18th International Conference on QCD in Extreme Conditions

Report of Contributions

https://indico.cern.ch/e/832600

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

Hybrid stars with large strange quark cores

Thursday, 28 July 2022 11:50 (25 minutes)

The possible existence of hybrid stars is studied using several multi-quark interaction channels. The hadronic phase consists of an EOS with presently accepted nuclear matter properties and the quark model constrained by the vacuum properties of several light mesons. The dependence of several NS properties on the different quark interactions is analyzed. We show that the present constraints from neutron stars observations allow for the existence of hybrid stars with a large strangeness content and large quark cores.

Primary authors: PROVIDÊNCIA, Constança (University of Coimbra); Dr FERREIRA, Márcio (University of Coimbra); PEREIRA, Renan

Presenter: Dr FERREIRA, Márcio (University of Coimbra)

Session Classification: Session

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

Open heavy flavour in a hot bath

Wednesday, 27 July 2022 16:25 (25 minutes)

We present the properties of open heavy mesons in hot mesonic matter based on a self-consistent theoretical approach that takes into account chiral and heavy-quark spin-flavour symmetries. The heavy-light meson-meson unitarized scattering amplitudes in coupled channels incorporate thermal corrections as well as the dressing of the heavy mesons with the self-energies [1, 2]. As a result, the open heavy-flavour ground-state spectral functions broaden and their peak is shifted towards lower energies with increasing temperatures. This has strong implications for the excited mesonic states generated dynamically in this heavy-light molecular model. In addition, we show the meson Euclidean correlators calculated using the thermal ground-state spectral functions obtained within our approach and compare them with recent calculations of lattice correlators [3].

[1] G. Montaña, A. Ramos, L. Tolos and J. M. Torres-Rincon, Phys. Lett. B 806 (2020), 135464 doi:10.1016/j.physletb.2020.
[2] G. Montaña, A. Ramos, L. Tolos and J. M. Torres-Rincon, Phys. Rev. D 102 (2020) 9, 096020 doi:10.1103/PhysRevD.102.096020
[3] G. Montaña, O. Kaczmarek, L. Tolos and A. Ramos, Eur. Phys. J. A 56 (2020) 11, 294 doi:10.1140/epja/s10050-020-00300-y

Primary authors: Prof. RAMOS, Angels; Ms MONTAÑA, Gloria (University of Barcelona); TOLOS, Laura; TORRES-RINCON, Juan (Universitat de Barcelona)

Presenter: TOLOS, Laura

Session Classification: Session

Contribution ID: **15** Type: **Poster presentation**

cal N=4$supersymmetricYang-Millsthermodynamicsfromeffectivefieldtheory$

The free energy density of $calN = 4$ supersymmetric Yang-Mills theory in four space-time dimensions is derived through second order in the 't Hooft coupling λ at finite temperature using effective-field theory methods. The contributions to the free energy density at this order come from the hard scale T and the soft scale $\sqrt{\lambda}T$. The effects of the scale T are encoded in the coefficients of an effective three-dimensional field theory that is obtained by dimensional reduction at finite temperature. The effects of the electric scale $\sqrt{\lambda}T$ are taken into account by perturbative calculations in the effective theory.

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Presenter: Mr TANTARY, Ubaid (Kent State University, Kent Ohio, USA)

Session Classification: Poster session

Contribution ID: **16** Type: **Poster presentation**

Scale invariance of quantum electrodynamics in three dimensionss

I will present a summary of results on parity invariant quantum electrodynamics in three Euclidean dimensions using lattice regularization. The results will show scale invariance independent of the number of massless fermions. Results for monopole scaling dimensions and their relevance will also be discussed.

Primary authors: NARAYANAN, Rajamani; NARAYANAN, Rajamani (Florida International University)

Presenter: NARAYANAN, Rajamani (Florida International University)

Session Classification: Poster session

Contribution ID: **17** Type: **Poster presentation**

Phase diagram of QCD in strong magnetic field

We discuss the phase diagram of QCD in the presence of a strong magnetic background field, providing numerical evidence, based on lattice simulations of QCD with $2+1$ flavors and physical quark masses, that the QCD crossover turns into a first order phase transition for large enough magnetic field, with a critical endpoint located between $eB = 4$ GeV^2 (where we found an analytic crossover at a pseudo-critical temperature $T_c = (98 \pm 3)$ MeV) and $eB = 9$ GeV^2 (where the measured critical temperature is $T_c = (63 \pm 5)$ MeV).

Primary authors: D'ELIA, Massimo (University of Pisa); MAIO, Lorenzo; Dr SANFILIPPO, Francesco (INFN sezione di Roma Tre); Mr STANZIONE, Alfredo (SISSA)

Presenter: MAIO, Lorenzo

Session Classification: Poster session

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

3+1D observables in the dilute Glasma of relativistic heavy ion collisions

Friday, 29 July 2022 12:15 (25 minutes)

According to the Color Glass Condensate effective theory, the early stages of heavy ion collisions are described by a quasi-classical state called Glasma, whose dynamics are governed by the Yang-Mills (YM) equations. Extending prior work [1], we solve the YM equations analytically in the weak-field limit, which reduces the field strength tensor components to three-dimensional integrals. These integrals can then be evaluated numerically for different nuclear models. Specifically, we allow the nuclei to have finite extent in the longitudinal direction, which gives access to the non-trivial spacetime rapidity dependence of observables such as the energy-momentum tensor of the Glasma.

Presenter: LEUTHNER, Markus

Session Classification: Session

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

Skyrmions in a magnetic field: pion domain wall versus hadronic phase

Skyrme model is among the simplest extensions of chiral effective theory including anomaly. Within such framework we investigate how an external magnetic field deforms a Skyrmion while preserving its topological winding. A crystal constituted by multiple magnetically deformed Skyrmions provides us insights of the ground state of nuclear matter in strong magnetic field. We manifest such Skyrme crystal can realize the previously found \piˆ0 domain wall structure as one special class of solution. Another class of solution with both charged and neutral pions is revealed by us, representing the hadronic phase. We establish the thermodynamics and phase diagram of these two classes of baryonic structure, demonstrating how they compete with each other to take place as the ground state, underneath which is the topological transmutation between \piˆ3(Sˆ3) and <\piˆ1(Sˆ1)>.

Primary authors: FUKUSHIMA, Kenji (The University of Tokyo); QIU, Zebin (The University of Tokyo); Mr CHEN, Shi (The university of Tokyo)

Presenter: QIU, Zebin (The University of Tokyo)

Session Classification: Session

Contribution ID: **20** Type: **Poster presentation**

Deconfinement and Clustering of color sources in pp and A-A collisions at LHC energies.

We present the extraction of the temperature by analyzing the charged particle transverse momentum spectra in lead-lead (Pb-Pb) and proton-proton (**pp**) collisions at LHC energies from the ALICE Collaboration using the Color String Percolation Model (CSPM) [1]. From the measured energy density ε and the temperature T the dimensionless quantity ε/T^4 is obtained to get the degrees of freedom (DOF), ε/T^4 = DOF $\pi^2/30$.
We observe for the first time a two-step behavior in the increase of DOF, characteristic of deconfinement, above the hadronization temperature at temperature $\sim$ 210 MeV for both Pb-Pb and **pp** collisions and a sudden increase to the ideal gas value of $\sim$ 47 corresponding to three quark flavors in the case of Pb-Pb collisions.
[1].M. A. Braun, J. Dias de˜Deus, A. S. Hirsch, C. Pajares, R. P. Scharenberg, and B. K. Srivastava, Deconfinement and clustering of color sources in nuclear collisions, Phys. Rep. 599, 1 (2015).

Primary author: Dr SRIVASTAVA, Brijesh (Purdue University)

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Presenter: Dr SRIVASTAVA, Brijesh (Purdue University)

Session Classification: Poster session

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

Machine Learning model driven prediction of the initial geometry in Heavy-Ion Collision experiments

We demonstrate high prediction accuracy of three important properties that determine the initial geometry of the heavy-ion collision (HIC) experiments by using supervised Machine Learning(ML) methods. These properties are the impact parameter, the eccentricity and the participant eccentricity. Though ML techniques have been used previously to determine the impact parameter of these collisions, we study multiple ML algorithms, their error spectrum, and sampling methods using exhaustive parameter scans and ablation studies to determine a combination of efficient algorithm and tuned training set that gives multi-fold improvement in accuracy for all three different heavy-ion collision models. The three models chosen are a transport model, a hydrodynamic model and a hybrid model. The motivation of using three different heavy-ion collision models was to show that even if the model is trained using a transport model, it gives accurate results for a hydrodynamic model as well as a hybrid model. We show that the accuracy of the impact parameter prediction depends on the centrality of the collision. With the standard application of ML training methods, prediction accuracy is considerably low for central collisions. Our method increases this accuracy by multiple folds. We also show that the eccentricity prediction accuracy can be improved by inclusion of the impact parameter as a feature in all these algorithms. We discuss how the errors can be minimized and the accuracy can be improved to a great extent in all the ranges of impact parameter and eccentricity predictions.

Primary authors: SAHA, Abhisek (University of Hyderabad); Dr DAN, Debasis (Microsoft India (R& D) Pvt. Ltd.); Dr SANYAL, Soma (University of Hyderabad)

Presenter: SAHA, Abhisek (University of Hyderabad)

Session Classification: Session

Contribution ID: **22** Type: **Poster presentation**

Nonextensive statistics for analysing temperature fluctuations in heavy ion collisions.

We study temperature fluctuations in the initial stages of the relativistic heavy-ion collision using a multiphase transport model. We consider the plasma in the initial stages after the collision before it has a chance to equilibrate. We have considered Au + Au collision with a varying center of mass energy. We use the non-equilibrium Tsallis statistics to find the entropic index in the partonic stage of the relativistic heavy-ion collision. The Tsallis statistics is a generalization of the Boltzmann-Gibbs thermodynamic approach to non-equilibrium systems. The temperature fluctuations of an out of equilibrium system can be studied using the Tsallis statistics, provided the inverse of the temperature β can be fitted with a χ^2 distribution. The β obtained from our simulations is fitted with a χ^2 distribution and then used to obtain the entropic index (q). Previously, the entropic index was calculated by fitting the transverse momentum spectra of hadrons to the Tsallis distribution. We have shown that the entropic index can also be obtained for the partonic stage using temperature fluctuations. We see that the entropic index found from the temperature fluctuations for the partonic stage behaves similarly to the entropic index obtained from the final stage hadronic spectra. Similar to previous studies, we find that there is a linear dependency between the temperature T_{eff} and the entropic index q for the partonic system. However, the slope of the linearity depends on the kind of particles chosen to obtain the temperature of the system. A detailed analysis of the dependence of the entropic index on the system shows that for increasing space-time rapidity, the entropic index of the partonic system increases. The entropic index was also dependent on the beam collision energy. Thus, our current work indicates that a non-extensive formalism can be used in conjunction with a transport model to study the partonic stages of relativistic heavy-ion collisions.

Primary authors: SAHA, Abhisek (University of Hyderabad); Dr SANYAL, Soma (University of Hyderabad)

Presenter: SAHA, Abhisek (University of Hyderabad)

Session Classification: Poster session

Contribution ID: **23** Type: **Poster presentation**

Isolated photon-hadron production in high energy pp and pA collisions at RHIC and LHC

We compute the isolated photon production in association with a charged hadron at mid rapidity in pp and pA based on the Color Glass Condensate (CGC) framework of high energy QCD where, for the first time, we incorporate the Sudakov effect of soft gluon emissions. Our results are based on the leading order qg→qγ channel in the CGC framework and confronted with the recent data from RHIC and LHC concerning the angular distributions and out-of-plane transverse momentum distributions. We find that, while the CGC computation alone results in too narrow distributions, with the help of the Sudakov effect, we can get a satisfactory description of the data. With this as a benchmark, we provide predictions for the magnitude of the nuclear effect brought by the phenomena of gluon saturation in the CGC.

Primary authors: PERKOV, Anton; Dr GARCIA-MONTERO, Oscar (Institute for theoretical physics Frankfurt); Dr BENIC, Sanjin (University of Zagreb)

Presenter: PERKOV, Anton

Session Classification: Poster session

Contribution ID: **24** Type: **Poster presentation**

Adiabatic hydrodynamization in the bottom-up thermalization scenario

In this talk we demonstrate that the early stages of the bottom-up thermalization scenario [1] are well described by the adiabatic hydrodynamization framework. All of the qualitative features exhibited in QCD effective kinetic theory (EKT) simulations at weak coupling [2] are captured by the emergence of an effective low-energy instantaneous ground state for the 1-particle gluon distribution function, which defines the early-time kinetic theory attractor. This ground state may be pulled back to arbitrarily early times, where it represents a free-streaming solution, and at later times it integrally describes the BMSS fixed point, including the recently observed deviations from the original predictions for the scaling exponents [2].

Our discussion is guided by our observations of the deep connections between scaling and adiabaticity in expanding gluon plasmas [3]. To showcase this, we first solve the Boltzmann equation for gluons in the small-angle scattering approximation numerically and find that time-dependent scaling is a feature of this kinetic theory, capturing the QCD EKT scaling of hard gluons [2]. We then proceed to study scaling analytically and semi-analytically in this equation. We find that an appropriate momentum rescaling allows the scaling distribution to be identified as the instantaneous ground state of the operator describing the evolution of the distribution function, and the approach to the scaling function is described by the decay of the excited states. That is to say, there is a frame in which the system evolves adiabatically, and the instantaneous ground state describes the early-time kinetic theory attractor. We obtain this ground state analytically. Corrections to the BMSS fixed point exponents in the small-angle approximation agree quantitatively with those found previously in QCD EKT and arise from the evolution of the ratio between hard and soft scales.

[1] R. Baier, A.H. Mueller, D. Schiff and D.T. Son, "'Bottom up'thermalization in heavy ion collisions,"Phys. Lett. B 502 (2001) 51
[2] A. Mazeliauskas and J. Berges, "Prescaling and far-from-equilibrium hydrodynamics in the quark-gluon plasma,"Phys. Rev. Lett. 122 (2019) 122301
[3] J. Brewer, B. Scheihing-Hitschfeld and Y. Yin, "Scaling and adiabaticity in a rapidly expanding gluon plasma,"arXiv:2203.02427 [hep-ph]

Primary authors: SCHEIHING HITSCHFELD, Bruno Sebastian (Massachusetts Institute of Technology); BREWER, Jasmine Therese (CERN); YIN, Yi (Institute of modern physics, Chinese Academy of Sciencessti)

Presenter: SCHEIHING HITSCHFELD, Bruno Sebastian (Massachusetts Institute of Technology)

Session Classification: Poster session

Contribution ID: **25** Type: **Poster presentation**

Strange Quark Matter from Baryons

Cold and dense matter can be explored in a systematic way both in the high-density (perturbative QCD) and low-density (Chiral EFT) regime. However, the path connecting them is yet to be discovered. As a result, these descriptions are usually extrapolated into the intermediate density regime and then connected at some transition point. In this work I will present a model that has features of both, but within a unified description. The model contains hadronic degrees of freedom and is calibrated using nuclear matter properties; yet it exhibits a phase transition towards a "quark matter"phase that has approximately restored chiral symmetry, strangeness, and asymptotes to the conformal limit of the speed of sound. While this model can describe different qualitative scenarios regarding the phase transition and the strangeness onset, empirical constraints significantly narrow down the allowed parameter range. Moreover, hybrid stars above two solar masses are predicted, exhibiting a stiff "quark matter"core. This approach has implications for the hyperon puzzle and is also crucial for future exploration of inhomogeneous phases and the surface tension between hadron and quark phases.

Primary authors: SCHMITT, Andreas (University of Southampton); FRAGA, Eduardo (Universidade Federal do Rio de Janeiro); Mr DA MATA MELO DA SILVA, Rodrigo (Universidade Federal do Rio de Janeiro); Mr PITSINIGKOS, Savvas (University of Southampton)

Presenter: Mr PITSINIGKOS, Savvas (University of Southampton)

Session Classification: Poster session

Contribution ID: **26** Type: **Poster presentation**

Light nuclei production with/without critical fluctuation

Light nuclei production is a hot research topic in heavy-ion collision at RHIC-BES. The observed non-monotonic behavior with the colliding energies[1,2] was declared to be related to the critical point of the QCD phase diagram[3,4]. In this talk, we focus on investigating the light nuclei production with and without critical fluctuations within the framework of the coalescence model.
In the first part [5], we derive the yield of light nuclei in terms of various orders of cumulants for the density distribution function by the implementation of the characteristic function of the phase space density without considering the critical fluctuations. We found that the leading terms of the phase-space cumulants in the yield of light nuclei share a similar form and could be canceled out in light nuclei ratio, whereas the higher-order ones (non-Gaussian shaped density profile) remain and play an important role in the interpretation of the behavior of light nuclei yield ratio.
In the second part [6], we introduce the static critical correlation contribution to the phase space density and derive the light nuclei production in terms of phase space cumulant. Because the leading terms of the phase-space cumulants in the yield of light nuclei share the similar form, we can construct a new light nuclei yield ratio, which is directly proportional to the critical contribution. By mapping the equation of state from the three-dimension Ising model, the new light nuclei yield ratio ($N_t N_p/N_d^2 - g_t/g_d^2$) has a double peak as a function of collision energy. And we also predict more obvious double peak structure of ratio $N_{^4He}N_p^2/N_d^3 - g_{^4He}/g_d^3$, requiring further experiment measurements.
[1] H. Liu, D. Zhang, S. He, K.-j. Sun, N. Yu, and X. Luo, Phys. Lett. B 805, 135452 (2020).
[2] D. Zhang (STAR), JPS Conf. Proc. 32, 010069 (2020).
[3] E. Shuryak and J M.Torres-Rincon, Eur.Phys.J.A 56 (2020) 9,241.
[4] K.-j. Sun, F.Li and C.M.Ko, Phys.Lett.B 816 (2021) 136258.
[5] S.Wu, K.Murase, S.Tang and H.Song, in preparation.
[6] S.Wu, K.Murase, S.Zhao and H.Song, in preparation.

Primary author: WU, Shanjin

Co-authors: SONG, Huichao; MURASE, Koichi (Yukawa Institute for Theoretical Physics, Kyoto University)

Presenter: WU, Shanjin

Session Classification: Poster session

Contribution ID: **27** Type: **Poster presentation**

Stability of Classical Chromodynamic Fields

A system of gluon fields generated at the earliest phase of relativistic heavy-ion collisions can be described in terms of classical fields. Numerical simulations show that the system is unstable but a character of the instability is not well understood. With the intention to systematically study the problem, we analyze a stability of classical chromomagnetic and chromoelectric fields which are constant and uniform. We consider the Abelian configurations discussed in the past where the fields are due to the single-color potentials linearly depending on coordinates. However, we mostly focus on the nonAbelian configurations where the fields are generated by the multi-color non-commuting constant uniform potentials. We derive a complete spectrum of small fluctuations around the background fields which obey the linearized Yang-Mills equations. The spectra of Abelian and nonAbelian configurations are similar but different and they both include unstable modes. We briefly discuss the relevance of our results for fields which are uniform only in a limited spatial domain.

Primary authors: MROWCZYNSKI, Stanislaw (Jan Kochanowski University); BAZAK, Sylwia (Jan Kochanowski University)

Presenter: BAZAK, Sylwia (Jan Kochanowski University)

Session Classification: Poster session

Contribution ID: **28** Type: **Poster presentation**

Collective modes of gluons in an anisotropic thermo-magnetic medium

It is found from viscous hydrodynamics that the QGP created in ultra relativistic heavy-ion collisions has different longitudinal and transverse pressures at early times. This occurs due to the large momentum space anisotropy in the p_T-p_L plane. This momentum space anisotropy can cause plasma instabilities that are largely responsible for the thermalization and isotropization of the system. Additionally, the production of a very strong magnetic field created in the non-central heavy-ion collisions naturally motivates one to ask if the dynamics of the anisotropic QGP gets affected by the magnetic field. We systematically study the collective modes of gluon using the generalized 'Romatschke-Strickland' form of the distribution functions in the presence of a magnetic field. Studying the behavior of the unstable modes, We may conclude that the magnetic field and the anisotropy behave in an opposite manner which is contrary to one's intuition.

Primary author: KARMAKAR, Bithika (Saha Institute of Nuclear Physics, India)

Presenter: KARMAKAR, Bithika (Saha Institute of Nuclear Physics, India)

Session Classification: Poster session

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

Anisotropic jet momentum broadening from effective kinetic theory

Friday, 29 July 2022 11:25 (25 minutes)

We study jet momentum broadening in heavy-ion collisions at anisotropic initial stages with focus on the jet quenching parameter $\hat{q}$, which we extract using effective kinetic theory. We obtain its non-equilibrium properties during the bottom-up thermalization scenario in a Bjorken-expanding plasma with non-thermal anisotropic initial conditions.
By studying the time-dependence of the momentum broadening we find that $\hat{q}$ along the beam axis is suppressed compared to the transverse plane during the overoccupied phase, and enhanced during the underoccupied phase.

Primary authors: KURKELA, Eero Aleksi (University of Stavanger (NO)); LINDENBAUER, Florian (TU Wien); PEURON, Jarkko; BOGUSLAVSKI, Kirill (Vienna University of Technology (AT)); LAPPI, Tuomas

Presenter: LINDENBAUER, Florian (TU Wien)

Session Classification: Session

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

An effective theory of medium induced radiation

Friday, 29 July 2022 14:30 (25 minutes)

We revisit the picture of jets propagating in the quark-gluon plasma. In addition to vacuum radiation, related to the high initial virtuality of a jet, jet particles scatter on the medium constituents resulting in induced emissions. Analytical approaches to resumming these interactions have traditionally dealt separately with multiple, soft [1,2], or rare, hard scatterings [3,4]. A full resummation has so far only been available using numerical methods [5,6,7]. Our goal is to achieve full analytical control of the relevant scales and map out the dominant physical processes in the full phase space. To this aim, we extend existing resummation schemes for the medium-induced spectrum [4,8,9] to the Bethe-Heitler regime, to cover the whole phase space from early to late times, and from hard splittings to emission below the thermal scale. Based on the separation of scales, a space-time picture naturally emerges: at early times, jets start to build from both vacuum and rare, hard scattering induced emissions. At a later stage, determined by a resolution criterion, these emissions initiate a turbulent cascade [10] that rapidly degrades their energy down to, and including the Bethe-Heitler regime. We quantify the impact of such an improved picture, compared to the current state of the art factorization that includes only soft scatterings [11], by both analytical and numerical methods for the jet fragmentation function. Our work serves to improve our understanding of jet quenching from small to large systems and for future upgrades of Monte Carlo generators.

[1] R. Baier, Y. L. Dokshitzer, A. H. Mueller, S. Peigne, and D. Schiff, Nucl. Phys. B 483 (1997) 291–320.
[2] B. Zakharov, JETP Lett. 63 (1996) 952–957.
[3] M. Gyulassy, P. Levai, and I. Vitev, Nucl. Phys. B 594 (2001) 371–419.
[4] U. A. Wiedemann, Nucl. Phys. B 588 (2000) 303–344.
[5] S. Caron-Huot and C. Gale, Phys. Rev. C82 (2010) 064902.
[6] C. Andres, L. Apolinario, and F. Dominguez, JHEP 07 (2020) 114.
[7] S. Schlichting and I. Soudi, arXiv:2111.13731.
[8] Y. Mehtar-Tani, JHEP 07 (2019) 057.
[9] J. a. Barata and Y. Mehtar-Tani, JHEP 10 (2020) 176.
[10] J.-P. Blaizot, E. Iancu, and Y. Mehtar-Tani, Phys. Rev. Lett. 111 (2013) 052001.
[11] P. Caucal, E. Iancu, A. H. Mueller, and G. Soyez, Phys. Rev. Lett. 120 (2018) 232001.

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Presenter: ISAKSEN, Johannes Hamre (University of Bergen)

Session Classification: Session

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

Extending AMY Shear Viscosity Calculations to Finite Baryon Chemical Potentials

Wednesday, 27 July 2022 15:05 (25 minutes)

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 the results for shear viscosity calculations at leading-log in QCD in a regime of high baryon density, where the chemical potentials are greater than the temperature, which is a very unknown region of the QCD phase diagram. For that, we extend the results obtained by Arnold, Moore, and Yaffe. Such conditions of temperature and baryon density are found in medium-energy heavy-ion collisions and in the nuclei of neutron star mergers.

Primary author: Ms DANHONI, Isabella

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

Presenter: Ms DANHONI, Isabella

Session Classification: Session

Contribution ID: **32** Type: **Poster presentation**

Phase Diagram of QCD in Three Dimensions

QCD in three dimensions allows for a Chern-Simons term resulting in non-standard spontaneous symmetry breaking patterns. In three dimensions the standard breaking pattern for $2N_f$ flavors is $U(2N_f) \to U(N_f) \times U(N_f)$. However, in the presence of a Chern-Simons term at level k the breaking pattern changes to $U(2N_f) \to U(N_f + k) \times U(N_f - k)$.
In this talk we will discuss the phase diagram of this theory in the chemical potential —temperature plane using an effective four-fermion interaction that also include the effect of a Chern-Simons term.
We analyze this theory for different regimes of the coupling constants, and find a rich phase diagram with a cascade of phase transitions as a function of the temperature or chemical potential, which correspond to the breaking patterns induced by the Chern-Simons term. The phase transitions can be either first or second order and we also find a tricritical point. In addition, we observe exotic patterns of chiral symmetry breaking in a small region of the parameter space, such as for example $U(3) \to U(1)^3$ and $U(4) \to U(2) \times U(1)^2$. Implications of these results will be discussed.
Based on https://arxiv.org/abs/2102.09089 with Takuya Kanazawa and Mario Kieburg.

Primary author: VERBAARSCHOT, Jacobus

Presenter: VERBAARSCHOT, Jacobus

Session Classification: Poster session

Contribution ID: **33** Type: **Poster presentation**

Confining QCD-like theory on non-SUSY D2 brane and partial deconfinement

We study the nonperturbative aspects of nonconformal 2+1D Yang-Mills like worldvolume theories on both the isotropic and anisotropic non-supersymmetric D2 brane solution of type II supergravity. Because of broken conformality, the theories for both the cases are found to have running coupling similar to the real world QCD theories. In this context, some salient QCD-like confining properties, for instance, flux-tube tension and glueball masses are analysed in our non-SUSY theories through the holographic notion. In the anisotropic case, tuning the anisotropy parameter in the low energy nonperturbative scale manifests the essence of the Hawking-Page (HP) transition from thermal AdS to a black brane. We present an empirical finite temperature scenario for the same where there appears a competent dual picture of HP transition and QCD confinement-deconfinement phase transition from the behaviours of the aforementioned QCD features in the pure YM theory under consideration. Furthermore, such observations surprisingly exhibit a smooth crossover at the transition point. We argue on this issue by speculating the presence of "partially deconfined" mixed phases of both glueballs and quark-gluon plasma in the prescribed worldvolume theory on the anisotropic non-SUSY D2 brane.

Primary authors: Ms CHAKRABORTY, Adrita (Indian Institute of Technology Kharagpur); Dr NAYEK, Kuntal (Indian Institute of Technology Kharagpur)

Presenter: Ms CHAKRABORTY, Adrita (Indian Institute of Technology Kharagpur)

Session Classification: Poster session

Contribution ID: **34** Type: **Poster presentation**

Heavy quark dynamics in a strongly magnetized quark-gluon plasma

We present a calculation of the heavy quark transport coefficients in a quark-gluon plasma under the presence of a strong external magnetic field, within the Lowest Landau Level (LLL) approximation. In particular, we apply the Hard Thermal Loop (HTL) technique for the resummed effective gluon propagator, generalized for a hot and magnetized medium. Using the derived effective HTL gluon propagator and the LLL quark propagator we analytically derive the full results for the longitudinal and transverse momentum diffusion coefficients as well as the energy losses for charm and bottom quarks beyond the static limit. We also show numerical results for these coefficients in two special cases where the heavy quark is moving either parallel or perpendicular to the external magnetic field.

Primary author: BANDYOPADHYAY, Aritra

Presenter: BANDYOPADHYAY, Aritra

Session Classification: Poster session

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

QCD equation of state via the complex Langevin method

Thursday, 28 July 2022 11:25 (25 minutes)

We present results on the phase diagram of Quantum Chromodynamics (QCD) with two light quark flavours at finite chemical potential from first principle lattice simulations. To circumvent the sign problem we use the complex Langevin method. The pion mass is of approximately 480 MeV. We report on the pressure, energy and entropy equations of state. A particular emphasis is put on the "cold"regions of the phase diagram and the observation of the Silver Blaze phenomenon.

Primary author: ZIEGLER, Felix P. G. (The University of Edinburgh)

Co-authors: JÄGER, Benjamin; ATTANASIO, Felipe (Heidelberg University)

Presenter: ZIEGLER, Felix P. G. (The University of Edinburgh)

Session Classification: Session

Contribution ID: **36** Type: **Poster presentation**

Fluctuations and phases in baryonic matter

The phase structure of baryonic matter is investigated with focus on the role of fluctuations beyond the mean-field approximation. The prototype test case studied is the chiral nucleon-meson model, with added comments on the chiral quark-meson model. Applications to nuclear matter include the liquid-gas phase transition. Extensions to high baryon densities are performed for both nuclear and neutron matter. The role of vacuum fluctuations is systematically explored. It is pointed out that such fluctuations tend to stabilize the hadronic phase characterized by spontaneously broken chiral symmetry, shifting the chiral restoration transition to very high densities. This stabilization effect is shown to be further enhanced by additional dynamical fluctuations treated with functional renormalisation group methods.

This work has been supported in part by DFG (Project-ID 196253076 - TRR 110) and NSFC as well as the DFG Excellence Cluster ORIGINS.

Primary authors: Mr BRANDES, Len (Technical University of Munich); Prof. KAISER, Norbert (Technical University of Munich); Prof. WEISE, Wolfram (Technical University of Munich)

Presenter: Mr BRANDES, Len (Technical University of Munich)

Session Classification: Poster session

Contribution ID: **37** Type: **Poster presentation**

Progress on stabilisation of complex Langevin for real-time simulations of non-abelian gauge theories

Complex actions lead to highly oscillatory weight functions in the calculation of ensemble averages, which is known as the numerical sign problem and renders modern standard techniques such as Hybrid-Monte-Carlo (HMC) integration inappropriate for these calculations. The complex Langevin (CL) method proposes to resolve this issue by introducing a fifth artificial Langevin time and complexifying the fields of the theory.
We present our current work on the simulation of real-time SU(2) Yang-Mills theory by complexifying the gauge group to SL(2,C) and specifying complex time-contours based on the Schwinger-Keldysh formalism. It is known that for this application the CL process suffers from numerical instabilities and problems with convergence. We lay out our recent progress on improving stabilisation techniques and present results from real-time simulations obtained with our numerical framework. We further review how combinations of modern stabilisation techniques such as gauge cooling and dynamical stabilisation can be used to mitigate the convergence issues but also discuss their limitations.

Primary authors: BOGUSLAVSKI, Kirill (Vienna University of Technology (AT)); HOTZY, Paul (TU Wien); MUELLER, David (TU Wien)

Presenter: HOTZY, Paul (TU Wien)

Session Classification: Poster session

Contribution ID: **38** Type: **Poster presentation**

NLO quark self-energy and dispersion relation using the hard thermal loop resummation

Using the hard-thermal-loop (HTL) resummation in real-time formalism, we study the next-to-leading order (NLO) quark self-energy and corresponding NLO dispersion laws. In NLO, we have replaced all the propagators and vertices with the HTL effective ones in the usual quark self-energy diagram. Additionally, a four-point vertex diagram also contributes to the quark NLO self-energy. We calculate the usual quark self-energy diagram and the four-point vertex diagram separately. Using those, we express the NLO quark self-energy in terms of the three- and four-point HTL effective vertex functions. We express the integrals containing the three- and four-point HTL effective vertex functions in terms of the solid angles using the Feynman parametrization. After completing the solid angle integrals, we calculate the momentum integrals in the transverse part of the NLO quark self-energy numerically and plot them as a function of the ratio of momentum and energy. Using the NLO quark self-energy transverse part, we plot the transverse contribution of NLO dispersion laws.

Primary author: Mr RANA, Sumit (IIT Roorkee)

Co-authors: Prof. PATRA, Binoy Krishna (IIT Roorkee); Dr HAQUE, Najmul (NISER)

Presenter: Mr RANA, Sumit (IIT Roorkee)

Session Classification: Poster session

Contribution ID: **39** Type: **Poster presentation**

Charge and heat transport in hot quark matter with chiral dependent quark masses

As the strength of the magnetic field (B) becomes weak, novel phenomena, similar to the Hall effect in condensed matter physics emerges both in charge and heat transport in a thermal QCD medium with a finite quark chemical potential (μ). So we have calculated the transport coefficients in a kinetic theory within a quasiparticle framework, wherein we compute the effective mass of quarks for the aforesaid medium in a weak magnetic field (B) limit ($|eB| << T^2$; T is temperature) by the perturbative thermal QCD up to one loop, which depends on T and B differently to left- (L) and right-handed (R) chiral modes of quarks, lifting the prevalent degeneracy in L and R modes in a strong magnetic field limit ($|eB| >> T^2$). Another implication of weak B is that the transport coefficients assume a tensorial structure: The diagonal elements represent the usual (electrical and thermal) conductivities: $\sigma_{\rm Ohmic}$ and κ_0 as the coefficients of charge and heat transport, respectively and the off-diagonal elements denote their Hall counterparts: $\sigma_{\rm Hall}$ and κ_1, respectively. It is found in charge transport that the magnetic field acts on L- and R-modes of the Ohmic-part of electrical conductivity in opposite manner, *viz.* $\sigma_{\rm Ohmic}$ for L- mode decreases and for R- mode increases with B whereas the Hall-part $\sigma_{\rm Hall}$ for both L- and R-modes always increases with B. In heat transport too, the effect of the magnetic field on the usual thermal conductivity (κ_0) and Hall-type coefficient (κ_1) in both modes are identical to the abovementioned effect of B on charge transport coefficients.

We have then derived some coefficients from the above transport coefficients, *namely* Knudsen number (Ω is the ratio of the mean free path to the length scale of the system) and Lorenz number in Wiedemann-Franz law. The effect of B on Ω either with κ_0 or with κ_1 for both modes are identical to the behavior of κ_0 and κ_1 with B. The value of Ω is always less than unity for the entire temperature range, validating our calculations. Lorenz number ($\kappa_0/\sigma_{\rm Ohmic}T$) and Hall-Lorenz number ($\kappa_1/\sigma_{\rm Hall}T$) for L-mode decreases and for R-mode increases with a magnetic field. It also does not remain constant with T, except for the R-mode Hall-Lorenz number where it remains almost constant for smaller values of B.

Primary author: Ms PANDAY, Pushpa (Indian Institute of Technology Roorkee)

Co-author: Prof. PATRA, Binoy Krishna (Indian Institute of Technology Roorkee)

Presenter: Ms PANDAY, Pushpa (Indian Institute of Technology Roorkee)

Session Classification: Poster session

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

The complex heavy-quark potential in an anisotropic quark-gluon plasma - Statics and dynamics

We generalize a complex heavy-quark potential model from an isotropic QCD plasma to an anisotropic one by replacing the Debye mass m_D with an anisotropic screening mass depending on the quark pair alignment with respect to the direction of anisotropy.
Such an angle-dependent mass is determined by matching the perturbative contributions in the potential model to the exact result obtained in the Hard-Thermal-Loop resummed perturbation theory. An advantage of the resulting potential model is that its angular dependence can be effectively described by using a set of angle-averaged screening masses as proposed in our previous work. Consequently, one could solve a one-dimensional Schrodinger equation with a potential model built by changing the anisotropic screening masses into the corresponding angle-averaged ones, and reproduce the full three-dimensional results for the binding energies and decay widths of low-lying quarkonium bound states to very high accuracy. Finally, turning to dynamics, we demonstrate that the one-dimensional effective potential can accurately describe the time evolution of the vacuum overlaps obtained using the full three-dimensional anisotropic potential. This includes the splitting of different p-wave polarizations.

Primary authors: DONG, Lihua (Guangxi Normal University); GUO, Yun (Guangxi Normal University); ISLAM, Ajaharul (Kent State University); ROTHKOPF, Alexander (University of Stavanger); STRICKLAND, Michael (Kent State University)

Presenter: ISLAM, Ajaharul (Kent State University)

Session Classification: Poster session

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

3+1D observables in the dilute Glasma of relativistic heavy ion collisions

According to the Color Glass Condensate effective theory, the early stages of heavy ion collisions are described by a quasi-classical state called Glasma, whose dynamics are governed by the Yang-Mills (YM) equations. Extending prior work [1], we solve the YM equations analytically in the weak-field limit, which reduces the field strength tensor components to three-dimensional integrals. These integrals can then be evaluated numerically for different nuclear models. Specifically, we allow the nuclei to have finite extent in the longitudinal direction, which gives access to the non-trivial spacetime rapidity dependence of observables such as the energy-momentum tensor of the Glasma.

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[1] A. Ipp, D. Müller, S. Schlichting and P. Singh, Phys.Rev.D 104 (2021) 11, 114040 [arXiv:2109.05028]

Primary authors: IPP, Andreas; LEUTHNER, Markus; MÜLLER, David I.; SCHLICHTING, Sören; SINGH, Pragya

Presenter: LEUTHNER, Markus

Session Classification: Poster session

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

Thermoelectric coefficients of a hot QCD medium in the limits of strong and weak magnetic field

We study the thermoelectric response of a thermal medium of deconfined quarks and gluons in the framework of relativistic kinetic theory. The response of the medium is quantified by the Seebeck and Nernst coefficients which relate the mutually longitudinal and transverse components, respectively, of the induced electric field and the temperature gradient. To obtain the above coefficients, we use the relativistic Boltzmann transport equation in the relaxation-time approximation, with interactions being incorporated via masses generated by thermal medium, extracted from one loop perturbative thermal QCD.

In the strong magnetic field regime ($|eB| \gg T^2$), thermal excitation of fermions to higher Landau levels is exponentially suppressed. As such, the lowest landau level (LLL) approximation becomes feasible which leads to fermion dynamics purely along the direction of the magnetic field, B (1-dimensional). Owing to this vanishing transverse motion, the Nernst coefficient vanishes.
In the weak magnetic field regime ($|eB| \ll T^2$), 2 prominent changes occur: 1) The fermion dynamics is no longer restricted which leads to non zero Nernst coefficient. Thus, the thermoelectric response becomes a 2×2 matrix with diagonal elements representing Seebeck coefficient and the off-diagonal elements, the Nernst coefficient. 2) The quasiparticle mass of the fermion evaluated using one-loop perturbation theory yields different masses for the left and right handed chiral quark modes, thereby lifting the degeneracy of the chiral modes.

The Seebeck coefficient of the medium (absolute values) is found to be a decreasing function of temperature (T) in both regimes of the magnetic field, B. However, its sign is negative in strong B and positive in weak B, suggesting that the direction of the induced electric field is flipped as $|B|$ decreases in the medium. The magnitudes in the weak $|B|$ regime are larger (~ 2 times) than that in strong $|B|$. Further, in the weak $|B|$ regime, the L-mode Seebeck coefficient elicits a larger response than the R-mode. The sensitivity of the Seebeck coefficient to changes in temperature is found to be comparatively enhanced in the strong $|B|$ limit. The Nernst coefficient is also a decreasing function of temperature with the L mode response being stronger than the R mode. It is zero in the LLL approximation (strong $|B|$ limit) as well as for $B = 0$. An interesting consequence of the non-degenerate chiral quark masses in the weak $|B|$ limit is that for certain values of T and B, the R-mode quasiquark mass comes out to be negative, which is unphysical. It is found that this happens in such a way so as to generate an upper bound for the ratio $|eB/T^2|$. For $|eB| = 0.2\, m_\pi^2$ and above, the condition $|eB|/T^2 \ll 1$ is thus enforced by the theory, consistent with the initial assumption.

Primary author: DEY, Debarshi (Indian Institute of Technology Roorkee)

Co-author: Prof. PATRA, Binoy (Indian Institute of Technology Roorkee)

Presenter: DEY, Debarshi (Indian Institute of Technology Roorkee)

Session Classification: Poster session

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

Searching for quark matter: from loops to neutron-star cores

Thursday, 28 July 2022 09:00 (45 minutes)

I will describe recent advances in the study of dense quark matter, expected to be present inside the cores of massive neutron stars. I will concentrate on two somewhat differing topics: first, on perturbative studies of the bulk thermodynamic properties of unpaired quark matter, and second, on the application of these results to the model-independent determination of the neutron-star-matter equation of state. I will argue that with recent improvements in ab-initio calculations at low and high density as well as in astrophysical measurements, we are close to being able to pinpoint the properties of matter inside neutron-star cores to such an extent that a reliable phase identification will soon become possible.

Primary author: Prof. VUORINEN, Aleksi (University of Helsinki)

Presenter: Prof. VUORINEN, Aleksi (University of Helsinki)

Session Classification: Session

Contribution ID: **44** Type: **Poster presentation**

Stability and instability of strange dwarfs

More than 20 years ago, Glendenning et al. (1995) proposed the existence of stable white dwarfs with a core of strange quark matter. More recently, by studying radial modes, Alford et al. (2017) concluded that those objects are unstable. We investigate again the stability of these objects by looking at their radial oscillations, and we assume that there is no phase transition between hadronic and quark matter at the strange core interface, following the formalism developed by Pereira et al. (2018) and Di Clemente et al. (2020). Our analysis shows that if the star is not strongly perturbed and ordinary matter cannot transform into strange quark matter, this type of objects are indeed stable. On the other hand, ordinary matter can be transformed into strange quark matter if the star undergoes a violent process, as in the early stages of a supernova, causing the system to become unstable (as described by Alford et al. (2017)) and collapse into a strange quark star. In this way, km-sized objects with subsolar masses can be produced.

Di Clemente, Drago, Pagliara and Char, in preparation.
Glendenning, Kettner, Weber, PRL 74 (1995) 3519; ApJ 450 (1995) 253
Alford, Harris, Sachdeva, ApJ 847 (2017) 109
Pereira, Flores, Lugones, ApJ 860 (2018) 12
Di Clemente, Mannarelli, Tonelli, PRD 101 (2020) 103003

Primary authors: DRAGO, Alessandro; DI CLEMENTE, Francesco (University of Ferrara); CHAR, Prasanta (University of Liege); PAGLIARA, giuseppe

Presenter: DI CLEMENTE, Francesco (University of Ferrara)

Session Classification: Poster session

Contribution ID: **45** Type: **Oral presentation**

Holographic approach to dense QCD and neutron star mergers

Thursday, 28 July 2022 14:15 (25 minutes)

The gauge/gravity duality, combined with information from lattice QCD, nuclear theory, and perturbative QCD, can be used to constrain the equation of state of hot and dense QCD. I discuss an approach based on the V-QCD model, which predicts a strongly first order nuclear to quark matter phase transition with a critical endpoint. By using this model in state-of-the-art simulations of neutron star binaries with parameters consistent with GW170817, I study the formation of quark matter during the merger process.

Primary author: JARVINEN, Matti

Presenter: JARVINEN, Matti

Session Classification: Session

Contribution ID: **46** Type: **Oral presentation**

Quarkonia phenomenology with ALICE

Friday, 29 July 2022 14:55 (25 minutes)

Heavy quarks are efficient probes of different physics aspects related to heavy-ion collisions (HIC), as they experience the full evolution of the system. Quarkonia notably provide a direct probe of the deconfinement of nuclear matter. Recently, the production of J/ψ via (re)generation within the quark-gluon plasma (QGP) or at the phase boundary has been identified as an important ingredient for the interpretation of quarkonium production in Pb–Pb collisions at the LHC. In particular, it is found to be the dominant production mechanism at low p_{T} and in central collisions. Measurements of the quarkonium elliptic flow and polarization bring more insights on the properties of the QGP, while the non-prompt J/ψ, originating from beauty hadron decays, gives access to the interaction of b quarks with the QGP. Quarkonium measurements are also now contributing to the study of the initial state of the collision, via for instance polarization measurements in Pb–Pb as a function of the event plane, to probe the strong magnetic field generated by the fast motion of the charges of the nuclei as well as the large angular momentum of the medium in non-central events. J/ψ measurements in p–Pb recently started to be included in the data pool used for nuclear Parton Distribution Function determination via global fits. Quarkonium studies in pp and p–Pb, besides serving as a reference for HIC, allow for investigating collective effects in small systems and shed light on multiparton interactions through measurements of the multiplicity-dependent production.

In this contribution, the latest ALICE results on quarkonia will be presented and their phenomenological implications will be discussed via comparisons with the latest theoretical developments describing quarkonium production and interaction with the QGP. Even in a high-multiplicity environment, the ALICE detector possesses excellent particle identificationm track and vertex reconstruction capabilities, offering unique opportunities to study the quarkonium production in small and large systems, at both mid- and forward rapidities, and down to zero p_{T}. The measurements, carried out for different collision systems and energies, include the (multiplicity dependent) production and nuclear modification factor of (prompt and non-prompt) J/ψ, ψ(2S) and Υ(nS), as well as the J/ψ v_2 and polarization, with the latter measured also as a function of the event plane. A short overview of the expectations for the LHC Run 3 and 4 will conclude the talk.

Primary author: TAILLEPIED, Guillaume (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

Presenter: TAILLEPIED, Guillaume (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

Session Classification: Session

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

Equilibration of quark-gluon plasma in heavy-ion collisions

Non-equilibrium systems are omnipresent in nature. QCD plasma out of equilibrium and its equilibration are of particular interest given that the relativistic heavy-ion collisions (HICs) produce the non-equilibrium quark-gluon plasma (QGP) which eventually emerges to thermal hydrodynamic states. We investigate the kinetic and chemical equilibration of weakly coupled QCD plasma at finite density with a numerical implementation of QCD effective kinetic theory based on leading-order QCD, revealing the relevant equilibration pattern and turbulent nature of the QCD plasma far from equilibrium. We then show its equilibration in HICs as an attractor towards hydrodynamics. Based on that, some phenomenological applications such as pre-equilibrium dilepton production in HICs are discussed.

Primary author: Dr DU, Xiaojian (Bielefeld University)

Presenter: Dr DU, Xiaojian (Bielefeld University)

Session Classification: Session

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

Hadrons at high temperature: a lattice update

Wednesday, 27 July 2022 11:00 (25 minutes)

We present the most recent results from the FASTSUM collaboration for hadron properties at high temperature from anisotropic lattice QCD. This includes the temperature dependence of the light and charmed meson and baryon spectrum, as well as properties of heavy quarkonia.

Primary authors: JÄGER, Benjamin; ALLTON, Chris (Swansea University); AARTS, Gert; SKULLERUD, Jon-Ivar; LOMBARDO, Maria Paola (INFN); KIM, Seyong (Unknown); HANDS, Simon; RYAN, Sinead (Trinity College Dublin); BURNS, Timothy

Presenter: SKULLERUD, Jon-Ivar

Session Classification: Session

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

Order parameters from persistent homology in non-Abelian lattice gauge theory

Finding order parameters for the detection of critical phenomena and self-similar behavior in and out of equilibrium is a challenging endeavour in non-Abelian gauge theories. Tailored to detect topological structures in noisy data and accompanied by stability and limit theorems, persistent homology allows for the construction of sensible and sensitive observables. Based on state-of-the-art hybrid Monte Carlo simulations of SU(2) lattice gauge theory I will show how the persistent homology of filtrations by chromoelectric and -magnetic fields, topological densities and Polyakov loops can be used to gauge-invariantly and without cooling algorithms uncover interpretable features of the confinement-deconfinement phase transition. In classical-statistical simulations far from equilibrium persistent homology observables reveal clear self-similar scaling related to a nonthermal fixed point, demonstrating the universality of scaling beyond correlation functions. Our results showcase the extensive versatility of persistent homology in non-Abelian gauge theories.

Primary author: SPITZ, Daniel (Heidelberg University, Institute for Theoretical Physics)

Presenter: SPITZ, Daniel (Heidelberg University, Institute for Theoretical Physics)

Session Classification: Poster session

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

Jet quenching in evolving anisotropic matter

Over the last decades, the theoretical picture of how hadronic jets interact with nuclear matter has been extended to account for the medium's finite longitudinal length and expansion. However, only recently a first-principle approach has been developed that allows to couple the jet evolution to the medium flow and anisotropic structure in the dilute limit. In this talk, we will show how to extend this approach to the dense regime, where the resummation of multiple in-medium scatterings is necessary. Particularly, we will consider the modifications of the single particle momentum broadening distribution and single gluon production rate in evolving matter. The resummation is performed by either computing the opacity series or starting from the all order BDMPS-Z formalism. We will also discuss the (novel) resulting modifications to jets' substructure.

Primary authors: SADOFYEV, Andrey (University of Santiago de Compostela); SALGADO LOPEZ, Carlos Albert (Universidade de Santiago de Compostela (ES)); BARATA, João; MAYO LÓPEZ, Xoán

Presenter: MAYO LÓPEZ, Xoán

Session Classification: Poster session

Contribution ID: **51** Type: **Poster presentation**

Application of Gribov quantization in deconfined nuclear matter

Gribov quantization is a method to improve the infrared dynamics of Yang-Mills theory. We study the thermodynamics and transport properties of a plasma consisting of gluons whose propagator is improved by the Gribov prescription. We first construct the thermodynamics of Gribov plasma using the gauge-invariant Gribov dispersion relation for interacting gluons. When the Gribov parameter in the dispersion relation is temperature-dependent, one expects a mean-field correction to the Boltzmann equation. We formulate a covariant kinetic theory for the Gribov plasma and determine the mean-field contribution in the Boltzmann equation. This leads to a quasiparticle-like framework with a bag correction to pressure and energy density, mimicking confinement. The temperature dependence of the Gribov parameter and bag pressure is fixed by matching lattice results for a system of gluons. The quark contribution is considered using the usual quasiparticle approach. Finally, we calculate the temperature dependence of the transport coefficients, i.e., bulk and shear viscosities for both gluon plasma and the QGP case.

Recently, we have also studied the heavy quark diffusion coefficient in a Gribov plasma, and we get good agreement with the available lattice data even in the non-perturbative region.

Primary author: HAQUE, Najmul (NISER, India)

Presenter: HAQUE, Najmul (NISER, India)

Session Classification: Poster session

Contribution ID: **52** Type: **Oral presentation**

All order resummed next-to-leading soft modes of cold and dense QCD pressure

Thursday, 28 July 2022 14:40 (25 minutes)

By identifying {\em massive} renormalization group (RG) properties within the hard thermal loop (HTL)
formalism, we resum to all orders $\alpha_S^p, p \geq 3$ the leading and next-to-leading logarithmic
soft mode $m_E \sim \alpha_S^{1/2}\mu_B$ contributions to the cold and dense QCD pressure
at high baryon chemical potential μ_B.
We obtain noticeably reduced residual scale dependence with respect to the state-of-the art results.
We will discuss applications to the NNLO Equation of State of cold and dense
quark matter, also including extension to massive quarks, relevant in particular for the phenomenology of neutron stars.

Mostly based on L. Fernandez and J.-L. Kneur, arXiv:2109.02410 and more recent work in progress.

Primary authors: KNEUR, Jean-Loic (Univ. Montpellier); FERNANDEZ, Loïc (Laboratoire Charles Coulomb)

Presenter: FERNANDEZ, Loïc (Laboratoire Charles Coulomb)

Session Classification: Session

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

Diffusion coefficient of heavy quark from classical lattice: A non-static case

The propagation of heavy quarks in the thermal medium closely resembles a Brownian motion characterized by the transport coefficients. In the leading order expansion of inverse mass, these transport coefficients, in particular momentum diffusion, are obtained from the correlators of chromo-electric (E) and chromo-magnetic (B) fields. We investigate longitudinal and transverse diffusion coefficients for a non-static heavy quark in the medium. While the longitudinal diffusion coefficient ($\kappa_L(p)$) is related to the EE correlator, the transverse momentum diffusion coefficient ($\kappa_T(p)$) is controlled by both BB and EB correlators. We show that in the perturbative limit, $O(v^2)$ correction to the leading order in both κ_L and κ_T are purely given by the electric field correlators. In the strong coupling limit, we estimate these field correlators (EE, BB, EB) and hence diffusion coefficients within the classical lattice Yang-Mills theory.

Primary author: Dr SINGH, BALBEER (Tata Institute of Fundamental Research)

Co-author: Dr DATTA, Saumen (Tata Institute of Fundamental Research)

Presenter: Dr SINGH, BALBEER (Tata Institute of Fundamental Research)

Session Classification: Poster session

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

Topological objects and the local Polyakov loop

We compare the behavior of zero-modes of the overlap Dirac operator measured on the finite temperature 2+1 flavor lattice QCD configurations, generated with domain wall fermion discreitzation, to the local Polyakov Loop in the temperature range 1.1-1.2T_c, T_c being the pseudo-critical temperature. We show how the position of the zero-modes are anti-correlated to the local value of the Polyakov Loop.

Primary authors: LARSEN, Rasmus (University of Stavanger); SHARMA, Sayantan (IMSc)

Presenter: LARSEN, Rasmus (University of Stavanger)

Session Classification: Poster session

Contribution ID: **55** Type: **Poster presentation**

Non-invertible symmetries of Cardy-Rabinovici model and mixed gravitational anomaly

In this talk, we discuss new symmetries of the Cardy-Rabinovici model and their applications. The Cardy-Rabinovici model is the 4d $U(1)$ gauge theory with electric and magnetic matters, and it is a good playground for studying the dynamics of 4d gauge theories. Although this model is not invariant under the $SL(2,\mathbb{Z})$ electromagnetic transformations strictly, we can realize these transformations as dualities by gauging the $\mathbb{Z}_N$ 1-form symmetry, from which we can construct noninvertible symmetry defects at self-dual points. As an application, we show that the mixed gravitational anomaly of this symmetry rules out the trivially gapped vacuum for some parameters. We also reveal how the conjectured phase diagram of the Cardy-Rabinovici model is consistent with this anomaly. This talk is based on arXiv:2204.07440.

Primary authors: HAYASHI, Yui (YITP, Kyoto University); TANIZAKI, Yuya (YITP, Kyoto University)

Presenter: HAYASHI, Yui (YITP, Kyoto University)

Session Classification: Poster session

Contribution ID: **56** Type: **Poster presentation**

Thermal transitions of dense two colour QCD

We study the thermal transitions of dense two colour QCD with two flavours of Wilson fermions at a fixed chemical potential $\mu = 443$ MeV on a coarse isotropic lattice $a = 0.18$ fm. The results on a larger lattice volume ($N_s = 24$) are compared with earlier results with the same lattice spacing but a smaller lattice volume ($N_s = 16$). Only small finite volume effects are found.
We also present first results from simulations with a finer lattice spacing $a = 0.14$ fm and lighter quarks $m_\pi = 0.44$ MeV than previously studied.

Primary authors: Prof. HANDS, Simon (University of Liverpool); Mr LAWLOR, Dale (National University of Ireland, Maynooth); Dr SEYONG, Kim (Sejong University); Dr SKULLERUD, Jon-Ivar (National University of Ireland, Maynooth)

Presenter: Mr LAWLOR, Dale (National University of Ireland, Maynooth)

Session Classification: Poster session

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

Pion properties under strong magnetic fields in the NJL model

In the presence of an external uniform magnetic field B, we show that new axial and vector decay constants appear for pions. A general expression for the weak decay $\pi^- \to l^- \bar{\nu}_l$ is also obtained. We calculate these decay constants within the Nambu-Jona–Lasinio (NJL) model, obtaining an enhancement of the total decay rate up to $\sim 10^3$ for eB = 1 GeV^2, as well as some anisotropy in the angular distribution of outgoing antineutrinos for large B. For this purpose, pion masses also have to be calculated. Charged pions have to be carefully treated. Since its Schwinger phases do not cancel, it is expanded in the Ritus momentum basis. We find that while the ^{0} mass shows a slight decrease with B, the magnetic-field dependent mass of π^- steadily increases.

Primary authors: GOMEZ DUMM, Daniel (IFLP, CONICET - Dpto. de Física, Fac. de Cs. Exactas, Universidad Nacional de La Plata, Argentina); Mr COPPOLA, Máximo (National Atomic Energy Commission); SCOCCOLA, Norberto (Comision nacional energia atomica); NOGUERA, Santiago (Universidad de Valencia)

Presenter: Mr COPPOLA, Máximo (National Atomic Energy Commission)

Session Classification: Poster session

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

Thermalization of spatially homogeneous systems of gluons

We study thermalization of gluons with momentum p characterized by Q in spatially homomgeneous systems. In initially under-populated systems in which the equilibrium temperature $T \ll Q$, soft gluons are found to be rapidly generated via radiation to fill a classical thermal distribution $\propto T^*/p$ with $T^* \gg T$. Thermal equilibrium is established only after T^* approaches to T via radiation. Similar features are also found among soft gluons in initially over-populated cases. In these cases, thermal equilibrium is established when the momentum of gluons increases from Q to T mainly due to momentum broadening. No transient formation of the Bose-Einstein condensate is observed.

Primary authors: WU, Bin; SALGADO LOPEZ, Carlos Albert (Universidade de Santiago de Compostela (ES)); BARRERA CABODEVILA, Sergio (Instituto Galego de Física de Altas Enerxías (IGFAE))

Presenter: BARRERA CABODEVILA, Sergio (Instituto Galego de Física de Altas Enerxías (IGFAE))

Session Classification: Poster session

Contribution ID: **59** Type: **Oral presentation**

Stability of Classical Chromodynamic Fields

Friday, 29 July 2022 15:20 (25 minutes)

A system of gluon fields generated at the earliest phase of relativistic heavy-ion collisions can be described in terms of classical fields. Numerical simulations show that the system is unstable but a character of the instability is not well understood. With the intention to systematically study the problem, we analyze a stability of classical chromomagnetic and chromoelectric fields which are constant and uniform. We consider the Abelian configurations discussed in the past where the fields are due to the single-color potentials linearly depending on coordinates. However, we mostly focus on the nonAbelian configurations where the fields are generated by the multi-color non-commuting constant uniform potentials. We derive a complete spectrum of small fluctuations around the background fields which obey the linearized Yang-Mills equations. The spectra of Abelian and nonAbelian configurations are similar but different and they both include unstable modes. We briefly discuss the relevance of our results for fields which are uniform only in a limited spatial domain.

Presenter: BAZAK, Sylwia (Jan Kochanowski University)

Session Classification: Session

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

Sphalerons on 4D Euclidean lattices

The aim of this project is to compute the strong sphaleron rate (the diffusion constant for the Chern-Simons topological number for quantum chromodynamics) on 4D lattices in a range of temperatures between 500 MeV and 3 GeV. This rate is important to understand the equilibration between axial quarks through the anomaly equations. Although this quantity has been previously computed in real-time lattices with Langevin dynamics, this only allowed to confidently access the very high temperature regime. Here, instead, we use a novel method in 4D Euclidean lattices that exploits the periodicity in the time direction, and the topological nature of the Chern-Simons number, and thus we extend the range of validity of the calculation to temperatures closer to those of interest in heavy ion collisions experiments.

Primary author: Mr BARROSO MANCHA, Marc (TU Darmstadt)

Co-author: Prof. MOORE, Guy (TU Darmstadt)

Presenter: Mr BARROSO MANCHA, Marc (TU Darmstadt)

Session Classification: Poster session

Contribution ID: **61** Type: **Oral presentation**

Lattice study of electromagnetic conductivity of quark-gluon plasma at finite baryon density

Wednesday, 27 July 2022 11:25 (25 minutes)

In this talk we present our study of the electromagnetic conductivity in dense quark-gluon plasma obtained within lattice simulations with Nf = 2 + 1 dynamical quarks. We employ stout improved rooted staggered quarks at the physical point and the tree-level Symanzik improved gauge action. The simulations are performed at imaginary chemical potential. To reconstruct electromagnetic conductivity from current-current correlators, we employ the Tikhonov regularisation method as well as the modified Backus-Gilbert method, computing the convolution of the spectral density with the target function. Our results are analytically continued to real values of baryon chemical potential. Our study indicates that electromagnetic conductivity of quark-gluon plasma rapidly grows with the real baryon density.

Primary authors: SANFILIPPO, Francesco (INFN sezione di Roma Tre); MAIO, Lorenzo (University of Pisa); NAVIGLIO, Manuel; D'ELIA, Massimo (University of Pisa); ASTRAKHANTSEV, Nikita; BRAGUTA, Victor (ITEP)

Presenter: NAVIGLIO, Manuel

Session Classification: Session

Contribution ID: **62** Type: **Oral presentation**

Quarkonium transport in weakly and strongly coupled plasmas

Friday, 29 July 2022 11:00 (25 minutes)

Suppression of open heavy flavors and quarkonia in heavy-ion collisions is among the most informative probes of the quark-gluon plasma. Interpreting the full wealth of data obtained from the collision events requires a precise understanding of the evolution of heavy quarks and quarkonia as they propagate through the nearly thermal and strongly coupled plasma. In particular, a systematic theoretical calculation of the dissociation and recombination rates of quarkonia had been lacking until recently.

It has recently been shown in [1] that such a calculation requires the evaluation of a gauge-invariant correlator of chromoelectric fields dressed with Wilson lines, which is very similar to, but different from the correlator used to define the well-known heavy quark diffusion coefficient [2]. In this talk, we will show a complete next-to-leading order (NLO) calculation result of the chromoelectric field correlator for quarkonium at finite temperature [3], which only differs from that for open heavy quarks by a temperature-independent constant. We explain both their similarities and differences. Crucial insights are obtained by studying them in temporal axial gauge, where these correlators would naively be equal [4]. Finally, going beyond perturbation theory, we will explain how to perform an AdS/CFT calculation of the analogous correlator for quarkonium in $\mathcal{N} = 4$ SYM and show some preliminary results in the strong coupling limit [5].

[1] X. Yao and T. Mehen, "Quarkonium Semiclassical Transport in Quark-Gluon Plasma: Factorization and Quantum Correction,"JHEP 02 (2021) 062
[2] J. Casalderrey-Solana and D. Teaney, "Heavy quark diffusion in strongly coupled N=4 Yang-Mills"
[3] T. Binder, K. Mukaida, B. Scheihing-Hitschfeld, X. Yao, "Non-Abelian Electric Field Correlator at NLO for Dark Matter Relic Abundance and Quakonium Transport,"JHEP 01 (2022) 137
[4] B. Scheihing-Hitschfeld, X. Yao, "Gauge Invariance of Non-Abelian Field Strength Correlators: the Axial Gauge Puzzle,"arXiv:2205.04477 [hep-ph]
[5] G. Nijs, B. Scheihing-Hitschfeld, X. Yao, in preparation

Primary authors: SCHEIHING HITSCHFELD, Bruno Sebastian (Massachusetts Institute of Technology); NIJS, Govert (Massachusetts Institute of Technology); YAO, Xiaojun (Massachusetts Institute of Technology)

Presenter: SCHEIHING HITSCHFELD, Bruno Sebastian (Massachusetts Institute of Technology)

Session Classification: Session

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

Heavy quark diffusion coefficient from the lattice

Wednesday, 27 July 2022 11:50 (25 minutes)

The heavy quark diffusion coefficient is encoded in the spectral functions of the chromo-electric and the chromo-magnetic correlators, of which the latter describes the T/M contribution. We study these correlators in the deconfined phase of SU(3) gauge theory on the lattice using the gradient flow. We perform both continuum and zero flow time limits to extract the heavy quark diffusion coefficient at a few different temperatures.

Primary author: LEINO, Viljami (Technical University Munich)

Co-authors: BRAMBILLA, Nora (TUM); VAIRO, Antonio (TUM); MAYER-STEUDTE, Julian (TUM); PETRECZKY, Peter (BNL)

Presenter: LEINO, Viljami (Technical University Munich)

Session Classification: Session

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

Topology in electromagnetic fields and the axion-photon coupling

The introduction of electric and magnetic fields in the QCD vacuum generates topological sectors with a non-zero topological charge. For weak fields, there is a linear response for the topological charge. We study this linear response which can be interpreted as the axion-photon coupling. In this work we use lattice simulations with improved staggered quarks including background electric and magnetic fields.

Primary authors: BRANDT, Bastian (University of Bielefeld); CUTERI, Francesca (Goethe Universität); ENDRODI, Gergely (University of Bielefeld); MARKO, Gergely (University of Bielefeld); HERNÁNDEZ HERNÁNDEZ, José Javier

Presenter: HERNÁNDEZ HERNÁNDEZ, José Javier

Session Classification: Poster session

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

Anomalous transport phenomena on the lattice

We study anomalous transport phenomena with lattice QCD simulations using improved staggered quarks. In particular, we calculate the conductivities both in the free case and in the interacting case, analysing the dependence of these coefficients with several parameters, such as the temperature and the quark mass.

Primary authors: BRANDT, Bastian (University of Bielefeld); GARNACHO VELASCO, Eduardo; CUTERI, Francesca (Goethe Universität); ENDRODI, Gergely (University of Bielefeld); MARKO, Gergely (University of Bielefeld)

Presenter: GARNACHO VELASCO, Eduardo

Session Classification: Poster session

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

Hydrodynamic attractor solutions and thermal particles from expanding QGP

We study the analytical attractor solutions of higher-order causal viscous hydrodynamics by considering thermal particle production from heavy-ion collisions, within the longitudinal boost-invariant expansion.
Using these analytical solutions, the allowed initial states are constrained by demanding positivity and reality of energy density throughout the evolution. Further, we calculate the thermal particle spectra
within the framework of hydrodynamic attractors. It has been observed that the evolution corresponding to attractor solution leads to maximum production of thermal particles.

Primary authors: Ms NAIK, Lakshmi J; Mr JAISWAL, Sunil (TIFR, Mumbai, India); Ms SREELAKSHMI, K (Amrita Vishwa Vidyapeetham, Coimbatore, India); Dr JAISWAL, Amaresh (NISER, Jatni, India); Dr SREEKANTH, V (Amrita Vishwa Vidyapeetham, Coimbatore, India)

Presenter: Ms NAIK, Lakshmi J

Session Classification: Poster session

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

Hyperon bulk viscosity and r-mode suppression in massive neutron stars

We propose and apply a new parameterization of the modified chiral effective model to study rotating neutron stars with hyperon core in the framework of the relativistic mean-field theory. The inclusion of the mesonic cross couplings in the model has improved the density content of the symmetry energy slope parameters, which are in agreement with the findings from recent terrestrial experiments. The bulk viscosity of the hyperonic medium is analyzed to investigate its role in the suppression of gravitationally driven -modes. The hyperonic bulk viscosity coefficient caused by non-leptonic weak interactions and the corresponding damping timescales are calculated and the -mode instability windows are obtained. The present model predicts a significant reduction of the unstable region due to more effective damping of oscillations. We find that from $10^8 K$ to $10^9 K$, hyperonic bulk viscosity completely suppresses the -modes leading to a stable region between the instability windows. The instability can reduce the angular velocity up to 0.15 , where is the Kepler frequency of the star.

Primary authors: Ms JYOTHILAKSHMI, O. P. (Amrita Vishwa Vidyapeetham, Coimbatore, India); Mr KRISHNAN, P. E. Sravan (Amrita Vishwa Vidyapeetham, Coimbatore, India); Mr THAKUR, Prashant (BITS PILANI K K Birla Goa Campus, India); Dr SREEKANTH, V. (Amrita Vishwa Vidyapeetham, Coimbatore, India); Dr JHA, T. K. (BITS PILANI K K Birla Goa Campus, India)

Presenter: Dr SREEKANTH, V. (Amrita Vishwa Vidyapeetham, Coimbatore, India)

Session Classification: Poster session

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

Thermodynamical probe of collectivity in small systems

Quantum Chromodynamics, the theory of strong interactions, predicts the existence, under extreme conditions, of a deconfined state of matter known as the quark-gluon plasma (QGP). We have strong evidence that such an extreme state is produced in relativistic heavy-ion collision experiments, such as RHIC and the LHC. A daring question is what is the smallest possible QGP size, one that can be rephrased as "what is the possible smallest fluid in the universe?". To investigate this question, we have utilised a state-of-the-art hybrid model to simulate p-Pb collisions and calculate a series of thermodynamical quantities, such as the hadronisation temperature, entropy density and the number of degrees of freedom. Together with experimental data, they allow us to probe whether the collective description of the matter produced in small systems collisions is consistent with first-principles calculations from Lattice QCD.

Primary authors: GARDIM, Fernando (Federal University of Alfenas); Prof. NUNES DA SILVA, Tiago Jose (Universidade Federal de Santa Catarina); Ms KRUPCZAK, Renata (Universidade Federal de Santa Catarina)

Presenters: GARDIM, Fernando (Federal University of Alfenas); Prof. NUNES DA SILVA, Tiago Jose (Universidade Federal de Santa Catarina)

Session Classification: Poster session

Contribution ID: **69** Type: **Oral presentation**

Effect of dark matter on observable neutron star's properties and it's discrimination from the strongly interacting matter equation of state

Thursday, 28 July 2022 15:05 (25 minutes)

We study the impact of asymmetric fermionic and bosonic dark matter on neutron star properties, including tidal deformability, maximum masses, radii, etc. The conditions at which dark matter particles tend to condensate in the core of the star or create an extended halo are presented. We show that dark matter condensed in a core leads to a decrease of the total gravitational mass and tidal deformability compared to a pure baryonic star, which we will perceive as an effective softening of the equation of state. On the other hand, the presence of a dark matter halo increases those observable quantities. Thus, observational data on compact stars could be affected by an accumulated dark matter and, consequently, constraints we put on strongly interacting matter at high densities. We will discuss how the ongoing and future X-ray, radio and GW observations could shed light on dark matter admixed compact stars and put multi-messenger constraints on its effect

Presenter: SAGUN, Violetta (University of Coimbra)

Session Classification: Session

Contribution ID: **70** Type: **Oral presentation**

Gravitational wave signal for quark matter with realistic phase transition

Thursday, 28 July 2022 16:00 (25 minutes)

At extremely high densities, QCD predicts the possible liberation of quark degrees of freedom and the formation of quark matter. The cores of neutron stars (NS) may accommodate such high-density matter. Whether the quark matter exists inside NSs is still an open question. If the quark matter exists, then there should be the imprint of the hadron-to-quark phase transition in the equation of state (EoS). We expect that gravitational waves from the binary NS merger can further constrain the EoS with the help of future third-generation detectors.
In this talk, we show that gravitational waves in the post-merger phase can distinguish the theory scenarios with and without a hadron-to-quark phase transition. Instead of adopting specific phenomenological EoS as studied previously, we compile reliable EoS constraints from the ab-initio QCD calculations. We demonstrate that early collapse to a black hole after the NS merger signifies softening of the EoS associated with quark matter even without a strong first-order transition. We also explain that the electromagnetic counterparts may further constrain the nature of the hadron-to-quark phase transition; we need substantial mass ejection to energize the observed luminosity of the associated kilonova.

Primary authors: FUKUSHIMA, Kenji (The University of Tokyo); FUJIMOTO, Yuki (University of Washington); HOTOKEZAKA, Kenta (Hebrew University); KYUTOKU, Koutarou

Presenter: FUJIMOTO, Yuki (University of Washington)

Session Classification: Session

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

Equations of state with conserved charge conditions for heavy-ion collisions

In this talk, I will describe first-principles-based equations of state (EoSs) for QCD that serve as crucial input for simulations of strongly-interacting matter produced in the laboratory during heavy-ion collisions (HICs) [1,2]. The first is solely informed by the fundamental theory by utilizing all available diagonal and off-diagonal susceptibilities up to $\mathcal{O}(\mu_B^4)$ that allow for the reconstruction of a full EoS at finite baryon number, electric charge, and strangeness chemical potentials. For the second, we go beyond information from the lattice in order to explore the conjectured phase structure, not yet determined by Lattice QCD methods. We incorporate critical features into the EoS by relying on universal scaling behavior. This allows one to study the effects of a singularity on the thermodynamical quantities that make up the equation of state used for hydrodynamical simulations of HICs. Additionally, we ensure that these EoSs are valid for applications to HICs via constraints on the conserved charge chemical potentials that yield strangeness neutrality and a fixed electric-charge-to-baryon-number ratio of 0.4.

1) J. Noronha-Hostler, P. Parotto, C. Ratti, J.M. Stafford, Physical Review C 2019, 100, 064910
2) J.M. Karthein, D. Mroczek et al, Eur.Phys.J.Plus 136 2021 6, 621

Primary authors: KARTHEIN, Jamie (MIT); MROCZEK, Débora (University of Illinois at Urbana-Champaign); NAVA, Angel; NORONHA-HOSTLER, Jacquelyn (University of Illinois Urbana Champaign); PAROTTO, Paolo (University of Wuppertal); PRICE, Damien (University of Houston); RATTI, Claudia

Presenter: KARTHEIN, Jamie (MIT)

Session Classification: Poster session

Contribution ID: **72** Type: **Poster presentation**

Holographic Baryons

The holographic method is one of the only ways of getting analytic insight into most strongly coupled systems. When numerical methods are not available, it is even the best technique we know of to tackle these problems. In particular, lattice QCD is unable to provide results at finite baryon density, which is why a lot of effort is put into the study of holographic QCD at high density. Densities beyond the nuclear density are not only a theoretical frontier, but are reached in real systems such as neutron star cores and future heavy ion collision experiments. In this talk I will discuss the most elementary aspect of baryonic physics in holography, that is the study of a single baryon state. I will start by reviewing the construction of baryons in the chiral effective field theory to highlight the common points and differences with the holographic approach. I will then discuss the qualitative features of holographic baryons, obtained already in models where the back-reaction of quarks on the glue sector of QCD is neglected and finally present our recent work in the framework of the V-QCD model, which is the most complete holographic model of QCD and the only one to implement flavor back-reaction.

Primary author: PRÉAU, Edwan

Co-authors: NITTI, Francesco; JARVINEN, Matti; Prof. KIRITSIS, Elias (APC and UOC)

Presenter: PRÉAU, Edwan

Session Classification: Poster session

Contribution ID: **73** Type: **Oral presentation**

Quantum entanglement in relativistic particle collisions

I will discuss the potential connection between the entanglement entropy of the initial state and thermodynamic entropy of the final state in relativistic particle collisions, from proton-proton to heavy ion collisions. I will show that simple fragmentation models that ignore quantum mechanical effects break down in describing particle production and that evidence for the non-universality of heavy quark fragmentation in hadron collisions shows the impact of the initial entanglement. In heavy ion processes entanglement might also give rise to a seemingly thermal behavior and thus can be linked to the entropy and particle yields in the final state.

Primary author: BELLWIED, Rene (University of Houston (US))

Presenter: BELLWIED, Rene (University of Houston (US))

Session Classification: Session

Contribution ID: **74** Type: **Poster presentation**

Effect of dark matter on observable neutron star's properties and it's discrimination from the strongly interacting matter equation of state

We study the impact of asymmetric fermionic and bosonic dark matter on neutron star properties, including tidal deformability, maximum masses, radii, etc. The conditions at which dark matter particles tend to condensate in the core of the star or create an extended halo are presented. We show that dark matter condensed in a core leads to a decrease of the total gravitational mass and tidal deformability compared to a pure baryonic star, which we will perceive as an effective softening of the equation of state. On the other hand, the presence of a dark matter halo increases those observable quantities. Thus, observational data on compact stars could be affected by an accumulated dark matter and, consequently, constraints we put on strongly interacting matter at high densities. We will discuss how the ongoing and future X-ray, radio and GW observations could shed light on dark matter admixed compact stars and put multi-messenger constraints on its effect.

Primary authors: GIANGRANDI, Edoardo (CFisUC - University of Coimbra); IVANYTSKYI, Oleksii (University of Wroclaw); Dr SAGUN, Violetta (University of Coimbra)

Presenter: Dr SAGUN, Violetta (University of Coimbra)

Session Classification: Poster session

Contribution ID: **76** Type: **Oral presentation**

Quark-antiQuark potential from Wilson Line Correlators at finite temperature: A comparison between different methods

Wednesday, 27 July 2022 14:15 (25 minutes)

We present results for the analysis of the energy and spectral width of the quark-antiQuark potential obtained from wilson line correlators at finite temperature using 2+1 flavor HISQ configurations ms/ml=20. We extract the energy and spectral width using 4 different methods: Zero temperature subtraction, Pade fit, Bayesian Reconstruction and HTL motivated fit. We compare the results and discuss the pros and cons of each method.

Primary authors: ROTHKOPF, Alexander (University of Stavanger); PARKAR, Gaurang (University Of Stavanger); LARSEN, Rasmus (University of Stavanger); BALA, Dibyendu (Bielefeld University); WEBER, Johannes Heinrich (Humboldt University of Berlin); KACZMAREK, Olaf; PETRECZKY, Peter (BNL); MUKHERJEE, Swagato (Brookhaven National Laboratory)

Presenter: LARSEN, Rasmus (University of Stavanger)

Session Classification: Session

Contribution ID: **77** Type: **Oral presentation**

Recent results on hot and dense matter from the lattice

I will review recent results on lattice QCD at finite temperature and density, with special emphasis on the QCD equation of state, phase transition line and fluctuations of conserved charges.

Primary author: RATTI, Claudia

Presenter: RATTI, Claudia

Session Classification: Session

Contribution ID: **78** Type: **Poster presentation**

Production rate and ellipticity of lepton pairs from a rotating hot and dense QCD medium

Using a current-current correlation function (CF), the photon polarization tensor is calculated for a rotating hot and dense QCD medium [1]. The spectral function (SF) and the dilepton rate (DR) are estimated therefrom. Numerical results show that both SF and DR are enhanced in a rotating medium, especially in a low invariant mass region. SF and DR are also explored in the consequences of the interplay among the angular velocity, temperature and chemical potential. We also estimated the electromagnetic screening by calculating the Debye mass and it shows a suppression for a rotating QCD medium. The most interesting observation is the azimuthal anisotropy of the dilepton production, i.e, the elliptic flow v_2 of the lepton pair induced by the rotation as an external field. The competition between the centrifugal effect and the spin polarization effect due to rotation results in a convex down behaviour of the elliptic flow as a function of the transverse momentum in a relatively large magnitude of angular velocity. It is noticed that quark spin polarization induces a negative v_2 in the case of large angular velocity.

1. M. Wei, C. A. Islam and M. Huang; PRD 105, no.5, 054014 (2022)[arXiv:2111.05192].

Primary authors: Mr WEI, Minghua (Institute of High Energy Physics, Chinese Academy of Sciences); AMINUL ISLAM, Chowdhury; HUANG, Mei

Presenter: AMINUL ISLAM, Chowdhury

Session Classification: Poster session

Contribution ID: **79** Type: **Oral presentation**

Studying explicit $U(1)_A$ symmetry breaking in hot and magnetised two flavour non-local NJL model constrained using lattice results

Wednesday, 27 July 2022 16:00 (25 minutes)

We study the two-flavour non-local Nambu\textemdash Jona-Lasinio (NJL) model in the presence of a magnetic field and explore the chiral crossover in presence of a non-local form of the ‘t Hooft determinant term [1]. Its coupling is governed by a dimensionless parameter c. This term is responsible for the explicit breaking of $U(1)_A$ symmetry. We have attempted a systematic analysis of the model parameters by fitting to self-consistent lattice QCD calculations. Three parameters of the model are fixed by $eB = 0$ results from published lattice QCD on the chiral condensate, the pion decay constant (F_π), and the pion mass (m_π). The difference of the u and d quark condensates in the presence of a magnetic field (eB) is quite sensitive to c and we fix c using published lattice QCD results for this observable. We see no evidence that c depends on eB. The crossover temperature decreases with increasing eB only for condensate values at the lower end of the allowed values (as already seen in˜\cite{Pagura:2016pwr}) and F_π at the upper end of the allowed values. We further check our model predictions by calculating the topological susceptibility with the fitted c values and comparing it with lattice results. Since the topological susceptibility is related to the extent of the $U(1)_A$ symmetry breaking, we find that it is sensitive to the value of c.

M. S. Ali, C. A. Islam and R. Sharma
PRD 104, no.11, 114026 (2021) [arXiv:2009.13563].

Primary authors: AMINUL ISLAM, Chowdhury; ALI, Mahammad Sabir (Tata Institute of Fundamental Research); SHARMA, Rishi (TIFR)

Presenter: AMINUL ISLAM, Chowdhury

Session Classification: Session

Contribution ID: **80** Type: **Oral presentation**

Influence of relativistic rotation on QCD properties within lattice simulation

This report is devoted to our study of QCD properties effected by relativistic rotation. The study is carried out within lattice simulations which are performed in the reference frame rotating with the system under investigation. First we focus on rotating gluodynamics. We found that the critical temperature of the confinement/deconfinement transition in gluodynamics grows quadratically with increasing angular velocity. In addition, we present our first results on rotating QCD matter with dynamical fermions. The results indicate, that the effect of the rotation on fermions is opposite to gluons: it leads to the decrease of the critical temperature.

Primary authors: KOTOV, Andrey; Dr BRAGUTA, Victor (ITEP); ROENKO, Artem (JINR); Mr SYCHEV, Dmitri (MIPT)

Presenter: Dr BRAGUTA, Victor (ITEP)

Session Classification: Session

Contribution ID: **81** Type: **Oral presentation**

Three topics in extreme QCD

Friday, 29 July 2022 09:45 (45 minutes)

I discuss three topics in QCD at nonzero temperature and density. First, how confingurations with fractional topological charge $1/N$ in a $SU(N)$ gauge theory may contribute at low temperature. Second, how the Polyakov loop, which appears to be an artifact of Euclidean space-time, can be naturally introduced in the Hamiltonian form, by introducing new states with test charges. Lastly, I discuss the solution for the low energy excitations for a $SU(N_c)$ theory with N_f light fermions in 1+1 dimensions, which is just a modified free boson for fermion number.

Primary author: PISARSKI, Robert (Brookhaven National Laboratory)

Presenter: PISARSKI, Robert (Brookhaven National Laboratory)

Session Classification: Session

Contribution ID: **83** Type: **not specified**

Best poster award ceremony

Thursday, 28 July 2022 12:15 (15 minutes)

Presenters: Prof. VUORINEN, Aleksi (University of Helsinki); RATTI, Claudia; Dr TOLOS, Laura

Contribution ID: **84** Type: **Oral presentation**

QCD in extreme conditions on the lattice

Wednesday, 27 July 2022 09:45 (45 minutes)

The thermodynamics of strongly interacting matter in extreme conditions can be investigated via lattice QCD simulations. In this talk, I will give an overview of recent developments in this field, focusing on the impact of temperature, background electromagnetic fields as well as an isospin asymmetry between the light quark chemical potentials. Selected applications of the results for off-central heavy-ion collisions and the evolution of the early Universe will also be discussed.

Primary author: ENDRODI, Gergely

Presenter: ENDRODI, Gergely

Session Classification: Session

Contribution ID: **85** Type: **Poster presentation**

Bayesian inference on quark matter from observations of neutron stars

The existence of quark matter inside the cores of massive neutron stars can be probed by modern astrophysical observations. We model these hybrid stars using an (axial)vector meson extended quark-meson model to describe their quark cores, together with various hadronic models. We show that crossover phase transitions between the hadronic and quark phases can naturally create equations of state that are stiffer than both the hadronic and quark ones, enabling more massive neutron stars. We also show that the properties of the maximum mass hybrid star can be used to constrain the parameters of the quark model, while radius limits from GW170817 also give restraints on them. We combine gravitational wave and NICER measurements in our Bayesian analysis to determine the properties of quark matter and the hadron-quark phase transition.

Primary authors: WOLF, György (Wigner Research Centre for Physics); TAKÁTSY, János (Wigner Research Centre for Physics); Prof. SCHAFFNER-BIELICH, Jürgen (Goethe Universität Frankfurt); KOVÁCS, Péter (Wigner Research Centre for Physics)

Presenter: TAKÁTSY, János (Wigner Research Centre for Physics)

Session Classification: Poster session

Contribution ID: **86** Type: **Oral presentation**

Holographic Baryons

Thursday, 28 July 2022 16:50 (25 minutes)

The holographic method is one of the only ways of getting analytic insight into most strongly coupled systems. When numerical methods are not available, it is even the best technique we know of to tackle these problems. In particular, lattice QCD is unable to provide results at finite baryon density, which is why a lot of effort is put into the study of holographic QCD at high density. Densities beyond the nuclear density are not only a theoretical frontier, but are reached in real systems such as neutron star cores and future heavy ion collision experiments. In this talk I will discuss the most elementary aspect of baryonic physics in holography, that is the study of a single baryon state. I will start by reviewing the construction of baryons in the chiral effective field theory to highlight the common points and differences with the holographic approach. I will then discuss the qualitative features of holographic baryons, obtained already in models where the back-reaction of quarks on the glue sector of QCD is neglected and finally present our recent work in the framework of the V-QCD model, which is the most complete holographic model of QCD and the only one to implement flavor back-reaction.

Presenter: PRÉAU, Edwan

Session Classification: Session

Contribution ID: **87** Type: **Oral presentation**

3+1D observables in the dilute Glasma of relativistic heavy ion collisions

According to the Color Glass Condensate effective theory, the early stages of heavy ion collisions are described by a quasi-classical state called Glasma, whose dynamics are governed by the Yang-Mills (YM) equations. Extending prior work [1], we solve the YM equations analytically in the weak-field limit, which reduces the field strength tensor components to three-dimensional integrals. These integrals can then be evaluated numerically for different nuclear models. Specifically, we allow the nuclei to have finite extent in the longitudinal direction, which gives access to the non-trivial spacetime rapidity dependence of observables such as the energy-momentum tensor of the Glasma.

[1] A. Ipp, D. Müller, S. Schlichting and P. Singh, Phys.Rev.D 104 (2021) 11, 114040 [arXiv:2109.05028]

Presenter: LEUTHNER, Markus

Session Classification: Session

Contribution ID: **88** Type: **Oral presentation**

Early quark deconfinement in compact star astrophysics and heavy-ion collisions

Thursday, 28 July 2022 16:25 (25 minutes)

We outline the role that an early deconfinement phase transition from normal nuclear matter to a color superconducting quark-gluon plasma phase plays for the phenomenology of supernova explosions and binary neutron star mergers. To this end we extend the compact star equation of state (EoS) from vanishing to moderately high temperatures that become accessible in the CBM experiment at FAIR. We study the connection of such hybrid EoS with the mass-radius relation of cold compact stars, including the intriguing possibility of additional families, as a consequence of the presence of an early and strong phase transition. Special emphasis is devoted to the simultaneous fulfillment of the new NICER mass and radius constraint from PSR J0740+6620 and the tidal deformability constraint from GW170817 which require the EoS to be soft at about twice saturation density and then to stiffen. Such a pattern is provided by an early and strong deconfinement transition. Dynamical scenarios are being considered, such as binary compact star mergers including the subsequent emission of gravitational waves and supernova explosions of massive supergiant stars where neutrinos play the role of messengers.

Primary authors: BAUSWEIN, Andreas; BLASCHKE, David; IVANYTSKYI, Oleksii (University of Wroclaw); FISCHER, Tobias (Institute of Theoretical Physics, University of Wroclaw)

Presenter: IVANYTSKYI, Oleksii (University of Wroclaw)

Session Classification: Session

Contribution ID: **89** Type: **Oral presentation**

Lattice QCD with an inhomogeneous magnetic field background

Wednesday, 27 July 2022 14:40 (25 minutes)

The magnetic fields generated in non-central heavy-ion collisions are among the strongest fields produced in the universe, reaching magnitudes comparable to the scale of strong interactions. Backed by model simulations, the resulting field is expected to be spatially modulated, deviating significantly from the commonly considered uniform profile. In this work, we present the next step to improve our understanding of the physics of quarks and gluons in heavy-ion collisions by adding an inhomogeneous magnetic background to our lattice QCD simulations. We simulate $2 + 1$ staggered fermions with physical quark masses for a range of temperatures covering the QCD phase transition. We assume a $1/\cosh(x)^2$ function to model the field profile and vary its strength to analyze the impact on the chiral condensate and the Polyakov loop. These order parameters show non-trivial spatial features due to the interplay between the sea and the valence effects as the system approaches the crossover temperature. We use these quantities to draw the phase diagram in the T-B plane and understand the implications of B to QCD physics. We also find that in this set-up, the system develops steady electric currents which flow in equilibrium. We use these currents to present our new method of obtaining the magnetic susceptibility of the QCD medium and compare it to previously established methods.

Primary author: MARQUES VALOIS, Adeilton Dean (Bielefeld University)

Co-authors: BRANDT, Bastian (University of Bielefeld); CUTERI, Francesca (Goethe Universität); ENDRODI, Gergely; MARKO, Gergely (MTA-ELTE Statistical and Biological Physics Research Group)

Presenter: MARQUES VALOIS, Adeilton Dean (Bielefeld University)

Session Classification: Session

Contribution ID: **90** Type: **not specified**

Recent results on hot and dense matter from the lattice

Wednesday, 27 July 2022 09:00 (45 minutes)

Presenter: RATTI, Claudia

Session Classification: Session

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

Pion screening mass at finite density

Exploring the QCD phase diagram in the finite density region suffers from the well-known issue of the sign problem. One way to avoid this issue is by expanding the observables in a Taylor series in the chemical potential. We use this approach for the calculation of observables such as screening correlators and screening masses at the finite chemical potential. We will show our calculation of the screening mass of the pion at finite temperatures and chemical potential by expanding the screening mass in a Taylor series to obtain the second derivative of the screening mass w.r.t. the chemical potential. We used (2+1) HISQ action for our analysis.

Primary authors: HEGDE, Prasad (Indian Institute of Science); THAKKAR, Rishabh

Presenter: THAKKAR, Rishabh

Session Classification: Poster session

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

Complex Langevin simulations for finite density QCD

Thursday, 28 July 2022 09:45 (45 minutes)

Lattice simulations of non-zero density QCD introduce the so-called sign problem, which invalidates importance sampling methods. We use the Complex Langevin equation (CLE) to circumvent the sign problem. Recent results regarding the phase diagram and thermodynamics of QCD using Complex Langevin simulations will be reviewed. Theoretical developments about 'boundary terms' are also discussed: in some cases one observes the convergence of the CLE to incorrect results. A cheap observable is proposed which allows unambigous detection of the correctness of the simulations. Preliminary results of measurements of these 'boundary term' observables in full QCD are presented.

Primary author: SEXTY, Denes

Presenter: SEXTY, Denes

Session Classification: Session

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

Heavy quarkonium dynamics at next-to-leading order in the binding energy over temperature

Friday, 29 July 2022 09:00 (45 minutes)

Using the potential non-relativistic quantum chromodynamics (pNRQCD) framework we derive a Lindblad equation for the evolution of the heavy-quarkonium reduced density matrix that is accurate to next-to-leading order (NLO) in the ratio of the binding energy of the state and the temperature. The resulting NLO Lindblad equation can be used to more reliably describe heavy-quarkonium evolution in the quark-gluon plasma at low temperatures when compared to the leading-order truncation. In order to apply this to phenomenology, we demonstrate how to numerically solve the resulting NLO Lindblad equation using a quantum trajectories algorithm. To achieve this, we map the solution of the three-dimensional Lindblad equation to the solution of an ensemble of one-dimensional Schr\"odinger evolutions with Monte-Carlo sampled quantum jumps. Upon averaging over the Monte-Carlo sampled quantum jumps, we obtain a solution to the NLO Lindblad equation which does not require truncation in the angular momentum quantum number of the states considered. We also investigate evolving the system using only the complex effective Hamiltonian without stochastic jumps and demonstrate that this provides a quite reliable approximation for the ground state survival probability at NLO. Finally, we make comparisons with our prior leading-order pNRQCD results and experimental data available from the ATLAS, ALICE, and CMS collaborations.

Presenter: STRICKLAND, Michael (Kent State University)

Session Classification: Session

Contribution ID: **95** Type: **not specified**

Strange Quark Matter from Baryons

Thursday, 28 July 2022 11:00 (25 minutes)

Cold and dense matter can be explored in a systematic way both in the high-density (perturbative QCD) and low-density (Chiral EFT) regime. However, the path connecting them is yet to be discovered. As a result, these descriptions are usually extrapolated into the intermediate density regime and then connected at some transition point. In this work I will present a model that has features of both, but within a unified description. The model contains hadronic degrees of freedom and is calibrated using nuclear matter properties; yet it exhibits a phase transition towards a "quark matter"phase that has approximately restored chiral symmetry, strangeness, and asymptotes to the conformal limit of the speed of sound. While this model can describe different qualitative scenarios regarding the phase transition and the strangeness onset, empirical constraints significantly narrow down the allowed parameter range. Moreover, hybrid stars above two solar masses are predicted, exhibiting a stiff "quark matter"core. This approach has implications for the hyperon puzzle and is also crucial for future exploration of inhomogeneous phases and the surface tension between hadron and quark phases.

Presenter: Mr PITSINIGKOS, Savvas (University of Southampton)

Session Classification: Session

Contribution ID: **96** Type: **Oral presentation**

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Primary author: ANDERSEN, Jens Oluf

Presenter: ANDERSEN, Jens Oluf

Contribution ID: **97** Type: **not specified**

Quantum entanglement in relativistic particle collisions

Friday, 29 July 2022 11:50 (25 minutes)

I will discuss the potential connection between the entanglement entropy of the initial state and thermodynamic entropy of the final state in relativistic particle collisions, from proton-proton to heavy ion collisions. I will show that simple fragmentation models that ignore quantum mechanical effects break down in describing particle production and that evidence for the non-universality of heavy quark fragmentation in hadron collisions shows the impact of the initial entanglement. In heavy ion processes entanglement might also give rise to a seemingly thermal behavior and thus can be linked to the entropy and particle yields in the final state.

Presenter: BELLWIED, Rene (University of Houston (US))

Session Classification: Session

Contribution ID: **98** Type: **not specified**

Equilibration of quark-gluon plasma in heavy-ion collisions

Friday, 29 July 2022 12:40 (25 minutes)

Equilibration of quark-gluon plasma in heavy-ion collisions
Not scheduled
25m
Oral presentation Session
Speaker
Dr Xiaojian Du (Bielefeld University)
Description

Non-equilibrium systems are omnipresent in nature. QCD plasma out of equilibrium and its equilibration are of particular interest given that the relativistic heavy-ion collisions (HICs) produce the non-equilibrium quark-gluon plasma (QGP) which eventually emerges to thermal hydrodynamic states. We investigate the kinetic and chemical equilibration of weakly coupled QCD plasma at finite density with a numerical implementation of QCD effective kinetic theory based on leading-order QCD, revealing the relevant equilibration pattern and turbulent nature of the QCD plasma far from equilibrium. We then show its equilibration in HICs as an attractor towards hydrodynamics. Based on that, some phenomenological applications such as pre-equilibrium dilepton production in HICs are discussed.

Presenter: DU, Xiaojian (Bielefeld University)

Session Classification: Session