

**The 20th International  
Conference on QCD in  
Extreme Conditions (XQCD  
2024)**

**Report of Contributions**

Contribution ID: 1

Type: **Oral presentation**

## Spin alignment of $K^*$ induced by strange-baryonic inhomogeneity

*Friday, July 19, 2024 4:05 PM (25 minutes)*

The difference between the spin alignments of  $K^*$  and those of  $\phi$  at the low collision energies is a puzzle raised by the recent experiments. Unlike  $\phi$  meson,  $K^*$ , carrying a unit strange charge, should react to strange chemical potential  $\mu_S$ . In this talk, I shall first convince you that  $\mu_S$  is not small in a baryon-rich medium for keeping strange neutrality, and then derive the spin alignment induced by the gradient of  $\mu_S$ , and hence of baryon chemical potential  $\mu_B$ , using linear response theory, with the transport coefficients expressed, without any approximation, in terms of the  $K^*$ 's in-medium spectral properties by employing Ward-Takahashi identity. It turns out that such an effect applies mainly to the particles whose longitudinal and transverse modes diverge, and induces only the local spin alignment in a static medium. The magnitudes of these coefficients will be further estimated under the quasi-particle approximation.

**Primary author:** LI, Feng (Lanzhou University)

**Presenter:** LI, Feng (Lanzhou University)

Contribution ID: 3

Type: **Oral presentation**

## Charm degrees of freedom in the vicinity of $T_{pc}$ from lattice QCD

*Thursday, July 18, 2024 9:45 AM (25 minutes)*

We study the nature of charm degrees of freedom in hot strong interaction matter by performing lattice QCD calculations of the second and fourth-order cumulants of charm fluctuations, and their correlations with net baryon number, electric charge and strangeness fluctuations. We show that below the chiral crossover temperature, the thermodynamics of charm can be very well understood in terms of charmed hadrons. Above the chiral transition charm quarks show up as new degrees of freedom contributing to the partial charm pressure. However, up to temperatures as high as 175 MeV charmed hadron-like excitations provide a significant contribution to the partial charm pressure.

**Primary author:** SHARMA, Sipaz**Presenter:** SHARMA, Sipaz

Contribution ID: 4

Type: **Oral presentation**

## Exploration of the Phase Diagram of (2+1)-Flavor QCD through the Study of Fluctuations of Conserved Charges with Domain Wall fermions

*Wednesday, July 17, 2024 11:30 AM (25 minutes)*

In this presentation, we explore the phase diagram of (2+1)-flavor Quantum Chromodynamics (QCD) through the study of fluctuations of conserved charges using Domain Wall Fermions (DWF). DWF are known for their better control over chiral symmetry, closely matching the symmetries of continuum QCD. This implies that studies of QCD phase transitions using DWF fall within the same universality class as those in continuum QCD, making DWF a natural choice for studying QCD phase transitions at finite temperature, chemical potential, and quark masses.

We will present our ongoing calculations of chiral observables, quark number susceptibilities, and conserved charge fluctuations for two pion masses, approximately 220 MeV and 135 MeV, using Mobius Domain Wall fermions for aspect ratios of lattices  $LT = 2$  and  $LT = 3$ , respectively. We will demonstrate that the second-order conserved charge fluctuations, while following expected features obtained using staggered fermion discretization schemes, can differ quantitatively at lower temperatures. Furthermore, we argue that these differences, particularly for the second-order electric charge fluctuations, are a consequence of the pion spectrum distortion in the staggered fermion formalism. We will also present the first calculations of the kurtosis ratio of electric charge cumulants as well as various fourth-order cumulants calculated using Mobius Domain Wall fermions.

**Primary author:** GOSWAMI, Jishnu (RIKEN Center for Computational Science)

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**Presenter:** GOSWAMI, Jishnu (RIKEN Center for Computational Science)

Contribution ID: 5

Type: **Oral presentation**

## A novel quark pairing in sQGP induced by the non-Abelian feature of the interaction

*Friday, July 19, 2024 10:10 AM (25 minutes)*

In this talk I will show you our recent results on the quark pairing gap in sQGP by solving the coupled Dyson-Schwinger equations for quark propagator and quark gluon vertex in the Nambu-Gorkov basis which is widely applied to study the color superconductivity. We acquire a quark pairing gap in chiral limit above the chiral phase transition temperature  $T_c$ . The gap persists up to  $2 - 3T_c$  and vanishes at higher temperature. Such a quark pairing characterizes the strongly coupled quark gluon plasma phase as a new phase and distinct from the phase with quasi quarks and gluons.

**Primary authors:** Prof. GAO, Fei (Beijing Institute of Technology); Mr LU, Yi (Peking University); Prof. LIU, Yuxin (Peking University)

**Presenter:** Prof. GAO, Fei (Beijing Institute of Technology)

Contribution ID: 6

Type: **Oral presentation**

## Finite temperature QCD phase transition with 3 flavors of Mobius domain wall fermions

Wednesday, July 17, 2024 11:05 AM (25 minutes)

We present an update on the study of the finite temperature QCD phase transition at zero baryon chemical potential with 3 degenerate flavors of Mobius domain wall fermions. The simulation is performed on lattice extent  $N_t = 12$  with lattice spacing  $a = 0.1361(20)$  fm, corresponding to temperature around 121(2) MeV.

We investigate a range of quark masses and two different volumes with aspect ratios  $N_s/N_t = 2, 3$ . By analyzing the renormalized chiral condensate, susceptibility and binder cumulant, we found the rapid transition at  $m_q^{\overline{\text{MS}}}(2 \text{ GeV}) \simeq 3 - 4 \text{ MeV}$  for  $T=121(2) \text{ MeV}$  is in the broad crossover transition region. Besides that, we will discuss the residual chiral symmetry breaking effect on chiral condensate and chiral susceptibilities between  $L_s = 16$  and 32.

**Primary author:** ZHANG, Yu

**Co-authors:** YASUMICHI, Aoki; HASHIMOTO, Shoji; KANAMORI, Issaku; KANEKO, Takashi; NAKAMURA, Yoshifumi

**Presenter:** ZHANG, Yu

Contribution ID: 8

Type: **Oral presentation**

# Perturbatively Confined Phase of QCD under Imaginary Rotation

*Wednesday, July 17, 2024 9:45 AM (25 minutes)*

In this talk, I will report our recent achievements based on refs. [1,2]. Below are highlights from our results.

## **Perturbative Confinement under Imaginary Rotation**

We perturbatively calculated the Polyakov loop potential at high  $T$  with *imaginary* angular velocity. Under the rapid imaginary rotation, the potential favors zero Polyakov loop, i.e. confinement. In ref. [1], we found a phase transition to confinement around  $\omega/T = i\pi/2$ . Furthermore, we argued that this perturbatively confined phase can be smoothly connected to the hadronic phase.

## **Chiral Symmetry Breaking**

In ref. [2], we introduced fermions and investigated the chiral phase transition. Our results show the spontaneous breaking of chiral symmetry in our previously found confined phase with imaginary angular velocity for any high  $T$ .

## **Inhomogeneity**

In ref. [2], we also showed that the Polyakov loop potential exhibits an inhomogeneous distribution of the Polyakov loop. There should appear a spatial interface separating the confined phase and the deconfined phase in imaginary rotating systems. Although the analytical continuation to real rotation has some subtle points, the inhomogeneity can presumably persist in real rotating systems.

[1] S. Chen, K. Fukushima, and Y. Shimada, Phys.Rev.Lett. 129 (2022)

[2] S. Chen, K. Fukushima, and Y. Shimada, arXiv:2404.00965

**Primary author:** SHIMADA, Yusuke (U Tokyo)

**Co-authors:** Prof. FUKUSHIMA, Kenji (The University of Tokyo); Dr CHEN, Shi (University of Minnesota)

**Presenter:** Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Contribution ID: 10

Type: **Poster**

## Heavy quark dynamics via Gribov-Zwanziger approach

We investigate the momentum-dependent drag and diffusion coefficient of heavy quarks (HQs) moving in the quark-gluon plasma (QGP) background. The leading order scattering amplitudes required for this purpose have been obtained using the Gribov-Zwanziger propagator for the mediator gluons to incorporate the non-perturbative effects relevant to the phenomenologically accessible temperature regime. The drag and diffusion coefficients so obtained have been implemented to estimate the temperature and momentum dependence of the energy loss of the HQ as well as the temperature dependence of the specific shear viscosity ( $\eta/s$ ) of the background medium. Our results suggest a higher energy loss of the propagating HQ compared to the perturbative estimates, whereas the  $\eta/s$  is observed to comply with the AdS/CFT estimation over a significantly wider temperature range compared to the perturbative expectation.

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**Presenter:** Mr RANA, SUMIT (IIT Roorkee)

**Session Classification:** Reception and Poster Session



Contribution ID: 11

Type: **Oral presentation**

## Pressure and speed of sound in two-flavor color-superconducting quark matter at next-to-leading order

*Thursday, July 18, 2024 3:10 PM (25 minutes)*

We investigate the thermodynamic properties of color-superconducting two-flavor quark matter at high densities and zero temperature at next-to-leading order (NLO) in the strong coupling and the gap. Assuming that the ground state of dense quark matter is a color superconductor, we calculate the pressure and the speed of sound for two massless quark flavors. Our results show that the NLO correction is comparable to the leading-order effects of the gap. In particular, we find that gap-induced corrections become increasingly relevant for both the pressure and the speed of sound. Finally, we provide a parameterization of the speed of sound and discuss generalizations of our results to three-flavor quark matter relevant to neutron stars.

**Primary authors:** GEISSEL, Andreas (TU Darmstadt); Prof. BRAUN, Jens; Dr GORDA, Tyler

**Presenter:** GEISSEL, Andreas (TU Darmstadt)

Contribution ID: 12

Type: **Poster**

## Dynamics of the conserved net-baryon density near QCD critical point within QGP profile

Searching the QCD critical point is one of the most important goals of the relativistic heavy-ion collisions. It is essential to build a realistic dynamical model near the QCD critical point and predict the characteristic signature induced by critical fluctuations in experimental measurements. By studying the dynamics of the conserved net-baryon density near critical point, it was found that both second- and fourth-order multiplicity fluctuations behave non-monotonically with respect to the increasing rapidity acceptance [1,2]. However, these works base on the assumption that the QGP fireball is homogeneous with constant temperature and chemical potential in the coordinate space, which is not realistic in the context of heavy-ion collisions. In this talk, we will present the dynamics of conserved net-baryon density near the critical point within the inhomogeneous temperature and chemical potential background, borrowing from hydrodynamic simulations [3]. With the freeze-out hyper surface obtained by the hydro simulation, we find the pronounced enhancement of multiplicity fluctuations at large rapidity, which corresponds to the early evolution of conserved net-baryon density.

[1] Miki Sakaida, Masayuki Asakawa, Hirotsugu Fujii, Masakiyo Kitazawa. Phys.Rev.C 95 (2017) 6, 064905

[2] Grégoire Pihan, Marcus Bluhm, Masakiyo Kitazawa, Taklit Sami, Marlene Nahrgang. Phys.Rev.C 107 (2023) 1, 014908

[3] Shanjin Wu and Huichao Song. In preparation.

**Primary author:** WU, Shanjin

**Co-author:** SONG, Huichao

**Presenter:** WU, Shanjin

Contribution ID: 13

Type: **Oral presentation**

## Exploring Dense QCD through Hamiltonian Lattice Simulations in (1+1) Dimensions

*Thursday, July 18, 2024 11:05 AM (25 minutes)*

We study one-flavor SU(2) and SU(3) lattice QCD in (1 + 1) dimensions at zero temperature and finite density using matrix product states and the density matrix renormalization group.

We compute physical observables such as the equation of state, chiral condensate, and quark distribution function as functions of the baryon number density.

As a physical implication, we discuss the inhomogeneous phase at nonzero baryon density, where the chiral condensate is inhomogeneous, and baryons form a crystal.

We also discuss how the dynamical degrees of freedom change from hadrons to quarks through the formation of quark Fermi seas.

**Primary authors:** NISHIMURA, Kentaro; HIDAKA, Yoshimasa (YITP, Kyoto University); HAYATA, Tomoya (Keio University)

**Presenter:** NISHIMURA, Kentaro

Contribution ID: 14

Type: **Oral presentation**

## Gauge invariance and thermodynamic stability of rotating magnetized systems

*Friday, July 19, 2024 11:30 AM (25 minutes)*

In this presentation, I revisit the Dirac theory under an external magnetic field and rotation. Motivated by experimental observations of significant vorticities in heavy ion collisions, there has been active exploration into the thermodynamics of rotating QCD matter. While the pure rotational effect has received attention, the interplay between rotation and magnetic fields remains insufficiently elucidated. In this talk, I address two significant issues present in previous formulations of rotating magnetized systems: gauge invariance and thermodynamic stability. I demonstrate that resolving both issues necessitates considering the kinetic angular momentum coupled with angular momentum. The reformulated Dirac theory presented here reproduces a well-known charged density first discovered by Hattori and Yin. Moreover, it indicates that higher-order contributions of angular velocity do not affect the charge density, providing evidence of its anomalous nature. Lastly, I offer insights into the rotational response of QCD vacuum from the perspective of the Savvidy vacuum.

**Primary author:** Prof. MAMEDA, Kazuya (Tokyo University of Science)

**Presenter:** Prof. MAMEDA, Kazuya (Tokyo University of Science)

Contribution ID: 16

Type: **Oral presentation**

# Quantum critical point from competition between Dirac Kondo effect and chiral symmetry breaking

*Thursday, July 18, 2024 10:10 AM (25 minutes)*

We discuss the QCD phase diagram in strong magnetic fields, where the chiral condensate is enhanced by the magnetic catalysis mechanism. In contrast to the conventional discussions, we include heavy-quark impurities that have been known to induce the Kondo effect. We propose a quantum critical point that arises as a consequence of the Kondo effect and the chiral symmetry breaking. Our phase diagram is obtained from a self-consistent determination of the magnitudes of the chiral condensate and the Kondo condensate, which is a particle pairing composed of conducting Dirac fermions and localized impurities. We also discuss finite-temperature effects and implications for condensed matter physics including bilayer graphene.

Koichi Hattori, Daiki Suenaga, Kei Suzuki, Shigehiro Yasui, "Dirac Kondo effect under magnetic catalysis," Phys.Rev.B 108 (2023) 24, 245110. 2211.16150 [hep-ph]

**Primary author:** HATTORI, Koichi (Zhejiang University)

**Co-authors:** SUENAGA, Daiki (RIKEN); Dr SUZUKI, Kei (JAEA); Dr YASUI, Shigehiro (Keio Univ.)

**Presenter:** HATTORI, Koichi (Zhejiang University)

Contribution ID: 17

Type: **Oral presentation**

## Radial Oscillations in Hybrid Stars: Investigating Slow Quark Phase Transition

This study delves into the radial oscillations of hybrid neutron stars, which possess a unique structure comprising hadronic external layers and a quark matter core. Using a density-dependent relativistic mean-field model incorporating hyperons and  $\Delta$  baryons to describe hadronic matter, along with a density-dependent quark model for quark matter, we explore the ten lowest eigenfrequencies and their corresponding oscillation functions. Our investigation centers on neutron stars with equations-of-state involving  $N$ ,  $N+\Delta$ ,  $N+H$ , and  $N+H+\Delta$ , featuring a phase transition to quark matter.

A key focus is on the effects of a slow phase transition at the hadron-quark interface. We observe that the maximum mass is reached before the fundamental mode's frequency decreases for slow phase transitions. This observation suggests the stability of stellar configurations with higher central densities than the maximum mass, termed Slow Stable Hybrid Stars (SSHs), even under minor radial perturbations. The length of these SSH branches depends on the energy density jump between the two phases and the stiffness of the quark EoS.

References:

1. Radial Oscillations of Hybrid Stars and Neutron Stars including Delta baryons: The Effect of a Slow Quark Phase Transition, arXiv:2401.07789v2 (2024).

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**Presenter:** RATHER, Dr. ISHFAQ AHMAD (Institute for Theoretical Physics, Goethe University, 60438 Frankfurt am Main, Germany)

Contribution ID: 18

Type: **Poster**

## Chiral symmetry for an accelerated and rotated observer

In the relativistic heavy ion collision experiment, there exist a large acceleration and rapid rotation in the non-central collision which can be considered as a system with acceleration and rotation. According to the Hawking-Unruh effect, the accelerated observer sees himself in a system with Unruh temperature  $T/2\pi$ . And the color glass condensate picture predicts that in heavy ion collision the particle under a strong color-electric field with strength  $E \sim Q_s^2/g$  ( $Q_s$  is the saturation scale, and  $g$  is the strong coupling) which will provide a typical acceleration  $a \sim Q_s \sim 1\text{GeV}$  such that the Unruh temperature  $T \sim 200\text{MeV}$  which is large than the pseudo-critical temperature for QCD phase transition. It means that the Unruh effect may play an important role in QCD phase transition. The chiral symmetry breaking and restore for an accelerating observer have been discuss in the past study. As the QGP is the most vortical fluid, QCD matter under rotation has attracted many attentions. In this work we study the chiral symmetry for an observer under both acceleration and rotation.

We study the chiral condensate as observed by an accelerating and rotating observer using field theory in general spacetime. We develop the formalism to calculate the chiral condensate using the Nambu-Jona-Lasinio model in accelerating and rotating frame. We solve the gap equation and obtain the chiral condensate as a function of proper acceleration and angular velocity. We also defined a critical acceleration  $a_c$  where the chiral symmetry restore. As one of our main results,  $a_c$  as a function of rotation angular velocity  $\omega$  was obtained. And we also study the constituent quark mass and neutral pion condensate in the case with the presence of  $a \cdot \omega$ . Like the case in parallel electromagnetic field, we observe a chiral rotation form the  $\sigma$ -direction toward the  $\pi$ -direction.

**Primary author:** ZHU, Zhibin

**Co-author:** Prof. HUANG, Xu-Guang

**Presenter:** ZHU, Zhibin

**Session Classification:** Reception and Poster Session

Contribution ID: 19

Type: **Oral presentation**

## Spin Alignment Induced by Curvature of Freezeout Hypersurface

*Friday, July 19, 2024 4:30 PM (25 minutes)*

We derive a Cooper-Frye-type formula for the spin alignment of spin-1 bosons at local thermal equilibrium described by a grand canonical ensemble specified by temperature, fluid velocity, and spin potential. We develop a set of Feynman rules to evaluate the Wigner function order by order in space-time gradient.

We assume that the vector mesons freeze out on a space-like hypersurface in the Minkowski space-time that is close to a hyperplane. We find that the leading order of the spin alignment is proportional to the curvature of the hypersurface and the hydrodynamic fields at first-order space-time gradient, such as thermal shear. It is a non-dissipate mechanism that induces spin alignment proportional to the hydrodynamic fields with the first-order space-time gradient.

**Primary author:** ZHANG, Zhong-Hua (Fudan University)

**Co-author:** Prof. HUANG, Xu-Guang (Fudan University)

**Presenter:** ZHANG, Zhong-Hua (Fudan University)



Contribution ID: 20

Type: **Oral presentation**

## **Mass spectra of neutral mesons ( $K_0$ , $\pi_0$ , $\eta$ , $\eta'$ ) and the related QCD phase transitions under strong magnetic fields**

*Friday, July 19, 2024 11:05 AM (25 minutes)*

Mass spectra of light mesons ( $K_0$ ,  $\pi_0$ ,  $\eta$ ,  $\eta'$ ) under external magnetic fields are investigated in temperature-baryon chemical potential plane by using quark model. We observe that there appear mass jumps for mesons at their Mott transitions, which are induced by the Landau levels of their constituent quarks. The critical temperature of the Mott transition shows different behaviors, which first decreases and then increases with magnetic fields for  $\pi_0$  meson, decreases monotonically for  $K_0$  meson, but increases monotonically for  $\eta$  meson. We will also discuss the chiral symmetry restoration and  $UA(1)$  symmetry restoration phase transition in terms of mesons.

**Primary author:** Prof. SHIJUN, mao (Xi'an Jiaotong University)

**Presenter:** Prof. SHIJUN, mao (Xi'an Jiaotong University)

Contribution ID: 22

Type: **Poster**

## Spin-alignment of $J/\psi$ meson: Dissociation mechanism of magnetic interaction

Recently, ALICE first measured the spin polarization of the  $J/\psi$  with respect to the event plane. To explain the experiment, we considered a possible mechanism for the spin alignment of  $J/\psi$  — gluon dissociation, in which flow induce spin alignment. This spin dependent process contains chromo-magnetic coupling between  $J/\psi$  and gluon, and the dissociation rate may contribute to the spin alignment.

**Primary author:** LIN, Shu

**Co-author:** CHEN, Zhishun (SYSU)

**Presenter:** CHEN, Zhishun (SYSU)

**Session Classification:** Reception and Poster Session

Contribution ID: 23

Type: **Poster**

## Dilepton production rates from charged pion-pair annihilations on inhomogeneous chiral condensates

In the context of study of QCD phase diagram, the possibility of inhomogeneous chiral condensed phase in low-temperature and high-density regions has been discussed using the low-energy effective theory of QCD such as the Ginzburg-Landau theory, the Nambu-Jona-Lasinio model and so forth. It has also been pointed out that the dispersion relations of Nambu-Goldstone bosons may change in this phase. Therefore, the dilepton production rates such as the electron-positron pair production rates from charged pion-pair annihilations in the inhomogeneous chiral condensed phase are also expected to be modified as compared with those in the usual vacuum, and this modification may be considered as one of the possible experimental signatures for the existence of the inhomogeneous chiral condensed phase.

In this study, we assume a dual chiral density wave as an inhomogeneous chiral condensate, and start from a low energy effective Lagrangian expanded with respect to the order parameter based on  $O(4)$  symmetry up to the sixth order because of the low-energy effective model of QCD. We, then, derive the dispersion relations of the Nambu-Goldstone modes in inhomogeneous chiral condensed phase. As a result, the derived dispersion relation is anisotropic and may contain higher-order terms of momentum than those derived in the usual homogeneous condensed phase.

Using the dispersion relation of the Nambu-Goldstone modes obtained by our model, we calculate dilepton production rates from charged pion-pair annihilation as a function of an invariant mass. We show how the obtained results may be modified compared with the results of dilepton production rates in the homogeneous chiral condensed phase.

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**Presenter:** HAYASHI, Kentaro (Kochi University)

**Session Classification:** Reception and Poster Session

Contribution ID: 24

Type: **Oral presentation**

## QCD topology with extreme electromagnetic fields

*Wednesday, July 17, 2024 4:30 PM (25 minutes)*

We present the first non-perturbative determination of the magnetic field dependence of the QCD topological susceptibility for temperatures in the crossover region from Lattice QCD. At low temperatures we observe that the sum rule that relates the magnetic field dependence of the susceptibility and the chiral condensate is maintained well beyond the weak magnetic field limit. Furthermore we will also discuss our recent progress regarding the non-perturbative determination of the QCD contributions to the axion-photon coupling.

**Primary authors:** Dr BRANDT, Bastian (University of Bielefeld); Prof. ENDRÓDI, Gergely; Dr MARKÓ, Gergely (University of Bielefeld); HERNÁNDEZ HERNÁNDEZ, José Javier (University of Bielefeld); Dr PANNULLO, Laurin (Bielefeld University)

**Presenter:** HERNÁNDEZ HERNÁNDEZ, José Javier (University of Bielefeld)

Contribution ID: 25

Type: **Oral presentation**

## Towards a “bottom-up” construction of quantum kinetic theory with spin

*Friday, July 19, 2024 11:55 AM (25 minutes)*

Quantum Kinetic Theory (QKT) is a versatile tool for studying quantum effects in various many-body systems, including Quark-Gluon Plasma in a weakly coupled regime. Such a theory is commonly obtained from a “top-down” approach, starting from a microscopic theory and deriving the equation of motion for the distribution function. In this talk, we propose a “bottom-up” effective theory approach to formulate kinetic theory with spin. The low-energy effective degrees of freedom in SKT are identified as the spin averaged and spin-dependent distribution function. In the spirit of effective theory, the kinetic theory includes the equation of motion for those distribution functions as well as the constitutive relation connecting them to observables. We compare the resulting quantum kinetic theory with those constructed from the “top-down” approach. We also demonstrate the matching between our kinetic theory’s description and that from the real-time field theory calculations.

**Primary authors:** Dr YIN, Yi (Institute of modern physics, Chinese Academy of Sciences); MO, Zonglin

**Presenter:** MO, Zonglin

Contribution ID: 27

Type: **Oral presentation**

# Chiral Kinetic Theory in Curved Space Revisited and Radiative Corrections

*Friday, July 19, 2024 9:45 AM (25 minutes)*

It is usually believed that physics in off-equilibrium state can be equivalently studied using equilibrium state with suitable metric perturbation. We point out it is not the case for spin polarization phenomena: the existing chiral kinetic theory in curved space fails to recover all the couplings between spin and hydrodynamic gradients [1]. We present a new form of chiral kinetic theory in curved space, in which the equivalence is established [2]. The equivalence allows us to formulate spin polarization in hydrodynamic medium as a scattering problem, which is then studied using in-medium form factors [3,4]. We find radiative corrections to all couplings between spin and hydrodynamic gradients. Implications for local spin polarization of Lambda hyperon will be discussed.

[1] Y.-C. Liu, L.-L. Gao, K. Mameda and X.-G. Huang, Phys.Rev.D 99 (2019) 8, 085014

[2] J. Tian and S. Lin, to appear

[3] S. Lin and J. Tian, Acta Phys.Sin. 72 (2023) 7, 071201

[4] S. Lin and J. Tian, Eur.Phys.J.Plus 139 (2024) 2, 109

**Primary author:** LIN, Shu

**Co-author:** TIAN, Jiayuan (Sun Yat-sen University)

**Presenter:** LIN, Shu

Contribution ID: 28

Type: **Poster**

## Anomalous Hall instability in chiral magnetohydrodynamics

The quark gluon plasma(QGP) is expected to exhibit a chiral imbalance known as the chiral anomaly which induces various anomalous currents, such as: the chiral magnetic effect(CME), the chiral vortical effect(CVE) , the anomalous Hall effect(AHE) and so on. To describe these anomalous effects, one can use the chiral magnetohydrodynamics (CMHD).

We study the collective excitations and instabilities in a CMHD and focus on the anomalous Hall instability(AHI) which is due to the AHE in this talk.

Like the CME's instability, the AHI is dependent on the value of  $k$  and appears in a limited scope which is decided by the AHE coefficient  $\xi_H$ . Notably, the AHE does not trigger an instability by itself in a pure electrodynamic context without fluid, but it does in the CMHD. For small  $k$  expansion, we show that the Alfvén wave modified by the AHE leads to an unstable solution. In particular, one can introduce an axion field  $\theta(x)$  which interacts with the electromagnetic field in the form of  $\theta E \cdot B$ , to reproduce the AHE  $\nabla \theta \times E$ , the chiral chemical potential  $\mu_5(x) \equiv \partial_t \theta$ , where  $E, B$  are electric and magnetic fields, the AHE coefficient is  $\xi_H \equiv \nabla \theta$ . Because the AHI happens in a small scope and the total helicity is conserved, these give rise to a novel type of inverse cascade: the fermionic helicity will be transferred to various helicities of the small  $k$  modes. Then the AHI ceases eventually by depleting the value of  $\mu_5, \xi_H$ .

Finally, we briefly discuss three different instabilities such as: the chiral plasma instability(CPI), the chiral magnetovortical instability(CMVI), the AHI and the possible relevance in QGP and other physical systems.

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**Co-author:** Prof. HUANG, Xu-Guang

**Presenter:** WANG, Shuai (Fudan University)

**Session Classification:** Reception and Poster Session

Contribution ID: 29

Type: **Oral presentation**

## Critical dynamics of phase transition in the QCD phase diagram within the real-time fRG approach

*Wednesday, July 17, 2024 11:55 AM (25 minutes)*

The Schwinger-Keldysh functional renormalization group (fRG) is employed to investigate critical dynamics of Model A and Model H that is related to second-order phase transition in the QCD phase diagram. The purely dissipative relaxation of a non-conserved field is described in Model A. The effective action of model A is expanded to the order of  $O(\partial^2)$  in the derivative expansion for the  $O(N)$  symmetry. A conserved order parameter coupled to transverse momentum density is contained in Model H which describes the gas-liquid and binary-fluid transitions. According to the dynamic scaling analysis, Model H and QCD critical end point belong to the same dynamic universality class in the critical region. The higher-order correction of the transport coefficient  $\bar{\lambda}$  and shear viscosity  $\bar{\eta}$  coming from the mode-couplings contribution are obtained by calculating the two-point correlation functions. Finally, the dynamical critical exponent  $z$  are obtained as a function of the spatial dimension  $d$ .

**Primary author:** CHEN, Yong-ru (Dalian University of Technology)

**Co-authors:** Dr TAN, Yang-yang (Dalian University of Technology); Prof. FU, Wei-jie (Dalian University of Technology)

**Presenter:** CHEN, Yong-ru (Dalian University of Technology)



Contribution ID: 30

Type: **Poster**

## Dissociation Reactions of Large- $p_T$ Charmonia

In this talk I will discuss dissociation of large-momentum charmonia with light mesons in hadronic matter. Momenta of charmonia created in Pb-Pb collisions at the CERN Large Hadron Collider are so large that three or more mesons may be produced when the charmonia collide with light mesons in hadronic matter. We study the meson-charmonium collision in a mechanism where the collision produces two quarks and two antiquarks; the charm quark then fragments into charmed mesons, and the other three constituents as well as quarks and antiquarks created from vacuum give rise to two or more mesons. The absolute square of the transition amplitude for the production of two quarks and two antiquarks is derived from the S-matrix element, and cross-section formulas are derived from the absolute square of the transition amplitude and charm-quark fragmentation functions. With a temperature-dependent quark potential, we calculate unpolarized cross sections for inclusive  $D^+$ ,  $D^0$ ,  $D_s^+$ , or  $D^{*+}$  production in scattering of charmonia by  $\pi$ ,  $\rho$ ,  $K$ , or  $K^*$  mesons. At low center-of-mass energies of the charmonium and the light meson, the cross sections are very small. At high energies the cross sections have obvious temperature dependence and are comparable to peak cross sections of two-to-two meson-charmonium reactions. This study has been published in Phys. Rev. C106 (2022) 054901.

**Primary author:** Dr PAN, Yihao (Jiangxi University of Science and Technology)

**Co-authors:** Mr SHI, Wenhao (Shanghai University); Prof. XU, Xiaoming (Shanghai University); Prof. WEBER, H. J. (University of Virginia)

**Presenter:** Dr PAN, Yihao (Jiangxi University of Science and Technology)

**Session Classification:** Reception and Poster Session

Contribution ID: 31

Type: **Oral presentation**

# Real-time dynamics of pseudo-Goldstone and critical mode in QCD

*Friday, July 19, 2024 3:10 PM (25 minutes)*

The low energy QCD matter can be effectively described by  $O(4)$  model. The spontaneous breaking of approximate symmetries gives rise to emergent pseudo-Goldstone modes and a radial  $\sigma$  mode. It has been proposed that the damping of pseudo-Goldstone modes at finite temperatures is universally constrained in the way that  $\Omega_\varphi/m_\varphi^2 \simeq D_\varphi$  in the broken phase, where  $\Omega_\varphi$  and  $m_\varphi$  are the relaxation rate at zero wavenumber and the mass of pseudo-Goldstones,  $D_\varphi$  is the Goldstone diffusivity in the limit of purely spontaneous breaking. We find that, away from the critical temperature, the proposed relation is always valid. When the temperature is very close to the critical value the pseudo-Goldstone damping displays a novel scaling behavior that follows  $\Omega_\varphi/m_\varphi^2 \propto m_\varphi^{\Delta_\eta}$  with a correction  $\Delta_\eta$  controlled by the critical fluctuations and obeying the critical universalities. Near the critical temperature the radial mode emerges as the critical mode. We analyze the relaxation dynamics by incorporating the effective potential and transport coefficients derived from first-principles fRG-QCD calculations. Our results indicate that once away from the critical point, the relaxation time of the critical mode decreases dramatically. Specifically, along the freeze-out line, the relaxation time remains mild. Consequently, the non-equilibrium dynamics have limited effects on observables along the freeze-out line.

**Primary author:** TAN, Yang-yang (Dalian University of Technology)

**Co-authors:** CHEN, Yong-rui; Dr YIN, Shi; Dr HUANG, Chuang (Dalian University of Technology); Prof. LI, Wei-jia (Dalian University of Technology); FU, Wei-jie (Dalian University of Technology)

**Presenter:** TAN, Yang-yang (Dalian University of Technology)

Contribution ID: 32

Type: **Poster**

## Fierz-complete four-quark interactions within fRG-QCD

This work is based on 2+1 flavor quantum chromodynamics (QCD) calculations within the functional renormalization group (fRG) approach. We calculate the four-fermi interaction of QCD under the Fierz-complete basis, and improve the flow equations of dynamical hadronization. We also calculate the contributions of different four-fermi channels under finite temperature and density, split the Yukawa couplings to scalar and pseudo-scalar channels. Finally, we study their effects on the phase structure of QCD.

**Primary author:** WANG, Zining (Dalian University of Technology)

**Presenter:** WANG, Zining (Dalian University of Technology)

**Session Classification:** Reception and Poster Session

Contribution ID: 34

Type: **Poster**

## Rotational effect of $J/\psi$ particle dissociation

ALICE collaboration observed the spin polarization of  $J/\psi$  particles with respect to the event plane, finding less particles in the spin zero states. A possible explanation is the spin dependent dissociations of prompt  $J/\psi$  in the quark-gluon plasma. we consider the effect of vorticity on the dissociation rate in the dominant inelastic scattering process. Using quark and gluon propagators from the quantum kinetic theories, we find correction to dissociation first order in vorticity.

**Primary authors:** LIN, Shu; YUHAO, Liang

**Presenter:** YUHAO, Liang

**Session Classification:** Reception and Poster Session

Contribution ID: 35

Type: **Poster**

## One-pion exchange potential in a strong magnetic field

The properties of QCD matter in a strong magnetic field have attracted much attention because of their relevance to the physics of relativistic heavy-ion collisions and magnetars. For example, the effects of magnetic fields are intensely studied in both single-body and many-body problems, such as modifications of the hadron mass spectrum and the QCD phase diagram. On the other hand, recent progress in lattice QCD and femtoscopy has enabled more direct investigations of hadron-hadron interactions. Given these developments, it is now timely to investigate the hadron-hadron interaction in the presence of strong magnetic fields.

In this study, we analyze how a strong magnetic field affects the long-range behavior of the nuclear force, specifically the one-pion exchange potential. Based on chiral perturbation theory in magnetic fields, we demonstrate that the potential between the proton and neutron is strongly modified, acquiring anisotropy due to charged pion exchange.

**Primary author:** MIURA, Daiki (Niigata University)

**Co-author:** Dr HONGO, Masaru (Niigata University)

**Presenter:** MIURA, Daiki (Niigata University)

**Session Classification:** Reception and Poster Session

Contribution ID: 36

Type: **Oral presentation**

## The interplay of hydrodynamics and fluctuations

*Friday, July 19, 2024 2:45 PM (25 minutes)*

Fluctuations are ubiquitous phenomena emerging across all physical length scales and play a crucial role in determining properties and dynamics when the system's degrees of freedom are notably finite. Such extreme conditions can be achieved in heavy-ion collision experiments, where fluctuations are important measures of collectivity and criticality. We focus on non-equilibrium fluctuations integrated into hydrodynamics —an interplay of long-wavelength effective theory and additional non-hydrodynamic modes. This integration leads to a deterministic and covariant description of fluctuation dynamics through a closed set of nonlinear differential equations for n-point correlation functions involving full hydrodynamic degrees of freedom. I will discuss recent progress and future challenges within this general formalism.

**Primary authors:** Prof. BASAR, Gokce (University of North Carolina, Chapel Hill); YEE, Ho-Ung (University of Illinois at Chicago); STEPHANOV, Misha (UIC); AN, Xin (National Center for Nuclear Research)

**Presenter:** AN, Xin (National Center for Nuclear Research)

Contribution ID: 37

Type: **Poster**

## Universal Love-C relation for hybrid stars with crystalline quark core

The extreme conditions within neutron stars provide a unique laboratory for probing QCD phases, like the crystalline colour superconducting (CCS) phase. We investigate the observable properties of hybrid stars (HSs) with a solid quark matter core in the CCS phase. These HS models are characterized by a sharp phase transition with a significant density discontinuity, which softens the equations of state. We found that the maximum masses and the corresponding radius of HS models with a solid core increase with larger stiffness parameterized by the speed of sound. Our results also show substantial deviations in the tidal Love number-Compactness (Love-C) relations of HS with a solid core from those for fluid neutron stars when HS models have a larger shear modulus, lower transition pressure, and large density gap. Notably, we observe a non-monotonic behaviour in the deviations of the Love-C relations of HS models as the density gap increases, which can also be found in Newtonian incompressible two-layer models. However, current observational data from events like GW170817 and measurements from NICER have not yet been able to distinguish neutron stars and HSs due to their limited sensitivity. The advancement of detectors with higher precision may help us further understand the likelihood and nature of the CCS phase in neutron stars.

**Primary author:** DONG, Zhiyuan (Central China Normal University)

**Co-authors:** YAGI, Kent (University of Virginia); Dr LAU, Shu Yan (University of Virginia)

**Presenter:** DONG, Zhiyuan (Central China Normal University)

**Session Classification:** Reception and Poster Session

Contribution ID: 39

Type: **not specified**

# Planery 1

**Session Classification:** Session 1



Contribution ID: 40

Type: **Oral presentation**

## Thermalization of the Wigner function —a real time, non-perturbative quantum simulation based on the Schwinger Model

*Thursday, July 18, 2024 11:55 AM (25 minutes)*

Thermalization of the quark gluon plasma (QGP) created in relativistic heavy-ion collisions is a crucial theoretical question in understanding the onset of hydrodynamics, and in a broad sense, a key step to the exploration of thermalization in quantum systems.

Addressing this problem theoretically, in a first principle manner, requires a real-time, non-perturbative method. To this end, we carry out a fully quantum simulation on a classical hardware, of a massive Schwinger model, which well mimics QCD as it shares the important properties such as confinement and chiral symmetry breaking. We focus on the real-time evolution of the Wigner function, namely, the two-point correlation function, which approximates quark momentum distribution, etc. Starting from a non-equilibrium initial state, the real time evolution of the Wigner functions, as well as the entanglement entropy, both demonstrate that thermalization of the quantum system is approachable. In particular, relaxation to the thermalized state depends on coupling strength, in the presence of quantum fluctuations. We also study the connection of the Wigner function thermalization to the well-known Eigenstate Thermalization.

**Primary authors:** YAN, Li (Fudan University); CHEN, Shile; Dr SHI, Shuzhe (Tsinghua University)

**Presenter:** CHEN, Shile

Contribution ID: 41

Type: **Oral presentation**

# Microscopic Encoding of Macroscopic Universality: Scaling properties of Dirac Eigenspectra near QCD Chiral Phase Transition

*Wednesday, July 17, 2024 10:10 AM (25 minutes)*

The core goal of heavy-ion collision experiments is to shed light on how the phases and properties of strong-interaction matter arise from the fundamental constituents and interactions of QCD. But even if macroscopic critical behaviors are finally established in experiments, how do they arise from the microscopic degrees of freedom, the quarks and gluons, remains to be solved. In this talk we will answer this question.

We establish a connection between the cumulants of the chiral order parameter, i.e. the chiral condensate, and the correlations among the energy levels of quarks in the background of gluons, i.e. the eigenspectra of the massless QCD Dirac operator [1]. This relation elucidates how the fluctuations of the chiral condensate arise from the correlations within the infrared part of the energy spectra of quarks, and naturally leads to generalizations of the Banks–Casher relation for the cumulants of the chiral condensate.

Then, through (2+1)-flavor lattice QCD calculations with varying light quark masses near the QCD chiral transition, we demonstrate the correlations among the infrared part of the Dirac eigenvalue spectra exhibit same universal scaling behaviors as expected of the cumulants of the chiral condensate [1]. Our study reveals how the hidden scaling features at the microscale give rise to the macroscopic universal properties of QCD. Furthermore, for higher temperatures away from the critical window we see dilute instanton gas picture goes from breakdown to restoration by investigating the correlation among Dirac eigenvalues at physical point [2], where a non-trivial region appears.

**Reference:**

- [1] H.-T. Ding, W.-P. Huang, S. Mukherjee, and P. Petreczky, Phys. Rev. Lett. 131, 161903 (2023)
- [2] H.-T. Ding, W.-P. Huang, Y. Zhang, et al., work in progress.

**Primary authors:** DING, Heng-Tong; HUANG, Wei-Ping; MUKHERJEE, Swagato; PETRECZKY, Peter

**Presenter:** HUANG, Wei-Ping

Contribution ID: 42

Type: **Poster**

## QCD EoS in non-zero baryon density and strong magnetic field

Equilibrium properties of strongly interacting matter are typically characterized by the quantum chromodynamics (QCD) equation of state (EoS). External factors, especially magnetic fields, can significantly influence this characterization. In efforts to delve deeper into these properties, we perform lattice simulations of  $(2 + 1)$ -flavor QCD using improved staggered quarks at the physical pion mass on  $32^3 \times 8$  and  $48^3 \times 12$  lattices. We explore the QCD EoS at non-zero baryon density and in strong magnetic fields, with magnitudes up to  $0.8 \text{ GeV}^2$ , using the Taylor expansion framework. We present leading order lattice QCD analysis, along with the hadron resonance gas framework comparison, for the coefficients of bulk thermodynamic quantities such as pressure, number density, energy density, and entropy density, discussing the significant impact of strong magnetic fields.

**Primary authors:** Dr KUMAR, Arpith (Central China Normal University); Prof. DING, Heng-Tong (Central China Normal University); Mr GU, Jin-Biao (Central China Normal University); Dr LI, Sheng-Tai (Central China Normal University)

**Presenter:** Dr KUMAR, Arpith (Central China Normal University)

Contribution ID: 43

Type: **Oral presentation**

## Baryon electric charge correlation as a magnetometer of QCD

Wednesday, July 17, 2024 4:55 PM (25 minutes)

We present the first lattice QCD results of quadratic fluctuations and correlations of conserved charges in (2+1)-flavor lattice QCD in the presence of a background magnetic field. The simulations were performed using the Highly Improved Staggered Quarks with physical pion mass  $m_\pi = 135$  MeV on  $N_\tau = 8$  and 12 lattices. We find that the correlation between net baryon number and electric charge, denoted as  $\chi_{11}^{\text{BQ}}$ , can serve as a magnetometer of QCD. At pseudocritical temperatures the  $\chi_{11}^{\text{BQ}}$  starts to increase rapidly with magnetic field strength  $eB$  *gtrsim*  $2M_\pi^2$  and by a factor 2 at  $eB \simeq 8M_\pi^2$ .

By comparing with the hadron resonance gas model, we find that the  $eB$  dependence of  $\chi_{11}^{\text{BQ}}$  is mainly due to the doubly charged  $\Delta(1232)$  baryon. Although the doubly charged  $\Delta(1232)$  could not be detected experimentally, its decay products, protons and pions, retain the  $eB$  dependence of  $\Delta(1232)$ 's contribution to  $\chi_{11}^{\text{BQ}}$ .

Furthermore, the ratio of electric charge chemical potential to baryon chemical potential,  $\mu_Q/\mu_B$ , shows significant dependence on the magnetic field strength and varies with the ratio of electric charge to baryon number in the colliding nuclei in heavy ion collisions. These results provide baselines for effective theory and model studies, and both  $\chi_{11}^{\text{BQ}}$  and  $\mu_Q/\mu_B$  could be useful probes for the detection of magnetic fields in relativistic heavy ion collision experiments as compared with corresponding results from the hadron resonance gas model.

**Primary authors:** KUMAR, Arpith (Central China Normal University); DING, Heng-Tong (Central China Normal University); GU, Jin-Biao (Central China Normal University); LIU, Jun-Hong (Central China Normal University); LI, Sheng-Tai (Central China Normal University)

**Presenter:** GU, Jin-Biao (Central China Normal University)

Contribution ID: 44

Type: **Poster**

## Pseudoscalar Screening Mass at Finite Temperature and Magnetic Field

We present lattice QCD results on the screening mass of pseudoscalar mesons at finite temperatures and nonzero magnetic fields. The results, which have been continuum extrapolated, are based on (2+1)-flavor lattice QCD simulations at the physical point using the HISQ/tree action, with a lattice temporal extent ranging from 8 to 16. The investigated temperature range is near the pseudocritical temperature, and the magnetic field ranges from 0 to 1 GeV<sup>2</sup>. We will discuss the dependence of the screening masses of various pseudoscalar mesons on temperature, magnetic field strength, and quark mass.

**Primary authors:** DING, Heng-Tong; THAKKAR, rishabh

**Presenter:** THAKKAR, rishabh

**Session Classification:** Reception and Poster Session

Contribution ID: 45

Type: **Poster**

## Lee-Yang edge singularities in QCD via the Dyson-Schwinger Equations

We take the Dyson-Schwinger Equation approach of QCD for the quark propagator at complex chemical potential to study the QCD phase transition. The phase transition line of the (2+1) flavor QCD matter in the imaginary chemical potential region is computed via a simplified truncation scheme, which curvature is found to be consistent with the one at real chemical potential. Moreover, the computation in the complex chemical potential plane allows us to determine the location of the Lee-Yang edge singularities. We show explicitly that the critical end point coincides with the Lee-Yang edge singularities on the real  $\mu_B$  axis. We also investigate the scaling behavior of the singularities, check its model parameters dependency and discuss the possibility of extrapolating the CEP from a certain range of chemical potential.

**Primary author:** WAN, Ziyang (Peking University)

**Co-authors:** GAO, Fei; LU, Yi (Peking University); LIU, Yuxin (Peking University)

**Presenter:** WAN, Ziyang (Peking University)

**Session Classification:** Reception and Poster Session

Contribution ID: 46

Type: **not specified**

## Chiral Effects and Astrophysics

*Friday, July 19, 2024 9:00 AM (45 minutes)*

**Presenter:** YAMAMOTO, Naoki

Contribution ID: 47

Type: **not specified**

## **Closing Remark and announcing XQCD2025**

*Friday, July 19, 2024 4:55 PM (20 minutes)*



Contribution ID: 48

Type: **not specified**

## **Yang-Lee Edge singularity and the analytical structure of QCD phase diagram**

*Thursday, July 18, 2024 9:00 AM (45 minutes)*

**Presenter:** SKOKOV, Vladimir

Contribution ID: 49

Type: **not specified**

## **Probing dense QCD matter with neutron stars**

*Thursday, July 18, 2024 2:00 PM (45 minutes)*

**Presenter:** HAN, Sophia

Contribution ID: 50

Type: **not specified**

## **Recent results on the far-from-equilibrium phase of quark-gluon matter**

*Friday, July 19, 2024 2:00 PM (45 minutes)*

**Presenter:** BOGUSLAVSKI, Kirill (TU Wien (AT))

Contribution ID: 51

Type: **not specified**

# Experimental Study of QCD Phase Structure at RHIC Beam Energy Scan

*Wednesday, July 17, 2024 2:00 PM (45 minutes)*

**Presenter:** Prof. LUO, Xiaofeng

Contribution ID: 52

Type: **not specified**

## Mixing, moats and modulations in dense QCD matter

*Wednesday, July 17, 2024 9:00 AM (45 minutes)*

Interactions in the hot and dense QCD medium give rise to extensive mixing between hadronic and gluonic degrees of freedom. The resulting mass matrix is non-Hermitian, which can lead to moat regimes with spatial modulations and instabilities towards inhomogeneous phases. I will discuss the underlying physics, implications for the QCD phase diagram and experimental opportunities.

**Presenter:** RENNECKE, Fabian (Justus Liebig University Giessen)

Contribution ID: 53

Type: **Oral presentation**

## The shear viscosity of parton matter under two-body scatterings

*Wednesday, July 17, 2024 2:45 PM (25 minutes)*

The shear viscosity  $\eta$  of a quark-gluon plasma in equilibrium can be calculated numerically using the Green-Kubo relation or analytically using several methods, including the Israel-Stewart, Navier-Stokes, relaxation time approximation, and Chapman-Enskog methods. In this study [1], we first examine these analytical methods for two-body isotropic and anisotropic scatterings and confirm that the Chapman-Enskog method is the most accurate as it agrees best with the Green-Kubo numerical results. We then apply the Chapman-Enskog method to study the shear viscosity of the parton matter in the center cell of Au+Au collisions at 200 AGeV and Pb+Pb collisions at 2.76 ATeV from a multi-phase transport (AMPT) model. At the parton scattering cross section of 3 mb that enables the transport model to reproduce bulk observables including the elliptic flow, the average  $\eta/s$  of the parton matter is found to be very small, between one to three times  $1/(4\pi)$ .

We further find that as a result of using a constant Debye mass or cross section for parton scatterings, the  $\eta/s$  ratio from the AMPT model increases with time (as the effective temperature decreases), contrary to the pQCD results that use temperature-dependent Debye masses [2]. This is one direction to improve the AMPT model. Here we also plan to show some results on extending the analytical calculation of shear viscosity to a parton matter that consists of multiple parton species under their corresponding temperature-dependent pQCD cross sections. They will lay the foundation for directly linking the parton cross sections in the model to the actual/extracted QCD shear viscosity.

[1] N. MacKay and Z.W. Lin. Eur. Phys. J. C 82, 918 (2022).

[2] P.B. Arnold, G.D. Moore, and L.G. Yaffe, JHEP 11, 001 (2000); JHEP 05, 051 (2003).

**Primary author:** LIN, Zi-Wei (East Carolina University)

**Presenter:** LIN, Zi-Wei (East Carolina University)

Contribution ID: 55

Type: **Oral presentation**

## Carving out the landscape of relativistic transport

*Wednesday, July 17, 2024 3:10 PM (25 minutes)*

I will discuss constraints posed by relativistic causality on transport properties of quantum field theories when stochastic fluctuations can be ignored.

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**Presenter:** HELLER, Michal P. (Max Planck Institute for Gravitational Physics (Albert Einstein Institute))

Contribution ID: 56

Type: **Poster**

## Estimates on the convergence of expansions at finite baryon chemical potentials

Convergence of three different expansion schemes at finite baryon chemical potentials, including the conventional Taylor expansion, the Pad\`e approximants, and the  $T'$  expansion proposed recently in lattice QCD simulations, have been investigated in a low energy effective theory within the fRG approach. It is found that the convergence of the  $T'$  expansion and the Pad\`e approximants is consistent with the conventional Taylor expansion, within the expansion orders considered in this work. Furthermore, we find that the consistent regions of the three different expansions are in agreement with the convergence radius of the Lee-Yang edge singularities.

**Primary authors:** YIN, Shi; Prof. FU, Wei-jie (Dalian University of Technology); RUI, Wen (University of Chinese Academy of Sciences)

**Presenter:** RUI, Wen (University of Chinese Academy of Sciences)



Contribution ID: 57

Type: **Poster**

## Off-equilibrium corrections to fermion spin polarization in HIC

We discuss the off-equilibrium corrections to the fermion spin polarization vectors based on quantum kinetic theory. The collisions and self-energies can both play roles in the interaction corrections: the former can be estimated via a gradient expansion of spin Boltzmann equation while the later is automatically incorporated in the perturbative solution. We will show these different corrections and their possible effects on the explanation of  $\Lambda$  local spin polarization.

**Primary authors:** YANG, Di-Lun (Institute of Physics, Academia Sinica); PU, Shi; FANG, Shuo (USTC)

**Presenter:** FANG, Shuo (USTC)

Contribution ID: 58

Type: **Poster**

## Meson Mass in a Magnetic Field at Zero Temperature from Lattice QCD

We present preliminary lattice QCD results for the masses and decay constants of the pion and kaon in a background magnetic field at zero temperature, using three different lattice sizes. Our computations are performed on (2+1)-flavor ensembles using the highly improved staggered quark (HISQ) action with physical quark masses. We utilized seven different values of the magnetic field strength, reaching up to  $\sim 1.22 \text{ GeV}^2$  ( $\sim 66 M_\pi^2$ ) in the vacuum, and three values of the lattice spacing,  $a \approx 0.056, 0.084, 0.112 \text{ fm}$ , to facilitate continuum extrapolation. The meson masses and decay constants were extracted from two-point correlation functions, as these quantities can be derived from the exponential decay behavior and amplitude of the correlation functions. Finally, we discuss the dependence of the masses and decay constants on the magnetic field to enhance our understanding of mesonic properties in strong magnetic fields.

**Primary authors:** ZHANG, Dan; DING, Heng-Tong

**Presenter:** ZHANG, Dan

Contribution ID: 59

Type: **Poster**

## Dependency of Local Operators on Gauge Fixing Precision in Lattice QCD

For gauge-dependent operators, achieving high-precision gauge fixing is crucial. However, due to the limitations of computers, achieving perfect precision is impossible. In this study, we selected several local operators and computed them at different gauge fixing precisions across various lattice spacings and fermion actions to assess the extent of this dependency. Finally, we applied an empirical formula to fit the data, allowing for the estimation of the systematic error.

**Primary author:** ZHOU, Li-Jun

**Presenter:** ZHOU, Li-Jun

Contribution ID: 60

Type: **Oral presentation**

## Baryonic Vortex and Magnetic Field Generation

*Thursday, July 18, 2024 11:30 AM (25 minutes)*

We propose a vortex carrying baryon number in low energy dense QCD with finite baryon and isospin chemical potentials. The isospin chemical potential is responsible for the charged pion condensate, among which Abrikosov vortex could arise with quantized magnetic flux. Our discovery is that when the winding of neutral pion is added, such a vortex carries a baryon number conserved by the homotopy of Skyrmion. Then the energy is reduced by a finite baryon chemical potential through the gauged Wess-Zumino-Witten term. As a result, we reveal a baryonic vortex state above critical baryon density featuring energy lower than homogeneous pion condensates. Our vortex bears a self-generated magnetic field, which indicates applicable scenarios for Magnetar cores.

**Presenter:** Dr QIU, Zebin (Keio University)

Contribution ID: **61**

Type: **not specified**

## Discussion

*Thursday, July 18, 2024 4:05 PM (1h 30m)*

Contribution ID: 62

Type: **Oral presentation**

## **A quarkyonic matter model**

*Thursday, July 18, 2024 2:45 PM (25 minutes)*

**Presenter:** Prof. KOJO, Toru (Tohoku University)

Contribution ID: 63

Type: **not specified**

## **Polarization and Spin Alignment in Heavy-Ion Collisions**

*Wednesday, July 17, 2024 4:05 PM (25 minutes)*

**Presenter:** ESUMI, Shinichi (University of Tsukuba (JP))

Contribution ID: **64**

Type: **not specified**

## Welcome

*Wednesday, July 17, 2024 8:50 AM (10 minutes)*

**Presenter:** Dr YIN, Yi (Institute of modern physics, Chinese Academy of Sciences)