TNPI2023 - XIX Conference on Theoretical Nuclear Physics in Italy

Wednesday, 11 October 2023 - Friday, 13 October 2023

Cortona

Book of Abstracts

Contents

Hadron Physics (II) / 1

A global fit of unpolarised quark TMD PDFs at N3LL

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Building maps of the internal partonic structure of nucleons is a crucial step towards understanding the interactions between quarks and gluons and the phenomenon of confinement.

In this talk I will present an extraction of unpolarized transverse-momentum-dependent parton distribution and fragmentation functions, based on more than two thousand data points from several experiments for two different processes: Semi-Inclusive Deep-Inelastic Scattering and Drell-Yan lepton-pair production.

The baseline analysis is performed using the Monte Carlo replica method and resumming large logarithms at N^3LL accuracy: the resulting description of the data is very good (χ^2/N_{data}=1.06).

The availability of TMD analyses at increasing precision will be essential in guiding detector design and feasibility studies for the future Electron Ion Collider, and will also have a strong impact on precision measurements of observables particularly sensitive to the hadron structure, such as W mass measurements at hadron colliders.

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Glitches in rotating supersolids

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Glitches, spin-up events in neutron stars, are of prime interest as they reveal properties of nuclear matter at subnuclear densities. We numerically investigate the glitch mechanism using analogies between neutron stars and magnetic dipolar gases in the supersolid phase. In rotating neutron stars, glitches are believed to occur when many superfluid vortices unpin from the interior, transferring angular momentum to the stellar surface. In the supersolid analogy, we show that a glitch happens when vortices pinned in the low-density inter-droplet region abruptly unpin. These supersolid glitches show remarkable parallels with neutron star glitches: they are characterized by a rapid spin-up followed by a long post-glitch spin-down due to relaxation towards a steady state. Dipolar supersolids offer an unprecedented possibility to test both the vortex and crystal dynamics during a glitch. Here, we explore the glitch dependence on the supersolid quality, finding strong suppression at the supersolid-to-solid transition. This provides a tool to study glitches originating from different radial depths of a neutron star. Benchmarking our theory against neutron star observations, our work will open a new avenue for the quantum simulation of stellar objects from Earth.

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Massive gluodynamics: unlocking the infrared regime of QCD using perturbative techniques

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At the turn of the century, the availability of larger and more powerful supercomputers made it possible to push the lattice QCD calculations down into the deep infrared, where ordinary perturbation theory fails due to the presence of a Landau pole in its running coupling constant. There it was discovered that, instead of growing to infinity as would be typical of a massless field, the gluon propagator saturates to a finite value in the limit of vanishing momentum –an indication that the gluons develop an infrared dynamical mass due to the interactions. Despite being an established result, the fact that the gluons behave as massive degrees of freedom at low energies has somewhat eluded widespread recognition by the scientific community.
The aim of this contribution is to give an overview of the issue of dynamical mass generation in the gluon sector of QCD and to discuss some of the analytical methods that have been developed to describe it, with emphasis on two perturbative techniques termed the screened massive expansion and the dynamical model. We will show that these non-standard reformulations of ordinary perturbation theory are capable both of accounting for a non-vanishing gluon mass and of providing an accurate picture of the infrared dynamics of QCD –as revealed by the lattice calculations – already at one loop. Instead of developing a Landau pole, the running coupling constant computed by using these techniques remains finite and moderately small across all energy scales, thus ensuring that perturbation theory remains self-consistent down to arbitrarily small energies. A candidate mechanism for dynamical mass generation will be identified in the effect brought by a dimension-2 gauge-invariant gluon condensate on the vacuum structure of QCD, whose value can be computed from first principles and is directly proportional to the gluon mass squared.

Strongly correlated nuclear systems (I) / 5

Modelling neutrino-nucleus interactions for long baseline oscillation experiments

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The status of nuclear models used in the analysis of ongoing and planned neutrino oscillation experiments, notably T2K and DUNE, will be reviewed. Recent progress in the study of semi-inclusive reactions will be presented and discussed.

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Nuclear models for inclusive lepton-nucleus process in the quasi-elastic and 2p-2h processes

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Lepton-nucleus interaction is analyzed, in particular in the quasi-elastic region, using several nuclear models. The MEC are also included, that provide contributions in the so called 'dip region'. Both direct and exchange terms are evaluated.

Nuclear structure and reactions (II) / 7

Microscopic theory of infinite nuclear matter and connections to the nuclear energy functional

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In this talk, we will present our work at the interface between density functional theory (DFT) and *ab initio* theory. In particular, we will focus on infinite nuclear matter, that we simulate using a description based on a finite number of nucleons, and discuss three research directions:
1. a new *ab initio* Self-consistent Green's function (SCGF) approach, based on the algebraic diagrammatic construction (ADC) approximation scheme that has proved successful in finite nuclei, is applied to determine the equation of state (EOS) of nuclear matter using chiral interactions [1];
2. we go beyond homogeneous matter, and present results for nuclear matter perturbed by an external static potential, the so-called static response problem [2], within the DFT method [3] and, at a preliminary level, within Quantum Monte Carlo;
3. finally, we present our program aimed at the construction of *ab initio*-based energy density functionals (EDFs) [4], and discuss how the static response offers in principle the possibility to gain information on the surface terms of the EDF *ab initio*.

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The EMC effect of light nuclei within the light-front Hamiltonian dynamics

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In this talk I will discuss the calculation of the so called European Muon Collaboration (EMC) effect for light-nuclei. To this aim the nuclear structure is described within the relativistic Light-Front (LF) approach. Thanks to this choice, calculations fulfill Poincaré covariance, macroscopic locality, number of particles and momentum sum rules. The procedure has been applied to electron deep inelastic scattering (DIS) on He3 [1], H3 and He4 targerts in the Bjorken limit and in the valence region. The main theoretical ingredient for the calculations is the LF nuclear spectral function which

can be related to the momentum distribution. 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 has been used to calculate the structure functions of the considered nuclei. Our analysis predicts a sizable EMC effect [2]. Results are rather independent with respect to the use of different parametrizations of the nucleon DIS structure functions and the nuclear potentials. To our knowledge these are first realistic calculations of the EMC effect, for different targets, which fulfills Poincaré covariance and thus preserving all the fundamental sum rules. For these reasons, this is a relevant study also in view of the present and future experimental scenarios.

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Cluster Effective Field Theory calculation of electromagnetic breakup reactions with Lorentz Integral Transform method

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The inverse process of $^9\mathrm{Be}$ photo-disintegration, including both sequential and direct reactions combining two α and a neutron into ^{9}Be, is a reaction of astrophysical interest, because it represents an alternative path to the $^{12}\mathrm{C}$ formation in a neutron-rich environment. Here we present the study of the inclusive reaction $\gamma + {}^9\mathrm{Be} \to \alpha + \alpha + n$, in the low-energy regime, where the cross section is calculated using the Lorentz Integral Transform method [1]. Furthermore, we calculate the ^{9}Be three-body binding energy via the Non-Symmetrized Hyperspherical Harmonics (NSHH) method [2].

The shallow binding of $^9\mathrm{Be}$ below the $\alpha\alpha n$ three-body threshold and the deep binding of α indicates a clear separation of energy scales, therefore, in the low energy regime, we are allowed to study $^9\mathrm{Be}$ as a three-body *clustering* system interacting through *effective* potentials. In the literature one finds calculations where α-α and α-n potentials of phenomenological character have been used; here we present an attempt to use potentials derived from Halo Effective Field Theory (EFT) [3].

In order to quantify the contributions of the one- and *higher*-body nuclear currents to the reaction cross section, we compute the nuclear current matrix element using either the one-body convection current [4] or the dipole operator matrix element. The reason for this twofold calculation is that, at low energy, the latter includes the contributions of the one-body convection current as well as that of *higher*-body currents (Siegert theorem). We will discuss the results focusing on the interplay between these two contributions, driven by the EFT parameters, and in connection with the experimental results.

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Study of dark matter scattering off 2H and 4He nuclei within chiral effective field theory

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We study dark matter scattering off ^{2}H and ^{4}He nuclei, assuming DM to be composed by weak interacting massive particles, WIMPs. In order to parametrize the WIMP-nucleon interaction the chiral effective field theory (χEFT) approach is used. Considering only interactions invariant under parity, charge conjugation and time reversal, we examine five interaction types: scalar, pseudoscalar, vector, axial and tensor. Scattering amplitudes between two nucleons and a WIMP are calculated up to second chiral order, and used to calculate the nuclei responses. We apply this program to calculate the interaction rate as function of the WIMP mass and of the magnitude of the WIMP-quark coupling constants. From our study, we conclude that the scalar nuclear response functions result much greater than the others due to theirs large combination of low energy constants. We also verify that the leading order contributions are dominant in this low energy process.

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Heavy Barions and new Interacting Boson Fermion Fermion Model results

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In the first part of the presentation, we present a study of the spectra and strong decay widths of heavy baryons. The masses of single heavy baryons up to the D-wave are calculated within a constituent quark model, employing both the three-quark and quark-diquark schemes. We calculated the decay widths of the ground and excited single heavy baryons into the heavy single baryon-(vector/pseudoscalar) meson pairs and the (octet/ decuplet) baryon-(pseudoscalar/vector) heavy meson pairs. Moreover, we discuss why the presence or absence of the ρ-mode excitations in the experimental spectrum is the key to distinguishing between the quark-diquark and three-quark behaviours, as it was originally pointed out in \cite{Santopinto2019}.
Our quantum number assignments and predictions for mass spectra and strong-decay widths are in agreement with the available data \cite{Bijker:2020tns,Garcia-Tecocoatzi:2022zrf,Garcia-Tecocoatzi:2023btk}. Hence, our findings provide valuable guidance for future measurements in experiments conducted at LHC, Belle, and Belle II.

In the second part of this talk, we present a new application of the Interacting Boson Fermion-Fermion Model (IBFFM) for describing double charge exchange reactions. The study of double charge exchange reactions induced by heavy ions involving candidate nuclei for neutrinoless double beta decay is a complex task carried out by the NUMEN collaboration \cite{NUMEN:2022ton}. This investigation faces the intricacies of complex odd-odd intermediate nuclei in sequential double charge exchange processes. We offer a comprehensive description of heavy odd-odd nuclei using the (IBFFM). Additionally, we outline the methodology for describing transfer operators within this framework. Finally, we explore the potential applications of our results in future reaction codes for describing double charge exchange reactions. "

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Clustering and two-body correlations within extended density functional approaches

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The formation of nuclear clusters constitutes an essential feature for the construction of global and unified equation-of-state (EoS) for nuclear matter. They emerge as many-body correlations, which can be attributed to the nucleon-nucleon (NN) interaction, and exist at sub-saturation densities in nuclear matter.

Phenomenological models that make use of energy density functionals (EDFs) offer a convenient approach to account for the presence of these bound states of nucleons when clusters are introduced as additional degrees of freedom. However, these models are constructed in such a way that clusters dissolve when the density approaches the nuclear saturation density, so that only nucleons survive as independent quasi-particles at higher densities. These models reveal thus inconsistencies with recent findings that evidence the existence of sizeable NN short-range correlations (SRCs) even at larger densities.

In our work, we propose a novel approach which allows, within the EDF framework, for an explicit treatment of SRCs at supra-saturation densities, by using effective quasi-clusters immersed in dense matter as a surrogate for correlations. Our idea is to embed the SRCs within generalized relativistic energy density functionals through the introduction of suitable in-medium modifications of the cluster properties. As a first exploratory step, the example of a quasi-deuteron in a relativistic mean-field

model with density dependent couplings is explored. A full covariant and self-consistent scheme, based on the two-body Dirac equations, is moreover proposed to explicitly determine the many-body wave function of the quasi-deuteron in the medium.

Some parameterizations of the cluster mass shift at zero temperature, as constrained by experimental results for the effective deuteron fraction in nuclear matter near saturation and by microscopic many-body calculations in the low-density limit, are derived for all baryon densities. Novel effects on some thermodynamic quantities, such as the matter incompressibility, the symmetry energy and its slope, are finally discerned.

Implications in the widest scope of astrophysical applications are envisaged and the impact of these studies for general aspects of reactions dynamics, such as the clustering processes emerging in heavy-ion collisions, will be also discussed.

Nuclear structure and reactions (I) / 13

Quantum computing for nuclear physics

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With the recent experimental realization of quantum computing devices containing tens to hundreds of qubits and fully controllable operations, the theoretical effort in designing efficient quantum algorithms for a variety of problems has seen a tremendous growth worldwide. In this talk I will discuss the potential impact of quantum computing for application in nuclear physics and present some recent result of quantum simulations for simple nuclear models on current generation devices.

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Solving the homogeneus Bethe-Salpeter equation with a quantum annealer

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This work aims to solve the Bethe-Salpeter equation (BSE) [1] of two massive scalars bound by the exchange of a massive scalar (solved in Ref. [2] with classical computation) with a Quantum Annealer (QA). One can transform the BSE into a non-symmetric generalized eigenvalue problem (GEVP) (see Ref. [2] for details). For our scope, we are interested to determine only in the maximum and minimum real eigenvalues, with the corresponding eigenvectors, so we have to solve a suitable quadratic minimization problem. After transforming the non symmetric GEPV into a Quadratic Unconstrained Binary Optimization (QUBO) form, the only type of problem manageable by the QA, we have applied a hybrid algorithm: first, we classically reduced the GEVP to a standard eigenvalue problem, then, we used the QA to solve the variational problem. We started with the approach of

Ref. [5] for symmetric matrices and we generalized the algorithm for the non-symmetric case, which notably involves complex eigenvalues (see Ref. [6] for details). We are studying how the algorithm scales with the dimension of the matrices involved in the problem to explore the possible advantages of quantum computation compared to the classical one. We want to remark that the GEVP is a problem of general interest, so the results we will obtain could be relevant for a large area of fields. Our code is running on the D-Wave QA, thanks to the agreement D-Wave-CINECA[3], in the context of an international project approved by Q@TN (INFN-UNITN-FBK-CNR)[4]. We are performing the benchmarking and the analysis of the statistical distribution of the results through different parameters of the algorithm by running the algorithm with a simulated annealing sampler[7].

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Neutron star properties from gravitational-wave observations of r-modes and post-merger events

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Gravitational wave events involving neutron stars provide interesting information of their interiors. In this talk I will not focus on the compact binary inspirals (GW170817-type events), related to the measurements of the tidal deformability of the components, but present instead other types of observations expected in the future: r-modes from rotating neutron stars, as well as the signals related to post-merger emission.

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Effect of composition fluctuations in quark nucleation

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At the typical conditions of compact objects and related phenomena, exotic degrees of freedom such as free quarks are expected. The deconfinement of quarks in hadronic matter begins after

the first seed of quark matter is created. This process is called nucleation, which occurs by local thermal or quantum fluctuations when the hadronic phase is metastable. I will initially present the nucleation conditions in hadronic stars in the two-family scenario. Finally, I will show a new possible framework for the study of nucleation that considers thermal fluctuations in the composition of hadronic matter occurring at finite temperatures.

Nuclear structure and reactions (III) / 17

Kinetic approach of light-nuclei production in intermediate-energy heavy-ion collisions

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We develop a kinetic approach to the production of light nuclei up to mass number A = 4 in intermediate-energy heavy-ion collisions by including them as dynamic degrees of freedom. The conversions between nucleons and light nuclei during the collisions are incorporated dynamically via the breakup of light nuclei by a nucleon and their inverse reactions. We also include the Mott effect on light nuclei, i.e., a light nucleus would no longer be bound if the phase-space density of its surrounding nucleons is too large. With this kinetic approach, we obtain a reasonable description of the measured yields of light nuclei in central Au+Au collisions at energies of 0.25 - 1.0A GeV by the FOPI collaboration. Our study also indicates that the observed enhancement of the α-particle yield at low incident energies can be attributed to a weaker Mott effect on the α-particle, which makes it more difficult to dissolve in nuclear medium, as a result of its much larger binding energy.

Nuclear structure and reactions (I) / 18

Digital quantum computing for collective neutrino oscillations

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Studies of neutrinos from astrophysical environments such as core-collapse supernovae, neutron star mergers and the early universe provide a large amount of information about various phenomena occurring in them. The description of the flavor oscillation is a crucial aspect for such studies, since the physics of matter under extreme conditions is strongly flavor-dependents. The neutrino flavor changes under the effect of 3 contributions: the vacuum oscillation, the interaction with the electrons of the surrounding matter, and the collective oscillations due to interactions between different neutrinos. This last effect adds a non-linear contribution to the equations of motion, making the exact simulation of such a system inaccessible from any current classical computational resource.

Our goal is to describe the real time evolution of a system of many neutrinos by implementing the unitary propagator $U(t) = e^{-iHt}$ using quantum computation and paying attention to the fact that the flavor Hamiltonian, in the presence of neutrino-neutrino term, presents an all-to-all interaction that makes the implementation of $U(t)$, into a quantum algorithm, strongly dependent on the qubit topology. In this contribution we present an efficient way to simulate the coherent collective oscillations of a system of N neutrinos motivating the benefits of full-qubit connectivity which allows for more freedom in gate decomposition and a smaller number of quantum gates making simulation on near-term quantum devises more feasible. We present the results obtained from a real quantum simulation on a trapped-ions based quantum machine.

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Revealing the shell model structure via neural-network quantum states

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We compute ground-state properties of atomic nuclei with up to A = 20 nucleons, using as input a leading order pionless effective field theory Hamiltonian. A variational Monte Carlo method based on a new, highly-expressive, neural-network quantum state ansatz is employed to solve the many-body Schroedinger equation in a systematically improvable fashion. In addition to binding energies and charge radii, we accurately evaluate the magnetic moments of these nuclei, as they reveal the self-emergence of the shell structure, which is not a priori encoded in the neural-network ansatz. To this aim, we introduce a novel computational protocol based on adding an external magnetic field to the nuclear Hamiltonian, which allows the neural network to learn the preferred polarization of the nucleus within the given magnetic field.

Nuclear structure and reactions (II) / 20

Systematics of reaction cross sections from double folding and single folding optical potentials

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The study of knockout reactions in which exotic nuclei are used as projectiles, is a hot research topic. We evaluate the accuracy of the description of the core-target interaction, by comparing theoretical and experimental reaction cross sections for a large dataset of knockout reactions carried out with light projectiles on a 9Be target. Our results show that single-folded potential, derived from a phenomenological optical potential and projectile densities, lead to cross sections which are larger and in better agreement with data, compared with double-folded potentials. Moreover, the absorption radius parameter extracted from S matrices has a stable value for all projectile masses, indicating a clear separation between the region of surface reactions and the region of strong absorption.

I will also briefly describe my contribution to the development of the "Theo4Exp Virtual Access Infrastructure"in the framework of the EU project EuroLabs. This aim of the project is the creation of user-friendly open-access platform for a variety of computer codes to be used by the physics community, and in particular by experimental nuclear physicists. I am presently working at the Theo4Exp Milano node. I have just completed the installation of a spherical HF plus RPA code that allows studying multipole excitations, and I plan to extend the platform by installing other codes like a shell-model one.

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Dynamical Attractors in a Full Transport Approach

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In the description of the heavy-ion collisions, the success of hydrodynamics even when the system is far from equilibrium has raised some questions about the applicability of this theory and about the evolution of the medium itself, especially for smaller systems like p-A and p-p collisions. It has been found that, well before equilibrium is reached, systems with different initial conditions show a universal behavior in several physical quantities: this universality is evident in the appearance of dynamical attractors. We investigate the existence of far-from equilibrium attractors in momentum moments of the one particle distribution function by means of a 3+1D Boltzmann transport approach at fixed η/s with the full collision integral. Attractors are found in the normalized moments of the distribution function and in the evolution of the distribution function itself. We show the results in systems with Bjorken symmetry, for which analytical relaxation-time approximation and hydrodynamic solutions are available, by simulating a 1D boost-invariant system and compare our outcomes with the analytical ones. Afterwards, we find that attractors still exist when the boost-invariance is explicitly broken by the initial particle distribution. Finally, we show that attractors appear also if we consider various temperature dependencies for η/s. The results that will be discussed prove that the universal behavior of the distribution function is more general than as so far explored in literature.

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Spin polarization and spin alignment in relativistic heavy-ion collisions

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In noncentral relativistic heavy-ion collisions, the system carries a large initial orbital angular momentum, inducing strong vorticity fields and magnetic fields in the quark-gluon plasma. These fields will in turn polarize partons and are converted into spin polarization for baryons and spin alignment for vector mesons at the hadronization stage. Based on the Kadanoff-Baym equations on the closed-time-path contour, we propose a relativistic theory for the quark combination processes with spin degrees of freedom. Within this theory, we formulate the spin alignment for vector mesons as a function of spin polarizations for the constitute quark and antiquark. We argue that the nontrivial spin alignment for the ϕ meson, observed in experiments by the STAR collaboration, is mainly attribute to the strong field fluctuations in the quark-gluon plasma, while contributions from vorticity and magnetic fields are negligible. This may open a potential new avenue for studying the behaviour of strong fields.

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From OQS to Quantum Trajectories for Quarkonia

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Open quantum systems (OQS) have shown a good performance within other fields of physics, including quantum optics and solid state physics. Recently, it has been implemented in the Heavy Ion Collisions (HIC) field to study different kinds of events such as jet quenching or quarkonia propagation inside the quark-gluon plasma. We will do an overview of OQS towards the motivation and its application for the quarkonia in QGP case through the so-called Lindblad equation. Quantum trajectories (QTRAJ), on the other hand, is an algorithm to simulate this Lindblad equation, in our case, in a C++ framework.
It will be discussed how Lindblad's formalism is implemented through the QTRAJ as well as the current state of some code upgrades in progress to include new theoretical developments obtained within the last three years.

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Presentation of SIM

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From OQS to Quantum Trajectories for Quarkonia

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Gluon production in high-energy proton-nucleus collisions

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Dynamical Attractors in a Full Transport Approach

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Spin polarization and spin alignment in relativistic heavy-ion collisions

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Compact stars / 31

Presentation of IS: NEUMATT

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Compact stars / 32

Equation of state of dense matter for application to binary neutron star mergers

I will review the various ways of deriving an equation of state (EOS) of dense matter both at zero and finite temperature, according to the possible presence of exotic degrees of freedom like hyperons and deconfined quarks. I will then discuss the need for an accurate knowledge of such EOS in order to describe astrophysical systems of actual interest like binary neutron star mergers and supernova explosions.

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Gluon production in high energy proton nucleus collisions at the LHC

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The initial stage of Ultra Relativistic Heavy Ion Collisions is dominated by low Bjorken-x degrees of freedom, which can be understood as a classical color field, obeying classical Yang-Mills equations. Such a phase, occurring in the first fractions of a fm after the collision and leading towards an equilibrated quark gluon plasma, is called the Glasma. Indeed, we will discuss particle production by the Glasma fields in high energy p-A collisions. We investigate the behaviour of the energy density, the transverse and longitudinal pressures and highlight the setting up of a free streaming regime after a very short time. We then compute the gluon spectrum and its dependence on the saturation scale. We also discuss the possibility of non-zero v_n in the initial stage.

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Recent Developments in β decay studies within the Nuclear Shell Model

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The necessity of calculating reliable nuclear matrix elements for neutrinoless double β decay has further stimulated the research on the mechanisms responsible for the renormalization of the β-decay operator. We tackle this point using the many-body perturbation theory to derive effective Hamiltonian and operators for nuclear shell model calculations. Here, I will present recent results obtained for medium-mass nuclei, discussing the effect of the renormalization for both allowed and forbidden β-decay transitions.

Strongly correlated nuclear systems (I) / 35

IS presentation: NUCSYS

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A Catania-Goa-Turin's tale of charm and beauty: recent advances on heavy quarks in high energy nuclear collisions

Authors: Marco Ruggieri[None]; Vincenzo Greco[1]

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We discuss the diffusion and the energy loss of heavy quarks (HQs), charm and beauty, in relativistic heavy ion collisions. HQs are produced by hard QCD scatterings in the very early stage of the collision. Consequently, they probe the entire evolution of the medium produced by the collision, from the pre-equilibrium stage up to the freezout passing by the evolution in the quark-gluon plasma (QGP). We review recent advances in the modeling of this evolution, summarizing the work done by the units of Turin and Catania on the subject. Emphasis will be put on the most relevant findings, that include advances on the hadronization mechanism of HQs, estimate of the transport coefficients, interaction with strong gluon fields in the early stage and diffusion and energy loss in a bath with memory.

Hadron Physics (I) / 37

IS Presentation: NINPHA

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Nuclear structure and reactions (I) / 38

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Precise tests of the strong interaction among hadrons via femtoscopy

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The description and quantitative understanding of the strong interaction between hadrons is one of the most fundamental problems in nuclear physics and it is crucial to describe the evolution and the properties of matter under extreme conditions.

Results from high energy nucleus-nucleus collision experiments using two-particle correlations in the momentum space will be presented. Such a method, called femtoscopy, enables a direct insight into short-range hadron-hadron strong interactions, delivering measurements with unprecedented precision also in the strangeness sector.

The femtoscopy method is being extended to study the charm sector and to three hadron systems, with potential sensitivity to the three-body dynamics and forces.

Heavy-ion collisions / **41**

A Catania-Goa-Turin's tale of charm and beauty: recent advances on heavy quarks in high-energy nuclear collisions

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Heavy-ion collisions / **42**

Heavy-ion collisions and critical dynamics

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In ricordo / **43**

In ricordo di Ricardo Broglia

In ricordo / **44**

In ricordo di Sergio Rosati

In ricordo / **45**

In ricordo di Gianni Fiorentini e Pier Pizzochero

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The 3He spin-dependent structure functions within the Light-front Hamiltonian Dynamics

Authors: Eleonora Proietti[1]; Emanuele Pace[2]; Filippo Fornetti[1]; Giovanni Salme'[3]; Matteo Rinaldi[1]; Sergio Scopetta[1]

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ABSTRACT
In this talk I will present the results of the calculations of the spin-dependent structure functions (SSFs) of the ^{3}He nucleus.
These quantities parametrize the hadronic tensor entering the deep inelastic scattering cross-section involving polarized beams and targets. In particular, the SSFs encode
relevant information on the spin structure of the target. In this analysis we calculate the ^{3}He SSFs [1]
within the relativistic Light-Front approach successfully tested
to evaluate the ^{3}He EMC effect [2]. In this framework, the calculation fulfills
Poincaré covariance, macroscopic locality,
number of particles and momentum sum rules.
As nuclear input use has been made of the
realistic ^{3}He wave-functions obtained from
the
phenomenological Av18 + UIX potential. Moreover, a procedure to extract the neutron SSFs from those of the ^{3}He and the proton is also proposed. Finally, I show that the calculations here discussed are in excellent agreement with the present data for the ^{3}He SSFs.
Hence, this analysis could be very relevant in particular for the future experimental program of, e.g., the Electron ion Collider, where processes off polarized ^{3}He targets are planned.

REFERENCES

[1] E. Proietti, F. Fornetti, E. Pace, M. Rinaldi, G. Salmè and S. Scopetta, in prep

[2] E. Pace, M. Rinaldi, G. Salme', S. Scopetta, PLB 839 (2023) 137810

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Heavy ion Collisions and Critical Dynamics

Author: Eduardo Grossi[1]

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In this talk, I will present the basic models used to understand the dynamics of an ultrarelativistic heavy ion collision.
After the collision of the two nuclei, accelerating at relativistic energy,
the system rapidly local equilibrate and subsequently expand according
to the generic law of relativistic hydrodynamics.
After the system's cooling due to its rapid expansion, the hadrons are produced and stop interacting until they are detected.
The overall experimental pictures are consistent with the hydrodynamic model. However, some discrepancy regarding pion production at low transverse momenta could indicate that this soft

pion could be produced due to the non-equilibrium effects of the dynamics of chiral phase transition.

based on:
arXiv:2306.06887
arXiv:2111.03640
arXiv:2101.10847

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The 3He spin-dependent structure functions within the Light-front Hamiltonian Dynamics

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These quantities parametrize the hadronic tensor entering the deep inelastic scattering cross-section involving polarized beams and targets. In particular, the SSFs encode
relevant information on the spin structure of the target. In this analysis we calculate the 3He SSFs [1] within the relativistic Light-Front approach successfully tested to evaluate the 3He EMC effect [2]. In this framework, the calculation fulfills Poincaré covariance, macroscopic locality, number of particles and momentum sum rules.
As nuclear input use has been made of the realistic 3He wave-functions obtained from
the phenomenological Av18 + UIX potential. Moreover, a procedure to extract the neutron SSFs from those of the 3He and the proton is also proposed. Finally, I show that the calculations here discussed are in excellent agreement with the present data for the 3He SSFs.
Hence, this analysis could be very relevant in particular for the future experimental program of, e.g., the Electron ion Collider, where processes off polarized 3He targets are planned.

REFERENCES

[1] E. Proietti, F. Fornetti, E. Pace, M. Rinaldi, G. Salmè and S. Scopetta, in preparation

[2] E. Pace, M. Rinaldi, G. Salme', S. Scopetta, PLB 839 (2023) 137810