Quark Matter 2023

Report of Contributions

https://indico.cern.ch/e/1139644

Contribution ID: **6** Type: **Oral**

Heavy quark diffusion from 2+1 flavor lattice QCD

Tuesday, September 5, 2023 4:50 PM (20 minutes)

Heavy quarks are produced in the early stages of the ultra-relativistic heavy-ion collisions and probe the produced hot medium created in these collisions through its entire evolution. The kinetic thermalization of heavy quarks can be characterized by the heavy quark diffusion coefficient. In this talk we report the first determination of the heavy diffusion coefficient in 2+1 flavor lattice QCD in temperature range 195 <T< 352 MeV using the heavy quark effective theory approach combined with novel gradient flow technique. We found that our full QCD determinations are significantly smaller than the quenched lattice QCD determinations and recent phenomenological estimates, implying a very fast kinetic thermalization the heavy quarks. Within this approach we also estimate the first mass suppressed correction to the diffusion coefficient for the first time in 2+1 flavor QCD for the above temperature range.

Category

Theory

Collaboration (if applicable)

Primary authors: ALTENKORT, Luis; KACZMAREK, Olaf; LARSEN, Rasmus (University of Stavanger); MUKHERJEE, Swagato; PETRECZKY, Peter; SHU, Hai-Tao

Presenter: SHU, Hai-Tao

Session Classification: QCD at finite T and density

Track Classification: QCD at finite density and temperature

Contribution ID: **9** Type: **Poster**

Advanced coalescence model based on the Wigner function formalism

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The production of deuterons in pp collisions at $\sqrt{s} = 13$ TeV is simulated on an event-by-event basis using a coalescence afterburner based on a state-of-the-art Wigner-function formalism, and EPOS 3 and PYTHIA 8.3 as event generators. The space-momentum correlations of the nucleon pairs provided by the event generators are preserved, while the nucleon-emitting source is modelled such to reproduce the m_{T}-dependence of the source size measured by ALICE. For the first time, the results of this model show that using a realistic wavefunction for deuterons, namely Argonne v_{18}, it is possible to reproduce the measured deuteron spectra with no free parameters.

Category

Experiment

Collaboration (if applicable)

Primary authors: SINGH, Bhawani (Technische Universitaet Muenchen (DE)); PINTO, Chiara (Technische Universitaet Muenchen (DE)); BELLINI, Francesca (Universita e INFN, Bologna (IT)); FABBIETTI, Laura (Technische Universität München); BARIOGLIO, Luca (Universita e INFN Torino (IT)); HORST, Maximilian (Technische Universitaet Muenchen (DE)); TRIPATHY, Sushanta (CERN)

Presenter: PINTO, Chiara (Technische Universitaet Muenchen (DE))

Session Classification: Poster Session

Track Classification: Small systems

Contribution ID: **11** Type: **not specified**

Welcome and Introductions

Monday, September 4, 2023 8:45 AM (30 minutes)

Contribution ID: **12** Type: **Oral**

Keynote talk

Monday, September 4, 2023 9:15 AM (45 minutes)

Collaboration (if applicable)

Category

Presenter: GROSS, David (KITP/UCSB)

Contribution ID: **13** Type: **Oral**

ALICE Overview

Monday, September 4, 2023 10:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: ARSENE, Ionut Cristian (University of Oslo (NO))

Session Classification: Plenary Session

Contribution ID: **14** Type: **Oral**

ATLAS Overview

Monday, September 4, 2023 11:00 AM (25 minutes)

Collaboration (if applicable)

Category

Presenter: ANGERAMI, Aaron (Lawrence Livermore Nat. Laboratory (US))

Session Classification: Plenary Session

Contribution ID: **15** Type: **Oral**

CMS Overview

Monday, September 4, 2023 11:25 AM (25 minutes)

Collaboration (if applicable)

Category

Presenter: BATY, Austin Alan (Rice University (US))

Session Classification: Plenary Session

Contribution ID: **16** Type: **Oral**

LHCb Overview

Monday, September 4, 2023 11:50 AM (25 minutes)

Collaboration (if applicable)

Category

Presenter: DURHAM, John Matthew (Los Alamos National Laboratory)

Session Classification: Plenary Session

Contribution ID: **17** Type: **Oral**

HADES Overview

Monday, September 4, 2023 12:15 PM (20 minutes)

Presenter: SPIES, Simon (Johann-Wolfgang-Goethe Univ. (DE))

Session Classification: Plenary Session

Contribution ID: **18** Type: **Oral**

STAR Overview

Monday, September 4, 2023 2:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: REED, Rosi

Session Classification: Plenary Session

Contribution ID: **19** Type: **Oral**

PHENIX Overview

Monday, September 4, 2023 2:30 PM (20 minutes)

Collaboration (if applicable)

Category

Presenter: NATTRASS, Christine (University of Tennessee (US))

Session Classification: Plenary Session

Contribution ID: **20** Type: **Oral**

sPHENIX Overview

Monday, September 4, 2023 2:50 PM (20 minutes)

Collaboration (if applicable)

Category

Presenter: O'BRIEN, Edward (Brookhaven National Lab)

Session Classification: Plenary Session

Contribution ID: **21** Type: **Oral**

NA61/SHINE Overview

Monday, September 4, 2023 3:10 PM (20 minutes)

Collaboration (if applicable)

Category

Presenter: PODLASKI, Piotr (University of Warsaw (PL))

Session Classification: Plenary Session

Contribution ID: **22** Type: **Oral**

Lattice QCD Overview

Monday, September 4, 2023 4:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: PASZTOR, Attila (Eötvös University)

Session Classification: Plenary Session

Contribution ID: **23** Type: **Oral**

Quark Matter and Nuclear Astrophysics

Monday, September 4, 2023 4:30 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: GORDA, Tyler (TU Darmstadt)

Session Classification: Plenary Session

Contribution ID: **24** Type: **Oral**

New Tools for Data Analysis and Simulations

Monday, September 4, 2023 5:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: MULLIGAN, James (University of California, Berkeley (US))

Session Classification: Plenary Session

Contribution ID: **25** Type: **Oral**

Diversity, Equity and Inclusion in Nuclear and Particle Physics

Monday, September 4, 2023 5:30 PM (30 minutes)

Collaboration (if applicable)

Category

Primary author: COCHRAN, Geraldine

Presenter: COCHRAN, Geraldine (Rutgers University)

Session Classification: Plenary Session

Contribution ID: **26** Type: **Oral**

The Physics of small systems (remote)

Thursday, September 7, 2023 8:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: SUN, Jiayin (Universita e INFN, Cagliari)

Session Classification: Plenary Session

Contribution ID: **27** Type: **Oral**

Collective Dynamics - experimental overview

Thursday, September 7, 2023 9:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: DOBRIGKEIT CHINELLATO, David (University of Campinas UNICAMP (BR))

Session Classification: Plenary Session

Contribution ID: **28** Type: **Oral**

Collective Dynamics - theoretical overview

Thursday, September 7, 2023 9:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: KANAKUBO, Yuuka (University of Jyväskylä)

Session Classification: Plenary Session

Contribution ID: **29** Type: **Oral**

Search for the critical endpoint

Thursday, September 7, 2023 11:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: PANDAV, Ashish

Session Classification: Plenary Session

Contribution ID: **30** Type: **Oral**

QCD at finite temperature and density - Criticality

Thursday, September 7, 2023 11:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: VOVCHENKO, Volodymyr (University of Houston)

Session Classification: Plenary Session

Contribution ID: **31** Type: **Oral**

QCD at finite temperature and density - Equation of State

Thursday, September 7, 2023 12:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: KARTHEIN, Jamie (MIT)

Session Classification: Plenary Session

Contribution ID: **32** Type: **Oral**

Jet modifications - experimental overview

Friday, September 8, 2023 2:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: HAVENER, Laura Brittany (Yale University (US))

Session Classification: Plenary Session

Contribution ID: **33** Type: **Oral**

Medium response to jets - experimental overview

Friday, September 8, 2023 2:30 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: GO, Yeonju (K)

Session Classification: Plenary Session

Contribution ID: **34** Type: **Oral**

Jet modifications and medium response - theoretical overview

Friday, September 8, 2023 3:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: PABLOS, Daniel (INFN Torino)

Session Classification: Plenary Session

Contribution ID: **35** Type: **Oral**

Open heavy flavor - experimental overview

Friday, September 8, 2023 3:30 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: GROSA, Fabrizio (CERN)

Session Classification: Plenary Session

Contribution ID: **36** Type: **Oral**

Quarkonium - experimental overview

Friday, September 8, 2023 4:30 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: STAHL LEITON, Andre Govinda (CERN)

Session Classification: Plenary Session

Contribution ID: **37** Type: **Oral**

Open heavy flavor and quarkonium - theoretical overview

Friday, September 8, 2023 5:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: ESCOBEDO ESPINOSA, Miguel Angel

Session Classification: Plenary Session

Contribution ID: **38** Type: **Oral**

Chirality, Vorticity and Spin Polarization - experimental overview

Friday, September 8, 2023 11:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: TANG, Aihong (Brookhaven National Laboratory)

Session Classification: Plenary Session

Contribution ID: **39** Type: **Oral**

Initial State Physics

Friday, September 8, 2023 8:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: MÄNTYSAARI, Heikki (University of Jyvaskyla (FI))

Session Classification: Plenary Session

Contribution ID: **40** Type: **Oral**

Approach to Equilibrium

Friday, September 8, 2023 9:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: SCHLICHTING, Soeren (Universität Bielefeld)

Session Classification: Plenary Session

Contribution ID: **41** Type: **Oral**

New theoretical developments

Friday, September 8, 2023 9:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: BERGES, Jürgen (Heidelberg University)

Session Classification: Plenary Session

Contribution ID: **42** Type: **Oral**

Electromagnetic Probes

Friday, September 8, 2023 10:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: BAILHACHE, Raphaelle (Goethe University Frankfurt (DE))

Session Classification: Plenary Session

Contribution ID: **43** Type: **Oral**

Ultra-peripheral Collisions

Friday, September 8, 2023 11:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: BRANDENBURG, Daniel (Ohio State University)

Session Classification: Plenary Session

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

The Physics of the EIC

Saturday, September 9, 2023 8:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: STASTO, Anna Maria (Penn State)

Session Classification: Plenary Session

Contribution ID: **48** Type: **Oral**

Future Facilities and Instrumentation

Saturday, September 9, 2023 9:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: MUSA, Luciano (CERN)

Session Classification: Plenary Session

Contribution ID: **49** Type: **not specified**

Best Presentation Awards

Saturday, September 9, 2023 11:45 AM (15 minutes)

Contribution ID: **50** Type: **not specified**

Zimanyi Medal Award

Saturday, September 9, 2023 12:00 PM (15 minutes)

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

QM 2025 Presentation

Saturday, September 9, 2023 12:15 PM (20 minutes)

Collaboration (if applicable)

Category

Presenter: RISCHKE, Dirk (University Frankfurt)

Contribution ID: **52** Type: **not specified**

Closing Remarks

Saturday, September 9, 2023 12:35 PM (20 minutes)

Contribution ID: **53** Type: **Oral**

Quantum Computing for Nuclear Physics

Friday, September 8, 2023 12:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: SAVAGE, Martin J.

Session Classification: Plenary Session

Contribution ID: **54** Type: **Poster**

Polarization of vector mesons in non-equilibrium hydrodynamics with spin

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We argue that spin alignment of hadrons of spin 1 and higher provide a unique window into the study of hydrodynamics with spin, because it is capable to probe non-equilibrium between spin density and vorticity.
This happens because most of the full 3X3 density matrix is in principle accessible experimentally, and non-zero off-diagonal matrix elements can be directly linked to such non-equilibrium.
We illustrate this using a coalescence model for light vector mesons [1] as well as a potential model for quarkonia, and compare our calculations to experimental data [2].

[1] Kayman J. Gonçalves, Giorgio Torrieri
Phys.Rev.C 105 (2022) 3, 034913 • e-Print: 2104.12941
[2] Paulo de Moura, Kayman J. Gonçalves, Giorgio Torrieri 2305.02428

Category

Theory

Collaboration (if applicable)

Primary authors: TORRIERI, Giorgio; GONÇALVES, Kayman; DE MOURA, Paulo (Unicamp)

Presenter: GONÇALVES, Kayman

Session Classification: Poster Session

Track Classification: Chirality

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

EPJ Featured Talk: Exotic Particle and Nuclei

Thursday, September 7, 2023 10:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: BELLINI, Francesca (Universita e INFN, Bologna (IT))

Session Classification: Plenary Session

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

Quantum Computing for Relativistic Particle Collisions

Collaboration (if applicable)

Category

Presenter: SHANAHAN, Phiala

Session Classification: Plenary Session

Contribution ID: **57** Type: **Oral**

Conference Summary and Outlook

Saturday, September 9, 2023 9:30 AM (45 minutes)

Collaboration (if applicable)

Category

Presenter: CAINES, Helen (Yale University (US))

Session Classification: Plenary Session

Contribution ID: **60** Type: **Poster**

Shear Viscosity at High Chemical Potentials

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Transport coefficients, such as viscosity, can be calculated theoretically in weakly coupled quantum field theory, and present interesting information about hydrodynamic models of heavy-ion collisions. We present results for shear viscosity calculations at almost leading order in weakly coupled QCD in a regime of high baryon density, where the chemical potentials are greater than the temperature. In previous work, we have shown that shear viscosity at leading log order in this regime is dominated by quark scattering.

Category

Theory

Collaboration (if applicable)

Primary author: Ms DANHONI, Isabella

Co-author: Dr MOORE, Guy (TU Darmstadt)

Presenter: Ms DANHONI, Isabella

Session Classification: Poster Session

Track Classification: QCD at finite density and temperature

Contribution ID: **63** Type: **Oral**

Detectors in Heavy Ion Physics

Sunday, September 3, 2023 9:00 AM (45 minutes)

Collaboration (if applicable)

Category

Presenter: HEMMICK, Thomas

Session Classification: Student Lectures

Contribution ID: **64** Type: **Oral**

Jet Physics

Sunday, September 3, 2023 9:45 AM (45 minutes)

Collaboration (if applicable)

Category

Presenter: KUNNAWALKAM ELAYAVALLI, Raghav (Vanderbilt University)

Session Classification: Student Lectures

Contribution ID: **65** Type: **Oral**

Bulk Physics - Flow and Correlations

Sunday, September 3, 2023 11:00 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: ZBROSZCZYK, Hanna (Warsaw University of Technology (PL))

Session Classification: Student Lectures

Contribution ID: **66** Type: **Oral**

Heavy Flavor Physics

Sunday, September 3, 2023 2:00 PM (45 minutes)

Collaboration (if applicable)

Category

Presenter: SCOMPARIN, Enrico (INFN Torino (IT))

Session Classification: Student Lectures

Contribution ID: **67** Type: **Oral**

Ultra-peripheral Collisions and Electromagnetic Probes

Sunday, September 3, 2023 2:45 PM (45 minutes)

Collaboration (if applicable)

Category

Presenter: Prof. TAPIA TAKAKI, Daniel (University of Kansas)

Session Classification: Student Lectures

Contribution ID: **68** Type: **Oral**

The Physics of the EIC

Sunday, September 3, 2023 3:30 PM (45 minutes)

Collaboration (if applicable)

Category

Presenter: ASCHENAUER, Elke

Session Classification: Student Lectures

Contribution ID: **78** Type: **Oral**

Interferometry in a Moat Regime

Wednesday, September 6, 2023 3:20 PM (20 minutes)

The QCD phase diagram at large chemical potential is largely uncharted territory. Based on model studies, there are various phases that could occur in this regime. Among them are phases related to spatial modulations, such as inhomogeneous/crystalline phases, liquid crystals or a quantum pion liquid. A common feature of all these phases is that particles can have a moat dispersion, where the energy is minimized at nonzero momentum. This can directly affect particle production in heavy-ion collisions and leads to characteristic signatures in particle correlations. I will discuss the underlying physics and present a formalism to study particle spectra on general hypersurfaces in a medium. Using this formalism, I will show that the correlations generated by the Hanbury-Brown–Twiss effect are promising probes for a moat regime in heavy-ion collisions.

Category

Theory

Collaboration (if applicable)

Primary author: RENNECKE, Fabian

Co-authors: RISCHKE, Dirk (University Frankfurt); PISARSKI, Robert

Presenter: RENNECKE, Fabian

Session Classification: QCD at finite T and density

Track Classification: QCD at finite density and temperature

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

Molecular dynamics analysis of particle number fluctuations of a first-order phase transition

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We study the critical point effects on particle number fluctuations both in the crossover ($T > T_c$) and mixed phase ($T < T_c$) regions by means of molecular dynamics simulations of a Lennard-Jones fluid, motivated by the ongoing search for the QCD critical point in heavy-ion collisions.

In the crossover region, we find large fluctuations associated with the critical point in coordinate space, but in the absence of collective flow and expansion, they are essentially washed out when momentum cuts are imposed instead.

In the mixed phase region, the behavior depends on whether the system is in a metastable nucleation or cavitation region, or in the spinodal decomposition region, and can be interpreted in terms of simplified analytic models. For the case of nucleation, we find that fluctuations are qualitatively described by a non-interacting cluster model.
The spinodal decomposition, on the other hand, leads to large fluctuations in coordinate space, which can be understood to arise due to the interplay between the size of the acceptance region and that of the liquid phase.

Category

Theory

Collaboration (if applicable)

Primary author: Mr KUZNIETSOV, Volodymyr (Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine)

Co-authors: STOECKER, Horst (GSi); GORENSTEIN, Mark; Mr SAVCHUK, Oleh (Frankfurt Institute for Advanced Studies); Dr POBEREZHNYUK, Roman (Bogolubov Institute for Theoretical Physics); KOCH, Volker; Dr VOVCHENKO, Volodymyr (Lawrence Berkeley National Laboratory)

Presenter: Mr KUZNIETSOV, Volodymyr (Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine)

Session Classification: Poster Session

Track Classification: Collective Dynamics

Contribution ID: **82** Type: **Poster**

Spin alignment of vector mesons by glasma fields

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We explain how spin alignment of vector mesons can be induced by background color fields. Our study is based on the quantum kinetic theory of spinning quarks and antiquarks and incorporates the relaxation of the dynamically generated spin polarization. The spin density matrix of vector mesons is obtained by quark coalescence via the Wigner function and kinetic equation. Our approach predicts a local spin correlation that is distinct from the non-local expressions previously obtained in phenomenological derivations. We estimate the magnitude of such local correlations in the glasma model of the preequilibrium phase of relativistic heavy ion collisions. It is found that the resulting spin alignment could be greatly enhanced and may be comparable to the experimental measurement in order of magnitude. We further propose new phenomenological scenarios to qualitatively explain the transverse-momentum and centrality dependence of spin alignment in a self-consistent framework.

Category

Theory

Collaboration (if applicable)

Primary authors: Dr KUMAR, Avdhesh (Institute of Physics, Academia Sinica); MUELLER, Berndt (Duke University); YANG, Di-Lun (Institute of Physics, Academia Sinica)

Presenter: YANG, Di-Lun (Institute of Physics, Academia Sinica)

Session Classification: Poster Session

Track Classification: Chirality

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

A solvable quantum field theory with asymptotic freedom in 3+1 dimensions

Tuesday, September 5, 2023 12:20 PM (20 minutes)

Wouldn't it be nice to solve large N QCD analytically? While QCD is hard, it is fairly easy to solve scalar field theories with many components, such as the O(N) model in the large N limit. Traditional wisdom has it that such theories are ill defined because they have the wrong beta function, possess a Landau pole, and are quantum trivial for N=1. In this talk, I throw out conventional wisdom, and critically re-examine scalar field theories in 4d, borrowing heavily from PT-symmetric field theory results. It's a solvable wonderland with asymptotic freedom, bound states in the infrared and a phase transition in between.

Category

Theory

Collaboration (if applicable)

Primary author: ROMATSCHKE, Paul

Presenter: ROMATSCHKE, Paul

Session Classification: New Theory

Track Classification: New theoretical developments

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

New Insights to the Weak Interaction and Quark Model

Tuesday, September 5, 2023 5:30 PM (2h 10m)

A quark is a subatomic particle, composed of the mass, electric charge, and color charge, the three fundamental elements found in the nature. Among these three fundamental elements, there are four fundamental interactions, which are the gravitational force between masses, the electromagnetic force between electric charges, the strong force between color charges, and the weak force between electric and color charges. Inside a quark, the weak force or interaction between electric and color charges influences and excites the quark, which relaxes and transits from one state to another by emitting a quark-antiquark pair, in analogy to the emission of a photon by an excited electron in an atom. A quark and an antiquark with either the same or different flavors and states combine to form a meson when they couple together via mainly the strong interaction, a charged lepton when they annihilate their color charges and combine their electric charges and masses, a neutrino when they annihilate both their color and electric charges and combine their masses, and a photon or gamma ray when they entirely annihilate all their mass, electric, and color charges. The decay of a particle (e.g. the beta decay of a neutron) with formation of leptons involves one or more quark-antiquark pair emissions and annihilations. This multi-pair quark and antiquark emission and annihilation process establishes a fine structure of the Feynman diagram for the quark decay with lepton formation and indicates the formed leptons as products rather than participants of the weak interaction. This study attempts to fully explain and describe how various possible particles (far more than the discovered so far) are formed, generated, decayed, and interacted via quark excitations, degenerations, pair productions and annihilations. We aim at advancing and developing the standard model of particle physics and quantum chromodynamics in terms of innovatively theorizing the weak interaction as an interaction between electric and color charges and creatively modelling quarks with two flavors and multiple excitations. This quantum science study is partially supported by the IBM-HBCU Quantum Center.

Category

Theory

Collaboration (if applicable)

Primary author: ZHANG, Dr. Tianxi

Presenter: ZHANG, Dr. Tianxi

Session Classification: Poster Session

Track Classification: New theoretical developments

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

Alignment from spin-1 hydrodynamics

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The spin alignment of vector mesons emitted in heavy-ion collisions has recently been measured by the ALICE and STAR collaborations over a wide range of energies [1, 2]. The alignment is part of the so-called tensor polarization, which is a property that is exclusive to particles of spin 1 and higher. Even though there have been substantial theoretical efforts, a definite explanation for the tensions between theory and experiments does not yet exist.

In this work [3], we derive an expression for the tensor polarization of a system of massive spin-1 particles in a hydrodynamic framework. Starting from quantum kinetic theory based on the Wigner-function formalism, we employ a modified method of moments which also takes into account all spin degrees of freedom. We find that the tensor polarization is independent of the nonlocal part of the collision term and sourced by the usual dissipative quantities of the fluid, i.e., the bulk-viscous pressure, the particle-diffusion current, and the shear-stress tensor. As an example, we compute the relevant transport coefficient in the case of an uncharged fluid, where, neglecting bulk effects, the tensor polarization is determined solely by the shear-stress tensor. In order to quantify this polarization effect, we provide a formula which can be used for numerical calculations of vector-meson spin alignment in relativistic heavy-ion collisions.

[1] S. Acharya et al. (ALICE), Phys. Rev. Lett. 125, 012301 (2020), 1910.14408.
[2] M. Abdallah et al. (STAR), Nature 614, 7947 (2023), 2204.02302.
[3] D. Wagner, N. Weickgenannt, E. Speranza, Phys. Rev. Res. 5, 013187 (2023), 2207.01111.

Category

Theory

Collaboration (if applicable)

Primary authors: WAGNER, David (Goethe University Frankfurt); SPERANZA, Enrico (University of Illinois at Urbana-Champaign); WEICKGENANNT, Nora

Presenter: WAGNER, David (Goethe University Frankfurt)

Session Classification: Poster Session

Track Classification: Collective Dynamics

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

Testing new proxies of B,Q and S cumulants in Au-Au collisions at BES energies with EPOS 4

Tuesday, September 5, 2023 5:30 PM (2h 10m)

In the exploration of the nuclear matter phase diagram, the susceptibilities of conserved charges are useful theoretical tools to probe the existence of a 1st order phase transition, and a possible critical endpoint. They can be related to the cumulants of the considered net-charges, for which STAR collaboration recently published experimental measurements of proxies, in Au-Au collisions at several energies of the Beam Energy Scan. Hence, the measured (co)variances of $\pi^{\pm}$, $p/\overline{p}$ and $K^{\pm}$ are used to build proxy ratios for the corresponding 2nd order cumulant ratios of electric charge Q, baryonic number B and strangeness S.

It is nevertheless important to disentangle the different effects contributing to these net-multiplicity cumulants of hadronic species, in addition to the fluctuations which they are supposed to probe. For this reason, we studied the impact of hadronic cascades on these observables, thanks to complete simulations of Au-Au collisions performed with EPOS 4. The results are compared with cumulant ratios of exact conserved charges, and proposed enhanced proxy ratios based on a study of the hadronic breakdown contributions to the total susceptibilities with lQCD and HRG model calculations.

We show that the use of Λ baryons variance, additionally to σ^2_π, σ^2_p and σ^2_K used by STAR, allow to build proxies that reconstruct quantitatively better the ratios of B, Q and S correlations. Moreover, even if hadronic cascades modify the signal amplitude for all (co)variances, they have little impact on most of their ratios.

Category

Theory

Collaboration (if applicable)

Primary author: Dr JAHAN, Johannès (University of Houston - Department of Physics)

Co-authors: RATTI, Claudia; WERNER, Klaus

Presenter: Dr JAHAN, Johannès (University of Houston - Department of Physics)

Session Classification: Poster Session

Track Classification: Critical point searches

Contribution ID: **92** Type: **Oral**

Reaching percolation and conformal limits in neutron stars

Wednesday, September 6, 2023 11:40 AM (20 minutes)

In this talk, I discuss the statistically determined equation of state of dense matter that fulfills the multimessenger constraints and determine the properties of dense matter found in neutron stars. I demonstrate that the speed of sound and trace anomaly are driven towards their conformal values at the center of maximally massive NSs. I argue that the local peak of the speed of sound is located at values of energy and particle densities consistent with deconfinement and percolation conditions in QCD matter. I also analyze fluctuations of the net-baryon number density in the context of possible remnants of critical behavior.

talk based is on:
M. Marczenko, L. McLerran, K. Redlich, C. Sasaki, Phys.Rev.C 107 (2023) 2, 025802

Category

Theory

Collaboration (if applicable)

Primary authors: MARCZENKO, Michał (University of Wrocław); MCLERRAN, Larry; REDLICH, Krzysztof (University of Wroclaw); SASAKI, Chihiro

Presenter: SASAKI, Chihiro

Session Classification: Astrophysics

Track Classification: Nuclear astrophysics

Contribution ID: **93** Type: **Oral**

Bulk Physics - Critical point searches

Sunday, September 3, 2023 11:30 AM (30 minutes)

Collaboration (if applicable)

Category

Presenter: RUAN, Lijuan

Session Classification: Student Lectures

Contribution ID: **94** Type: **Oral**

Bulk Physics - Finite Density QCD

Sunday, September 3, 2023 12:00 PM (30 minutes)

Collaboration (if applicable)

Category

Presenter: SCHAEFER, Thomas

Session Classification: Student Lectures

Contribution ID: **95** Type: **Oral**

Multi-scale Imaging of Nuclear and Proton Geometries

Wednesday, September 6, 2023 3:40 PM (20 minutes)

Determining the structure of protons and nuclei at high energy is one of central goals of the heavy-ion collisions and the future Electron-Ion Collider (EIC). We first use Bayesian inference within the color glass condensate framework to extract the proton shape fluctuations from HERA exclusive vector meson production data at $x = 10^{-3}$. With this input, we employ the JIMWLK evolution for the proton and nucleus geometry from HERA to LHC energies. We then do the hydrodynamic simulations to quantify the various hydrodynamic observables obtained using this setup with evolved geometry parameters with full JIMWLK evolution. We find the multiplicity distributions and $v_n - p_T$ correlations are sensitive to the JIMWLK evolution. These help us to understand the energy evolution of nuclear geometry in the future.
For electron+nucleus collisions, we find out that the nuclear geometric deformations and fluctuations affect diffractive vector meson productions, and that multi-pole deformations at different length scales manifest themselves at different regions of transverse momentum transfer. Further more, the JIMWLK evolution doesn't wash out this effects. We systematically study the deformations effects of Uranium (U), Gold (Au), Oxygen-16 (^{16}O), and Neon (^{20}Ne) on the diffractive J/Ψ productions. Our work demonstrate that the future EIC diffractive data can provide direct information on the nuclear structure at small x and the complementary constraints for the nuclear geometric shape for the traditional hydrodynamic simulations in heavy-ion collisions.

Category

Theory

Collaboration (if applicable)

Primary author: ZHAO, Wenbin (Wayne State University)

Co-authors: SCHENKE, Bjoern (Brookhaven National Lab); SHEN, Chun (Wayne State University); Dr MÄNTYSAARI, Heikki (University of Jyvaskyla (FI))

Presenter: ZHAO, Wenbin (Wayne State University)

Session Classification: Initial State

Track Classification: Initial state

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

Exploring the strangeness enhancement and collective-like effects in small collision systems with ALICE at LHC

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Recent measurements in proton-proton (pp) and proton-lead (p–Pb) collisions have shown features that are reminiscent of those observed in lead-lead (Pb–Pb) collisions, such as near-side long-range correlations, mass-dependent hardening of p_{T} spectra, strangeness enhancement etc. Therefore, one of the key challenges today is understanding the origin of strangeness enhancement in small collision systems at very high energies, i.e. the increase of (multi-)strange hadron yields relative to non-strange hadron yields with increasing charged-particle multiplicity ($\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta_{\,|\eta|<0.5} < 100$) and saturation for high multiplicities.

We report the new preliminary mid-rapidity measurement of the transverse momentum spectra and yields of $\mathrm{K}^0_{\mathrm{S}}$, Λ and $\bar{\Lambda}$ in the p–Pb collision system at $\sqrt{s_{\mathrm{NN}}}$ = 8.16 TeV. The ratio of baryon to meson yields and the nuclear modification factor will also be included. These observables are used to study the hadronization process in small collision systems. Results have been obtained in several multiplicity bins, so that a comparison to lower energy p–Pb results and to similar measurements in pp and Pb–Pb collisions can be performed. Finally, the comparison to phenomenological models including the latest version EPOS4 and Pythia8 will be discussed.

Category

Experiment

Collaboration (if applicable)

ALICE Collaboration

Primary author: Ms SHARMA, Meenakshi (University of Jammu (IN))

Co-author: BHASIN, Anju (University of Jammu (IN))

Presenter: BHASIN, Anju (University of Jammu (IN))

Session Classification: Poster Session

Track Classification: Light and strange flavor

Contribution ID: **98** Type: **Oral**

Bayesian calibration of viscous anisotropic hydrodynamic simulations of heavy-ion collisions*

Wednesday, September 6, 2023 8:50 AM (20 minutes)

Due to large pressure gradients at early times, standard hydrodynamic model simulations of relativistic heavy-ion collisions do not become reliable until $O(1)$ fm/c after the collision. To address this one often introduces a pre-hydrodynamic stage that models the early evolution microscopically, typically as a conformal, weakly interacting gas. In such an approach the transition from the pre-hydrodynamic to the hydrodynamic stage is discontinuous, introducing considerable theoretical model ambiguity. Alternatively, fluids with large anisotropic pressure gradients can be handled macroscopically using the recently developed Viscous Anisotropic Hydrodynamics (VAH). In high-energy heavy-ion collisions VAH is applicable already at very early times, and at later times transitions smoothly into conventional second-order viscous hydrodynamics (VH). We present a Bayesian calibration of a multi-stage dynamical evolution model built around a VAH fluid dynamic core with experimental data for p_T-integrated observables from Pb-Pb collisions at the LHC at $\sqrt{s_{\rm NN}} = 2.76$ TeV. We find that the VAH model has the unique capability of constraining the specific viscosities of the QGP at higher temperatures than other previously used models [1]. We also find that the model has fewer tensions with the p_T-integrated input data than the previously calibrated JETSCAPE SIMS model [2]. Finally, we use the calibrated VAH and JETSCAPE SIMS models, with the four different particlization models studied in [2], to predict a number of p_T-*differential* observables, including p_T-spectra and anisotropic flow coefficients $v_{2,3,4}\{2\}(p_T)$ for several identified hadron hadron species. We find [3] that the p_T-dependence of the anisotropic flow coefficients is *very sensitive* to the choice of particlization model, and that the VAH predictions agree with available data much better than all available calibrated variants of the JETSCAPE SIMS model. We therefore propose the VAH approach as a superior framework for describing the dynamical evolution of heavy-ion collisions at LHC energies.
*Supported by the NSF CSSI program under grant OAC-2004601 (BAND Collaboration) and by the DOE Office of Science, Office for
Nuclear Physics under Award No. DE-SC0004286.
[1] D. Liyanage et al., arXiv:2302.14184 [nucl-th]
[2] D. Everett et al., PRL 126, 242301 (2021); and PRC 103, 054904 (2021).
[3] C. Gantenberg, research honors thesis, The Ohio State University, April 2023

Category

Theory

Collaboration (if applicable)

Primary author: HEINZ, Ulrich

Co-authors: GANTENBERG, Cullen (The Ohio State University); Dr LIYANAGE, Dananjaya (The Ohio State University)

Presenter: HEINZ, Ulrich

Session Classification: Collective Dynamics

Track Classification: Collective Dynamics

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

Partonic Critical Opalescence and Its Impact on the Jet Quenching Parameter $\hat{q}$}

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Jet quenching parameter $\hat{q}$ is essential for characterizing the interaction strength between jet partons and nuclear matter. Based on the quark-meson (QM) model, we develop a new framework for calculating $\hat{q}$ at finite chemical potentials, in which $\hat{q}$ is related to the spectral function of the chiral order parameter. A perturbative calculation up to the one-loop order indicates that the momentum broadening of jets is enhanced at both the high temperature and high chemical potential, and approximately proportional to the parton number density in the partonic phase. We further investigate the behavior of $\hat{q}$ in the vicinity of the critical endpoint (CEP) by coupling our calculation with a recently developed equation of state that includes a CEP in the universality class of the Ising model, from which we discover the partonic critical opalescence (PCO) – a prominent enhancement of the momentum broadening of jets near CEP, contributed by the scatterings via the σ exchange process. Hence, for the first time, jet quenching is connected with the search of CEP.

Category

Theory

Collaboration (if applicable)

Primary author: WU, Jing (lanzhou university)

Co-authors: LI, Feng (Lanzhou University); CAO, Shanshan (Shandong University)

Presenter: WU, Jing (lanzhou university)

Session Classification: Poster Session

Track Classification: Critical point searches

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

Transport coefficients of heavy quarkonia comparing with heavy quark coefficients

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We discuss the transport coefficients of heavy quarkonia moving in high temperature QCD plasmas. The thermal width and mass shift for quarkonia are closely related to the momentum diffusion coefficient and its dispersive counterpart for heavy quarks, respectively. For quarkonium at rest in plasmas, the longitudinal gluon part of the color-singlet self-energy diagram is sufficient to determine the leading-log thermal width, whereas the momentum dependence is obtained from the transverse gluon channel. Using the quarkonium-gluon effective vertex derived from the Bethe-Salpeter amplitude with the dipole interaction, we discuss the damping rate and mass shifts of slowly moving quarkonia and compare with the corresponding coefficients of heavy quarks. [Phys.Lett.B 833 (2022) 137351]

Category

Theory

Collaboration (if applicable)

Primary author: HONG, Juhee (Yonsei University)

Co-author: LEE, Su Houng

Presenter: HONG, Juhee (Yonsei University)

Session Classification: Poster Session

Track Classification: Heavy Flavor

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

Dense matter in a constituent quark model

Tuesday, September 5, 2023 5:30 PM (2h 10m)

In this work, we investigate the color-spin interaction of a quark, a diquark and a baryon with their surrounding baryons and/or quark matter. This is accomplished by classifying all possible flavor and spin states of the resulting multiquark configuration in both the flavor SU(2) and SU(3) symmetric cases. We also discuss the three-body confinement potential and show that this does not contribute to the outcome. Furthermore, we find that a quark becomes more stable than a baryon when the number of surrounding baryons is three or more. Finally, when we consider the internal color-spin factor of a probe, our results show that the effects of the color-spin interaction of a multiquark configuration is consistent with the so-called diquarkyonic configuration.

Category

Theory

Collaboration (if applicable)

Primary authors: PARK, Aaron; Prof. LEE, Su Houng (Yonsei University)

Presenter: PARK, Aaron

Session Classification: Poster Session

Track Classification: Nuclear astrophysics

Contribution ID: **104** Type: **Poster**

Investigating collective effects in small collision systems using PYTHIA8 and EPOS4 simulations

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Studies have yielded strong evidence that a deconfined state of quarks and gluons, the quark–gluon plasma, is created in heavy-ion collisions. This hot and dense matter exhibits almost zero friction and a strong collective behavior. An unexpected collective behavior has also been observed in small collision systems. In this talk, the origin of collectivity in small collision systems is addressed by confronting PYTHIA8 and EPOS4 models using measurements of azimuthal correlations for inclusive and identified particles. In particular, anisotropic flow coefficients measured using two- and four-particle correlations with various pseudorapidity gaps, per-trigger yields, and balance functions are reported in pp collisions at $\sqrt{s} = 13.6$ TeV and p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. The results are compared with the available experimental data.

Category

Theory

Collaboration (if applicable)

Primary author: DANU, Andrea (Institute of Space Science (RO))

Co-authors: DOBRIN, Alexandru Florin (Institute of Space Science (RO)); MANEA, Alexandru (Institute of Space Science (RO))

Presenter: DANU, Andrea (Institute of Space Science (RO))

Session Classification: Poster Session

Track Classification: Small systems

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

Flowing to the future: Simulating the tiniest fluids in 3+1 dimensions

Tuesday, September 5, 2023 4:30 PM (20 minutes)

Employing a dynamical initial state model coupled to (3+1)D viscous relativistic hydrodynamics, we explore the rapidity dependence of anisotropic flow in the Relativistic Heavy-Ion Collider (RHIC) small system scan at 200 GeV center of mass energy. We demonstrate that approximately 50% of the pT-differential triangular flow difference between the measurements by the STAR and PHENIX Collaborations can be explained by the use of reference flow vectors from different rapidity regions. This emphasizes the importance of longitudinal flow decorrelation for anisotropic flow measurements in asymmetric nuclear collisions, and the need for (3+1)D simulations. We further present results for the beam energy scan of d+Au collisions and compare to PHENIX data. The same framework is used to describe p+Pb collisions and photo-nuclear events in ultra-peripheral Pb+Pb collisions at the Large Hadron Collider (LHC). We compare to experimental data on momentum anisotropies from the ATLAS Collaboration and find good agreement with the measured elliptic flow. Again, the importance of longitudinal flow decorrelations is highlighted, as they dominate the elliptic flow hierarchy between p+Pb and γ+Pb collisions. Our results imply that QCD fluids can be created at the future Electron Ion Collider, where they could be studied in great detail.

References:

3D structure of anisotropic flow in small collision systems at energies available at the BNL Relativistic Heavy Ion Collider
Wenbin Zhao, Sangwook Ryu, Chun Shen, Björn Schenke
e-Print: 2211.16376 [nucl-th] DOI: 10.1103/PhysRevC.107.014904
Published in: Phys.Rev.C 107 (2023) 1, 014904

Collectivity in Ultraperipheral Pb+Pb Collisions at the Large Hadron Collider
Wenbin Zhao, Chun Shen, Björn Schenke
e-Print: 2203.06094 [nucl-th] DOI: 10.1103/PhysRevLett.129.252302
Published in: Phys.Rev.Lett. 129 (2022) 25, 252302

Category

Theory

Collaboration (if applicable)

Primary authors: SCHENKE, Bjoern (Brookhaven National Lab); SHEN, Chun (Wayne State University); ZHAO, Wenbin (Wayne State University and BNL)

Co-author: Dr RYU, Sangwook (Wayne State University)

Presenter: SCHENKE, Bjoern (Brookhaven National Lab)

Session Classification: Small Systems

Track Classification: Small systems

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

Exploration of hadronization through heavy flavor production at the future Electron-Ion Collider

Wednesday, September 6, 2023 12:20 PM (20 minutes)

The proposed Electron-Ion Collider (EIC) will utilize high-luminosity high-energy electron+proton ($e+p$) and electron+nucleus ($e+A$) collisions to solve several fundamental questions including searching for gluon saturation and studying the proton/nuclear structure. Due to their high masses ($M_{c,b} > \Lambda_{QCD}$), heavy quarks do not transfer into other quarks or gluons once they are produced. This feature makes the heavy flavor product an ideal probe to explore how a heavy flavor hadron is formed from a heavy flavor quark, which is referred to as the heavy quark hadronization. A series of heavy flavor hadron and jet simulation studies have been carried out with the newly developed EIC project detector conceptual designs. We will present reconstructed heavy flavor hadron mass and heavy flavor jet transverse momentum spectrums, the projected nuclear modifications of heavy flavor hadrons inside jets, and heavy flavor jet substructure distributions in $e+p$ and $e+A$ collisions with the EIC project detector design and the projected integrated luminosities at the EIC. These proposed EIC heavy flavor measurements will provide a unique path to explore the flavor dependent fragmentation functions and reveal the heavy quark nuclear transport properties in cold nuclear medium. The expected results will provide great discriminating power in separating different theoretical calculations and help constraining initial and final state effects for heavy ion measurements at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC).

Category

Experiment

Collaboration (if applicable)

Primary author: LI, Xuan (Los Alamos National Laboratory)

Presenter: LI, Xuan (Los Alamos National Laboratory)

Session Classification: Spin/EIC Physics

Track Classification: Spin/EIC physics

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

Empirical Characteristics of Light and Heavy Flavor Parton Energy Loss Dynamics at the LHC and RHIC

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Nuclear modification factors (R_{AA}) of leading particles provide valuable information about the flavor dependent magnitude and characteristics of parton energy loss in $A + A$ collisions. Experimental measurements of R_{AA} exhibit a distinct different dependence on transverse momentum (p_T) at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC). Previous analyses of RHIC data treated the difference in the p_T spectrum between $p + p$ and $A + A$ collisions as a leading parton p_T loss and empirically concluded that the flat p_T dependence of R_{AA} corresponds to a constant fractional p_T loss ($\Delta p_T/p_T$) [1]. This feature of Δp_T proportional to p_T can be understood via elastic collisions in classical dynamics. We analyze LHC measurements of the strong p_T dependence of R_{AA} for light and heavy flavor leading particles. Our analyses indicate that LHC data for a variety of leading particle species are consistent with Δp_T proportional to $\sqrt{p_T}$, in contrast to proportional to p_T at RHIC. In addition, Charm hadrons exhibit differing behavior compared to the other species studied, revealing possible unique heavy flavor dynamics. These distinct features are consistent with the scenario of increased contributions from radiative energy loss at LHC energies compared with stronger collisional energy loss dominance at RHIC energies. Moreover, linear trends between fractional energy loss and initial parton density at varying p_T magnitudes indicate that the amount of parton energy loss does not depend strongly on the traversing geometrical path length of the parton during collision evolutions, which is in agreement with previous empirical findings at RHIC despite significant different initial parton densities formed at LHC and RHIC. We will also discuss further implications of the observed proportionality in LHC data and differences in fractional energy loss at varying p_T scales.
[1] Wang, G. and Huang, H. Phys. Lett. B 672, 30 (2009).

Category

Experiment

Collaboration (if applicable)

Primary author: MARSHALL, THOMAS

Presenter: MARSHALL, THOMAS

Session Classification: Poster Session

Track Classification: Heavy Flavor

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

Heavy flavor phenomenology in Pb+Pb collision with IP-Glasma initial state and Bayesian calibrated hydrodynamics

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Heavy quarks serve as effective probes of relativistic heavy-ion collisions as they are created in the initial stages of the collision event and exist at all stages. We study the dynamics of heavy flavors using a hybrid framework that incorporates the MARTINI event generator, pythia8.1 for the initial production of heavy quarks, and Langevin dynamics to describe the evolution of heavy quarks in a 3+1-D expanding QGP medium. We include the interactions of heavy quarks with the medium constituents through the heavy quark transport coefficients. The space-time expansion of the QGP medium is described using the hydrodynamical approach MUSIC with IP-Glasma initial state and Bayesian-quantified viscous coefficients of the strongly-interacting matter. The properties of the QGP medium are probed by analyzing the heavy meson nuclear modification factor and flow coefficient for Pb+Pb collision. In this work utilizing for the first time IP-Glasma fluctuating initial states and hydrodynamics tuned to a global Bayesian analysis, we show that the observables associated with D-mesons are strongly influenced by the IP-Glasma initial state and bulk evolution. Additionally, we provide new insights into the interaction strength of charm quarks in the expanding medium, including elastic collisional processes with medium constituents, gluon emission processes, and non-perturbative interactions.

Category

Theory

Collaboration (if applicable)

Primary authors: Dr KURIAN, Manu (McGill University); Dr SINGH, Mayank (University of Minnesota); Prof. JEON, Sangyong (McGill University); Prof. GALE, Charles (McGill University)

Presenter: Dr KURIAN, Manu (McGill University)

Session Classification: Poster Session

Track Classification: Heavy Flavor

Contribution ID: **111** Type: **Poster**

Non-interdependent Collective Motions in Heavy-ion Collisions

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The widely used Fourier expansion for studying collective motions in heavy-ion collisions implies that different modes of collectivity could be non-interdependent, driven by factorized actions in the created nuclear medium. Following this line of thought, we assume each non-dependent collective motion modulates the probability of particle emission with a single-harmonic Fourier expansion, and then express the final-state particle azimuthal distribution as the product of these expansions, $\frac{2\pi}{N^{\pm}}\frac{dN^{\pm}}{d\varphi} = \prod_{n=1}^{\infty}(1+2\tilde{a}_n^{\pm}\sin n\Delta\varphi)\prod_{n=1}^{\infty}(1+2\tilde{v}_n^{\pm}\cos n\Delta\varphi)$, instead of a long linear Fourier series. Here, $\Delta\varphi$ is the particle azimuthal angle with respect to the reaction plane. This scheme may better capture the genuine strength of each collectivity mode ($\tilde{a_n}$ and $\tilde{v_n}$), and results in non-leading cross terms between collectivity modes, with significant impacts on experimental observables. We explore the possibility that the chiral magnetic effect (CME) [1] and elliptic flow can evolve separately, thereby their convolution affecting not only the observable that is sensitive to the CME, but also that to the shear-induced CME [2]. We employ the event-by-event anomalous-viscous fluid dynamics model to showcase the implications of this scenario on searches for the CME. In addition, we also propose practical experimental tests using conventional flow harmonics and exploit a multiphase transport model to demonstrate the emergence of non-leading cross terms, such as the rapidity-odd component of triangular flow. The universality of the assumption regarding factorized actions can be investigated by analyzing real data collected from RHIC and the LHC, which will enhance our understanding of the collective motions.

[1] D. E. Kharzeev, L. D. McLerran and H. J. Warringa, Nucl. Phys. A 803, 227 (2008).

[2] M. Buzzegoli, D. E. Kharzeev, Y.-C. Liu, S. Shi, S. A. Voloshin, H.-U. Yee, Phys. Rev. C 10, L051902 (2022).

Category

Theory

Collaboration (if applicable)

Primary authors: Dr TANG, Aihong (BNL); WANG, Gang (UCLA); Prof. HUANG, Huan (UCLA); Mrs XU, Zhiwan (UCLA)

Presenter: WANG, Gang (UCLA)

Session Classification: Poster Session

Track Classification: Chirality

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

Energy loss and chiral magnetic effect

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Chiral media, such as quark-gluon plasma, possess a number of unique properties originating from the quantum phenomenon of the chiral anomaly. These properties can be measured by observing the propagation of fast charged particles moving through the medium and the radiation produced in the process. We show how the chiral anomaly confers distinctive features onto the particle energy loss and its radiation spectrum. We argue then that this makes quantum tomography a powerful and versatile tool to investigate the properties of chiral systems ranging from the Weyl semimetals to the quark-gluon plasma to the axion stars.

Based on Hansen and Tuchin, Phys. Rev. C 104, no.3, 034903 (2021) and Phys. Rev. D 105, no.11, 116008 (2022).

Category

Theory

Collaboration (if applicable)

Primary authors: HANSEN, Jeremy (Iowa State University); TUCHIN, Kirill (Iowa State University / RBRC)

Presenter: HANSEN, Jeremy (Iowa State University)

Session Classification: Poster Session

Track Classification: Chirality

Contribution ID: **114** Type: **Oral**

Sphaleron damping and effects on normal and anomalous charge transport in high-temperature QCD plasmas

Wednesday, September 6, 2023 2:40 PM (20 minutes)

We modify the hydrodynamic equations of a relativistic chiral plasma to account for dissipative effects due to QCD sphaleron transitions. By analyzing the linearized hydrodynamic equations, we show that sphaleron transitions lead to nontrivial effects on vector and axial charge transport phenomena in the presence of a magnetic field. Notably, dissipative effects of sphaleron transitions lead to the emergence of a wavenumber threshold that characterizes the onset of Chiral Magnetic Waves. Sphaleron damping also significantly impacts the time evolution of both vector and axial charge perturbations in the presence of a magnetic field. We further investigate the dependence of charge separation on the rate of sphaleron transitions, which may have implications for the experimental search for the Chiral Magnetic Effect in heavy ion collisions.

Category

Theory

Collaboration (if applicable)

Primary author: DE BRUIN, Lillian

Co-author: Prof. SCHLICHTING, Soeren (Universität Bielefeld)

Presenter: DE BRUIN, Lillian

Session Classification: Chirality

Track Classification: Chirality

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

Exploring neutron stars with three conserved charges in a newly optimized C++ Chiral Mean Field code

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The Chiral Mean Field model (CMF) has been successful in describing the equation of state at large baryon densities, such as those found in neutron stars, neutron star mergers, and heavy-ion collisions. The MUSES collaboration has rewritten the zero-temperature CMF model from Fortran 77 into a parallelized modern C++20 using OpenMP, which has resulted in at least an order of magnitude improvement in runtime. We obtained equations of state across μ_B, μ_S, and μ_Q, and within the metastable regime around the quark deconfinement phase transition. The improved numerical resolution allows for the accurate computation of higher-order derivatives such as susceptibilities. Finally, we computed neutron star observables like quadrupole moment, Love number, moment of inertia, and mass-radius curve.

Category

Theory

Collaboration (if applicable)

MUSES collaboration

Primary author: Mr CRUZ CAMACHO, Nikolás (University of Illinois at Urbana-Champaign)

Co-authors: Prof. NORONHA-HOSTLER, Jacquelyn (University of Illinois Urbana Champaign); KUMAR, Rajesh; Mr HAAS, Roland (University of Illinois); Prof. DEXHEIMER, Veronica

Presenter: Mr CRUZ CAMACHO, Nikolás (University of Illinois at Urbana-Champaign)

Session Classification: Poster Session

Track Classification: Nuclear astrophysics

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

Study of Baryon Number Transport via Ω-hadron Correlations

Tuesday, September 5, 2023 5:30 PM (2h 10m)

In nuclear collisions at low RHIC energies, although s and $\bar{s}$ quarks are produced in pairs, there is a significant excess of Ω^- over $\bar{\Omega}^+$ which suggests that Ω^- carries a net baryon number. Such an excess of net baryon number at mid-rapidity in Au+Au collisions manifests effective mechanisms of baryon number transport over a large rapidity gap. Gluon junction has been proposed as a possible structure allowing for baryon number transport over large rapidity gaps. We also argue that the net Ω^- production on the proton-going side of p+Au collisions may provide a sensitive probe of the gluon junction mechanism. We will present AMPT model simulations of Ω-K, Ω-Ξ, and Ω-Λ correlations in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6 GeV and 7.7 GeV as well as p+Au collisions at 62 GeV. These correlations reflect the effects of strangeness conservation and baryon number transport in nuclear collisions. In particular, the Ω-hadron correlations in AMPT show distinct dependence on baryon densities indicating quantitative sensitivity to details of the baryon number transport dynamics. Results from the default and string-melting versions of the AMPT calculations are used to examine the imprints on such correlations left by the hadronization schemes of string fragmentation and quark coalescence, respectively. AMPT calculations predict very significant differences in the correlations at 7.7 GeV between these hadronization schemes, which can be used experimentally to investigate the extent of roles played by partonic degrees of freedom in Au+Au collisions at this energy. Implications on the experimental program to measure these correlations with the STAR experiment at RHIC will also be discussed.

Category

Experiment

Collaboration (if applicable)

Primary authors: WU, XIATONG (Department of Physics and Astronomy, University of California, Los Angeles, CA 90095, USA); DONG, Weijie (Key Laboratory of Nuclear Physics and Ion-beam Application, Fudan University, Shanghai, China); PING, Siyuan (Key Laboratory of Nuclear Physics and Ion-beam Application, Fudan University, Shanghai, China); YU, Xiaozhou (Key Laboratory of Nuclear Physics and Ion-beam Application, Fudan University, Shanghai, China); Dr WANG, Gang (Department of Physics and Astronomy, University of California, Los Angeles, CA 90095, USA); Prof. HUANG, Huan Zhong (Department of Physics and Astronomy, University of California, Los Angeles, CA 90095, USA; Key Laboratory of Nuclear Physics and Ion-beam Application, Fudan University, Shanghai, China)

Presenter: WU, XIATONG (Department of Physics and Astronomy, University of California, Los Angeles, CA 90095, USA)

Session Classification: Poster Session

Track Classification: Light and strange flavor

Contribution ID: **118** Type: **Oral**

A new approach to stochastic relativistic fluid dynamics from information flow

Tuesday, September 5, 2023 2:50 PM (20 minutes)

The study of thermal fluctuations in relativistic hydrodynamics is essential for understanding physics near the expected critical endpoint in the QCD phase diagram. Furthermore, the incorporation of stochastic fluctuations may be important for the modeling of hydrodynamics in small systems such as proton-proton and proton-nucleus collisions. We present a new general formalism for introducing thermal fluctuations in relativistic hydrodynamics which incorporates the recent developments on the causality and stability of relativistic hydrodynamic theories. Our approach is based on the recently introduced information current [1], which measures the net amount of information carried by perturbations around equilibrium in a relativistic many-body system. The resulting noise correlators are guaranteed to be observer-independent for thermodynamically stable models, which differs from previous approaches employed in the literature. We obtain a Martin-Siggia-Rose [2] action principle within our formalism and compare it to previous proposals for hydrodynamic effective actions. Finally, we present a few applications, which include the Israel-Stewart theory in a general hydrodynamic frame [3]. We find the adoption of a general hydrodynamic frame introduces new independent structures to the two-point function of the energy-momentum tensor which are not present in previous calculations done in the Landau or Eckart hydrodynamic frames.

[1] L. Gavassino, M. Antonelli, and B. Haskell, "Thermodynamic stability implies causality,"Physical Review Letters 128 (2022)

[2] P. C. Martin, E. D. Siggia, and H. A. Rose, "Statistical Dynamics of Classical Systems,"Phys. Rev. A 8, 423–437 (1973).

[3] Jorge Noronha, Michal Spali´nski, and Enrico Speranza, "Transient relativistic fluid dynamics in a general hydrodynamic frame,"Physical Review Letters 128 (2022)

Category

Theory

Collaboration (if applicable)

Primary authors: Prof. NORONHA, Jorge (University of Illinois at Urbana-Champaign); HIPPERT TEIXEIRA, Mauricio (University of Illinois at Urbana-Champaign); MULLINS, Nicki

Presenter: MULLINS, Nicki

Session Classification: New Theory

Track Classification: New theoretical developments

Contribution ID: **120** Type: **Poster**

Proton-Endcap Electromagnetic Calorimeter of the ePIC Experiment at Electron-Ion Collider

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The proton-endcap Electromagnetic Calorimeter (pECal) of the ePIC experiment at the future Electron-Ion Collider (EIC) will cover the pseudorapidity range of $1.3 < \eta < 4$ in the hadron-going direction. In semi-inclusive deep inelastic scattering, the pECal is essential for measuring jets and heavy quarks in the hadron-going direction. These physics measurements require the pECal to have a moderate energy resolution, fine granularity, and a compact structure. We will present the current design of the pECal, a sampling calorimeter with a W-powder/ScFiber (W/ScFi) structure initially developed at UCLA. The W/ScFi detector design has unique features, such as a close-to-one e/h ratio suitable for hadron compensation, which is required for jet measurements. The simulated pECal performances match the requirements of the EIC scientific program very well. This design has been adopted by the current EIC detector plan (ePIC) and implemented in the ePIC software frameworks. I will discuss the design, advantages, and performances of the W/ScFi pECal detector based on the results of GEANT4 simulations. I will present the performances of the pECal in terms of separation of high-energy π^0 decay photons, identification of electrons, and measurements of jets and heavy-flavor jets.

Category

Experiment

Collaboration (if applicable)

ePIC pECal detector consortium (BNL, Fudan, Shandong University, Tsinghua, South China Normal University, Indiana University, UCLA, and UCR)

Primary authors: Dr TSAI, Oleg (UCLA); XU, ZHIWAN; Dr JI, ZHONGLING (UCLA); HUANG, huan

Presenter: Dr JI, ZHONGLING (UCLA)

Session Classification: Poster Session

Track Classification: Future facilities/detectors

Contribution ID: **122** Type: **Poster**

Structure in the speed of sound: from neutron stars to heavy-ion collisions

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Neutron star equations of state that can sustain heavy neutron stars over 2 Msun necessitate a large, rapid rise in the speed of sound. The family of equations of states, which assume electric neutrality along beta equilibrium and vanishing temperatures, with large bumps in the speed of sound have been suggested to be incompatible with the equation of state extracted from heavy-ion collisions. If it is true that heavy-ions exclude large bumps in the speed of sound up to values close to the causal limit, then this in turn excludes the possibility of ultra-massive neutron stars (i.e. up to 2.5 Msun).
In our studies, we convert equations of state with a bump in the speed of sound that are compatible with massive neutron stars to nearly symmetric nuclear matter using the nuclear symmetry energy expansion with 4 coefficients. With a range of different coefficients, we are able to obtain upper and lower bounds for converted symmetric nuclear matter with causality and stability constraints. We compare our converted equation of state with heavy-ion collision data by the hadronic transport method SMASH with the mean-field potential.

Category

Theory

Collaboration (if applicable)

Primary author: YAO, Nanxi (University of Illinois, Urbana-Champaign)

Presenter: YAO, Nanxi (University of Illinois, Urbana-Champaign)

Session Classification: Poster Session

Track Classification: Nuclear astrophysics

Contribution ID: **123** Type: **Oral**

Bayesian Inference of QGP Properties and 3D Dynamics in Heavy-Ion Collisions in the RHIC Beam Energy Scan Program

Tuesday, September 5, 2023 3:30 PM (20 minutes)

This talk will present the Bayesian inference approach for quantitatively characterizing the 3D dynamics of heavy-ion collisions and the Quark-Gluon Plasma (QGP) properties in the RHIC Beam Energy Scan (BES) program. To model the dynamics of the collisions from 7.7 to 200 GeV, we employ a (3+1)D dynamical initialization model coupled with the relativistic viscous hydrodynamics + hadronic cascade hybrid framework [1]. To account for shear and bulk viscous effects at RHIC BES energies, we derive the out-of-equilibrium corrections to particle distributions with multiple conserved charge currents using Grad's moment and Chapman-Enskog methods. A fast model emulator is then trained in a 22-dimensional parameter space to accurately predict identified particle yields, average transverse momenta, and charged hadron anisotropic flow coefficients. By carrying out a joint Bayesian analysis of the RHIC BES phase I measurements for Au+Au collisions at 7.7, 19.6, and 200 GeV, we set robust constraints on initial-state baryon stopping and the μ_B and T dependence of the QGP shear and bulk viscosity. Our results show that the Bayesian inference approach with our full (3+1)D hybrid framework effectively extracts the QGP properties and the 3D dynamics of the collision events from the RHIC BES measurements and provides quantitative insights into the QCD matter in a baryon-rich environment.

[1] C. Shen and B. Schenke, "Longitudinal dynamics and particle production in relativistic nuclear collisions," Phys. Rev. C105, no.6, 064905 (2022)

Category

Theory

Collaboration (if applicable)

Primary author: SHEN, Chun (Wayne State University)

Co-authors: SCHENKE, Bjoern (Brookhaven National Lab); ZHAO, Wenbin (Wayne State University)

Presenter: SHEN, Chun (Wayne State University)

Session Classification: QCD at finite T and density

Track Classification: QCD at finite density and temperature

Contribution ID: **124** Type: **Poster**

Measurement of D^0 Meson Tagged Jets in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV at STAR

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The properties of the Quark-Gluon Plasma (QGP) produced in heavy-ion collisions can be studied using jets generated in hard scattering processes at the early stages of the collision. These jets lose energy and have their shower structures modified relative to that in the vacuum due to jet-medium interaction —known as 'jet quenching'.

The transverse momentum (p_T) fraction of the jet carried by hadrons along the jet axis ($z = \vec{p}_{T,hadron} \cdot \hat{p}_{T,jet} / |\vec{p}_{T,jet}|$) is related to the jet fragmentation function, and connects the production of quarks and gluons in the perturbative regime with the hadronized final-state particles in the non-perturbative regime. In the QGP medium, modifications to the fragmentation function compared to that in a vacuum can provide insights into the underlying mechanism of jet quenching. A study of the fragmentation function for charm meson tagged jets can reveal further details about the flavor dependence of the medium-induced parton energy loss.

In this poster, we report measurements of D^0 meson tagged jets in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV, collected by the STAR experiment at RHIC. We show the nuclear modification factors as a function of $p_{T,jet}$ and z for D^0 jets. Additionally, we report the radial profile of the D^0 mesons in these tagged jets. Such flavor tagged measurements can help to discriminate between different models of jet quenching in the medium and study the properties of the QGP.

Category

Experiment

Collaboration (if applicable)

STAR Collaboration

Primary author: Mr ROY, Diptanil (Rutgers University)

Presenter: Mr ROY, Diptanil (Rutgers University)

Session Classification: Poster Session

Track Classification: Heavy Flavor

Contribution ID: **129** Type: **Oral**

Can we observe using the collective flow effects of the early nonequilirium dynamics

Tuesday, September 5, 2023 10:10 AM (20 minutes)

The early dynamics in heavy-ion collisions involves a rapid, far from equilibrium evolution. This early pre-equilibrium stage of the dynamics can be modeled using kinetic equations. The effect of this pre-equilibrium stage on final observables derived from transverse momenta of emitted particles is negligible. Therefore, the kinetic equations in the relaxation time approximation for a non-boost invariant system are solved (P.Bozek Phys.Rev.C 107 (2023) 034916). The asymmetry of the flow with respect to the reaction plane at different rapidities is found to be very sensitive to the degree of non-equilibrium in the evolution. This suggests that the rapidity odd directed flow is a sensitve probe of the occurrence of non-equilibrium effects and could be used to estimate the asymmetry of the pressure between the longitudinal and transverse directions. The study of kinetic evolution in the longitudinal direction allows also a modelling of the early pre-Bjorken flow stage of the equilibration.

Category

Theory

Collaboration (if applicable)

Primary author: BOZEK, Piotr (AGH University of Science and Technology)

Presenter: BOZEK, Piotr (AGH University of Science and Technology)

Session Classification: Collective Dynamics

Track Classification: Collective Dynamics

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

An Augmented QCD Phase Portrait: Mapping Quark-Hadron Deconfinement for Hot, Dense, Rotating Matter under Magnetic Field

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The quark-hadron transition that happens in ultra-relativistic heavy-ion collisions is expected to be influenced by the effects of rotation and magnetic field, both present due to the geometry of a generic non-head-on impact. We augment the conventional T–μ_B planar phase diagram for QCD matter by extending it to a multi-dimensional domain spanned by temperature T, baryon chemical potential μ_B, external magnetic field B and angular velocity ω. Using two independent approaches, one from a rapid rise in entropy density and another dealing with a dip in the speed of sound, we identify deconfinement in the framework of a modified statistical hadronization model. We find that the deconfinement temperature $T_C(\mu_B, \omega, eB)$ decreases nearly monotonically with increasing μ_B, ω and eB with the most prominent drop (by nearly 40 to 50 MeV) in T_C occurring when all the three quasi-control (collision energy and impact parameter dependent) parameters are simultaneously tuned to finite values that are typically achievable in present and upcoming heavy-ion colliders.

Category

Theory

Collaboration (if applicable)

Primary author: MUKHERJEE, Gaurav (Bhabha Atomic Research Centre, Homi Bhabha National Institute)

Co-authors: Dr DUTTA, Dipanwita (Bhabha Atomic Research Centre); Dr MISHRA, Dipak (Bhabha Atomic Research Centre)

Presenter: MUKHERJEE, Gaurav (Bhabha Atomic Research Centre, Homi Bhabha National Institute)

Session Classification: Poster Session

Track Classification: QCD at finite density and temperature

Contribution ID: **133** Type: **Poster**

Dilepton anisotropic flow from hadronic transport

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We present the first results for dielectron anisotropic flow computed directly from hadronic transport in different systems, and explore the different calculation methods. Because leptons are insensitive to the strong interaction, they are mostly undisturbed by the hadronic medium created after a heavy-ion collision, and therefore serve as direct probes for it. In particular, the HADES experiment at GSI measures flow of dielectrons using the reaction plane method, which can lead to large systematic uncertainties. At the low beam energies of GSI, the evolution is mainly off-equilibrium, and hadronic transport provides an appropriate description and gives access to the full phase space, as well as knowledge on the dilepton origin, being a useful tool in studying the mechanisms behind flow generation from this off-equilibrium hadron resonance gas.

Category

Theory

Collaboration (if applicable)

Primary author: HIRAYAMA, Renan (FIAS)

Co-author: ELFNER, Hannah

Presenter: HIRAYAMA, Renan (FIAS)

Session Classification: Poster Session

Track Classification: EM Probes

Contribution ID: **134** Type: **Oral**

Quantum to classical parton evolution in the QGP

Tuesday, September 5, 2023 12:40 PM (20 minutes)

We study the time evolution of the density matrix of a high energy quark in the presence of a dense QCD background that is modeled as a stochastic Gaussian color field. At late times, we find that only the color singlet component of the quark's reduced density matrix survives the in-medium evolution and that the density matrix becomes asymptotically diagonal in both transverse position and momentum spaces. In addition, we observe an accelerated entropy growth due to the larger phase space being explored by the quark and that the quantum and classical quark entropies converge at late times. We further observe that the quark state loses all memory of the initial condition. Combined with the fact that the reduced density matrix satisfies Boltzmann-diffusion transport, we conclude that the quark reduced density matrix can be interpreted as a classical phase space distribution. Finally, we comment on how this approach can offer a generic way to study parton evolution in the QGP and establish a strong connection to initial stage physics.

Category

Theory

Collaboration (if applicable)

Primary authors: BLAIZOT, Jean-Paul (IPhT); BARATA, João; Dr MEHTAR-TANI, Yacine (Brookhaven National Laboratory)

Presenter: BARATA, João

Session Classification: Jets

Track Classification: Jets

Contribution ID: **136** Type: **Oral**

Temperature and Strong Magnetic Field Effects in Dense Matter

Wednesday, September 6, 2023 5:50 PM (20 minutes)

We study consistently the effects of magnetic field on hot and dense matter. In particular, we look for differences that arise due to assumptions that reproduce the conditions produced in particle collisions or astrophysical scenarios, such as in the core of fully evolved neutron stars. We assume the magnetic field to be either constant or follow a profile extracted from general relativity calculations of magnetars and make use of two realistic models that can consistently describe chiral symmetry restoration and deconfinement to quark matter, the CMF and the PNJL models. We find that net isospin, strangeness, and weak chemical equilibrium with leptons can considerably change the effects of temperature and magnetic fields on particle content and deconfinement in dense matter. This could be important for detecting quark matter e.g. in neutron star mergers.

[1] Submitted to Phys. Rev. D, e-Print::2304.02454 [nucl-th]
[2] Phys. Rev. D 102 (2020) 7, 076016, e-Print: 2004.03039 [nucl-th]

Category

Theory

Collaboration (if applicable)

MUSES

Primary author: Prof. DEXHEIMER, Veronica (Kent State Universtity)

Co-authors: Dr PETERSON, Jeffrey (Kent State University); Mr ARYAL, Krishna (Kent State University); Prof. COSTA, Pedro (University of Coimbra)

Presenter: Prof. DEXHEIMER, Veronica (Kent State Universtity)

Session Classification: QCD at finite T and density

Track Classification: QCD at finite density and temperature

Contribution ID: **138** Type: **Poster**

Measurement of non-prompt D-mesons production in pp collisions at √s = 13 TeV using Machine Learning (ML) techniques with ALICE

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The production of hadrons containing charm or beauty quarks in pp collisions provides an important test for quantum chromodynamics calculations. These measurements also serve as reference for more complex systems such as Pb–Pb collisions, helping to characterize the various in-medium partonic energy loss mechanisms and their dependence on the quark mass.
The excellent particle identification, track and decay-vertex reconstruction capabilities of the ALICE experiment, together with machine-learning techniques for multi-class classification, are exploited to separate the non-prompt D mesons from the prompt ones. The precise measurements of non-prompt D-mesons production, in particular, allow us to investigate the production of beauty quarks in pp collisions. In this contribution, the latest results of the ALICE Collaboration on the measurement of non-prompt D mesons with Machine-Learning techniques will be presented. The results will also be compared with various theoretical models.

Category

Experiment

Collaboration (if applicable)

ALICE Collaboration

Primary author: BALA, Renu (University of Jammu (IN))

Presenter: BALA, Renu (University of Jammu (IN))

Session Classification: Poster Session

Track Classification: Heavy Flavor

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

Strange hadron production in d+Au collisions at √sNN = 200 GeV using the STAR detector

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Strangeness production has been suggested as a sensitive probe to the dynamics of the deconfined matter created in heavy-ion collisions. Ratios of particle yields involving strange particles are often utilized to study properties of the nuclear matter at freeze-out, such as the strangeness chemical potential and the chemical freeze-out temperature. The d+Au collisions bridge the multiplicity gap between p+p and Au+Au collisions and can provide insight to the role of event multiplicity in strange hadron production. The study of strange hadrons in d+Au collisions can also help to understand their cold nuclear matter effects, a necessary ingredient for interpreting similar measurements in heavy-ion collisions.

In this poster, we will present new measurements on the production of strange hadrons ($K_S{}^0$, Λ) for different rapidity intervals in d+Au collisions at $\sqrt{s_{\rm NN}} = 200$ GeV, recorded by the STAR experiment in 2016. We will report transverse momentum ($p_{\rm T}$) spectra, $p_{\rm T}$ integrated yield dN/dy, average transverse momentum, yield ratios, nuclear modification factors, and rapidity asymmetry ($Y_{\rm Asym}$) for these strange hadrons. The physics implications of these measurements on the collision dynamics will be discussed.

Category

Experiment

Collaboration (if applicable)

STAR COLLABORATION

Primary author: AGGARWAL, Ishu

Presenter: AGGARWAL, Ishu

Session Classification: Poster Session

Track Classification: Light and strange flavor

Contribution ID: **140** Type: **Poster**

Probing the effect of the nonextensivity on the transport properties of hot QCD medium at finite magnetic field and chemical potential

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We have probed the effect of the nonextensivity on the transport properties related to the charge and heat in hot QCD medium at finite magnetic field and chemical potential. The coefficients associated with the charge and heat transport, such as the electrical conductivity, Hall conductivity, thermal conductivity and Hall-type thermal conductivity are determined using the nonextensive Tsallis framework within the relaxation time approximation of kinetic theory. The Tsallis distribution function encodes the effect of the nonextensivity, where the deviation of parameter q from unity signifies the extent of the nonextensivity. The matter produced in heavy ion collisions may not be exactly in the locally equilibrated state, and for understanding the properties of such matter to a greater degree, the nonextensive Tsallis framework is a relevant approach to follow. Our observation shows that the electrical and thermal conductivities as well as their Hall components increase with the nonextensivity and this implies an increased deviation of both charge and heat transports from their counterparts at $q = 1$. It is observed that the deviations of the abovementioned transport coefficients from their respective equilibrated values get further increased at finite magnetic field, whereas these deviations become decreased at finite chemical potential. Furthermore, the effects of the nonextensivity on the flow characteristics through the Knudsen number, specific heat and elliptic flow have been explored.

Category

Theory

Collaboration (if applicable)

Primary author: RATH, Shubhalaxmi (Indian Institute of Technology Bombay)

Co-author: Prof. DASH, Sadhana (Indian Institute of Technology Bombay)

Presenter: RATH, Shubhalaxmi (Indian Institute of Technology Bombay)

Session Classification: Poster Session

Track Classification: QCD at finite density and temperature

Contribution ID: **142** Type: **Poster**

Prospects for light (anti)nuclei measurements in jets in Run 3 with ALICE

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The production of light (anti)nuclei in high-energy hadronic collisions has been studied in depth with the ALICE experiment at the LHC. Despite this, the production mechanism of light (anti)nuclei is still not well understood and remains a highly-discussed topic in the scientific community. One of the phenomenological models typically used to describe the hadronization process is the coalescence model. In this model, if the nucleons at kinetic freezeout are close in phase space and match their spin state they can bind and form a nucleus. More advanced coalescence model uses the Wigner formalism for the bound state. A prediction of this model is an enhanced coalescence probability of nuclei in jets with respect to the underlying event in small collision systems. To test this prediction, ALICE has published a work where the (anti)deuteron coalescence parameter in and out of jets is measured in pp collisions, and the same study has been performed in p-Pb collisions, observing in both cases such enhancement. In this poster, the prospects for light (anti)nuclei measurements in jets and in underlying event during the Run 3 will be presented, considering the developments along this research line and the expected precision obtained thanks to the integrated luminosity that will be collected.

Category

Experiment

Collaboration (if applicable)

ALICE Collaboration

Primary author: RASA, Marika (University and INFN Catania)

Presenter: RASA, Marika (University and INFN Catania)

Session Classification: Poster Session

Track Classification: Light and strange flavor

Contribution ID: **143** Type: **Poster**

MC-EKRT event generator for initializing 3+1 D hydrodynamics

Tuesday, September 5, 2023 5:30 PM (2h 10m)

We present a Monte-Carlo implementation of the EKRT initial-state model (MC-EKRT) [1]. Our new MC-EKRT event generator is based on collinearly factorized, dynamically fluctuating pQCD minijet production, supplemented with a saturation conjecture that controls the low-p_T particle production. Previously, the EKRT model has been very successful in describing low-p_T observables at mid-rapidity in heavy-ion collisions at RHIC and LHC energies [2,3]. As novel features, our new MC implementation gives a full 3-dimensional initial state event-by-event, and includes dynamical fluctuations in the saturation and particle production. As a proof of principle study, we average a large set of event-by-event MC-EKRT initial conditions and compute the rapidity and centrality dependence of the charged hadron multiplicities and elliptic flow for the LHC Pb+Pb collisions using 3+1 D viscous fluid dynamical evolution. In particular, we show that global energy conservation and spatial dependence of the nuclear PDFs are essential features to reach a good agreement with the measurements.

[1] M. Kuha, J. Auvinen, K. J. Eskola, H. Hirvonen, Y. Kanakubo, H. Niemi, in preparation
[2] H. Niemi, K. J. Eskola and R. Paatelainen, Phys. Rev. C 93, no.2, 024907 (2016)
[3] H. Hirvonen, K. J. Eskola and H. Niemi, Phys. Rev. C 106, no.4, 044913 (2022)

Category

Theory

Collaboration (if applicable)

Primary authors: KUHA, Mikko (University of Jyväskylä); Prof. ESKOLA, Kari J. (University of Jyväskylä); HIRVONEN, Henry (University of Jyväskylä); KANAKUBO, Yuuka (University of Jyväskylä); NIEMI, Harri (University of Jyväskylä); AUVINEN, Jussi (University of Jyväskylä)

Presenter: KUHA, Mikko (University of Jyväskylä)

Session Classification: Poster Session

Track Classification: Initial state

Contribution ID: **144** Type: **Poster**

Probing parton shower and hadronization with novel jet substructure measurements at STAR

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Jets are collimated sprays of final-state particles produced from initial high-momentum-transfer partonic scatterings in particle collisions. Since jets are multi-scale objects that connect asymptotically free partons to confined hadrons, jet substructure measurements in vacuum can provide insight into the parton evolution and the ensuing hadronization processes. With $\sqrt{s} = 200$ GeV pp collision data recorded by the STAR experiment, we reconstruct full jets to measure CollinearDrop−SoftDrop jet correlation and the charge correlation ratio (r_c) with hadrons in jets, which probe the dynamics of the parton shower and hadronization, respectively.

The interplay between different stages of the parton shower can be explored with the correlation between SoftDrop and CollinearDrop groomed jet observables, the latter of which have an enhanced sensitivity to the soft radiation within jets. We present the first measurements of CollinearDrop jet mass and its correlation with SoftDrop groomed jet observables, such as the opening angle $R_{\rm g}$ and the shared momentum fraction $z_{\rm g}$. They are fully corrected for detector effects with a novel machine learning method, MultiFold, which preserves the correlations in the multi-dimensional observable phase space.

Precision measurements sensitive to the hadronization process are crucial for testing phenomenological models and furthering our understanding of non-perturbative QCD. The observable r_c characterizes the fraction of string-like fragmentation by distinguishing the charge signs of leading and subleading charged particles within jets. We present the first measurement of r_c in hadronic collisions and compare it to event generator predictions.

Category

Experiment

Collaboration (if applicable)

STAR

Primary author: SONG, Youqi

Presenter: SONG, Youqi

Session Classification: Poster Session

Track Classification: Jets

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

Azimuthal correlations of heavy-flavor decay electrons and charged particles with the ALICE detector

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Heavy-flavor (charm and beauty) quarks are generated primarily via hard scattering processes in high-energy hadronic collisions, and then undergo parton shower (fragmentation) and hadronization. Two-particle azimuthal correlations of heavy-flavor particles is a differential measurement which allows for the study of the fragmentation of heavy quarks. By measuring the azimuthal correlation in different transverse momentum (p_T) regions, one can study the details of the structure and particle momentum distribution of jets produced by the heavy-quark fragmentation process. The azimuthal correlations between electrons from heavy-flavor decays (trigger) and charged particles (associated) are studied in different trigger and associate particle p_T regions. A distinguishing feature of heavy-ion collisions is the production of a hot and deconfined state of nuclear matter, called Quark Gluon Plasma (QGP). By comparing the heavy-flavor and charged particle azimuthal correlations in Pb-Pb collisions to measurements in smaller collision systems, we can determine how the heavy-quark fragmentation is modified by interactions with the QGP medium. In this poster, ALICE results on the modifications of the azimuthal distribution in Pb-Pb collisions with respect to pp collisions will be presented. The results in pp and p-Pb collision systems will also be shown and compared to predictions from Monte Carlo simulations.

Category

Experiment

Collaboration (if applicable)

ALICE Collaboration

Primary author: FLORES, Amanda Nicole (University of Texas at Austin (US))

Presenter: FLORES, Amanda Nicole (University of Texas at Austin (US))

Session Classification: Poster Session

Track Classification: Heavy Flavor

Contribution ID: **147** Type: **Oral**

Initial-state and final-state effects on hadron production in small collision systems

Wednesday, September 6, 2023 12:20 PM (20 minutes)

Heavy meson production in reactions with nuclei is an active new frontier to understand QCD dynamics and the process of hadronization in nuclear matter. Measurements in various colliding systems at RHIC and LHC, including Pb-Pb, Xe-Xe, O-O, p-Pb, and p-O, enable precision tests of the medium-size, temperature, and mass dependencies of the in-medium parton propagation and shower formation. We employ a coupled DGLAP evolution framework that takes advantage of splitting functions recently obtained in soft-collinear effective theory with Glauber gluons ($\mathrm{SCET_G}$) and hard thermal loop (HTL) motivated collisional energy loss effects. With jet quenching effects constrained to the nuclear modification factor R_{AA} of charged hadrons in Pb-Pb collisions at 5.02~TeV, we present predictions for light and heavy-meson R_{AA} in Xe-Xe, O-O and p-Pb collisions at the LHC. We find that the nuclear modification scales non-trivially with the quark mass and medium properties. In particular, there can be sizeable collision-induced attenuation of heavy mesons in small systems such as oxygen-oxygen and high-multiplicity p-Pb events. Finally, we analyze the impact of different models of initial-state parton dynamics on the search for QGP signatures in small colliding systems.

Category

Theory

Collaboration (if applicable)

Primary authors: Dr VITEV, Ivan; Dr KE, Weiyao (Los Alamos National Laboratory)

Presenter: Dr VITEV, Ivan

Session Classification: Small Systems

Track Classification: Small systems

Contribution ID: **148** Type: **Poster**

Measurement of the ϒ production in heavy-ion collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV with the STAR detector

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Quarkonia play a unique role in probing the properties of the quark-gluon plasma (QGP). The dissociation of quarkonia due to the color screening was proposed as a direct signature of the QGP formation. On top of that, different states of quarkonium are expected to dissociate at different temperatures depending on their binding energies. Therefore, measurement of the expected sequential suppression for the three ϒ states in heavy-ion collisions can be used to study the modification of the QCD force in the medium and the QGP's thermodynamic properties.

This poster presents the ϒ measurements in Au+Au and isobar (Ru+Ru and Zr+Zr) collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV with the STAR experiment at RHIC. The nuclear modification factors are presented as functions of centrality and transverse momentum. In addition, these results are compared to those at the LHC and theoretical calculations. The physics implications are discussed as well.

Category

Experiment

Collaboration (if applicable)

STAR Collaboration

Primary author: YANG, Shuai (South China Normal University)

Presenter: YANG, Shuai (South China Normal University)

Session Classification: Poster Session

Track Classification: Heavy Flavor

Contribution ID: **150** Type: **Poster**

Strange hadron production in pp collisions with Run 3 data

Tuesday, September 5, 2023 5:30 PM (2h 10m)

The ratio between (multi-)strange and non-strange hadron yields increases with the multiplicity of charged particles produced in hadronic collisions, revealing a smooth transition from low multiplicity pp collisions to central Pb-Pb collisions. The microscopic origin of this behaviour, known as strangeness enhancement, has yet to be understood. The data collected by the ALICE experiment during Run 3 provide a unique opportunity to further investigate this phenomenon in high-multiplicity pp collisions, thanks to the unprecedented number of recorded events and to dedicated software filters developed for selecting and storing pp collisions containing strange hadron candidates. This poster presents the first measurement of strange hadron production in pp collisions at $\sqrt{s} = 13.6$ TeV collected by the ALICE experiment in 2022.

Category

Experiment

Collaboration (if applicable)

ALICE

Primary author: DE MARTIN, Chiara (Universita e INFN Trieste (IT))

Presenter: DE MARTIN, Chiara (Universita e INFN Trieste (IT))

Session Classification: Poster Session

Track Classification: Light and strange flavor

Contribution ID: **154** Type: **Poster**

Measurement of heavy-flavor electron production in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV at STAR

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Studying heavy flavor can enhance our comprehension of parton interactions with the Quark-Gluon Plasma (QGP). Due to their significant mass, heavy quarks (charm and bottom) are mainly generated during the initial phase of high-energy heavy-ion collisions when hard scatterings are prevalent, and experience the entire evolution of the QGP. One way to study the production of heavy quarks is through the measurement of Heavy Flavor Electrons (HFE) - electrons emitted from the semi-leptonic decays of heavy-flavor hadrons.

In this contribution, we will present measurements of HFE at low transverse momentum (p_{T}) in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV using data taken in 2017 by the STAR experiment. We will show the yields and central-to-peripheral nuclear modification factors as functions of p_{T} and centrality.

Category

Experiment

Collaboration (if applicable)

STAR Collaboration

Primary author: Mrs PROZOROVA, Veronika (Czech Technical University in Prague)

Presenter: Mrs PROZOROVA, Veronika (Czech Technical University in Prague)

Session Classification: Poster Session

Track Classification: Heavy Flavor

Contribution ID: **155** Type: **Poster**

QCD mesonic screening masses using Gribov quantization

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Chiral symmetry is lost at low temperatures, and pions are massless in the chiral limit; there is no longer any screening mass. The screening mass of mesons approaches the standard value of $2\pi T$ at high temperatures. The screening masses of mesons provide a gauge invariant and definite order parameter of chiral symmetry restoration. Different mesonic correlation lengths for flavor non-singlets, at least up to NLO, are well-defined gauge invariant physical quantities calculated earlier using the perturbative resummation techniques. It was found that these NLO corrections are small and come with a positive sign. The lattice simulation results match the existing perturbative results only in the high-temperature regime. There needs to be more clarity between the lattice results and the theoretical calculations at low temperatures, as the perturbative expansion fails at low temperatures. One of the ways to probe the low-temperature region is by using the non-perturbative Gribov resummation. We have studied the spatial correlation lengths ζ of various mesonic observables using the Gribov action in quenched QCD and for $(2+1)$ flavor QCD. In particular, we have calculated the non-perturbative NLO correction to the meson screening mass using the Gribov propagator. This correction has been calculated by following the analogies with the NRQCD effective theory, a well-known theory for studying heavy quarkonia at zero temperature.

Category

Theory

Collaboration (if applicable)

Primary author: Mr N/A, SUMIT (IIT Roorkee)

Co-authors: PATRA, Binoy Krishna (Indian Institute of Technology Roorkee); HAQUE, Najmul (NISER, India)

Presenter: Mr N/A, SUMIT (IIT Roorkee)

Session Classification: Poster Session

Track Classification: QCD at finite density and temperature

Contribution ID: **157** Type: **Oral**

Establishing the Range of Applicability of Hydrodynamics in High-Energy Collisions

Tuesday, September 5, 2023 11:00 AM (20 minutes)

We simulate the space-time dynamics of high-energy collisions based on a microscopic kinetic description, in order to determine the range of applicability of an effective description in relativistic viscous hydrodynamics [1,2]. We find that hydrodynamics provides a quantitatively accurate description of collective flow when the average inverse Reynolds number Re^{-1} is sufficiently small and the early pre-equilibrium stage is properly accounted for. By determining the breakdown of hydrodynamics as a function of system size and energy, we find that it is quantitatively accurate in central lead-lead collisions at LHC energies, but should not be used in typical proton-lead or proton-proton collisions, where the development of collective flow can not accurately be described within hydrodynamics.

[1] V.E. Ambruș, S. Schlichting, C. Werthmann. To appear in Phys.Rev.D, arXiv: 2211.14379 [hep-ph]
[2] V.E. Ambruș, S. Schlichting, C. Werthmann. Phys.Rev.Lett. 130 (2023) 152301, arXiv: 2211.14356 [hep-ph]

Category

Theory

Collaboration (if applicable)

Primary author: WERTHMANN, Clemens (University of Wroclaw)

Co-authors: Prof. SCHLICHTING, Soeren (Universität Bielefeld); AMBRUS, Victor Eugen (West University of Timisoara (RO))

Presenter: WERTHMANN, Clemens (University of Wroclaw)

Session Classification: Collective Dynamics

Track Classification: Collective Dynamics

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

A New Horizon - Dielectron measurements with ALICE 3

Tuesday, September 5, 2023 5:30 PM (2h 10m)

Electromagnetic radiation is emitted throughout the whole evolution of high-energy heavy-ion collisions. Due to their penetrating nature, real and virtual photons reach the detector unimpeded. Their measurement makes it possible to shed light on the different stages of the extreme states of matter created in such collisions.

In this poster, we will discuss dielectron measurements that will only be possible with a new generation's experiment at the LHC and the features of the ALICE 3 detector that will enable them. In particular, the rejection of dielectrons from correlated semi-leptonic decays of heavy-flavour hadrons will be evaluated. We will present the expected performance of differential measurements of the thermal emission of dielectrons and the derived early-time temperature of the medium. The unique possibility to probe the pre-hydrodynamic phase of the medium with e^+e^- pairs will be discussed. In addition, the capability for detailed studies of chiral symmetry restoration mechanisms with a precise measurement of the rho spectral function will be addressed.

Category

Experiment

Collaboration (if applicable)

ALICE

Primary author: SCHEID, Horst Sebastian (Goethe University Frankfurt (DE))

Presenter: SCHEID, Horst Sebastian (Goethe University Frankfurt (DE))

Session Classification: Poster Session

Track Classification: Future facilities/detectors

Contribution ID: **159** Type: **Oral**

Universal cumulants from fluctuating width of rapidity distributions

Wednesday, September 6, 2023 2:20 PM (20 minutes)

In relativistic heavy-ion collisions, the longitudinal fluctuations of the fireball density caused, e.g., by baryon stopping fluctuations result in event-by-event modifications of the proton rapidity density distribution. I will present the multiparticle rapidity correlation functions due to the varying distribution width of the proton rapidity density in central Au+Au collisions at low energies. Then, I will discuss the cumulant ratios in the context of the recent STAR Collaboration results. It is found that the cumulant ratios for small width fluctuations are universal and are of the same order as those measured by the STAR Collaboration. This effect might be important in the search for the predicted QCD critical point.

Category

Theory

Collaboration (if applicable)

Primary author: Prof. BZDAK, Adam (AGH University of Science and Technology)

Co-author: BAREJ, Michal (AGH UST Krakow)

Presenter: Prof. BZDAK, Adam (AGH University of Science and Technology)

Session Classification: Critical Point

Track Classification: Critical point searches

Contribution ID: **160** Type: **Oral**

Fluctuations near the liquid-gas and chiral phase transitions in hadronic matter

Wednesday, September 6, 2023 2:40 PM (20 minutes)

In this talk I discuss the fluctuations of the net-baryon number density in dense hadronic matter. Chiral dynamics is modeled via the parity doublet Lagrangian, and the mean-field approximation is employed to account for chiral criticality. I explain the qualitative properties and systematics of the second-order susceptibility of the net-baryon number density for individual positive- and negative-parity nucleons whose masses become degenerate at the chiral restoration. I argue that the second-order susceptibility of the positive-parity state can become negative when the chiral symmetry is restored, as a natural consequence of the unique relationship of the mass to the order parameter and are indicative of approaching the critical point on the chiral phase boundary. The results may have consequences for the interpretation of the experimental data on net-proton fluctuations in heavy-ion collisions.

Talk based on:
M. Marczenko, K. Redlich, C. Sasaki, Phys.Rev.D 107 (2023) 5, 054046

Category

Theory

Collaboration (if applicable)

Primary authors: MARCZENKO, Michał (University of Wrocław); REDLICH, Krzysztof (University of Wroclaw); SASAKI, Chihiro

Presenter: MARCZENKO, Michał (University of Wrocław)

Session Classification: Critical Point

Track Classification: Critical point searches

Contribution ID: **162** Type: **Oral**

AMY Lorentz invariant parton cascade

Wednesday, September 6, 2023 12:40 PM (20 minutes)

The observation of signs of collectivity in small systems has highlighted the need for a better understanding of equilibration in small and large collisions systems. In search of this, the QCD effective kinetic theory formulated by Arnold, Moore and Yaffe (AMY) [1] has emerged as a promising candidate. In order to fully exploit the theory also for phenomenology we introduce ALPACA [2], a Lorentz invariant parton cascade which is a representation of the AMY effective kinetic theory in the form of a Monte Carlo event generator. It solves the Boltzmann equation with the full AMY kernels (elastic scattering and splitting/merging processes) by explicitly simulating the evolution of parton ensembles corresponding to single events. It is constructed in a fully Lorentz invariant way by using a method pioneered in [3], which also underlies the parton cascade PCPC [4]. A complication arises from quantities like the screening mass, that enter the AMY kernels and are defined as integrals over the phase space densities. We develop a method for extracting these locally from the parton ensemble without the need for further information. We perform an extensive validation of the framework in thermal equilibrium and present first results for out-of-equilibrium simulations for collisions of light nuclei down to protons. Here we focus on harmonic flow response to initial geometry deformations and the question to what extent such systems equilibrate.

[1] P. B. Arnold, G. D. Moore and L. G. Yaffe, JHEP 01 (2003), 030 [arXiv:hep-ph/0209353 [hep-ph]]
[2] A. Kurkela, R. Törnkvist and K. Zapp, [arXiv:2211.15454 [hep-ph]]
[3] G. Peter, D. Behrens and C. C. Noack, Phys. Rev. C 49 (1994), 3253-3265
[4] V. Borchers, J. Meyer, S. Gieseke, G. Martens and C. C. Noack, Phys. Rev. C 62 (2000), 064903 [arXiv:hep-ph/0006038 [hep-ph]]

Category

Theory

Collaboration (if applicable)

Primary authors: ZAPP, Korinna (Lund University); TÖRNKVIST, Robin (Lund University)

Co-author: Dr KURKELA, Aleksi (University of Stavanger)

Presenter: ZAPP, Korinna (Lund University)

Session Classification: Small Systems

Track Classification: Small systems

Contribution ID: **164** Type: **Oral**

Deep learning for flow observables in ultrarelativistic heavy-ion collisions

Saturday, September 9, 2023 10:52 AM (5 minutes)

We train a deep convolutional neural network to predict hydrodynamic results for flow coefficients, average p_T and charged particle multiplicities in ultrarelativistic heavy-ion collisions from the initial energy density profiles event-by-event [1]. We show that the network can be trained accurately enough so that it can reliably predict the hydrodynamic results for the flow coefficients and, remarkably, also their correlations like normalized symmetric cumulants, mixed harmonic cumulants and flow-p_T correlations. At the same time the required computational time decreases by several orders of magnitude. To demonstrate the effectiveness of the neural network, we train it using 5k hydro events, and validate it using 90k events per collision energy. The events are computed from the pQCD + saturation + hydrodynamics -based EKRT framework supplemented with a dynamical decoupling condition that improves the description of peripheral collisions [2]. We then generate 10M events using neural network and show that increasing the number of events from 90k to 10M can have significant effects on certain statistics-expensive flow correlations. Neural networks will therefore enable adding statistics-expensive flow correlations to the global Bayesian analysis with a fraction of computation time compared to the current state-of-the-art procedures [3].

[1] H. Hirvonen, K. J. Eskola and H. Niemi, arXiv:2303.04517 [hep-ph]
[2] H. Hirvonen, K. J. Eskola and H. Niemi, Phys. Rev. C 106, no.4, 044913 (2022)
[3] H. Hirvonen, J. Auvinen, K. J. Eskola and H. Niemi, in preparation

Category

Theory

Collaboration (if applicable)

Primary authors: HIRVONEN, Henry (University of Jyväskylä (FI)); Prof. ESKOLA, Kari J. (University of Jyväskylä (FI)); NIEMI, Harri (University of Jyväskylä (FI))

Presenter: HIRVONEN, Henry (University of Jyväskylä (FI))

Session Classification: Flash Talks

Track Classification: New theoretical developments