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Cortona

Book of Abstracts

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The two- and three-nucleon correlation functions

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When a high-energy pp or p−nucleus collision occurs, particles are produced and emitted at relative distances of the order of the nuclear force. The effect of the mutual interaction between hadrons is reflected as a correlation signal in the momentum distributions of the detected particles which can be studied using correlation functions. The correlation function incorporate information on the emission process
as well as on the final state interaction of the emitted pairs. By measuring correlated particle pairs or triplets at low relative energies and comparing the yields to theoretical predictions, it is possible to study the hadron dynamics.

Short contributions (V) / 2

Genetic Algorithm Modeling of ^{47}Sc Production via Proton Irradiation of ^{49}Ti

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The β^--emitting radionuclide ^{47}Sc is an attractive theranostic agent for nuclear medicine, offering both SPECT imaging capabilities and therapeutic efficacy for small tumors. However, its clinical deployment remains limited by production challenges, including insufficient radionuclidic purity, low yields for some reaction channels, and reliance on restricted infrastructure. In cyclotron-based irradiation of enriched ^{49}Ti, long-lived impurities such as ^{48}Sc and ^{46}Sc are co-produced through competing reactions, complicating purification compliance and increasing the dosimetric burden for patients. Reactor-based alternatives are not universally accessible and present logistical constraints.

In this study, we analyze the ^{49}Ti(p,x)^{47}Sc reaction using the TALYS 1.95G nuclear reaction code [1,2], calibrated against the only available experimental cross-section dataset for this route, recently reported by Pupillo et al. [3]. A genetic algorithm (GA) is employed to optimize twelve level-density parameters across six compound nuclei and nine reaction channels, including ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{43}Sc, ^{44}Sc, ^{42}K, ^{43}K, and ^{48}V. This represents the first application of GA-based joint optimization across multiple reaction pathways for a medically relevant radionuclide, demonstrating the feasibility of integrated AI-driven calibration in nuclear modeling.

The GA-driven optimization significantly improves the agreement between TALYS description and measured data. However, the refined simulations confirm that high co-production of ^{48}Sc and ^{46}Sc are intrinsic to the proton–^{49}Ti reaction path. As a result, this route remains unsuitable for routine clinical applications.

These findings emphasize the potential of evolutionary algorithms for nuclear model tuning and underscore the need for alternative production strategies. The methodology provides a scalable framework for integrating AI into predictive nuclear theory and applied isotope research.

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Invited session (III) / 4

TBA - Valentina Sarti Mantovani

Invited session (I) / 5

The 3-dimensional map of the proton

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Transverse-Momentum dependent (TMD) parton distributions are one of the main tools to study the structure of the proton in a three-dimensional momentum space. They encode information on the probability densities of finding a parton with some specific 3D momentum, as well as fundamental spin-orbit correlations between the transverse motion of partons and the proton spin. In this talk I will review different aspects of TMD distributions, from recent theoretical progress in the understanding of their structure to the newest extractions available from experimental data.

Short contributions (V) / 6

Production Strategies for High-Purity Terbium Radionuclides for Theranostic Applications

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Terbium offers a unique set of four clinically relevant radionuclides, 149Tb, 152Tb, 155Tb, and 161Tb,covering a broad spectrum of nuclear medicine applications, from PET and SPECT imaging to targeted alpha and beta therapies. Their complementary decay properties make them ideal candidates for theranostic approaches, where diagnostic and therapeutic isotopes can be used in matched pairs [1]. Despite their clinical potential, scalable production of these isotopes with sufficient radionuclidic purity remains a key challenge, particularly for hospital-based facilities.
This study investigates the 155Gd(p,n)155Tb reaction using the TALYS nuclear reaction code [2] to evaluate excitation functions, yields, and impurity profiles, with a focus on minimizing co-production of long-lived contaminants such as 156Tb. Cross section predictions were benchmarked against experimental data [3] to refine yield estimates under realistic irradiation conditions. Thick-target yields

and radionuclidic purity were derived across multiple 155Gd enrichment levels, and corresponding dosimetric impact was assessed using OLINDA software [4], quantifying patient dose increase (DI) from contaminant isotopes. The analysis identifies a 98% 155Gd enrichment as the optimal trade-off between production efficiency and clinical safety [5, 6].
In parallel, nuclear reaction modeling was utilized to investigate promising proton-induced production routes for 152Tb from Gadolinium and Dysprosium targets. The simulations provide key insights into reaction mechanisms and potential yields, supporting the optimization of irradiation parameters and guiding future experimental studies aimed at confirming production feasibility for clinical applications.
This study demonstrates how nuclear reaction modeling and parameter refinement can guide the development of scalable, high-purity production routes for terbium radionuclides, supporting their future adoption in clinical theranostic strategies.

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Short contributions (V) / 7

Beyond Protons: Unlocking ^{67}Cu Production with Triton Beams for Next-Generation Theranostics

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The radionuclide ^{67}Cu is a highly attractive theranostic agent, combining β^- emission for radiotherapy with γ-rays suitable for SPECT imaging. However, achieving efficient and clean cyclotron-based production remains a major obstacle. In this study, we explore an alternative nuclear reaction route using triton beams on zinc targets—specifically ^{68}Zn(t,x)^{67}Cu—as part of the NUCSYS CSN4, CUPRUM-TTD CSN5, and SPESMED CSN3 initiatives. Given the absence of experimental cross-section data for these triton-induced reactions, we employed comprehensive TALYS simulations across 24 model combinations, generating uncertainty bands and benchmarking against the well-documented ^{68,70}Zn(p,x)^{67}Cu proton-induced reactions.
Our simulations predict that triton-based reactions can outperform proton routes by more than an order of magnitude in yield for E > 30 MeV, while also significantly reducing stable copper contamination and cooling times. Notably, triton irradiation requires substantially thinner targets, translating into lower consumption of costly enriched material. These findings position triton-induced production as a superior and scalable route to ^{67}Cu, pending experimental validation. This work paves the way for novel strategies in the production of key theranostic radionuclides, potentially transforming their accessibility for nuclear medicine.

Short contributions (I) / 8

Exploring neutron star's glitches with rotating supersolids

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We investigate features of neutron stars glitches employing rotating dipolar supersolids. Understanding the rotational dynamics of such systems sheds light on the behavior of vortices in density-modulated superfluids. We demonstrate that supersolid rotation arises from two distinct flow components: one associated with vortices and another with a curl-free (irrotational) velocity field. At higher rotation frequencies, the curl-free component counteracts the overall rotation, contributing angular momentum that is anti-aligned with that of the vortices. This mechanism suggests that, in neutron stars, the total angular momentum is not solely determined by vortex dynamics but results from the combined contributions of both flow components.

Short contributions (II) / 9

Neutron Star Modeling: "Shortcuts"or Precision?

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Neutron stars provide a unique laboratory for probing the properties of dense nuclear matter under extreme conditions of density. Understanding their internal structure requires a description of the Equation of State of matter at very high densities, which remains one of the main challenges in modern nuclear physics and astrophysics.

A Chiral Effective Field Theory approach can quite faithfully fit the properties of the Equation of State at very high densities, and thus is easily applied to find the Equation of State of a neutron star.

However, using Chiral Effective Field Theory alone to parameterize the entire stellar structure may be insufficient. To improve the model, MUSES Calculation Engine [1] is a very important and modern tool that can be used for these purposes. This approach uses three different theories to describe the three different density profiles, leading to more reliable results.

In my presentation, I will show the results obtained employing both approaches to calculate key neutron star observables (mass, radius, love numbers and others), and compare them with observational astrophysical data.

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Short contributions (VII) / 10

^{12}C and ^{16}O α-particle systems and the triple-α reaction within near-zero range Effective Field Theory

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We investigate the structure of ^{12}C and ^{16}O within an ab-initio Hyperspherical Harmonics framework using short-range Effective Field Theory-inspired interactions. For ^{12}C, ground and excited states are accurately reproduced with a two-body potential plus a fine-tuned three-body force, while ^{16}O requires a genuine four-body interaction to match experiment. We also analyze the triple-α reaction, crucial for stellar nucleosynthesis but poorly constrained at low energies. Employing the adiabatic hyperspherical approximation, we study the 0^+ Hoyle state and its role in the reaction dynamics. These results underline the relevance of cluster structures and many-body forces in light nuclei and their impact on astrophysical reaction rates.

Short contributions (II) / 11

Relativistic corrections and three-nucleon forces in neutron star matter

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We discuss the inclusion of relativistic boost corrections in the correlated basis function (CBF) effective nuclear Hamiltonian. In this framework, a well-behaved nuclear effective interaction is derived from a realistic Hamiltonian through the CBF formalism and cluster expansion techniques. This approach has proven to be remarkably powerful in computing both equilibrium and transport properties of nuclear matter, allowing for several applications in the context of neutron star physics.

Our study analyzes the dependence of boost corrections on the non-relativistic nucleon-nucleon potential, as well as their strong interplay with three-nucleon forces. Because of the crucial role of three-nucleon forces in driving the stiffness of the equation of state at high density, a correct understanding of such interplay is essential for an accurate description of neutron star physics.

Short contributions (IV) / 12

Semi-inclusive neutrino-nucleus scattering within the relativistic distorted wave approach

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Nuclear effects in neutrino-nucleus scattering are one of the main sources of uncertainty in the analysis of neutrino oscillation experiments. Due to the extended neutrino energy distribution, very different reaction mechanisms contribute to the cross section at the same time. Measurements of muon momentum in CC0π events are very important for experiments like T2K, where most of the information about the oscillation signal comes from detection of the final-state muons only. However, those inclusive measurements make difficult to distinguish the contributions of nuclear effects. For instance, they do not allow to separate between different nuclear models and are not sufficient to put constraints on the amount of two-body current contributions. This is the reason why there is a growing interest in measurements of more exclusive processes, for instance the detection in coincidence of a muon and an ejected proton in the final state. Interpretation of such reactions, usually

called semi-inclusive reactions, is challenging as it requires realistic models of the initial nuclear state and an appropriate description of proton final-state interactions.

In this talk we're going to present the theoretical predictions of semi-inclusive νμ cross sections on 12C and 40Ar obtained within an unfactorized approach based on the relativistic distorted wave impulse approximation (RDWIA) and compare them with T2K, MINERνA and MicroBooNE measurements and predictions of the inclusive SuSAv2-MEC model implemented in the neutrino event generator GENIE.

Short contributions (IV) / 13

Quantum Simulations of Nuclear Dynamics in First Quantization

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Real-time simulations of nuclear reactions are classically intractable due to exponential scaling. By adopting a first-quantized formulation of pionless effective field theory, we show that quantum computers can simulate such dynamics efficiently, with costs that grow only polynomially in nucleon number and logarithmically with basis size. The approach demonstrates an exponential saving over previous methods and suggests that simple scattering problems could be tackled on early fault-tolerant devices, bringing ab initio reaction dynamics within reach of near-term quantum hardware.

Short contributions (III) / 14

QCD Equation of State from effective Lagrangians and constraints from Relativistic Mean-Field Models

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The finite-temperature equation of state (EOS) is analyzed within an effective Lagrangian framework, where the dilaton field encodes the breaking of scale symmetry in QCD. In the pure gauge $SU(3)_c$ sector, the gluon condensate dynamics are described through a dilaton Lagrangian: at low temperature the condensate is dominated by the dilaton, while above the critical temperature it evaporates into quasi-free gluons. Glueball excitations are included assuming a linear Regge trajectory, and the role of a string tension term on the spectrum is explored. To address thermal effects, we study the role of dilaton fluctuations, which has proven successful in reproducing lattice QCD results for thermodynamic observables such as pressure and energy density. Furthermore, a first-order phase transition is found, as expected from the results of lattice QCD. The analysis is extended using an effective Lagrangian that incorporates both broken-scale symmetry and explicit chiral symmetry breaking, including mesons (σ, π, ω, ρ) and nucleons at finite temperature and chemical potential, along with their thermal fluctuations. This approach enables the construction of an EOS over a wide range of temperature and chemical potential, providing a framework to study the nature of the QCD phase transition across different degrees of freedom.

In parallel, relativistic mean-field (RMF) models based on the exchange of σ, ω, and ρ mesons with non-linear nucleon-σ couplings and density-dependent ρ coupling are employed. A large set of models is generated via Bayesian methods and constrained by both nuclear physics and astrophysical observations, including GW170817 and NICER data, providing a tool to explore neutron star properties within present empirical limits.

Invited session (II) / 15

Enrico Trincherini TBA

Short contributions (VII) / 16

Application of nuclear covariance matrix in nuclear TMD effects

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In this work, we investigate the nuclear modification effects in transverse momentum dependent (TMD) observables by implementing a nuclear covariance matrix in the treatment of theoretical uncertainties. Global QCD analysis is performed with the aforementioned nuclear covariance matrix to verify its equivalence with the traditional approach of including a nuclear correction parameter. The data analyzed are the Drell-Yan q_T-differential data in pA and πA collisions. In addition, we also perform global QCD analysis with no treatment for the nuclear effects, verifying the necessity of implementing the nuclear corrections.

Short contributions (VI) / 17

Strange quark matter nucleation and implications for NS–QS coexistence

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The Bodmer-Witten hypothesis concerns the possibility that ordinary hadronic matter in bulk is a metastable state of strongly interacting matter, while strange quark matter (SQM) is absolutely stable (i.e., the global minimum). These two phases would be separated by a potential barrier that prevents the spontaneous decay of hadronic matter into SQM in ordinary conditions.
If this hypothesis is true, a family of hadronic neutron stars (NSs) and a family of strange quark stars (QSs) may coexist.

A fundamental question regards the conditions under which a hadronic star converts into a QS and in which astrophysical phenomena these conditions could be reached.
The conversion is triggered after the nucleation of SQM, namely, after that, a SQM droplet large enough to keep expanding is created by a local spontaneous fluctuation.

I will present the state of the art of SQM nucleation in astrophysical systems, including the roles of thermal fluctuations in the hadronic composition and color superconductivity.

Moreover, I will evaluate whether the nucleation conditions are reached during the evolution of a proton-neutron star (PNS) and discuss the implications for the possible coexistence of QSs and NSs.

- Guerrini et al, 2024, ApJ 974 45; doi:10.3847/1538-4357/ad67cc
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- Guerrini et al, *in preparation* (Testing the coexistence of QS and NS in the PNS evolution)

Short contributions (I) / 18

First insight into transverse-momentum-dependent fragmentation physics at photon-photon colliders

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Future planned lepton colliders, both in the circular and linear configurations, can effectively work as virtual and quasi-real photon-photon colliders and are expected to stimulate an intense physics program in the next few years. In this paper, we suggest to consider photon-photon scattering
as a useful source of information on transverse momentum dependent fragmentation functions (TMD FFs), complementing semi-inclusive deep inelastic scattering and e^+e^- annihilation processes, which provide most of the present phenomenological information on TMD FFs. As a first illustrative example, we study two-hadron azimuthal asymmetries around the jet thrust-axis in the process $\ell^+\ell^- \to \gamma^*\gamma \to q\bar{q} \to h_1 h_2 + X$, in which in a circular lepton collider one tagged, deeply-virtual photon scatters off
an untagged quasi-real photon, both originating from the initial lepton beams, producing inclusively an almost back-to-back light-hadron pair with large transverse momentum, in the $\gamma^*\gamma$ center of mass frame. Similar processes, in a more complicated environment due to the presence of initial hadronic states, can also be studied in ultraperipheral collisions at the LHC and the planned future hadron colliders.

Short contributions (VI) / 19

Hadron Cross Sections and Uncertainties in Cosmic Antiproton Production & Beyond

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Collider-based QCD calculations shed light on cosmic ray antiproton anomalies with novel cross-disciplinary results. Current astrophysical observations require a precise calculation of cross sections for direct proton-proton to antiproton production vs. indirect production (in which an antineutron is produced first and decays to an antiproton with branching ratio 1). The results of cross section and uncertainty calculations using two sets of fragmentation functions for 17.2 GeV and multiple TeV-scale center-of-mass energies include finding a discrepancy between the claimed ~30% difference in direct and indirect antiproton productions. Implications of this work on baryon/antibaryon yield puzzles will be discussed.

Short contributions (II) / 20

Neutron star crustal properties from Bayesian unified EoS with low-density ab initio constraints

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The nuclear equation of state (EoS) governs the structure of neutron stars and can be constrained by linking information from astrophysical observations, ab initio nuclear theory, and heavy-ion collisions within a Bayesian framework. In this work, we extend a unified meta-modeling approach to the EoS by implementing low-density corrections informed by energy density functionals calibrated to ab initio neutron matter results. This extension ensures improved consistency with nuclear theory in the dilute regime, which is essential for reliable predictions of crustal properties. We analyze the consequences for the crust-core transition density and pressure, crustal composition, and the fraction of the moment of inertia residing in the crust. These results underscore the need for complementary theoretical and experimental constraints across a wide density range, providing a more robust foundation for interpreting multimessenger observations of neutron stars with increasing precision.

Short contributions (IV) / 21

Charm and beauty quarks in the initial stages of proton-Ion Collisions

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In this talk I will discuss the dynamics of Heavy Quarks in the initial gluon-dominated phase of heavy ion collisions, called Glasma. I will first highlight the effect of such phase on the color de-correlation of Heavy Quark pairs, as shown by numerical studies in a 2+1D framework. Then, moving on to 3+1D studies, I discuss the effect of rapidity-dependent fluctuations on the momentum shift of static heavy quarks.

Short contributions (I) / 22

Extraction of di-hadron fragmentation functions at NNLO

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Parton distribution functions (PDFs) describe the internal structure of hadrons by providing information on the number densities of quarks and gluons inside them. Among the three leading-twist PDFs, the unpolarised distribution f_1 , the helicity distribution g_1, and the transversity distribution h_1, the transversity has only recently been extracted and the uncertainties are still high. Interest in transversity has grown due to its role in comparing phenomenological and Lattice QCD results, as well as its relevance in searches for physics beyond the Standard Model. The Collins effect has long been a key tool for accessing transversity, but di-hadron observables provide a powerful alternative, offering complementary information within a simpler theoretical framework.
In my work, I extracted the unpolarised di-hadron fragmentation functions D_1 at NNLO accuracy, using both a physics-informed and a neural network parametrisation. It is the first step towards extracting the collinear chiral-odd $H_1^{\angle}$ from the BELLE asymmetry data and, on the long run, towards improving the accuracy in the extraction of transversity from data on inclusive di-hadron production.

Long talks of IS (I) / 23

From deep inelastic scattering to double parton scattering off light nuclei

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In this talk I review the most important and recent results collected by the Perugia group about the study of polarized and unpolarized deep inelastic scattering (DIS) off light nuclei and the new project to propose extracting nuclear double parton distributions (DPDs) in the future electron Ion collider (EIC). In particular, I will discuss the calculation of the so-called European Muon Collaboration (EMC) effect for He3, H3 and He4 systems. The nuclear structure is described within the relativistic Light-Front (LF) approach which leads to fulfill Poincaré covariance and macroscopic locality, and therefore, number of particles and momentum sum rules are preserved. As inputs, use has been made of the nuclear wave-functions obtained from the phenomenological Av18 + UIX potential and the chiral potentials called NVIa +3N and NVIb+3N. The evaluated momentum distribution with the corresponding wf has been used to calculate the structure functions of the considered nuclei. We predict a sizable EMC effect for He3[1] and for He4[2]. The approach has been extended to evaluate the polarized He3 structure functions and results remarkably compare well with data [3].

Finally, we propose studying nuclear double parton scattering at the EIC to access nuclear DPDs for the first time. These quantities encode the probability of finding two partons with given longitudinal momentum fractions located at a specific transverse distance. DPDs are therefore sensitive to unknown double parton correlations that are crucial for understanding the non-perturbative structure

of hadrons. In this context, nuclear targets such as the deuteron [4] are essential for enhancing the production rate of this rare process, making the use of light nuclei indispensable for generating realistic predictions. Furthermore, we demonstrate how nuclear DPS studies could yield novel insights into the origin of the EMC effect [5].

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Long talks of IS (II) / 24

Nuclear Density Functional Theory and grounding it in ab initio

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The purpose of this contribution is twofold. First, I will highlight the status and some of the successes of nonrelativistic DFT, which is still, to date, the microscopic nuclear model with the broadest range of applicability. Some examples of applications, like the solution of the puzzle of the nuclear matter incompressibility and the case of nuclear photonics, will be discussed.
At the moment, however, it is hard to improve the accuracy of existing functionals. Ongoing and future prospects to achieve the "universal"functional will be touched upon, like Bayesian inference techniques and the possibility to use *ab initio* nuclear theory as a starting point. In this latter case, the recent convergence displayed by the results of several many-body methods in nuclear matter can be instrumental in order to design a firm constraint for the volume part of the functionals.
Throughout the talk, I will stress the existing and some possible collaborations with the Italian theory community, within the IS MONSTRE or outside it.

Short contributions (IV) / 25

Assessing lattice QCD charm space diffusion coefficient and thermalization time by mean of D meson observables at LHC

Authors: Maria Lucia Sambataro[1]; Vincenzo Minissale[2]; Salvatore Plumari[1]; Vincenzo Greco[1]

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A key objective in heavy-flavour studies is to quantify the interaction between heavy quarks (HQs) and the quark-gluon plasma (QGP) via the spatial diffusion coefficient $D_s(T)$. Recent lattice QCD results with dynamical fermions suggest a notably low value of $2\pi TD_s \approx 1$ at T_c for charm quarks —much lower than quenched QCD and phenomenological models, which predict $2\pi TD_s \approx 3.5-5$.

This raises questions about compatibility with experimental observables like R_{AA}, and flow coefficients v_2, v_3 for D mesons.
Using an event-by-event Langevin approach, we show that such low D_s values match experimental data only if the drag coefficient $A(p) = \tau_{th}^{-1}(p)$ has strong momentum dependence while a momentum-independent thermalization time fails to reproduce observed behavior. Moreover, a short $\tau_{th} \approx 1.5 fm/c$ reduces sensitivity to initial charm-quark momentum up to $p_T \approx M_c$, hinting at a universal dynamical attractor.

Long talks of IS (I) / 27

Effects of Fermionic Dark Matter on Electron-Capture Supernovae

Short contributions (III) / 28

Diagrammatic Monte Carlo for Structure and Reaction Calculations

Author: Stefano Brolli[1]

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The ab initio calculation of optical potentials, grounded in the microscopic Hamiltonian, and the consistent evaluation of cross sections requires accounting for high-order virtual excitations, whose number grows factorially with perturbative order. This limitation has long hindered ab initio calculations of scattering observables, which instead rely on phenomenological models of optical potentials that are inconsistent with the structure part of the calculation [1].
Diagrammatic Monte Carlo (DiagMC) offers a powerful way to tackle this challenge, as it can efficiently capture high-order excitations through a stochastic sampling. The method has already showed remarkable success in condensed matter physics [2, 3], where it enables the resummation of contributions in infinite systems at finite temperature.
I will present the first application of DiagMC to a problem of relevance to nuclear structure: the pure pairing Richardson model. Our results exceed the accuracy of the state-of-the-art ADC(3) approximation by including diagrams up to eighth order in the ladder expansion [4].
Work is ongoing to extend this approach to realistic Hamiltonians. This development will pave the way for the calculation of reliable optical potentials with minimal phenomenological input, strengthening the predictive power of nuclear reaction studies with radioactive ion beams. The challenges and progress in the applications of DiagMC to realistic nuclear models will be discussed.

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Short contributions (VI) / 29

Solving the homogeneous Bethe-Salpeter equation with a quantum annealer

Authors: Alessandro Roggero[1]; Alex Gnech[2]; Filippo Fornetti[1]; Francesco Pederiva[1]; Giovanni Salme'[3]; Matteo Rinaldi[1]; Michele Viviani[1]; Sergio Scopetta[1]; Tobias Frederico[4]

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The homogeneous Bethe-Salpeter equation (hBSE) [1], which models a bound system within a fully relativistic quantum field theory, has been solved for the first time using a D-Wave quantum annealer [2]. Following standard discretization methods, the hBSE in the ladder approximation can be reformulated as a generalized eigenvalue problem (GEVP) involving two square matrices, one symmetric and the other non-symmetric (see Ref. [3] for details). This problem is of significant interest in various scientific fields, making the results broadly impactful. The non-symmetric matrix presents a challenge for a formal approach to solving the GEVP on a quantum annealer, as it needs to be converted into a quadratic unconstrained binary optimization (QUBO) problem. We have developed a hybrid algorithm. First, we reduce the non-symmetric GEVP to a standard eigenvalue problem classically. Then, we employ the QA to solve the variational problem. Drawing inspiration from approaches for symmetric matrices [4], we generalize the algorithm to accommodate the non-symmetric case, which involves complex eigenvalues (see Ref. [5] for details). A thorough numerical evaluation of the proposed algorithms, applied to matrices of up to 64 dimensions, was conducted using the proprietary simulated annealing package and the D-Wave Advantage 4.1 system thanks to the D-Wave-CINECA agreement[6], as part of an international project approved by Q@TN (INFN-UNITN-FBK-CNR)[7]. The results show excellent agreement with classical algorithms and reveal promising scalability properties.

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Short contributions (III) / 30

Medium effects in HF-hadron production, from pp to AA collisions

Authors: Andrea Beraudo[1]; Arturo De Pace[1]; Daniel Pablos Alfonso[1]; Francesco Prino[1]; Marco Monteno[1]; Marzia Nardi[1]

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I will show how a unified picture of HF-hadron production in high-energy hadronic collisions can be developed under the assumption that both in pp and in AA events a small/large drop of hot deconfined matter is formed, affecting the propagation and eventual hadronization of heavy quarks. Our calculations include a transport setup (POWLANG) interfaced with an hadronization model based on a local color neutralization (LCN) mechamism occurring via recombination of opposite-color nearby partons.

Long talks of IS (I) / **31**

Nuclear structure calculations for neutrinoless double-beta decay: an overlook on present and future

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The detection of the double-beta decay without neutrino emission will represent a major turning point towards our knowledge of the neutrino nature. Moreover, it is going to open new scenarios for the Beyond-Standard-Model physics, because of the violation of the lepton number within such a process. In particular, the measurement of the half-life of such a decay will provide an almost direct evaluation of the neutrino effective mass, through the calculation of the nuclear matrix element of the decay process (M0nu) that connects the wave functions of the initial and final states.
In this presentation, I will overview the recent theoretical developments of the calculations of M0nu, and the future perspectives to obtain a precise and reliable evaluation of this quantity. In particular, I will focus on the results obtained by microscopic nuclear structure calculations, that have recent clarified the historical problem of the quenching of the axial coupling constant gA.

Long + short contributions / **32**

Finite density QCD thermodynamics from lattice simulations

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The thermodynamics of QCD is expected to exhibit a very rich structure as temperature and baryon density are varied, with possibly a first order transition at high density and a critical point. Heavy ion collision experiments have been hunting signs of critical behavior for more than a decade, but no clear signal has been found yet. On the theory side, lattice simulations are the major tool for investigating the equilibrium properties of QCD, but at finite density they are made difficult by the fermion sign problem. I will present recent results on the phase structure of the theory based on state-of-the-art calculations of different equilibrium observables.

Long + short contributions / **33**

Microscopic nuclear optical potentials: new developments and achievements

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The optical potential is a well-established and widely used tool to describe nucleon-nucleus scattering processes. Within this approach, it is possible to compute the scattering observables for elastic processes across a wide region of the nuclear landscape and extend its usage to inelastic scattering and other types of reactions.

Since phenomenological approaches lack predictive power, we strongly believe that a microscopic approach will be the preferred tool to make reliable predictions, in particular for upcoming experiments concerning exotic nuclei.

The Watson multiple scattering theory provides a successful framework to derive such optical potential for intermediate energies. In its simplest formulation, derived at the first order, the optical potential is obtained as the folding integral of the nucleon-nucleon scattering matrix and the target density, representing the two fundamental ingredients of the model. After many years of advances in theoretical nuclear physics, it is now possible to calculate these two quantities using the same nucleon-nucleon interaction that is the only input of our calculations. Results obtained within this framework will be presented for light- and medium-mass nuclei, adopting different ab initio approaches to calculate the densities, such as No-Core Shell Model and Self-Consistent Green's Function. Novel extensions of the model, such as the calculation of inelastic transitions or nucleus-nucleus collisions will be also presented.

Short contributions (VII) / 34

Few-nucleon systems within EFT-pionless framework

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Scattering observables in few-nucleon systems are explored using the interaction model and theoretical framework established in Phys. Rev. C **103**, 054003 (2021). By refining the low-energy constants of the potential to accurately reproduce key two-body scattering observables, we obtain fresh insights and updated predictions for the observables under consideration. Moreover, since the potential successfully reproduces the interaction in the S-wave partial wave, we intend to employ it in future studies of the proton–proton reaction.

Short contributions (VII) / 35

The hyperon-nucleon interaction in low-energy effective field theory

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In recent years, there has been a notable interest in investigating hypernuclear systems, which provide a unique laboratory for studying strong interactions in the strange quark sector. One of the main applications is related to the so-called "hyperon puzzle" in neutron stars, where theoretical models including hyperons predict maximum masses of $\sim 1.5\,M_\odot$ or less, in conflict with observations of neutron stars with masses up to $\sim 2\,M_\odot$.
Solving this puzzle with nuclear physics tools requires a detailed understanding of hyperon-nucleon (YN) interactions, hyperon-hyperon (YY) interactions, and three-body interactions involving hyperons and nucleons. In this talk, I will present the development of a local potential model for the ΛN interaction, derived using a low-energy EFT formalism that involves contact terms only. The present interaction has been derived up to next-to-leading order (NLO). I will also discuss the details of the fitting procedure to Λp elastic scattering cross sections and present our results for different cutoff parameters up to 2.5 fm.

Short contributions (IV) / 36

NQS for Hypernuclei, Neural-IDF, and Equivariant NQS for Excited-State Targeting

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Three advances in Neural Quantum States for nuclear physics: (i) We develop a Pfaffian–Jastrow VMC-NQS ansatz for single-Λ hypernuclei. Calibrated via Gaussian-process assisted LO pionless EFT it reproduces s- and p-shell binding and Λ-separation energies, capturing the proton "shrinkage" in ${}^{7}_{\Lambda}$Li relative to ^{6}Li; (ii) Neural Interacting Dynamical Fields (Neural-IDF) are a continuation of Madeira's dynamical-pion QMC recast as an NQS, treating pion modes as explicit variational DOFs jointly sampled with nucleons, enabling a unified N-π description; (iii) Excited states $-$ an explicitly $SO(3)$-equivariant backflow architecture targets $J > 0$ states.

Short contributions (VII) / 37

The photodisintegration cross section of ^{9}Be and ^{12}C within Cluster Effective Field Theory

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The photodisintegration processes $\gamma + {}^{12}\mathrm{C} \to \alpha + \alpha + \alpha$ and $\gamma + {}^{9}\mathrm{Be} \to \alpha + \alpha + n$ are reactions of astrophysical relevance, both representing a path to carbon nucleosynthesis. Here we present a thorough study of the latter process [1], which is relevant in specific astrophysical environments involving a large number of neutrons.
The photodisintegration of ^{9}Be is analyzed in the low-energy regime using a three-body *ab initio* approach, where the cross section is calculated by means of the Lorentz integral transform method [2], in conjunction with a non-symmetrized hyperspherical harmonics basis [3,4]. In studying the

three-body system provided by the Borromean ^{9}Be nucleus, i.e. $\alpha\alpha n$, the two-body interactions are derived using a halo/cluster effective field theory approach [5]. This *effective clustering* description is permitted by the clear separation of energy scales, which are defined by the shallow binding of ^{9}Be below the $\alpha\alpha n$ threshold ($\approx$ 1.57 MeV) and the deep binding of the α-particle ($\approx$ 20 MeV). To correctly reproduce the ^{9}Be three-body binding energy, a state-dependent three-body force is also introduced in the model. Our results for the cross section are consistent with the experimental data available from the literature, particularly in the energy range just above the three-body threshold. We will also briefly discuss the interesting results regarding the contribution to the cross section from nuclear current terms beyond the one-body term.
The same approach can also be used to study ^{12}C photodisintegration. However, we are still in the early stages of analysing this process and further research is necessary [6].

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Short contributions (II) / 38

Nucleon-nucleon correlation functions from different interactions

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More and more data on correlation functions between hadrons as they can be measured in heavy-ion collisions using the femtoscopy technique [1,2] have recently become available. This applies not only to the nucleon-nucleon system but also to the hyperon-nucleon system. Thereby, they might help in the future to constrain hyperon-nucleon interactions.

As a first step in this direction, it is instructive to study the sensitivity of correlation functions on the interaction. I will present our results where we analyzed the sensitivity of the nucleon-nucleon correlation function on the nucleon-nucleon interaction [3]. Specifically, we calculated the correlation function based on the Argonne V18 interaction as well as based on different version of the Norfolk chiral EFT interactions [4] differing in regulation scale as well as in the fitting region of low-energy constants. In the momentum region between 0 and 500 MeV we found a sensitivity of almost 6 % for the nn system and up to 1.4 % for the pp system. Moreover, I will also present indications regarding the relation between the correlation function and phase shifts. Another focus of this work was the study of the convergence in the partial waves as well as the effect of coupling between channels.

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Long talks of IS (II) / 39

Spin in relativistic heavy ion collisions: a theory overview

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An overview on spin observables as a tool to study the medium produced in heavy-ion collisions.
30' minute talk

Long talks of IS (II) / 41

Non-equilibrium correction to the spin-polarization vector in heavy-ion collisions

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We present a new method to compute the full non-equilibrium corrections to the Wigner function of a Dirac field from hadronic interactions after decoupling, including hadron-gas interactions and dissipative contributions. We compute the resulting corrections to both the spectrum and the spin-polarization vector at any order in linear response theory.

Long talks of IS (II) / 42

Initial-state-driven spin correlations in high-energy nuclear collisions

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In the study of spin-polarization phenomena in heavy-ion collisions, it is typically assumed that final-state particles are polarized through thermal vorticity and shear. In this sense, polarization is a final-state effect. Here, we propose a different mechanism. We postulate that the collision of spin-carrying nucleons generates an initial transverse spin density, inducing a net polarization of the QCD fireball along a random direction. If the net spin is conserved throughout the evolution of the fireball, the final-state particles should exhibit measurable polarization. Within a wounded nucleon picture, we estimate that initial-state fluctuations induce a net polarization of Lambda baryons which is around 1% in central collisions and 10% in noncentral collisions, exceeding the contributions from thermal vorticity and shear. We introduce a two-particle angular correlation observable designed to reveal initial net-spin fluctuations, and emphasize the main signatures to look for in experiments. We argue that the discovery of these phenomena would have profound implications for nuclear structure and our understanding of spin in relativistic hydrodynamics.In the study of spin-polarization phenomena in heavy-ion collisions, it is
typically assumed that final-state particles are polarized through thermal vorticity and shear. In this sense, polarization is a final-state effect. Here, we propose a different mechanism. We postulate that the collision of spin-carrying nucleons generates an initial transverse spin density, inducing a net polarization of the QCD

fireball along a random direction. If the net spin is conserved throughout the evolution of the fireball, the final-state particles should exhibit measurable polarization. Within a wounded nucleon picture, we estimate that initial-state fluctuations induce a net polarization of Lambda baryons which is around 1% in central collisions and 10% in noncentral collisions, exceeding the contributions from thermal vorticity and shear. We introduce a two-particle angular correlation observable designed to reveal initial net-spin fluctuations, and emphasize the main signatures to look for in experiments. We argue that the discovery of these phenomena would have profound implications for nuclear structure and our understanding of spin in relativistic hydrodynamics.

Long talks of IS (II) / 43

Medium effects in HF-hadron production, from pp to AA collisions

Short contributions (III) / 44

Non-equilibrium correction to the spin-polarization vector in heavy-ion collisions