓ ANALISADOS POR TÉCNICAS DE FLUORESCÊNCIA DE RAIOS X E RAMAN E SUAS APLICAÇÕES PARA ESTUDO DE PINTURAS DE CAVALETE

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A Arqueometria ou a Ciência do Patrimônio é uma área interdisciplinar que se ocupa com o estudo e com a caracterização de materiais sob diferentes aplicações das ciência (física, química e biologia) se propondo a investigar objetos históricos, artísticos, arqueológicos e de patrimônio cultural. Para tanto, se utiliza de técnicas analíticas e pode-se fazer uso de instrumentos não invasivos. Os resultados obtidos dessas análises podem ter aplicação nas diferentes áreas e principalmente na conservação e restauro de objetos do patrimônio cultural. Atualmente, no Brasil, o interesse pelo uso destas metodologias e dos diálogos interdisciplinares tem aumentado a produção científica na última década[1], principalmente nos diferentes estudos arqueométrico realizados para melhor conhecer os materiais dos pigmentos, pinturas, esculturas, entre outros artefatos artísticos.

Para o presente trabalho, pretende-se apresentar as análises e as caracterizações de uma coleção de pigmentos puros em pó fornecidos pela empresa *Joules e Joules* (*https://www.joulesejoules.com/*), identificando e correlacionando essa coleção por meio de espectros provenientes de técnicas de física experimental aplicada como Fluorescência de Raios X por Dispersão de Energia (ED-XRF) e Espectroscopia Raman. As técnicas citadas são utilizadas em conjunto, pois podem ser complementares entre si e fornecem uma caracterização mais completa em relação à composição e estrutura dos materiais presentes nos pigmentos. Esse estudo visa principalmente a melhor identificação dos componentes principais e secundários presentes nesses pigmentos com o intuito de, por meio da caracterização elementar e de estrutura cristalina, comparar os materiais nacionais que estão sendo utilizados para a fabricação de pigmentos.

Os estudos realizados com os referidos pigmentos forneceram importantes informações quanto à composição dos materiais dos pigmentos, indo dos elementos químicos ao arranjo molecular desses componentes, o que pode ser útil para verificar a complexidade das misturas, composições não convencionais e possibilitar um melhoramento na formulação de pigmentos de melhor qualidade.

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X-Ray Fluorescence, Raman and FTIR analysis of powdered pigments and its applications for the study of easel paintings

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The application of scientific methods for the analysis of materials can be carried out in various different ways. In the case of art materials and those involving cultural heritage, there is a special concern to use methods that are minimally destructive and provide maximum possible information about its elementary and compositional characteristics. Thus, it is important to pay attention to safe ways to study works through non invasive techniques. In such matter, an extremely useful way to understand the nature of artistic materials and their processes of development is through techniques using the emission of photon beams, such as X-ray Fluorescence (XRF), Raman and Transform Infrared spectroscopy Fourier (FTIR).

This Applied Physics work started with the main incentive to study artistic objects through analytical techniques with the support of the Laboratory of Archeometry and Science Applied to Cultural Heritage (LACAPC). The objective of this project is to enhance the contact of the student with scientific methods applied to the study of materials that constitute cultural heritage objects.

The experimental process of analysis of the powdered pigments allowed to notice particular characteristics of each technique as well as its respective limitations. Thus, it was also possible to study connections and possible complement between them from the collection of the same sample by different techniques.

In this project three types of blue pigments were analysed: Cobalt blue, Prussian blue and Phthalo blue. All of which were measured by those three techniques (XRF, Raman, FTIR). Specially for the FTIR measurements it was used two different methods in two scenarios. The first method used was the Attenuated Total Reflection (ATR), in which were measured the pure pigments and then placed on long grain paper to repeat the measure. Later, those latter were equally realised on the Reflectance mode.

The Raman microscopy was also divided in two parts, in which the first one used samples with pigments placed in a small glass container inside an obscure camara, and the other one using a laser pointer with 6mm focal lenght. All techniques were able to identify and distinguish the pigments except for both Prussian and Cobalt blue in the Raman obscure camara technique.

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Morphological Diversity and Inorganic Element Distribution in the Tapajós River: Insights from Gamma Ray Spectrometry Analysis

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The Tapajós River is one of the major clear-water rivers in the Amazon basin and ranks among the largest rivers in the world. Understanding its morphology is crucial for comprehending the distribution and flow of matter and energy within the system, as well as its genesis and evolution. This study aims to investigate the influence of morphological diversity in the Tapajós River channel on the distribution of inorganic elements. Bottom sediment samples were collected at 19 locations along cross-sectional profiles in the Tapajós River channel, ranging from the southern limit of the tidal river to its mouth. The identification and quantification of natural radionuclides, 40K radionuclides, and progeny nuclides from the 238U and 232Th series will be conducted using Gamma Ray Spectrometry analysis. The obtained results will be analyzed to identify any indications of geochemical patterns longitudinally and transversely within the sampled channel. A collaboration was established with the research group led by Prof. João Paulo S. de Cortes from the Federal University of Western Pará. Soil samples from the Tapajós River, collected at ten different points along the river, were collected by his team and sent for analysis at the Radiation Physics Laboratory (LAFIR) at the Centro Universitário FEI [1]. This research work aims to establish the total natural radiation dose found in the different analyzed samples, making it possible to identify correlations between the primary radionuclides as indicators. Data acquisition was performed with equipment available at the Laboratory of Radiation Physics (LAFIR) [2].

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ESTUDOS DE DENDROCRONOLOGIA COM A TÉCNICA PIXE

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Dendrocronologia é um estudo que integra tanto a área da botânica quanto a de climatologia. O estudo da implementação dessa análise com a técnica PIXE (Particle Induced X-ray Emission) visa a definição de processos e protocolos de análise em um tronco de árvore com o arranjo experimental de feixe externo do LAMFI-USP. O objetivo principal é desvendar informações detalhadas sobre a composição química dos anéis de crescimento da árvore, fornecendo uma base sobre as condições ambientais locais ao longo da vida da árvore, incluindo a presença de metais pesados e outros elementos traço, que podem indicar episódios de poluição ou mudanças significativas no ambiente. Como caso de estudo, utilizaremos uma seção de árvore extraída no Instituto de Física da Universidade de São Paulo no ano de 2023. A peça foi limpa e regularizada para se adequar ao arranjo experimental. Medidas preliminares apresentam bons resultados com sensibilidade para correlação temporal de diversos elementos.

Pigment determination in paintings by Vincent van Gogh from MASP collection by portable X-ray fluorescence (pXRF)

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Nuclear and atomic methods have long been used in studies of cultural heritage artifacts. X-ray fluorescence (XRF) spectroscopy is extensively and successfully used for investigating objects of historical and cultural value due to its non-destructive character. Four paintings by Vincent van Gogh (1853-1890), from São Paulo Museum of Art (MASP), was studied by portable X-ray fluorescence (pXRF). Namely, Vincent van Gogh is one of the most famous and influential figures in the history of western art. The paintings are "The Schoolboy" (1888), "The Stone Bench in the Garden of Saint-Paul Hospital" (1889), "Landscape with Couple Walking and Crescent Moon" (1889) and "The Arlesienne" (1890). The four paintings were performed by Vincent van Gogh while his stay in Arles and Saint-Remy-de-Provence, France. According to literature, there are only six van Gogh paintings in the southern hemisphere, one in Australia, one in Argentina, and the four paintings in Brazil, above mentioned. pXRF provided substantial information about the materials present in the paintings. The materials identified in the paintings were chalk and/or gypsum, lead white, lithopone, zinc white, chrome yellow, Prussian blue, cobalt blue, vermilion, eosin lake, emerald green, chrome orange, viridian, lake pigments, a black organic pigment and earth pigments. The results are in agreement with results obtained by other works on other paintings by Vincent van Gogh during his time in Arles and Saint-Remy, and it may help art historians, restorers and conservators to understand the artist's method of work, as well as his creative process, besides guiding future works employing other methodologies.

Gamma-ray Spectrometry combined with multivariate regression to predict soil fertility attributes: a case of study with Xanthic Hapludox.

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In the last decades, many researchers have explored the use of proximal soil sensors (PSS) based on spectroscopic methods to estimate soil attributes. The viability of using spectrometric data in soil samples is reached by applying machine learning regression methods to the data analysis. Gamma-ray spectrometry may prove itself an alternative to substitute conventional methods, once the soil is analyzed without preparation, it uses no chemicals, and the measured radioactivity may be correlated to the soil attributes of interest. The objective of this study was to test the possibility to determine soil fertility attributes using gamma-ray spectra and partial least square regression (PLS) in agricultural soils. In a farm at Guarapuava, Paraná State, Southern Brazil, where the soil is classified as Xanthic Hapludox with a very clayey texture 396 soil samples were collected at three depth layers and submitted to conventional analysis. Based in the results, a subset of 80 samples was selected, using Kennard-Stone algorithm, to be submitted to Gamma-ray spectrometry measurements. Aliquots of 130 g of soil of each sample were placed in cylindrical plastic containers and measured for 1800 s, using a NaI(Tl) detector (Amptek Gamma-Rad5, 76 mm diameter and 152 mm height, 8cm lead shield). The spectra from each measurement were used in the PLS considering 52 samples in the calibration set and 28 in the prediction set. The spectra were preprocessed using Savitzky–Golay (window 15, second order polynomial fit, first derivative) followed by mean-centering. The modeling parameters and some figures of merit from the 14 soil fertility attributes evaluated are summarized in Table 1. The best results were for CEC, exchangeable Fe, Cu, and Zn. The correlation coefficients for calibration ranged from 0.51 to 0.83 and from 0.003 to 0.20 for prediction, indicating that regression models are not correctly predicting the attributes. Moreover, based on RPD values ranging from 0.71 to 1.10, the models are classified as very poor (RPD <1.4, Viscarra Rossel et al., 2006[1]). This study is the first attempt to obtain soil fertility attributes from gamma-ray spectral data. Further studies with a wider dataset are necessary to evaluate the viability of this method as a PSS for precision agriculture application.

Table 1: Modeling parameters and figures of merit of the soil fertility attributes examined.

	pH	H+Al	exMg	exAl	exP	exK	exCa	exMn	exFe	exCu	exZn	SB	CEC	V%
nLV	3	3	3	3	3	3	3	3	4	3	3	4	3	3
CumVarExplx	74	74	73	71	75	75	71	75	76	75	74	76	72	75
CumVarExply	59	59	59	65	57	51	67	65	82	73	74	83	56	53
r2cal	0.59	0.59	0.59	0.65	0.57	0.51	0.67	0.65	0.82	0.73	0.74	0.83	0.56	0.53
r2pred	0.08	0.08	0.02	0.00	0.16	0.01	0.09	0.12	0.05	0.01	0.20	0.08	0.19	0.03
RMSEC	0.23	1.23	5.87	0.10	2.27	1.01	0.14	5.76	5.24	0.47	2.48	1.99	3.53	9.05
RMSEP	0.36	1.80	6.64	0.22	3.06	1.52	0.17	9.40	13.50	1.20	4.25	4.95	4.88	12.01
RPD	0.99	1.00	0.71	0.94	1.05	0.96	0.82	0.96	0.97	0.94	1.06	0.94	1.10	0.91
Bias_pred	-0.08	0.45	-3.15	0.02	0.51	0.08	-0.02	0.69	-0.59	0.12	-1.42	0.59	1.14	0.33
t_bias*	1.15	1.23	2.58	0.40	0.82	0.24	0.65	0.35	0.21	0.50	1.70	0.58	1.15	0.13
RE	7.6	25.5	68.0	85.1	38.0	46.3	58.4	33.1	43.4	50.7	65.0	42.2	26.6	20.2
DW_pvalue #	0.26	0.48	0.86	0.65	0.63	0.94	0.55	0.39	0.50	0.96	0.67	0.87	0.88	0.46

Soil fertility attributes: pH, potential acidity ($H^{+}+Al^{3+}$), exchangeable macro and micro nutrients (exCa, exMg, exK, exMn, exFe, exCu, exZn), available phosphorus (P_M), sum of exchange bases (SB), cation exchange capacity (CEC), and base saturation percentage (BSP). The Ca^{2+}, Mg^{2+}, K^{+}, $H^{+}+Al^{3+}$, SB, and CEC values are in $cmol_c\ kg^{-1}$. The PM, exMn, exFe, exCu, exZn values are in mg kg^{-1} and the BSP values are in %.
nLV= number of latent variables, cumVar= cumulative variance in matriz X and Y, RMSE= root mean square error of calibration and prediction, R^2= determination coefficient of calibration and prediction, RPD= ratio performance to deviation, RE = Relative Errors, DW = Durbin-Watson test,
*t-critic = 1.98, # Randomization test p-value with 0.05 probability significance level.

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NEW INTEGRATED ARCHITECTURE FOR DATA ACQUISITION AND SAMPLE POSITIONING OF THE LAMFI-USP FACILITY

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Abstract

With the commissioning of the new external beam setup at the Laboratory of Material Analysis with Ion Beam of University of São Paulo (LAMFI-USP), a new era of large amounts of data has begun at the laboratory. Integrating many detectors, this setup has become a versatile analytical station for in-air analysis. A fully automated robotic stage enables imaging capabilities by scanning the sample for sequential measurements. Current limitations of this setup include the slow response of the acquisition electronics and the limited count rates supported by the ADCs. Besides that, the self-consistent oriented approach adopted to the data obtained using the multipurpose chamber at the LAMFI-USP has pushed the limits of control and automation of this analytical station. High reproducibility in the 5-axis sample holder, control of the position of the movable detector, and the possibility of scheduling automatic measurements are the present limitations.

Aiming for solving of these limitations, an upgraded architecture was designed that integrates a new acquisition electronics, a new high sensibility picoammeter, processes of automatic data handling, together with the full automation of the 5-axis sample holder and the position of the movable detector in the multipurpose chamber. The acquisition electronics consists of two high sampling rate waveform digitizers commercially available from CAEN (model N6725 with 8 Channel 14-bit 250 MS/s). The new system architecture allows for simultaneous processing of data from sixteen individual channels of many sorts of different detectors and enables the possibility to use a complex logic control. The automation of the 5-axis sample holder and the movable detector position includes a customized software to control 6-stepper motors. It includes a list of previously configured coordinates and geometries for a fast and precise adjusting of the sample holder and detector with scheduling of automatic measurements.

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https://www.caen.it/support-services/documentation-area/

Characterizing the materials present in Drinkstone Park (1747) of Thomas Gainsborough applying spectroscopy and imaging techniques

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Abstract

The aim of this study is to characterize the materials present in the oil painting "Drinkstone Park", dated 1747, by the English painter Thomas Gainsborough (1727-1788), which is part of the Museu de Arte de São Paulo Assis Chateaubriand (MASP) collection. The analysis combines non-destructive techniques such as portable X-ray Fluorescence (pXRF) and Raman spectroscopy, along with colorimetric and imaging methods (visible, tangent, UV, IR, radiography and photomicrography). Spectrometric techniques, namely pXRF and Raman spectroscopy, complemented each other in characterizing the materials used by the artist. These materials include Calcium Carbonate and/or Sulfate, Lead White, Ivory Black, Charcoal, Naples Yellow, Yellow Ochre, Red Ochre, Minium, Azurite, Ultramarine, Indigo, Prussian Blue, Smalt, Verdigris, Green Earth, Malachite, Umbria, Sienna, Vitriol and Alizarin. Additionally, possible intervention materials were identified, including Barite, Lithopone, Graphite, Chrome Yellow, Cerulean Blue, Cobalt Blue, Phthalo Green, and Viridian. Imaging techniques allowed the analysis of punctual restoration areas. Infrared Reflectography (IR) imaging showed that no *pentimenti* were observed. Through imaging, it was possible to examine the pattern of crackling on the painting's surface, particularly in the varnish, and the canvas structure. Colorimetric measurements documented the colors of the analyzed regions using the CIELab* color space. This study demonstrates how each type of analysis contributes to characterizing the materials and pigments present in the analyzed painting, highlighting how the techniques complement each other. It's important to note that this study is part of a larger project characterizing three paintings by Thomas Gainsborough, utilizing the same analysis techniques for comparative results.

Key-words: spectroscopy, imaging, Drinkstone Park, characterization, materials.

Factorial planning in evaluating the influence of experimental parameters on X-ray micro-computed tomography imaging

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X-ray micro-computed tomography (micro-CT) is widely utilized for its ability to rapidly map the linear attenuation coefficients (μ) of various samples in three dimensions, facilitating high-resolution morphological studies. Spectral Computed Tomography techniques have recently emerged, aiming to characterize material density and effective atomic number based on registered μ. These outcomes are directly influenced by the chosen sample preparation methodology and predefined scanning parameters. This study investigates the effects of experimental parameters (uniaxial compression and image pixel size) on the imaging of certified composition samples, specifically metal oxide pellets – copper (II) oxide (CuO), manganese dioxide (MnO_2), and iron (III) oxide (Fe_2O_3). The oxides were compacted using a hydraulic press with pressures ranging from 74 to 370 MPa in 74 MPa increments. The pellets underwent examination using a Bruker Skyscan 1173 micro-CT scanner, operating with an X-ray tube at 130 kV and 61 μA. Concurrently, the pixel size ranged from 20 to 70 μm. The experimental points were established through a two-factor, five-level factorial design. Results were compared based on mean and standard deviation of grayscale distribution histograms for each sample. An analysis of linear, quadratic, and combined effects on the responses was performed. Uniaxial compression had a direct impact on the samples, leading to alterations in material density with increased applied pressure, consequently influencing the recorded μ. This effect is material-dependent and is influenced by atomic interactions and compressibility properties. The variation in grayscale values within the less compressed to the most compressed pellet ranged from less than 0.5% to more than 10%. Resolution directly impacted image details and, subsequently, the approximations and data processing used for obtaining final data. The influence of this parameter was found to be independent of the material studied, relying solely on equipment specifications. In summary, this study enabled the quantification of relevant parameters in certified samples, enhancing the precision of material characterization techniques based on micro-CT.

Título do Projeto:

Uso de algoritmos de aprendizado de máquina no processamento de dados de espectroscopia de raios-x

Autores e Co-autores

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- Prof. Dr. Tiago Fiorini da Silva

Resumo

Atualmente o Laboratório de Análise de Materiais por Feixes Iônicos (LAMFI) está equipado com uma estação de análise de feixe externo, fígura 1, qual o arranjo experimental nos permite fazer medidas em ar e fazer mapeamentos na amostra, com o auxilio da mesa móvel com 6 graus de liberdade. Acontece que em uma medida de mapeamento de superfície irá gerar um arquivo com os dados medidos para cada ponto mapeado. Então, supondo que deseja-se mapear um algo com 10 x 10 pixels o resultado será 100 arquivos para cada detector de raios-x envolvido no experimento. A rápida escalabilidade do número de arquivos gerados é uma limitação para a aplicação sistemática da técnica, pois torna inviável o processamento e análise de cada conjunto de dados gerados.
Uma vez diante de um problema de BigData, ou seja, precisamos lhe dar com uma grande quantidade de informação, recorremos a literatura a fim de conhecer métodos de machine learning que sejam aplicáveis a nossa situação e com ótima performance.
Propomos uma replicação dos métodos Non-negative Matrix Factorization(NMF) e K-Means utilizados pelos autores no artigo Multivariate analysis applied to particle-induced X-ray emission mapping [1], com a adição de um terceiro método, a Análise de Silhueta, para ajudar a determinar a melhor configuração de clusters gerado pelo K-Means.

Estudo de Padrões de Deposição de Resíduos de Pólvora em Disparos de Armas de Fogo pela Técnica PIXE

Yuri Idalgo de Matos da Silva, Manfredo H. Tabacniks,
Cleber L. Rodrigues, Tiago F. da Silva

RESUMO:

Quando ocorre um disparo de arma de fogo, um padrão de resíduos do elemento propelente é espalhado e se deposita nas mãos do atirador. Esse padrão tem relação com a composição e densidades do elemento propelente e com a geometria da arma de fogo. Neste trabalho pretendemos desenvolver um protocolo de análises com a técnica PIXE para se obter a distribuição de resíduos de pólvora nas mãos de um atirador. Para isso, um atirador credenciado executará disparos utilizando luvas especiais que serão analisadas no arranjo experimental de feixe externo do LAMFI-USP. O mapeamento das luvas como um todo é um desafio, e para tanto utilizaremos modelos substitutos obtidos por técnicas de aprendizado de máquina para se maximizar as informações obtidas sobre a distribuição e minimizar as incertezas. Esse processo é possível utilizando Processos Gaussianos e funções de ativação para sugerir os pontos a serem medidos na amostra. Trata-se de um processo de aprendizado por reforço.

Caracterizando Oscar Pereira da Silva: uma abordagem multi-técnicas, portátil e não invasiva aplicada ao estudo de seis obras do artista pertencentes ao Museu Paulista

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Resumo

O estudo e caracterização de objetos pertencentes ao patrimônio histórico-cultural é motivado pelo desejo de compreender sobre seus processos de criação, suas condições químicas, o que o compõem e se passou por intervenções, além de poder contribuir para discussões futuras pautadas na conservação destes bens culturais. Entre as diferentes abordagens possíveis, a combinação entre técnicas de análise não invasivas e portáteis possui um grande destaque para o estudo de objetos do patrimônio, uma vez que que não demandam de retiradas de amostras, podem ser transportadas até o local do acervo e combinam métodos de análise que operam para faixas do espectro eletromagnético com diferentes energias, possibilitando assim uma investigação mais completa acerca dos materiais que compõem o objeto de interesse.

Neste trabalho será discutido as diferentes aplicações (potencialidades) das técnicas espectroscópicas de Fluorescência de Raios por Dispersão de Energia (FRX-DE) e Raman em conjunto com o imageamento de Reflectografia de Infravermelho (RIV) para a investigação de seis pinturas à óleo de grande porte do artista Oscar Pereira da Silva, pertencentes ao acervo do Museu Paulista. Esse pintor, que se destaca como um dos nomes com maior renome entre os artistas do período neoclássico brasileiro (século XIX - XX), é conhecido pelo seu estilo artístico pragmático, cuidadoso e realista, o que garantiu que um ampla parcela de suas obras fossem adicionadas às coleções dos museus paulistas e coleções privadas.

A análise das obras selecionadas com a técnica de imageamento RIV forneceu informações importantes sobre o processo criativo de Oscar Pereira da Silva, revelando que o artista tinha como hábito desenhar um quadriculado, para guiar a construção dos cenários, e esboçar personagens e elementos, podendo corrigi-los em estágio de esboço e pintura. As análises espectroscópicas de FRX-DE e Raman mostram que a paleta de pigmentos do artista era vasta e composta por pigmentos naturais e sintéticos, com uma ampla utilização de pigmentos a base de ferro, zinco, bário, chumbo, cádmio, cromo e cobalto, além de pigmentos mais incomuns, como ultramarino e azul índigo. Essas informações estão de acordo com pesquisas anteriores sobre o trabalho do artista.

No entanto, em duas das seis obras estudadas não foram observadas as características do processo criativo identificadas com RIV, além destas apresentarem uma paleta de pigmentos muito reduzida e com pouca variabilidade química. Essas discrepâncias levantam o questionamento sobre quais seriam as motivações do artista para ter alterado seu processo criativo, ou se essas obras poderiam ter sido pintadas por outros membros que compunham o atelier do Oscar Pereira, como aprendizes ou ajudantes. A fim de ajudar a responder essas perguntas, este trabalho apresenta uma comparação mais rigorosa entre as seis obras, para apontar as principais diferenças criativas, além de investigar as semelhanças e diferenças entre os resultados espectroscópicos com a Análise de Componentes Principais (ACP).

Considerações importantes: este projeto recebeu apoio financeiro do Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brasil (CNPq), sob o processo 131907/2021-2 e da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001, sob o processo 88887.884965/2023-00 e fez parte do projeto temático financiado pela Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), sob o processo 2017/07366 –1. As autoras gostariam de agradecer ao Museu Paulista pelo acesso às obras do acervo e à equipe do Atelier Raul Carvalho por disponibilizar o espaço para análise.

Title: Thorium as nucear fuel in Brazil.

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Sumary: A statement by Rafael Mariano Grossi, Director General of the International Atomic Energy Agency (IAEA), emphasizes the potential of nuclear power in addressing global energy challenges and In the context of global warming, given that nuclear energy is environmentally clean,. Acknowledging concerns about radioactive waste, the history of nuclear power reveals a significant focus on thorium as a solution. Established in 1965 in Brazil, the Thorium Group collaborated with France and Germany. Besides that, recent theoretical studies in Brazil highlight thorium's promise as a nuclear fuel source. With the world's second-largest thorium reservoir, Brazil position is optimall for thorium research. Thorium, four times more abundant than uranium, offers safety advantages, produces less radioactive waste, and can recycle uranium waste for further energy production. The poster aims to summarize Brazil's contributions to thorium research and underscore its role in shaping a sustainable and secure nuclear energy future.

Título

Análise de Radioisótopos Naturais em Matrizes Ambientais

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Resumo

O projeto de pesquisa propõe uma investigação minuciosa dos radioisótopos de ocorrencia natural em diversas matrizes ambientais, como solo, sedimento de mangue, folhas e água. A abordagem, utilizando técnicas avançadas, como a espectrometria gama no Laboratório de Física Nuclear da Universidade Federal da Bahia, tem como objetivo identificar e quantificar radioisótopos específicos, incluindo urânio-238, tório-232 e potássio-40. Essa análise proporcionará uma compreensão mais aprofundada da origem geológica das amostras, dos processos ambientais que influenciam sua composição e das características intrínsecas dessas matrizes. Além de contribuir significativamente para o avanço da ciência ambiental, a pesquisa visa fornecer dados valiosos para avaliações do impacto ambiental advindo do enriquecimento na concentração desses radionuclídeos devido atividades antrópicas, orientando estratégias eficazes de gestão sustentável em ambientes naturais. Inicialmente, foram feitas amostragens de sedimentos na Área de Proteção Ambiental, localizado em Pratigi, no município de Ituberá-Ba. Para isso, foi utilizado um detector do tipo cintilador de iodeto de sódio concentrado em duas áreas próximas. A primeira foi encontrado valores médios de 0,7 % K, 1,47 ppm eU e 6,53 ppm Th, não havendo valores significativos de radionuclídeos. Por outro lado, a segunda área apresentou valores médios mais altos com 1,4 % K, 2,0 ppm eU e 10,35 ppm Th, onde o tório variou de 4,9 a 17,2 ppm, esses valores mais altos, mesmo sendo de ocorrencia natural necessitam de investigação.

Comparison of machine learning tools in systematic study of training samples set reduction for soil organic carbon determination through EDXRF spectrum

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The organic matter (OM) improves the physical and chemical environment of the soil by holding moisture, providing nutrients, and, thus, supporting plant growth. This means that periodic analysis to maintain appropriate levels of soil OM increases the chances of a good harvest [1]. The indirect determination of the OM through the Soil Organic Carbon (SOC) content is performed by most soil laboratories in Brazil using the wet method of Walkley–Black (WB), in which the SOC to OM conversion is performing by the van Bemmelen factor (OM = 1.724 *x* SOC) based on the assumption that 58% of the C is from OM [1]. However, although this method is accurate, it has some disadvantages such as hard sample preparation, is time consuming, uses reagents, and generates a significant amount of waste that must be properly discarded. Proximal Soil Sensors (PSS) based on spectral-analytical techniques such as energy dispersive X-ray fluorescence (EXRF) combined with machine learning (ML) tools have been shown to be able to estimate several fertility attributes from soil samples quickly and less expensively [2]. To develop robust ML models, the training database must be representative of the study area. Commonly, a huge number of training samples are employed. Managing with such sample sets may become laborious and computationally costly, in addition increases the processing time of the ML algorithm training step. So, the idea is to use EDXRF and WB methods to determine the SOC of the minimum number of samples required for ML model training and validation with reliable accuracy for quantitative analysis. Subsequently, only the EDXRF spectral reading of new soil samples from the same study area and prepared in the same procedure is required to estimate the SOC. This approach is promising to local soil fertility assessment and may reduce the sample set sent for conventional wet treatments. From this perspective, this research aims to systematic study of two ML tools (Partial Least Squares Linear (PLS) regression and Artificial Neural Network (ANN) regression) to SOC quantification through the raw EDXRF spectrum as a function of the number of training samples. Thus, 394 soil samples spectra from an area used for agricultural cultivation were randomly separated between training (276) and validation (118) sets. The full training set (276 samples) was subsequently randomly reduced 3 times (into 206, 136 and 66 samples). Then, theses four training samples sets was used to PLS and ANN modeling, validated with the independent 118 samples set. The LV optimal number of PLS models were selected by the minimum root mean squared error of 10-fold cross validation. ANN models were based on Multi-Layer Percepton architecture with Backpropagation algorithm. The number of neurons, learning rate, maximum tolerated error and number of epochs were defined by search grid. The results indicate that the models trained with 276 samples showed the best prediction performance (validation R^2 of 0.84 for ANN e 0.78 for PLS), succeeded by the models trained with 206, 136, and 66 samples. The highest difference in performance between both ML tools is for the model trained with 276 samples, approximately 10% of superiority to ANN, while the others show similar results. However, although all models have adequate RPD for quantitative analysis (>1.8 [3]), some of them showed significant prediction bias (95% significance level), specifically: ANN models trained with 206, 136 and 66 samples and PLS models trained with 66 samples. To complement these results, random tests comparing the reduced set models with the models trained with the full sample sets, both from the same ML tool, showed statistical equivalence in terms of accuracy (equivalent root mean square error of validation). These results demonstrate that only in PLS models the reduction of training samples in the scale of this study was viable, being possible to reduce from 276 to 136 samples without significant loss of accuracy and without bias. Adopting a reduced number of training samples and PLS as ML tool is advantageous from a financial, environmental, and analysis time perspective. This is due to the reduction in traditional analysis-related costs, waste, and reagent usage associated with fewer samples. Additionally, by reducing the number of samples, the time required to perform the analysis may be minimized. This is significant in scenarios where rapid results are desired. Therefore, local soil SOC analysis with PLS may turn agile the decision related to the use of fertilizers and other products for soil correction, favoring greater productivity and reduction of environmentally unfriendly procedures.

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Otimização de instrumentações analíticas para o estudo de objetos do patrimônio histórico e cultural

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Resumo

Para aumentar a potencialidade analítica na área de Arqueometria, ou Ciência do Patrimônio, sempre se faz necessário o desenvolvimento de novas instrumentações para contribuir no processo de estudo de objetos pertencentes aos acervos culturais. Dentro dessa motivação, é importante construir ou adaptar novos equipamentos que apresentem estruturas facilmente montáveis, e confeccionadas com material de baixo custo , mantendo a eficiência de aplicabilidade portátil com técnicas não-invasivas. A partir dessas considerações, o Laboratório de Arqueometria e Ciências Aplicadas ao Patrimônio Cultural (LACAPC) está atualizando sua câmara de degradação por irradiação ultravioleta, para projetos relacionados a degradação de amostras. . Além desta câmara de envelhecimento um novo sistema otimizado de mapeamento de fluorescência de raios X (MA-FRX) está sendo montado e otimizado, para realização de mapeamento elementar de bens culturais.

A câmara de degradação por irradiação ultravioleta consiste em uma caixa completamente escura e opaca com fontes UV e incandescente, sensores de temperatura, luminosidade e umidade e conta com um software para controle do ambiente interno e registro dos dados. A câmara pode ser utilizada no tratamento por reações fotoquímicas de qualquer material de interesse (papéis, pigmentos, fotografias, filmes finos, tecidos, etc). Esse equipamento, que possibilita simular em amostras o efeito de degradação fotoquímica que pode produzir transformações nos materiais, teve sua primeira versão (UV-1) adicionada ao LACAPC em 2017 (AGUERO, 2017). Atualmente, a câmara está sendo reformulada e atualizada para a versão UV-2, com a substituição das fontes UVA, UVB e incandescente por uma fonte germicida UVC, que permitirá aumentar a área de exposição dentro da câmara, abrangendo assim o estudo de degradação de um número maior de amostras. Também será adaptado ao sistema um sensor de ozônio (CJMCU-131) como medida de segurança. Também está em processo de otimização o equipamento de mapeamento 2D de FRX-DE pertencente ao laboratório, qu desenvolvido em 2019 (CAMPOS, et al., 2019). Para que a atualização deste sistema permita um mapeamento de alta eficiência (alta contagens e rapidez) um novo tubo de raios X (microfocado da linha Apogee - Oxford), bem como dois novos detectores de raios X de alta resolução Fast SDD, X-123 (Amptek) estão sendo adquiridos. Também está sendo reformulando todo o software de controle dos motores e aquisição de dados. Através da aquisição de novos microcontroladores construção de um novo software de controle em C# que fará o gerenciamento dos trilhos e equipamentos.

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Áreas Úmidas no Litoral Norte do Estado da Bahia: Caracterização, Distúrbios e Padrões de Biodiversidade

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O objetivo do trabalho é caracterizar as áreas úmidas do litoral Norte do Estado da Bahia. Para a consecução do projeto, foram coletadas amostras de testemunhos nas planícies de inundação dos rios Itapicuru e Crumaí, sendo todas as coletas realizadas utilizando tubos de policloreto de vinila (PVC) de aproximadamente um metro e meio (1,5 m) de altura e 60 mm de diâmetro. Em laboratório, os testemunhos foram abertos, fotografados e fatiados a cada centímetro. As amostras (aproximadamente dois gramas de material úmido) foram submetidas a um processo de liofilização, método utilizado para secagem de material por sublimação, evitando alterações químicas e degradação da matéria orgânica. Após obter-se o peso seco, as amostras foram maceradas em cadinhos de cerâmica, peneiradas em peneiras de malha de 0,5 mm. Uma quantidade de 0,5 mg do material seco macerado foi acondicionada em tubos de ensaio, nos quais foram adicionados 3 ml de ácido clorídrico, homogeneizado e colocados em estufa a 90°C por uma hora. Após o tempo encerrado, o material foi centrifugado e repetido o processo até que não fosse mais observada reação na amostra. Por último, a amostra foi colocada na estufa a 90°C até secar. Para a leitura de δC13 e δ15N foram pesados entre 3 a 5 mg da amostra, acondicionadas em cápsulas de estanho e postas em um Analisador Elementar acoplado a um espectrômetro de massa de razão isotópica. A partir das análises isotópicas e elementares, foi observado que os percentuais de carbono e nitrogênio apresentam uma tendência de diminuição em direção à base do testemunho. A variação de δC13 e δ15N encontrada ao longo do testemunho foi calculada em torno de -8,05 a -27,17 e -0,1 a 4,62, enquanto a média de C/N do testemunho por completo foi calculada em torno de 33,9. Este dado obtido em laboratório por meio da análise de carbono e nitrogênio total mostraram concentrações condizentes com o que é encontrado em substrato do tipo turfa encontrado em amostras do Rio de Janeiro e Santa Catarina.

DETERMINING THE SENSITIVITY CURVE OF AN ENERGY DISPERSIVE X RAY FLUORESCENCE AND PIXE SYSTEMS

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The challenge of conducting thin and thick quantitative analyses of materials persists in X-ray analysis. The calibration of Energy Dispersive X-Ray Fluorescence (ED-XRF) and Particle Induced X-Ray Emission (PIXE) sensibilities enhances quantitative analysis by facilitating the determination of chemical element concentrations within thin samples based on intensity measurements. The sensitivity curve is derived through the examination of elemental standards, which are samples possessing well-defined superficial densities (μg/cm²), thereby enabling the determination of the system's sensitivity to the elements present within these standards. Through the utilization of these standard values, a sensitivity curve can be fitted, thereby establishing the sensitivity equation as a function of atomic number. Subsequently, this equation enables the determination of the concentration of any chemical element from the periodic table within a given sample. It is noteworthy that PIXE and ED-XRF exhibit distinct sensitivities and limits of detection for determining elemental concentrations. In the context of this study, the sensitivities of a portable ED-XRF and a PIXE system were calculated and compared. The ED-XRF configuration utilized a FAST SDD® Ultra High-Performance Silicon Drift Detector from Amptek, whereas the PIXE setup at LAMFI employed two XR-100CR Si-PIN X-ray Detectors, also sourced from Amptek. The results showed that, within the experimental setups employed, ED-XRF demonstrated superior sensitivity towards chemical elements of intermediate atomic numbers, whereas PIXE exhibited more favorable sensitivities towards lighter and heavier elements within the periodic table.

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Medidas de alta acurácia de poder de freamento para prótons com energia de alguns MeV

Arilson da Silva, Tiago F. Silva

O poder de freamento (tradução do termo em inglês: *stopping power*) é definido pela Comissão Internacional de Unidades e Medidas de Radiação como a energia média dissipada por um determinado íon energético, por unidade de comprimento de sua trajetória, ao tentar transpassar um determinado meio material. Essa dissipação pode se dar tanto pela interação do íon com os elétrons quanto com os núcleos atômicos do material, recebendo os nomes de poder de freamento eletrônico e nuclear, respectivamente. O desenvolvimento de modelos para este fenômeno complexo beneficia diretamente aplicações baseadas em feixes de partículas, como o tratamento de tumores com feixes de íons (*proton therapy*), a dopagem de semicondutores, funcionalização de superfícies, produção de nanoestruturas e materiais quânticos, modificação de materiais bidimensionais, entre outras. Neste trabalho, realizamos medidas de alta acurácia de poder de freamento eletrônico para prótons dos elementos níquel, paládio e titânio na faixa de energia de 0,9–3,6 MeV. Para isso usamos o método de transmissão e os valores médios da incerteza total (aleatória e sistemática) foram abaixo de 1%. Essas incertezas foram estimadas por procedimentos que contemplaram o rastreamento de todas as incertezas do experimento e das caracterizações dos materiais. Os resultados apresentam boa aderência a modelos semi-empíricos amplamente utilizados, e revelam que os modelos teóricos ainda apresentam desvios, apesar dos avanços recentes.

Direct O_2+ production from CO_2 ionization

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Fragmentation processes can significantly impact the inventory of molecules in CO_2-rich atmospheres such as those of Venus and Mars, which are always exposed to ionizing radiation. However, the production of O_2+ as a direct result of CO_2 fragmentation had never been quantified yet. As molecular oxygen is considered a potential trace of living organisms, knowing the non-biotic pathways for its production is fundamental. In this work, we ensured that O_2+ comes directly from CO_2 fragmentation by measuring its kinetic energy distribution using the DETOF technique.

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Determination of biogenic fraction in aviation kerosene samples using carbon-14

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Motivated by escalating environmental concerns, there is a notable initiative aimed at mitigating overreliance on petroleum-derived fuels, which has been contributing to extensive environmental degradation. Worldwide, extensive research is underway to explore and develop alternative sources, as biodiesels or fuels blends with biogenic carbon contents. These fuels are produced by volumetrically mixing fossil and renewable sources during the production process. Although these options effectively reduce greenhouse gas emissions, it is crucial to maintain the same chemical composition and energy efficiency. Radiocarbon analysis is a highly precise and accurate method used to determine the biogenic fraction, enabling the distinction between fossil and modern carbon. In this study, aviation kerosene samples were analyzed in quintuplicate at LAC-UFF using the 14C-AMS technique. To prepare them, they were frozen in liquid nitrogen under vacuum prior to combustion. Graphitization was the performed using sealed Pyrex tubes using the zinc and Titanium hydride method. Renewable content was determined according to the ASTM-D6866-21 guidelines. This work shows preliminary tests and results that ensure the safe use of these mixtures for commercial purposes.

Key words: Fossil fuel; renewable fuel; aviation kerosene; radiocarbon.

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Evaluation of CO_2 in the atmosphere by ^{14}C measured on tree rings

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The burning of fossil fuels releases in the atmosphere a large amount of CO_2 into the atmosphere, becoming one of the mais problems of scientists and researches around the world. This fact occurs due to the serious consequences observed at a global level brought about by this burning, such as melting ice caps, ocean warming and acidification, and increase in Earth's average temperature.

The scarcity of data related to these emissions, as well as projections and reports produced based on the 2015 inventory (GEE 2015), in Brazil, culminate in the creation of a more direct and precise technique for measuring these concentrations. This need becomes greater in the big Brazilian cities, such as Rio de Janeiro, which is the birthplace of the largest emitters of fossil fuels in the country, and the city chosen to carry out the study. In this sense, the ^{14}C technique makes the method of analysis more effective for distinguishing between fossil sources and biogenic properties in the composition of any type of material.

In order to mitigate and help map these emissions, the analysis of ^{14}C in tree rings through the method of Accelerators Mass Spectrometry (AMS) performed at the UFF Radiocarbon Laboratory (LAC-UFF) has been carrying out this study and in this work will show the previous results for tree rings collected in the species *Terminalia catappa* in Rio de Janeiro.

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Elastic scattering studies for 12-Carbone reactions with Sao Paulo Potential

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Abstract

A systematic study of several reactions involving the collision of ^{12}C on different targets has been performed. The Sao Paulo Potential (SPP) [1] is adopted as the bare interaction. So far, only single-channel analyses have been considered, in which the imaginary part of the nuclear potential is adjusted to better describe the elastic data. In an upcoming phase of the project, coupled-channel calculations will be performed, and the effect of inelastic states on the elastic channel will be investigated.

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Di-neutron potential in the ^{6}He+^{58}Ni interaction

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Abstract

This work aims to obtain information about the di-neutron potential in the elastic scattering of the exotic nucleus ^{6}He with the ^{58}Ni target. For this purpose, elastic scattering angular distribution data of ^{4}He+^{58}Ni and ^{6}He+^{58}Ni systems were selected from the literature for energies below 100 MeV. In addition to the available literature data, the reduction of the ^{4}He and ^{6}He elastic scattering data on ^{58}Ni target measured at RIBRAS [1, 2, 3, 4, 5], was performed. To obtain accurate descriptions of the experimental data, global adjustments were performed of the ^{4}He+^{58}Ni system using the Optical Model formalism and a Woods-Saxon form factor. The optical model parameters were adjusted in an automatic search to best fit the experimental data in the energy range of interest. Subsequently, a di-neutron interaction potential (2n+^{58}Ni) was added to the ^{4}He+^{58}Ni potential to obtain the total ^{6}He+^{58}Ni potential. Only the 2n+^{58}Ni parameters were adjusted to accurately describe the elastic scattering data of the ^{6}He+^{58}Ni system [6]. In this way, it is possible to determine an optical potential for the dineutron-target interaction for ^{58}Ni target, providing a way to study the ^{6}He neutron halo. The computational calculations are performed using SFRESCO, part of the FRESCO code [7]. This work is still in progress.

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Elastic scattering and transfer reaction induced by 13C beam in the 9Be target

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Cluster structure is an interesting phenomenon in light nuclei. Theoretical calculations indicate that extra neutrons added to self-conjugate system, as ^{8}Be and ^{12}C, can give rise to a new form of clustering in nuclei, in where the extra neutron behaves as covalent particle, analog of covalent bonding in molecular physics. In the present work we are proposing to investigate the cluster structure of ^{13}C by the ^{9}Be(^{13}C,^{9}Be)^{13}C elastic transfer reaction (^{4}He transfer). The ^{13}C beam from the 20 UD Tandem Accelerator, installed at the TANDAR-Argentina Laboratory, has been used as projectile for bombarding a ^{9}Be target of 2 mm thickness. The mentioned reactions have been measured at two energies, E_{lab}= 55 and 62 MeV, and at an angular range from q_{lab} = 7.5 to 80 degrees. A system of 4 DE-E silicon telescopes (called T4) was used to detect the ^{13}C and ^{9}Be particles. In addition, the experiment allows for the investigation of excited states of transfer reactions, and still aims at obtaining the spectroscopic factor for $<^{13}C|^{9}Be+\alpha>$ from DWBA calculations. Details of the experiment and preliminary results are presented.

Tests of the new “Nossa Caixa” gamma-ray spectrometer

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Nuclear reaction mechanisms involving weakly bound beams, and their cluster structure, present very interesting aspects and great challenges both from a theoretical and experimental point of view [1-7], in particular due to the possibility of the projectile breaking, followed or not by absorption of one of the fragments, or both [1,2]. Understanding these mechanisms is important for the development of nuclear physics itself, and for the understanding of astrophysical processes, since the nucleosynthesis of elements almost invariably involves weakly bound nuclei, whether in the post-big-bang scenario (the primordial nucleosynthesis) or in various stellar processes, such as supernova explosions that, in a broad sense, determine the evolution of the universe. For this reason, this field of research is experiencing intense activity around the world.

In view of this, a new gamma-ray spectrometer was developed at the Nuclear Physics Open Laboratory (LAFN) of the USP Physics Institute, consisting of 12 pixelated scintillators (3x3 pixels) of LYSO(Ce). The spectrometer can be used with stable and radioactive beams, in measurements of the time coincidence between gamma rays and charged particles. This work aims to test the performance of the spectrometer for measurements of nuclear reaction mechanisms with heavy ions. The first tests will use a reaction with a stable ^{10}B beam at energies close to the Coulombian barrier and a ^{120}Sn target, given the recent publications of precise and extensive measurements of the angular distributions of charged particles in this system, including the elastic channel, which is important for validating predictions based on the theoretical models, as well as the various nucleon transfer channels and the charge exchange channel: ^{10}B beam and ^{10}Be beam, respectively. The observation of the charge exchange reaction channel is important because it opens up the possibility of a connection with the NUMEN project [8-11] developed in collaboration with the IFUSP.

The spectrometer is currently at the stage of machining the detectors support, which has already been assembled and is undergoing operational tests using radioactive sources of ^{60}Co and ^{152}Eu for detecting gamma rays and ^{241}Am for detecting alpha particles. Therefore, the following will be presented: the status of the assembly, the results of the tests of the gamma ray and particle detectors and the first results using the complete system.

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Elastic and inelastic scattering measurement for the $^{13}C+^{208}Pb$ system at energies close to the barrier.

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The description of the elastic scattering cross-section is very sensitive not only to the interaction potential between the projectile and the target nuclei, but also on and their structure. Therefore, elastic scattering measurements have been used to extract information about the dynamics and structures of the involved nuclei [1]. To investigate these effects for the ^{13}C nucleus, we performed for the first time, elastic scattering measurement on a ^{208}Pb target at energies close to the barrier. The ^{13}C ion beam was delivered by the 20-UD tandem accelerator located at Tandar Laboratory, Argentina. The detection setup consisted of eight single silicon surface barrier detectors, separated by ≈ 5° of each other, and four telescopes with angular separation of ≈ 10°. An extra silicon planar barrier detector, called monitor, was positioned at a fixed angle of θ_{lab} = 16.1°. Full angular distributions for the elastic scattering, ranging from θ_{Lab} = 30º to 150º, were obtained at three energies close to the barrier, i.e. E_{lab} = 60, 64 and 66 MeV. Angular distributions for the first excited states of ^{13}C (3.089 MeV) and ^{208}Pb (2.615 MeV) were also obtained. Results of the analysis with Optical Model (OM), coupled channel (CC) and coupled reaction channel (CRC) calculations, using the code FRESCO [2], will be present.

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Study of $^{10,11}B + ^{119}Sn$ reactions at energies aroud Coulomb barrier

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Abstract

The present project consists of the study of different reaction channel for the $^{10,11}B + ^{119}Sn$ systems at energies around the Coulomb barrier, using techniques already well established in the Nuclear Physics field. Measurements of angular distributions of elastic scattering, inelastic scattering and nucleon transfers for the mentioned systems have been conducted, aiming to better understand the mechanisms of nuclear interactions and to test hypotheses and models developed for such interactions. The experiments were carried out at the *Laboratório Aberto de Física Nuclear (LAFN)* at the *Instituto de Física - Universidade de São Paulo*, where the reformed 30B's beamline was used, together with appropriate electronics. Additionally, a new detection system, the STAR 2.0 (Silicon Telescopes Array for Reactions), was characterized and utilized for these experimental measurements. The new detector consists of a large-area detector with 256 high resolution pseudo telescopes. Theoretical analyses of the data presented in this work will be conducted based on the coupled channel formalism [1], using the São Paulo potential [2] as the model for nuclear interactions. Finally, we also intend to characterize and utilize the new detector OSCAR (hOdoscope of Silicon for Correlations and Reaction Analysis) [3], which is being constructed in collaboration with Italian researchers from the *Istituto Nazionale di Fisica Nucleare (IFN) in Legnaro*, to complement the presented data.

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Influence of ^{6}He breakup on the ^{6}He+^{27}Al collision

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Abstract

This work is based on the study of the collision between the ^{6}He projectile and the ^{27}Al target. It is known that the ^{6}He nucleus is exotic, with a Borromean structure and a cluster configuration (^{4}He+2n; E_{bu}=0.973 MeV). Therefore, high values of the total reaction cross-section are expected. One of the open reaction channels is the dissociation of the ^{6}He projectile into ^{4}He+n+n, in addition to neutron transfer to the target nucleus. In this work, our interest lies in studying the effect of the projectile breakup channel on the ^{6}He+^{27}Al elastic scattering angular distributions, as well as in the total reaction cross-section. Reference [1] provides data indicating that the effect of the breakup channel on the total reaction cross section may be smaller than previously observed in lighter and heavier systems [2, 3, 4, 5]. Measurements at E_{lab}=18 MeV were performed, at an energy higher than obtained in Reference [1], to verify this effect. The measurements were carried out using the "Radioactive Ion Beams in Brasil" (RIBRAS) system [6, 7, 8, 9] installed at the Open Laboratory of Nuclear Physics (LAFN) of the Institute of Physics at the University of São Paulo (IFUSP). Preliminary results will be presented.

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Fusion reactions in ^{6}Li + ^{90}Zr scattering

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Recently, the theoretical model proposed by Rangel *et al.* [1] was used to study CF and ICF in collisions of ^{6}Li with the heavy targets ^{124}Sn, ^{197}Au, ^{198}Pt and ^{209}Bi. The predictions of the model were shown to be in good agreement with the data [2, 3]. Comparing the CF cross section with predictions of barrier penetration models with a potential that neglects the low binding of the projectile, we found that the CF cross section was suppressed by $\sim 40\%$ above the Coulomb barrier, and enhanced at sub-barrier energies. The model also predicted that the CF and ICF cross sections for these systems have comparable values above the barrier. Further, one found that the ICFα cross section is systematically lower than that for ICFd. Above the Coulomb barrier, the former is about 2/3 of the latter, and at sub-barrier energies, it is at least one order of magnitude lower. Nevertheless, it is not known whether these conclusions remain valid for lighter targets. We use this same model recently proposed theoretical model to evaluate complete and incomplete fusion cross sections in collisions of ^{6}Li with ^{90}Zr. The former is compared to the data of Kumawat *et al.* [4], while the theoretical cross section for the incomplete fusion of the deuteron in ^{6}Li is compared to a cross section extracted from inclusive α-production data.The overall agreement between theory and experiment is good. Additional validation of the procedure is obtained by applying it to the ^{6}Li $+^{59}$Co reaction at energies above the Coulomb barrier.

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α + core structure described with an alternative *NN* effective interaction

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Abstract

In the last decades, there was an effort by different authors to describe the α + core structure through a systematics applicable to a set of nuclei, mainly nuclei with α-clustering above double-shell closures (e.g., Refs. [1–10]). In general, these works yield satisfactory results for energy spectra, electromagnetic transition rates, α-widths, half-lives, and rms charge radii; however, for some nuclear potential forms, the description of energy levels is unsatisfactory, requiring the use of a variable intensity parameter to obtain energy bands closer to the experimental levels. For example, the double-folding nuclear potentials are known to be successful in reproducing α-nucleus elastic scattering cross sections in a wide range of masses and energies, as shown in several works using the DDM3Y interaction; however, the double-folding potentials produce energy bands with strong rotational feature, which is incompatible with experimental spectra in many cases; in addition, for heavier nuclei, double-folding potentials can generate very compressed energy bands compared to the experimental levels, making it necessary to use the *L*-dependent intensity parameter. To provide a better description of the energy bands, the present work proposes the use of a double-folding nuclear potential with M3Y + $c_{\text{sat}}\,\delta(s)$ effective *NN* interaction, where the term $c_{\text{sat}}\,\delta(s)$ acts only between the saturation regions of α-cluster and core. A good general description of energy levels, $B(E2)$ rates, α-widths, and α-decay half-lives is obtained through a systematics applied to the ^{20}Ne, ^{44}Ti, ^{94}Mo, ^{104}Te, and ^{212}Po nuclei. It is shown the inclusion of the term $c_{\text{sat}}\,\delta(s)$ is determinant for a better description of the experimental energy levels compared to the usual *NN* interaction forms. This presentation is based on our recent paper published in The European Physical Journal A [11].

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Characterization of segmented detectors for large-area measurements of charged particles

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The group of reactions between heavy ions (GRIPe) from the Nuclear Physics Department of the Institute of Physics at the University of São Paulo has systematically investigated reactions involving weakly bound beams in the 30B beamline of the Open Laboratory of Nuclear Physics in recent years. With the aim of contributing to the understanding of reaction mechanisms associated with nuclear collisions at energies near the Coulomb barrier, cross-sections of different reaction channels for various systems have been inclusively studied. Initiating a new phase, we intend to conduct exclusive measurements, where charged particles resulting from the breakup of the projectile nucleus will be detected in temporal coincidence. To achieve this, a new experimental setup consisting of a set of segmented detectors of large area will be utilized. To enable the use of this new system, it is necessary to characterize such detectors.

Investigation of transfer mechanism involved in the $^{9}Be(^{13}C,^{15}N)^{7}Li$ and $^{9}Be(^{13}C,^{7}Li)^{15}N$ reactions.

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Transfer reactions is the most important tool to investigate cluster structure in nuclei. A series of experiments on transfer reactions has been performed recently at the Tandar Laboratory, Argentina, in a collaboration between the NEAN group of IFUSP [1], São Paulo and the group in Tandar. In one of these experiments, a beam of ^{13}C, with energies E_{Lab} = 55.0 and 62.0 MeV, was impinged on a ^{9}Be target. Several channels, elastic, inelastic, neutron, deuteron and alfa transfer reactions, have been opened from the interaction of $^{13}C+^{9}Be$. The setup consisted of 4 telescopes (ΔE-E detectors). Those detectors were assembled on a rotate plate, allowing the measurement at several angles from 7 to 55 degrees. The detectors were calibrated with the elastic scattering measurement of $^{13}C+^{197}Au$. I am currently working on the nitrogen and lithium channels, which correspond to the $^{9}Be(^{13}C,^{15}N)^{7}Li$ and $^{9}Be(^{13}C,^{7}Li)^{15}N$ transfer reactions. Although both reactions are complementary and end up with the same outgoing channel, the first one is a deuteron transfer, and the other is a possible direct ^{6}Li cluster transfer. The investigation of the angular distributions may bring some insights on the transfer mechanism involved. Preliminary results on the angular distributions for these reactions will be presented. The other channels produced by the interaction of $^{13}C+^{9}Be$ are being analyzed by other members of the NEAN group.

[1] https://valdir0guimaraes.wixsite.com/nean

Investigation of the resonant behavior of the astrophysical S-factor for the reaction $^{12}C(\alpha,\gamma)^{16}O$

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Abstract

The main goal of the present project is to investigate the reaction $^{12}C(\alpha,\gamma)^{16}O$ within the context of coupled channels. This is one of the most important reactions within the astrophysical scenario, and because it presents very low cross sections, and possibly resonances at energies around the Gamow peak, it represents an important gap in the understanding of stellar evolution. This reaction represents the first stage of Helium burning in massive stars, playing a crucial role in determining the ratio between carbon and oxygen in these stars. In 2014, our research group published results about this reaction. In this work, the coupled channel calculations were performed considering only the first excited state of $^{12}C(2_1^+; 4.44MeV)$. A detailed study of the behavior of the phases associated with the elastic scattering process (*phase-shifts*) was carried out for different values of angular momentum. In this project, we proposed to redo this analysis. In the first stage, we coupled only the first excited state, similar to what was done in the work published in 2014. Subsequently, the second-order coupling of the Hoyle State $(0^+; 7.65MeV)$ with the first excited state of carbon was carried out. The main motivation is to investigate the effect of including other channels in the description of *phase-shifts* and the resonant behavior of the fusion cross section of the reaction $^{12}C(\alpha,\gamma)^{16}O$. The coupled channel calculations were performed using the program **FRESCO**.

Keywords: Coupled Channel, Nuclear Potential, Stellar Nucleosynthesis, Nuclear Fusion

Uso de Redes Generativas Adversariais (GANs) para a exploração do espaço de soluções em um ajuste de dados de espalhamento nuclear

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As técnicas de feixes iônicos aplicadas à análise de materiais são de grande importância para a física dos materiais. No entanto, o processamento dos dados dessas técnicas é complexo para a obtenção do resultado final da análise. Essa perspectiva tem mudado sensivelmente com a exploração de métodos e algoritmos de aprendizado de máquina. No entanto, o procedimento de estimação de incertezas é altamente custoso computacionalmente. Uma forma de se reduzir o custo computacional da estimação de incertezas seria o treinamento de uma rede neural generativa para a geração de espectros de espalhamento nuclear. Desta forma, gerar-se-ia espectros para o treinamento da rede, e esta serviria como um modelo substituto para a simulação física, com a vantagem de um custo computacional de geração do espectro muito menor. Neste projeto, tem-se por objetivo o uso de redes generativas adversariais para a redução do custo computacional da simulação de processos físicos de espalhamento nuclear.

Título: Decaimentos nucleares num contexto computacional numérico

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Resumo: A Física Nuclear busca compreender as leis que regem as propriedades dos elementos que compõem núcleos dos átomos, não só como integrantes destes, mas também em colisões de íons pesados e sobretudo, nas condições presentes em objetos celestes mais densos, como estrelas. A Física Nuclear evoluiu muito nos últimos cem anos: desde as ideias primordiais que basicamente só trazem uma possibilidade de explicação para o fato dos núcleos aglomerarem-se em núcleos, passando por modelos que conseguem descrever a fenomenologia a certo nível quantitativo, até os mais atuais, que encontram-se em elevado grau de complexidade e conseguem prever toda a gama de valores observados. Em concordância com todos eles, o Modelo Padrão serve de base à compreensão das regras que regem os decaimentos nucleares. Propõe-se neste projeto o início do estudo da fenomenologia da Física Nuclear com objetivo de se chegar aos decaimentos de partículas nucleares, acompanhada de uso de linguagem de programação numérica para a inserção do aluno naquela área. A Metodologia usada será a revisão de literatura específica, tendo em vista o conjunto de conhecimentos já adquiridos pelo proponente, seguida da confecção de códigos computacionais. Os encontros aluno-orientador devem ter periodicidade semanal. Os resultados a serem alcançados são, a priori, um código computacional capaz de analisar reações nucleares em seus participantes/produtos, tendo em vista seus contextos (energias e/ou estado). O cronograma aproximado será: revisão de literatura concomitante com o estudo de linguagens de programação no primeiro semestre e confecção de códigos no semestre restante. A bibliografia principal será: “Introduction to Elementary Particles”, David Griffiths; “Vamos falar de Estrelas?” Chung Kai Cheong; “Introdução à Física Nuclear”, Débora Peres Menezes, Kauan Dalfovo Marquez e Tiago José Nunes da Silva.

Estudo do primeiro estado excitado do núcleo ^{4}He em teoria efetiva para núcleos halos

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1 Resumo

Este trabalho tem como finalidade estudar o primeiro estado excitado do núcleo de hélio-4 (partícula α) utilizando o formalismo de canais acoplados em teoria quântica de campos efetiva para núcleos halos. Este estado excitado encontra-se entre os limiares p-^{3}H e n-^{3}He, provavelmente associado a um estado Efimov de quatro corpos. Utilizaremos a teoria efetiva para núcleos halos visando compreender como este estado evolui de uma ressonância para o estado ligado de Efimov conforme desligamos artificialmente os termos de quebra de simetria de isospin. Adicionalmente, pretendemos investigar a influência desta ressonância na reação $^3\mathrm{H}(p, e^+e^-)^4\mathrm{He}$, dada a anomalia ATOMKI recentemente observada por Krasznahorkay e colaboradores. De acordo com a análise de distribuição angular do par de léptons produzidos, o excesso de eventos observado sugere a existência de um novo bóson, com massa de aproximadamente 17 MeV, e que pode ser um forte candidato a matéria escura.

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A new systematic for SPP2 using elastic scattaring optical potencials

The present work aims to study elastic scattering using optical potentials, with the objective of verifying if there is a systematic behavior for the recently developed SPP2 and BNP nuclear potentials, similar to that found for the São Paulo Potential (SPP). Such previous study found that the use of the SPP in the real and imaginary parts (with a normalization of 0.8 for the later one) could describe the scattering of several systems in a wide energy and mass ranges. Our objective in this work is to determine if this factor may be also found for the newer potentials, also checking if it may vary depending on the features of the reaction, such as the energy and the nuclei involved. In order to achieve this, we intend to study over 300 different systems. For this purpose, we are developing a Python code that automatically generates input files for the SFRESCO code and obtains the best fit to experimental data. Although the code is still undergoing tests, preliminary results show that it is possible to automate the process for all systems.

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Exploring low-energy breakup in the exotic nucleus ^{6}He

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Experimental data from the interaction of the exotic ^{6}He beam with a ^{9}Be target, acquired using the RIBRAS system, can be found in the literature [1]. These data allowed for different analyses, ranging from elastic scattering [1] to the study of several reaction channels responsible for alpha particle production [2]. These measurements are referred to as inclusive since they do not differentiate between different processes. The present work proposes exclusive measurements for the ^{6}He+^{9}Be collision at higher energy compared to previous experiments, which will enable a more precise characterization of the reaction channels. Newly acquired digital electronics, enabling particle detection in kinematic coincidence, will be employed. The coincidence detection of the projectile fragment and recoil nucleus allows, for example, to distinguish between processes such as elastic and inelastic scattering from others like projectile breakup and target breakup, where the identities of the projectile and target differ in the entrance and exit channels. The measurements will be performed using the "Radioactive Ion Beams in Brasil" (RIBRAS) system [3-6] at the Open Laboratory of Nuclear Physics and Applications (LAFNA) at the Institute of Physics of the University of São Paulo (IFUSP). The RIBRAS facility consists of two superconducting solenoids and three scattering chambers, enabling the production of ions beyond the stability line and their respective separation from other contaminants using the in-flight method. The ^{6}He exotic beam will be produced at 27 MeV using the ^{9}Be(^{7}Li,^{6}He) production reaction with a 32 MeV primary beam of ^{7}Li (Vterm = 8.0 MV). This work outlines the proposal and planning for our upcoming experiment.

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Investigation of the ^{6}He exotic nucleus with a ^{nat}Zr target

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Abstract

A study of ^{6}He elastic scattering on a ^{nat}Zr target is presented. The collision was measured at a laboratory energy of E_{lab} = 18 MeV using the RIBRAS facility (Radioactive Ion Beams in Brasil) at the Institute of Physics of the University of São Paulo [1, 2, 3, 4]. In this investigation, the ^{nat}Zr target was chosen due to its location in an unexplored experimental region, situated between ^{64}Zn and ^{120}Sn, regarding collisions with the exotic ^{6}He beam. This target provides an opportunity to explore a collision that remains unknown. The ^{6}He beam was produced through the ^{9}Be(^{7}Li,^{6}He)^{10}B production reaction. The detector system consisted of four ΔE-E Si telescopes, with thicknesses of 20-50 μm and 1000 μm, respectively. This configuration allowed for the effective separation of ^{6}He particles from other beam contaminants such as ^{7}Li and light particles. Preliminary results of the elastic scattering angular distribution will be presented.

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Shell Model nuclear structure calculations for describing observables of nuclei with A = 16-20

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The successfull of shell-model calculations have shwon the power of this tool for describing the nuclear structure of many nulei. Besides the energies eingenvalues, this model provided spectrocopic amplitudes of one- and two particle overlap wave functions used to describe the experimental data for one and two particles transfer reactions. In this work, we present the study of the structure informations for nuclei in the mass regioin A = 16 – 20.

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Equiparticle quark model: quark confinement in stellar matter

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Abstract

The strange quark matter (SQM) hypothesis, proposed by Bodmer [1] and Witten [2] in the 70s, brought up the idea that a fundamentally different form of matter exists and it is primarily composed of strange quarks. Since then a various amount of models [3, 4, 5, 6, 7, 8] have been developed in order to study SQM as the equiparticle (EQP) model [9] itself. This model consist in taking the quarks mass as density dependent quantities without losing its thermodynamic consistency. In the present work the implementation of the traced Polyakov loop (Φ) was performed in the EQP model in order to describe effects of quark confinement/deconfinement phase transition in stellar matter. The results pointed out a first order phase transition structure, in which the chiral symmetry is restored by the emergence of a deconfined phase in one of the analysis. In another one, the mass-radius profiles of quark stars using this new model was constructed and compared with the recent astrophysical observational data from the LIGO and Virgo Collaboration [10, 11, 12], as well as the NICER mission, in particular the millisecond pulsars PSR J0030+0451 [13, 14] and PSR J0740+6620 [15, 16].

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Superconductivity in a confining field-theory model

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Many models of superconductivity are already present in high energy physics, since the end of last century, mainly in the study of color superconductivity in Quantum Chromodynamics and in other effective models of Strong Interactions at high densities. These models use in general a gluon propagator with specific electric and magnetic effects, resulting in an integral gap equation whose solutions are frequency dependent and could reach gaps of the order of 100 MeV. In this work, we will investigate a simple superconductivity model by changing the usual propagator of the mediator to a confining propagator, with a structure similar to that encountered in Gribov-Zwanziger and Refined Gribov-Zwanziger theories. In these theories, the gluon has an explicit mass parameter that is related with the phenomenon of confinement. Through this modification we try to explore the superconductivity of confined particles with a simple toy model with a Yukawa-type interaction. We present results for the full integral gap equations as well as for differential gap equations that arise under a series of approximations and investigate the effect of corrections originated from the new propagators. Two mass limits in the bosonic propagator must be reached: the high mass limit, reproducing the behavior of the "point like" approximation, making the gap function behave like a usual BCS superconductivity and the small mass, making the gap function behave similar to early results in color superconductivity. Solving numerically the integral gap equation, we can calculate the gap in function of the mass parameter. These calculations were performed too with improved gluon propagators, such as the ones appearing in the Gribov-Zwanziger and Refined Gribov-Zwanziger theories. These results allow us to understand how the introduction of the explicit mass parameter to the gluon can affect the phenomenon of superconductivity in high energies. This study could be a first step towards assessing how nonperturbative confinement effects might affect the phenomenon of color superconductivity at intermediate densities.

Cinemática da interação fóton-próton em altas energias e suas implicações

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Este trabalho consiste em analisar as variáveis cinemáticas da interação fóton-próton com o desdobramento do fóton em dipolo de cor. Destas variáveis depende a seção de choque de dipolo, uma seção de choque com ampla aplicação em colisões de altas energias. Implicações do uso das quantidades corretas podem influenciar o ajuste com dados precisos do HERA para seção de choque de dipolo e as contribuições em ordem seguinte à dominante do processo. Com base nisso, os possíveis diagramas que dominam o espalhamentos poderão ser identificados.

Viscous corrections effects on final-state observables in hybrid simulations of Pb-Pb collisions

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Hybrid models are state-of-the-art tools for understanding the properties of the quark-gluon plasma (QGP), the deconfined phase of quantum chromodynamics (QCD) formed under the extreme conditions produced in ultrarelativistic heavy-ion collisions. In this type of modeling, hydrodynamical and transport approaches are combined to describe different stages of these collisions. Within this approach, hydrodynamical calculations inescapably require a model to translate continuum degrees of freedom into discrete ones, the particlization stage. Particlization is a model where all of the energy and momentum of the fluid is converted into hadrons on a switching hypersurface using the Cooper-Frye prescription. In this work, observables, such as multiplicities, transverse momentum, and anisotropic flow coefficients, in Pb-Pb collisions generated with different viscous corrections for the local equilibrium distributions functions used in the Cooper-Frye formulae are studied to understand how these types of corrections affect these final observables and the comparison with experimental observations.

Evidence of fractal structures in hadrons

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Abstract

This study focuses on the presence of (multi)fractal structures in hadronic matter through the momentum distributions of mesons produced in proton-proton collisions between 23 GeV and 63 GeV. The analysis demonstrates that the q-exponential behaviour of the particle momentum distributions is consistent with fractal characteristics, exhibiting fractal structures in confined hadronic matter with features similar to those observed in the deconfined quark-gluon plasma (QGP) regime. Furthermore, the systematic analysis of meson production in hadronic collisions at energies below 1 TeV suggests that specific fractal parameters are universal, independently of confinement or deconfinement, while others may be influenced by the quark content of the produced meson. These results pave the way for further research

exploring the implications of fractal structures on various physical distributions.

Non-extensive statistics in hadron production in heavy ion collisions

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This work analyzes the particle production in heavy-ion collisions, which create extreme conditions, forming the Quark-Gluon Plasma (QGP). Despite the impossibility of directly observing this plasma, the combination of experimental data and theoretical approaches are crucial to the understanding of these collisions. The Non-extensive statistics (NES)-based approach differs from traditional approaches by introducing a non-extensive parameter (**q**), which may play a role in describing the system and thus incorporating correlation effects in complex systems. The present research investigates the distributions of fermions and bosons in Au-Au collisions, using NES to describe the production of hadrons. An optimal fit between theoretical models and experimental data is sought, using χ^2 to minimize discrepancies. By minimizing χ^2, the optimal value of q is found to be 1.16, providing a more accurate description of the particle ratios produced in Au-Au collisions with non-extensive statistics in comparison with the usual Fermi-Dirac and Bose-Einstein statistics.

The approach to hydrodynamics of a nonconformal pre-equilibrium system

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Relativistic heavy-ion collision experiments can reproduce under lab conditions the extreme conditions in the first microsecond of the universe, producing a phase of matter called the Quark-Gluon Plasma (QGP). Computational methods using models based on relativistic hydrodynamics have had great success in describing QCD matter emerging from heavy-ion collisions, at extreme temperatures and densities, especially the so-called hybrid models, used to characterize the entire collision process, in which each stage of the collision is described by a different numerical model where the output of one is the input of the next one. The focus of our research lies on the pre-equilibrium stage of heavy-ion collisions, where matter approaches a fluid behavior from an out-of-equilibrium state, after which the system evolves according to relativistic viscous hydrodynamics. The pre-equilibrium stage of heavy-ion collisions is commonly modeled under the assumption that the system evolves in a conformal fashion. However, it is well known that QCD is not a conformal theory, and while current models assume the system has conformal invariance by reasoning that QCD can be approximately conformal at these relevant energy scales, this choice greatly impacts the model's final observables. It is thus paramount that a nonconformal pre-equilibrium model be developed for a more consistent treatment of the early stages of heavy-ion collisions, which is the goal of our research project.

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Artificial first-order phase transition in the NJL model with quark anomalous magnetic moment

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Abstract

The anomalous magnetic moment (AMM) of quarks emerges from the dynamical chiral symmetry breaking for massive quarks. In the hot and magnetized Nambu–Jona-Lasinio (NJL) model, first-order phase transitions have been observed with the inclusion of the AMM effect, which could lead to inverse magnetic catalysis even in the zero-temperature case. Such predictions can result from different kinds of regularization schemes that do not separate the vacuum contributions from the magnetic field ones. Consequently, by exploring an adequate regularization prescription, two situations arise: a mass-dependent (MD) regularization and a mass-independent (MI) regularization. In the MD scenario, for a high enough value of quark AMM, a nonmassive global minimum appears beyond the massive one in the thermodynamic potential, characterizing a possible first-order phase transition. In the MI case, we avoid this kind of behavior by using the vacuum magnetic regularization scheme (VMR) and thus obtaining results that adequately agree with the predictions of Lattice QCD. Furthermore, within the validity limits of MI, where the magnetic fields are smaller than the vacuum effective quark mass squared, we recover the one-loop Schwinger–Weisskopf effective QED approach, which has already been used in the NJL model literature.

*Speaker

Weak force influence in two bósons interaction of electron-positron colision.

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In the high energy physics regime, in dipole frame a boson have enough energy to floating in a quark-antiquark pair. Thereby the two boson interaction, between γ, $W^{\pm}$ and Z^{0} , can be calculated from QCD by dipole formalism, considering de dipole-dipole cross-section. In this work, we present important observables from two boson interaction with weak force influence on electron-positron collisions, that will be essential to study the background contributions of future colliders to obtain more sensitivity to physics BSM and estimate the inclusive hadron production and the structure function of real photon invetigated by weak bosons.

Photoproduction of light vector mesons in AA UPCs

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February 2024

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Abstract

We analyze the coherent photoproduction of light vector mesons in AA collisions via color dipole approach. We use the Glauber–Gribov formalism, however, it needs to be supplemented by the gluon shadowing, since the coherence length of higher dipole Fock states is smaller than the nucleus radius. We fit this gluon shadowing to the deep inelastic structure function F_2 (E665) and ρ meson photoproduction (ALICE) data, obtaining the value $R_G = 0.85$ with an excellent description of the available data. We have also made predictions for the coherent photoproduction of $\rho(2S)$, $\omega(1S, 2S)$ and $\phi(1S, 2S)$ using the holographic vector meson wave functions.

Associated works: Eur.Phys.J.C 83 (2023) 6, 551 and arXiv:2310.06965.

Dynamic Fluidization in a transport+hydrodynamics hybrid approach under different Equations of State

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Recent years have brought interest in the baryon dense region of the QCD phase diagram, probed by low energy heavy ion collisions (HICs) performed by the STAR Beam Energy Scan at RHIC, and by the HADES/CBM experiments at the upcoming FAIR facility. Such HICs are correctly described by hybrid simulations of hadronic transport and viscous hydrodynamics, connected initially by the fluidization of hadrons. In intermediate beam energy collisions, this process does not happen at the same time across the initial stage, but rather bubbles of fluid matter form and grow while absorbing more particles. Such expansion of the fluid depends on the input equation of state, in particular if a first-order phase transition is present. In this work, we present the new dynamic fluidization within the SMASH+vHLLE hybrid approach, which evolves hydrodynamics and off-equilibrium transport concurrently; and the effect of different equations of state for HICs in the intermediate range of beam energies.

Influence of chiral chemical potential on the QCD phase diagram

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Many efforts have been dedicated to understanding how the chiral imbalance between right and left quarks can influence the Quantum Chromodynamics (QCD) phase diagram. There are different motivations for such studies, for example, the possibility of chiral imbalance being present in heavy-ion collision experiments in particle accelerators such as the Relativistic Heavy Ion Collider (RHIC) and Large Hadron Collider (LHC). Furthermore, magnetic fields are created briefly in these collisions, and the presence of a chiral imbalance can induce an electric current along the direction of the magnetic field due to the total electric charge from quarks not being zero. This phenomenon is known as the Chiral Magnetic Effect (CME) in the literature, and it is not limited to QCD, being also observed in condensed matter systems. The effects of a chiral imbalance in the QCD phase diagram can be studied in the grand canonical ensemble by introducing a chiral chemical potential in the Lagrangian density of the theory. In this context, the behavior of hot quark matter with chiral imbalance can be described through QCD effective models. In this work, we perform modifications on the Polyakov potential at finite chiral chemical potential which allows the Polyakov-Nambu-Jona-Lasinio model to be in agreement with recent lattice QCD simulations. For the first time in the literature we show that the behavior for the pseudo-critical temperatures for deconfinement and chiral symmetry restoration are increasing functions of the chiral chemical potential, in agreement with recent lattice QCD results. The influence of these modifications in the PNJL model on the thermodynamic quantities is also investigated.

Abstract

Opportunities in Double Parton Scattering in Ap UPCs

Autor: Bruna de Oliveira Stahlhofer

6 de fevereiro de 2024

Double Parton Scattering (DPS) is a important way for which we can investigate the parton distributions of the proton and the nucleus. Although, we know that such scatterings should occur in high energy collisions, the formalism to describe it lack of answers to questions like — is there a universal effective cross section? In direction to explore such questions, we investigate DPS in ultraperipheral collision (UPC) where the effective cross section is not a constant as usually is in the central collisions, as we point in our results. Furthermore, once we allow the nucleus to break in a ultraperipheral proton–nucleus collision, we provide insights concerning the photon distribution of the nucleus. Also, as the effective cross section have a complex dependence with the longitudinal fraction energy carrying by the photon in the initial state, we evaluate cross sections with photon and gluons in the initial state producing quark–antiquark pairs or dilepton and quark–antiquark in the final state.

Aluno: Luis Lucas Rodrigues Ferreira – Mestrando na Universidade Federal de Santa Catarina

Orientador: Emmanuel G. de Oliveira

Título do trabalho: A teoria de Glauber Gribov na produção de di-hádrons em colisões nucleares.

Resumo: Quando quarks e glúons produzidos durante uma colisão de altas energias são transformados em hádrons, chamamos esse processo de Hadronização. Nesse trabalho vamos investigar as implicações da teoria de Glauber-Gribov na produção de di-hádrons, que são pares de hádrons. Vamos realizar predições numéricas da seção de choque desse observável para entender as discrepâncias e concordâncias com os dados experimentais dessas produções e com os outros modelos utilizados atualmente.

Describing the speed of sound peak of dense two-color QCD using effective model

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The non-monotonic behavior of the speed of sound for dense two-color QCD, found by recent lattice QCD simulations, can be reproduced within the Nambu–Jona-Lasinio model when the couplings become chemical potential-dependent. The introduction of medium-dependent couplings can potentially affect the equivalence between the thermodynamic relations and their definitions from statistical mechanics. We describe the procedure to compensate for the introduction of medium-dependent couplings to preserve the correct thermodynamic identities. We find the chemical potential dependence for the couplings from the density two-color LQCD data and, after finding the compensating function to correctly describe the pressure, we show that the description of the square of the speed of sound reported by LQCD is well reproduced when using the found medium-dependent couplings.

Resumo

Título do Trabalho: Análise Sistemática da produção de multipartículas em colisões de altas energias
Autor: Lucas Quinsan Rocha (USP)
Resumo:

Neste trabalho foram estudados modelos termodinâmicos baseados na estatística não extensiva de Tsallis através da análise de dados de distribuições de momento transversal de colisões do tipo próton-próton em energias ultra relativísticas. Os resultados dessa análise confirmam um comportamento constante do índice entrópico bem próximo do valor teórico pré-estabelecido de q=8/7 para sistemas termodinâmicos que se comportam como termofractais.

Palavras-Chave: Estatística não-extensiva, Espectro de momento transversal, Onda de explosão, Cleymans, Tsallis, Termofractais.

The rotation effect on the chiral symmetry restoration of the QCD matter

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In the realm of nuclear physics, the study of quark matter dynamics represents a frontier in understanding the fundamental constituents of matter under extreme conditions. Recently, significant attention has been directed towards exploring the effects of rotations on strongly interacting matter. In non-central heavy ion collisions, QCD matter carries angular momentum on the order of $\sim 10^5 \hbar$ and can attain angular velocities approaching ~0.1 GeV. Both fermions and gluons undergo relativistic rotations, with lattice QCD simulations revealing intriguing phenomena: pure gluodynamics suggest an increase in the chiral symmetry breaking critical temperature due to rotation, while the opposite trend is observed for the fermion sector. However, when considering both fermionic and gluonic contributions, the resulting effect is an elevation of the critical temperature. Additionally, lattice calculations demonstrate the presence of a negative moment of inertia. According to effective models, such as the Nambu-Jona-Lasinio model (NJL), rotations should cause the opposite effect on quark matter. Our research aims to reconcile this discrepancy into the analysis, offering insights into the intricate interplay between rotation and quark matter properties. This work delves into the influence of rotation on quark matter, utilizing the Polyakov-Nambu-Jona-Lasinio (PNJL) model as the theoretical framework. Specifically, we investigate the implications of rotational effects on quark matter by examining the modulation of a coupling constant being a function of the angular velocity.

Mestrando: Alyson Fernando de Barros
Orientador: Tiago José Nunes da Silva

Decomposição polinomial do espectros pt em colisões de íons pesados

O estudo das colisões de íons pesados e dos espectros de momento transversal (pT) são essenciais para a compreensão de fenômenos complexos relacionados à Cromodinâmica Quântica (QCD) e à formação do plasma de quarks e glúons (QGP). Em simulações de colisões próton-chumbo (p-Pb), os espectros pT foram analisados com uma energia de centro de massa de 5.02 TeV, utilizando modelos híbridos. Essas simulações, realizadas com diferentes parâmetros e variações de centralidade, permitiram a obtenção dos espectros pT por multiplicidade.

Para desenvolver a análise dos espectros, normalizou-se o espectro por meio dos momentos transversais médios (<pT>) e da multiplicidade (N) de cada processo, obtendo-se uma função dependente da fração de momento transversal (xT). O objetivo do estudo foi representar os espectros pT em polinômios ortogonais, como os de Laguerre, a fim de extrair informações significativas sobre o sistema produzido na colisão. Esses polinômios capturam características importantes da distribuição de pT e fornecem coeficientes ligados às propriedades fundamentais do QGP. A análise desses coeficientes revelou padrões na distribuição do pT e forneceu informações sobre a viscosidade do plasma.

O desenvolvimento teórico necessário para este estudo envolveu uma descrição das bases teóricas, incluindo uma introdução à QCD e ao QGP, bem como o estudo dos espectros pT e sua decomposição em coeficientes de polinômios ortogonais. Os modelos híbridos utilizados nas simulações foram cuidadosamente estudados e comparados em diferentes cenários.

Dark matter capture by hot neutron stars

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In this work, we analize the relation of the cooling of a neutron star and the quantity of dark matter that this object can accrete in its lifetime. In this context, two conditions can be inferred for neutron stars to exist and reach at least 10^9 years: the accumulated mass in the star's core does not gravitationally collapse; or, if it does collapse, the formed black hole from this process evaporates faster than it gains mass. For the mass region present in this work, it will be shown that the collapse will take place only if the dark matter is bosonic and, because of this property and the envirnoment around the star's core, it will form a Bose-Einstein condensate before the collapse. Hence, the required number of particles for a Bose-Einstein condensate to form, N_{bec}, and the time spent on the thermalization of this particles, t_{th}, are related with the central temperature of the star. Through the thermal evolution it is possible to study the behaviour of N_{bec} and t_{th} throughout the lifespan of a neutron star. The theoretical limits that arises from the evolution of these quantities demonstrates that the final years of a neutron star, once it has cooled down, are sufficient to get an exclusion profile of the cross section as a function of its mass.

Título: O que podemos aprender sobre estrutura nuclear via colisões de altas energias?

Autores:
Kevin Possendoro Pala* (Universidade de São Paulo)
Dr. Willian M. Serenone (Universidade de São Paulo)
Prof. Dr. Fernando Gardim (Universidade Federal de Alfenas)
Prof. Dr Andre Veiga Giannini (Universidade Federal da Grande Dourados)
Prof. Dra. Frederique Grassi (Universidade de São Paulo)

Resumo:

Em 2018, o RHIC realizou experimentos de colisões entre os isóbaros $^{96}_{44}$Ru e $^{96}_{40}$Zr. Esse experimento produziu medições de fluxo anisotrópico, evidenciando diferenças entre os dois sistemas com origem nas estruturas nucleares diferentes. Esse achado apresenta uma oportunidade única de conectar as áreas da física nuclear de baixa energia com a física de colisões de alta energia. Uma quantidade significativa de pesquisas recentes tem se concentrado em utilizar a geometria do estado inicial para prever observáveis de fluxo. Neste trabalho, expandimos os resultados apresentados em [1], testando o mapeamento entre condições iniciais e quantidades calculadas em diferentes etapas da simulação (free-streaming, hidrodinâmica, decaimentos e transporte).

[1] W. M. Serenone, F. G. Gardim, A. V. Giannini, F. Grassi and K. P. Pala, "Nuclear geometry and pre-equilibrium phase effects on high-energy isobar collisions," [arXiv:2305.03703 [nucl-th]]

UNIVERSIDADE FEDERAL DE SANTA MARIA
CENTRO DE CIÊNCIAS NATURAIS E EXATAS
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PROGRAMA DE PÓS-GRADUAÇÃO EM FÍSICA

A TERMODINÂMICA DA MATÉRIA FORTEMENTE INTERAGENTE NA PRESENÇA DE UMA ASSIMETRIA DE ISOSPIN

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Na física do modelo padrão, a cromodinâmica quântica (QCD) é a teoria responsável pela descrição da interação forte entre quarks e glúons. Atualmente, a estrutura de seu diagrama de fases é um dos tópicos de maior interesse em pesquisa, dada a vasta gama de sistemas nele descritos – do universo primordial a objetos estelares compactos. Apesar de tratar-se de uma teoria bem definida, o estudo da QCD requer uma abordagem não perturbativa no regime de acoplamento forte, como a baixas temperaturas. Uma das técnicas bem estabelecidas é a simulação de QCD na rede, baseada em métodos de Monte Carlo. No entanto, o problema de sinal impede a obtenção de resultados em densidade bariônica finita – o determinante fermiônico torna-se imaginário, e não é possível gerar pesos de configuração reais e positivos. A situação é diferente na presença de uma assimetria de isospin, caracterizada por um potencial químico de isospin finito – não há o problema de sinal. Estrelas de nêutrons são um exemplo de sistemas físicos em que essa assimetria é relevante. Assim, os resultados de rede nesse regime servem como uma referência para os efeitos que teorias efetivas devem descrever. Recentemente, essas simulações mostraram a existência de um pico na velocidade do som, o que não era previsto por modelos efetivos. Motivados por isso, mostramos em trabalho recente que uma maneira de reproduzir esse efeito no contexto do modelo de Nambu—Jona-Lasinio se dá através da introdução de um acoplamento dependente do potencial químico de isospin, obtido ao fazer com que o modelo satisfaça os dados de QCD na rede para a densidade de isospin. Portanto, como sequência natural, buscamos aqui ampliar a análise para o regime de temperatura finita, observando os efeitos trazidos por essa abordagem para a termodinâmica do sistema – e principalmente para a equação de estado.

Trabalho apoiado pelo CNPq – Conselho Nacional de Desenvolvimento Científico e Tecnológico.

Cooling of quark stars from perturbative QCD

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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.

Exploring the QCD phase diagram

Leonardo Barbosa*, [1] Vinicius Função*,[1] Kevin Pala*,[1]
Willian M. Serenone, [1] Frédérique Grassi [1]

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1 Abstract

The Quark Gluon Plasma (QGP) has been produced systematically in relativistic heavy ion collisions during the last decades. Despite this, one of the most important question about quark matter is still open: the existence and location of a critical point in the QCD phase diagram. At high energies, such as 200 GeV A at RHIC or a few Tev at LHC, the region of the QCD phase diagram being probed is, (at mid-rapidity), that of high temperature and almost zero baryonic chemical potential. In order to explore other regions of the QCD phase diagram, on the experimental side, many efforts are being done or planned at various laboratories and accelerators (for example RHIC in the United States, FAIR in Germany, NICA in Russia and J-PARC in Japan). This is accompanied by a large theoretical activity (in particular BEST in the United States and HIC for FAIR in Germany). The FAPESP project "Exploring the QCD phase diagram" (coordinated by F.Grassi) is into its 5th and final year. In this talk, we present three of our lines of investigation to search for a first order phase transition or critical point.

- Anisotropic flow observables in the longitudinal direction (presented by L.Barbosa)
- Cumulants of conserved charge (presented by K.Pala)
- HBT interferometry (presented by V.Função)

Exploring the phase diagram of dense and hot matter with HBT Interferometry

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Abstract

The Quark-Gluon Plasma (QGP) is a state of matter under extreme conditions of temperature and pressure, which can be obtained in Heavy-Ion Collisions (HIC). In HIC, this plasma expands and converts into a confined phase of hadrons. In this context, the question of whether there is a critical point in this transition arises, being the main focus of our work. Many experiments (such as RHIC and the LHC) perform these collisions, and the phenomenology of heavy ion collisions − employing models such as the hydrodynamic expansion models, among other things − is used to reproduce observables. Some of these observables are those of HBT Interferometry, the so-called HBT radii. HBT Interferometry is a technique that allows access to the space-time content of a particle-emitting source. Within the scope of HIC Phenomenology, it is possible to use HBT Interferometry as a tool to study how different equations of state impact the evolution of the system, since phase transitions significantly influence how long the evolution of the fluid lasts and consequently the particle emission time. In this work, we calculate HBT radii using a phenomenological model and obtain the characteristic mean time of particle emission in our events.

Study of the condensation of pions using the Functional Renormalization Group

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The full description of strongly interacting matter requires complete knowledge of the phase structure generated by a quantum field theory. In many cases, analyzing the fundamental theory that describes their interactions in a medium is quite complicated, so that it becomes interesting to use alternative theories that reproduce at least part of the physical characteristics of the fundamental theory. Effective theories provide us with a powerful mathematical and physical tool for the limit in which the application of the fundamental theory - Quantum Chromodynamics (QCD) in the case of Strong Interactions – becomes extremely complex. In the dense regime of matter, the main non-perturbative technique, lattice Monte Carlo simulations, presents an open problem called the Sign Problem due to the coupling of a specific chemical potential. However, in some situations, Monte Carlo simulations do not present such a problem, providing satisfactory results for various observable physical phenomena such as, for example, the dense isospin matter that could exist inside compact stars. Thus, the study of effective theories in environments with non-zero chemical potentials is even more relevant because it presents systems in which the Sign Problem is not present. In this work, we will investigate, using non-perturbative techniques, the phase transition of Bose-Einstein condensation in an effective theory for bosons at finite density and zero temperature. We will construct a toy model based on the Linear σ Model and implement the Functional Renormalization Group (FRG) to estimate the influence of non-perturbative effects on the critical parameters of the model.

Partonic hydrodynamics and the 3D structure of the nucleon

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Motivated by the hydrodynamics in small systems, we construct an example of how the spin-dependent 3D structure of the nucleon, parametrized by the GPDs (Generalised Parton Distributions), in which the mellin moments can be measured on the lattice, can give rise to a hydrodynamic initial state for a proton carrying an internal spin distribution. The main physical effect is that the spin distribution in the proton in cases where it is polarised introduces an anisotropy in its shape, which leads to an anisotropy in the final observable. We use this prescription to estimate the difference in initial eccentricity between polarised and unpolarised p-A collisions, therefore motivating a comparison of the elliptic flow of these regimes with a view to finding a classical-hydrodynamic response to quantum spin. This approach could pave the way for a systematic use of the lattice to extract the initial state relevant for capturing sub-nucleonic corrections in hydrodynamics.

Study of magnetized hadronic matter: the role of mesons

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The study of magnetized mesons and its properties is important to understand and verify key features of the QCD phase diagram. In this work we use the Nambu–Jona-Lasinio model in its $SU(3)$ formulation; with a six-point interaction given by the 't Hooft determinant; and under an external constant magnetic field. By applying the stationary phase approximation (SPA), we bosonize the lagrangian and, in the mean field approximation, we can find the quark condensates. This procedure is essential to determine the pole mass of the pseudoscalar mesonic nonet, which we calculate by considering the next order approximation. Then, by writing the polarization function in the Schwinger form, we can find the expressions for the pole masses in a constant magnetic field. For the neutral mesons, we apply the usual momentum basis, but for the charged ones we need to use the Ritus eigenfunction method to diagonalize the polarization functions. For the regularization, the Magnetic Field Independent Regularization (MFIR) is applied, which avoids nonphysical oscillations in the quark condensates.

Numerical results are obtained by considering the coupling constant given by the usual parametrization of the model, as well as a magnetic field-dependent coupling, fitted in order to emulate the inverse magnetic catalysis (IMC). In the former case, for the neutral meson masses we observe a non-monotonous behavior, while the charged meson masses increase as a function of the magnetic field. Meanwhile, for the magnetic field-dependent coupling, the pole masses of the neutral mesons decrease monotonously, while the behavior of the charged mesons is still the same.

Relativistic dissipative Magnetohydrodynamics for 2-particle species fluid

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We derive the equations of motion of relativistic magnetohydrodynamics, as well as microscopic expressions for all of its transport coefficients, from the Boltzmann equation using the method of moments. In contrast to reference Phys.~Rev.~D 98(7) 2018, where a single component gas was considered, we perform our derivation for a locally neutral fluid composed of two massless particle species with opposite charges. We demonstrate that the magnetohydrodynamical equations of motion become dramatically different for this more realistic system. The shear-stress tensor no longer obeys a single differential equation; it breaks into three non-degenerate components with respect to the magnetic field, each evolving according to different dynamical equations. For large magnetic fields, we further show that the solution of this theory displays oscillatory behavior that can no longer be described by an Israel-Stewart-like theory. Finally, we investigate the derived equations in a Bjorken flow scenario.

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Ultrarelativistic shock waves

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We know that the only solution of the hydrodynamic equations that propagates in wave form, except for small perturbations, is shock waves. However, shock waves haven't been thoroughly studied in the ultrarelativistic limit. In the relativistic formulation of hydrodynamics, causality must be intrinsically preserved, which, as a consequence, limits the maximum group velocity of the theory [1]. This naturally affects the propagation of ultra-relativistic shock waves, whose velocity can often exceed this maximum group velocity of the theory. In this work, numerical simulations of ultra-relativistic shock waves will be conducted to investigate what happens to shock waves when they exceed this maximum propagation velocity. The numerical method chosen was Smoothed Particle Hydrodynamics (SPH) [2]. So, I performed a large number of simulations, varying the physical parameters, to investigate the ultrarelativistic limit for shock waves [3]. There were two methods to investigate this limit, the first involved simulating different shocks with different velocities in the same fluid, and the second involved simulating the same shock in different fluids, each with different maximum propagation velocities. After the numerical simulations, we found that as the shock velocity exceeded the maximum group velocity, a second shock formed at the trailing edge of the first one due to a buildup of matter. However, there is no proof whether the second shock is a physical phenomenon or not.

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In-medium mass shift of two-flavored heavy mesons, B_c, B_c^*, B_s, B_s^*, D_s and D_s^*

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For the first time, we estimate the in-medium mass shift of the two-flavored heavy mesons $B_c, B_c^*, B_s, B_s^*, D_s$ and D_s^* in symmetric nuclear matter. The estimates are made by evaluating the lowest order one-loop self-energies. The enhanced excitations of intermediate state heavy-light mesons in symmetric nuclear matter are the origin of their negative mass shift. Our results show that the magnitude of the mass shift for the B_c meson ($\bar{b}c$ or $b\bar{c}$) is larger than those of the $\eta_c(\bar{c}c)$ and $\eta_b(\bar{b}b)$, different from a naive expectation that it would be in-between of them. While, that of the B_c^* shows the in-between of the J/ψ and Υ. We observe that the lighter vector meson excitation in each meson self-energy gives a dominant contribution for the corresponding meson mass shift, B_c, B_s, and D_s.

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Fourier coefficients for the vector interaction extended PNJL model at imaginary chemical potential

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Lattice Quantum Chromodynamics (LQCD) at finite baryon densities faces a significant obstacle known as the sign problem, which hampers reliable evaluations in this area. A promising strategy to bypass this issue involves extrapolating from real to imaginary chemical potentials, effectively circumventing the sign problem. A practical approach to incorporate a finite chemical potential into the equation of state is through a Taylor series expansion in terms of the chemical potential. Then, after analytically continuing the chemical potential, the main task is to obtain the Fourier coefficients, b_k, of the series expansion representing the first order baryon susceptibility, $\chi_1^B(T,\mu) = \sum_k b_k(T)\sinh(k\mu_B/T)$. In the present work, we consider the Polyakov–Nambu–Jona-Lasinio model (PNJL) with a repulsive vector interaction, parametrized by G_V, which is an essential ingredient to describe in medium properties. In order to do an optimal fitting we compare the PNJL b_k coefficients, obtained at the mean-field level, with those predicted by LQCD to analyze if G_V should eventually also depend on the temperature and/or chemical potential.

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Valence and sea parton correlations in double parton scattering from data

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Abstract

Numerous experiments have yielded diverse results when measuring the effective cross section of double parton scattering during proton collisions. This wide range motivated us to assume that parton correlations in the transverse plane vary depending on whether we are dealing with valence or sea partons. Adopting this approach allowed us to fit available data and found that sea parton pairs show higher correlation in the transverse plane compared to valence-sea parton pairs.

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Anomalous magnetic moments in QCD confining models

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The anomalous magnetic moment is an excellent observable to explore with quantum field theory (QFT), and proof of that is the successful theory (QED)/experiment agreement for the electron's magnetic moment.

The case of the proton's anomalous magnetic moment must be treated carefully since the proton is a composite particle, which, according to QCD, is made up of three valence quarks and a sea of virtual quarks and gluons, which are the elementary particles of the strong interaction. Due to the complexity of the nonperturbative nature of QCD and its effect on the behavior of the strong coupling, it has not yet been possible to analytically calculate the proton's anomalous magnetic moment from first principles.

However, to obtain this observable we can resort to the Constituent quark model (CQM), which treats the valence quarks as constituent effective quarks responsible for the properties of the hadrons, yielding good approximate results to the experimental values of the anomalous magnetic moment of some hadrons. So, we compute the quark-photon vertex, focusing on the F2 form factor related to the anomalous magnetic moment of quarks, and with this result, we construct the proton magnetic moment including the effects of QCD interactions generated by the different confining models. That could allow us to use the magnetic moment as a testing field and impose restrictions on the parameter values of some confining models that attempt to address non-perturbative aspects of QCD.

Perturbative evaluations of Yang-Mills correlation functions from the Curci-Ferrari model

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The Curci-Ferrari (CF) model in Landau gauge has been shown to be able to provide a good description of the infrared regime of Yang-Mills theory by perturbative means, by simply adding a gluon mass term to the standard Faddeev-Popov action. In this poster I present some results concerning the one- and two-loop evaluations of various correlation functions within the CF model. The results are compared with lattice data, displaying in all cases a high level of compatibility with the simulations. Moreover, we find that two-loop results systematically improve the agreement when compared to one-loop evaluations. These results strongly support the perturbative CF model as a valuable tool to access the infrared dynamics of YM theory.