XQCD 2019 (The 17th International Conference on QCD in Extreme Conditions)

Report of Contributions

https://conference-indico.kek.jp/e/76

Contribution ID: **2** Type: **Oral talk**

Pion condensation -chpt versus lattice

Wednesday, 26 June 2019 12:20 (25 minutes)

In this talk I will discuss pion condensation and the phase diagram at finite temperature and isospin density. I will present results for the quark-meson model and chiral perturbation theory. The results for the phase diagram, pressure and equation of state are compared with recent lattice results. I will also present results for pion stars that consist of a Bose condensate of pion electromagnetically neutralized by leptons.

Primary author: Prof. ANDERSEN, Jens Oluf (Norwegian University of Science and Technology)

Presenter: Prof. ANDERSEN, Jens Oluf (Norwegian University of Science and Technology)

Session Classification: Session 10

Contribution ID: **3** Type: **Poster**

Thermal Quarkonium Mass Shift from Euclidean Correlators

Monday, 24 June 2019 17:00 (20 minutes)

Brambilla et al. have derived an effective description of quarkonium with two parameters: a momentum diffusion term which has been widely explored within the community, and a real self-energy term. We derive a relation between the self-energy term and Euclidean electric field correlators along a Polyakov line, which can directly be studied on the lattice without the need for analytical continuation. We also discuss the problems in determining the correlator within the scope of the quenched QCD approximation.

Primary author: Mr ELLER, Alexander Maximilian (TU Darmstadt)

Presenter: Mr ELLER, Alexander Maximilian (TU Darmstadt)

Session Classification: Poster session

Contribution ID: **4** Type: **Poster**

QCD Topology to High Temperatures via Improved Reweighting

Monday, 24 June 2019 17:00 (20 minutes)

At high temperatures, the topological susceptibility of QCD becomes relevant for the properties of axion dark matter. However, the strong suppression of non-zero topological sectors causes ordinary sampling techniques to fail, since fluctuations of the topological charge can only be measured reliably if enough tunneling events between sectors occur. We present an improvement of a technique the we recently developed to circumvent this problem based on a combination of gradient flow and reweighting techniques and quote first results of the topological susceptibility in pure SU(3) Yang-Mills theory up to 7 T_c.

Primary author: Mr JAHN, P. Thomas (Technische Universität Darmstadt)

Presenter: Mr JAHN, P. Thomas (Technische Universität Darmstadt)

Session Classification: Poster session

Contribution ID: **5** Type: **Poster**

Thermodynamic properties of QGP at the physical point with the gradient flow method.

Monday, 24 June 2019 17:00 (20 minutes)

We study thermodynamic properties of 2+1 flavor QCD on the lattice applying the method of Makino and Suzuki based on the gradient flow, using a nonperturbatively $O(a)$-improved Wilson quark action and the renormalization group-improved Iwasaki gauge action. I report on results of the energy momentum tensor and chiral condensate obtained so far from our on-going simulations at the physical point.

Primary author: Prof. KANAYA, Kazuyuki (Tomonaga Center for the History of the Universe, University of Tsukuba)

Presenter: Prof. KANAYA, Kazuyuki (Tomonaga Center for the History of the Universe, University of Tsukuba)

Session Classification: Poster session

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

Conductivity of quark-gluon plasma in the presence of external magnetic field

Wednesday, 26 June 2019 09:45 (25 minutes)

We examine the electric conductivity of quark-gluon plasma in the presence of external magnetic field B within LQCD formulation for few temperatures in the deconfinement phase. Ensembles are generated with dynamical staggered 2+1 quarks at physical quark masses. At first we measure the electromagnetic current-current Euclidean correlators along and perpendicular to the magnetic field, then extract the conductivity via analytical continuation within the Backus-Gilbert method. We obtain, that $\sigma_{\parallel}$ grows in the direction of magnetic field and $\sigma_{\perp}$ decreases. Thus we observe the Chiral Magnetic Effect in quark-gluon plasma.

Primary author: Dr NIKOLAEV, Aleksandr (Swansea University)

Presenter: Dr NIKOLAEV, Aleksandr (Swansea University)

Session Classification: Session 9

Contribution ID: **7** Type: **Invited talk**

Studying the QCD phase diagram in RHIC-BES at STAR

Tuesday, 25 June 2019 09:00 (45 minutes)

Exploring the QCD phase structure is one of the ultimate goals of high-energy heavy-ion colliding experiments. At BNL-RHIC, the Beam Energy Scan (BES-I) program was carried out from 2010 to 2014, and many data sets have been collected by the STAR experiment in various collision energies from $\sqrt{s_{NN}} = 200$ GeV down to 7.7 GeV in Au+Au collisions. In order to reduce the uncertainties in the interested energy region ($7.7 < \sqrt{s_{NN}} < 19.6$ GeV), the BES-II program is scheduled for 2019-2021. In this talk, we present the BES-I results on hadron spectra, directed flow and higher-order cumulants of conserved charges which covers the physics issues of the freeze-out, first-order phase transition and the searching for the QCD critical point, respectively. The current status of BES-II and the future prospects for the fixed-target program will be also discussed.

Primary author: Dr NONAKA, Toshihiro (Central China Normal University)

Presenter: Dr NONAKA, Toshihiro (Central China Normal University)

Session Classification: Session5

Contribution ID: **8** Type: **Poster**

Linked cluster expansion method for the SU(3) spin models

Monday, 24 June 2019 17:00 (20 minutes)

An $SU(3)$ spin model is often used in the literature as a first step to deal with QCD at finite chemical potential. It approximates full lattice QCD in the strong coupling and large fermion-mass limit. We describe a series expansion method called Linked Cluster Expansion (LCE), and how to apply it to the spin model. The results are series of several couplings, which we analyze by generalized Padé approximants, called Partial Differential Approximants (PDAs). This method allows complex multi-critical behavior of quark matter to be investigated. We compare our results with those from complex Langevin and flux representation. We also indicate a couple of open problems.

Primary author: Mr PHAM, Anh Quang (Goethe University Frankfurt)

Presenter: Mr PHAM, Anh Quang (Goethe University Frankfurt)

Session Classification: Poster session

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

Universal scaling of conserved charge in the stochastic diffusion dynamics

Monday, 24 June 2019 17:00 (20 minutes)

In this work, we explore the Kibble-Zurek scaling of the conserved charge, using the stachastic diffusion dynamics. After determining the characteristic scales τ_{KZ} and l_{KZ} and properly rescaling the traditional correlation function and cumulant, we construct universal functions for both the two-point correlation function $C(y_1 - y_2; \tau)$ and second-order cumulant $K(\Delta y, \tau)$ of the conserved charge in the critical regime, which are insensitive to the initial temperature and a parameter in the mapping between 3D Ising model and the hot QCD system near the critical point.

Primary author: Mr WU, Shanjin (Peking University)

Presenter: Mr WU, Shanjin (Peking University)

Session Classification: Poster session

Contribution ID: **10** Type: **Poster**

Logarithms in perturbation theory – NNNLO pressure of cold and dense QCD

Monday, 24 June 2019 17:00 (20 minutes)

I will present results on computing the pressure of cold and dense QCD matter to high loop orders in perturbation theory. Such high-order computations are made possible by resumming contributions from the soft degrees of freedom. In particular, I will cover the computation of the nonanalytic logarithmic terms appearing at NNNLO for $T = 0$, both the leading logarithm based on a paper from 2018 (Phys.Rev.Lett. 121 (2018) no.20, 202701) as well as a work-in-progress computation for obtaining the subleading logarithmic term, which gets distinct contributions from both the resummed soft sector as well as the hard sector.

Primary author: Mr SAPPI, Matias (University of Helsinki)

Presenter: Mr SAPPI, Matias (University of Helsinki)

Session Classification: Poster session

Contribution ID: **11** Type: **Oral talk**

Neutron star equations of state and quark-hadron continuity

Monday, 24 June 2019 11:50 (25 minutes)

The properties of dense QCD matter are delineated through the construction of equations of state which should be consistent with QCD calculations in the low and high density limits, nuclear laboratory experiments, and the neutron star observations. These constraints, together with the causality condition of the sound velocity, are used to develop the picture of hadron-quark continuity in which hadronic matter continuously transforms into quark matter (modulo small 1st order phase transitions). The resultant unified equation of state at zero temperature and - equilibrium, which we call Quark-Hadron-Crossover (QHC18 and QHC19), is consistent with the measured properties of neutron stars and in addition gives us microscopic insights into the properties of dense QCD matter.

Primary author: Prof. KOJO, Toru (Central China Normal University)

Presenter: Prof. KOJO, Toru (Central China Normal University)

Session Classification: Session 2

Contribution ID: **12** Type: **Poster**

Order of the color superconducting phase transition

Monday, 24 June 2019 17:00 (20 minutes)

We investigate via the functional renormalization group the order of the color superconducting phase transition. We calculate the flow of the gauge coupling in a 3d Ginzburg-Landau theory and investigate whether it supports the existence of infrared stable fixed points.

Primary author: Dr FEJOS, Gergely (Keio University)

Presenter: Dr FEJOS, Gergely (Keio University)

Session Classification: Poster session

Contribution ID: **13** Type: **Invited talk**

Novel transport phenomena with chirality, vorticity and magnetic field

Tuesday, 25 June 2019 14:35 (45 minutes)

By colliding heavy ions at high energies, physicists are able to "break up" nuclear particles like protons and neutrons and create a hot "subatomic soup", the quark-gluon plasma (QGP). In recent years, there have been significant interests and progress on the spin degrees of freedom in the QGP fluid. In particular, novel transport phenomena arise from the nontrivial interplay between quark spin and chirality with extremely strong vorticity and magnetic field in heavy ion collisions. In this talk, a number of fascinating examples will be briefly surveyed. The first is the global polarization of particle spin from fluid rotation, demonstrating "fluid spintronics" on the subatomic scale. The second is the anomalous transport phenomenon known as the Chiral Magnetic Effect (CME) that has been enthusiastically studied not only in the "subatomic swirls" but also in Dirac and Well semimetals as well as in atomic, astrophysical and cosmological systems. The talk would also give a more detailed discussion on the ongoing efforts to search for the CME in heavy ion collisions. The pertinent progress in phenomenological modelings with the recently developed tool of Anomalous-Viscous Fluid Dynamics (AVFD) framework will also be presented. We end this talk with an outlook into the potential opportunity of discovery in the isobaric collision experiment.

Primary author: Prof. LIAO, Jinfeng (INDIANA UNIVERSITY)

Presenter: Prof. LIAO, Jinfeng (INDIANA UNIVERSITY)

Session Classification: Session 7

Contribution ID: **14** Type: **Poster**

Quarkonium suppression in streaming quark-gluon plasma

Monday, 24 June 2019 17:00 (20 minutes)

Quarkonium suppression in quark-gluon plasma has been investigated since original work by Matsui and Satz [1]. This topic remains actual due to the need of quark-gluon plasma diagnostics. In fact, both quarkonium suppression in quark-gluon plasma and recombination during hadronisation remain to be key open questions [2]. The bound state of quarkonium is theoretically well investigated in the case of equilibrium quark-gluon plasma [3]. However, the experimentally produced quark-gluon plasmas is strongly non-equilibrium. Therefore, in this work we present results for the quarkonium suppression in streaming quark-gluon plasmas. For this propose we use the concept of dynamical screening using the dielectric function of collisional quark-gluon plasma.

[1] T. Matsui and H. Satz, Physics Letters 178, 416 (1986)

[2] Jurgen Schukraft, Nuclear Physics A 967, 1 (2017)

[3] R. Rapp and X. Du, Nuclear Physics A 967, 216 (2017)

Primary author: Dr MOLDABEKOV, Zhandos (Al Farabi Kazakh National University)

Presenter: Dr MOLDABEKOV, Zhandos (Al Farabi Kazakh National University)

Session Classification: Poster session

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

Applicability of the complex Langevin method to QCD at finite density

Monday, 24 June 2019 17:00 (20 minutes)

The complex Langevin method (CLM) is a promising approach to overcome the sign problem. Here we examine its applicability to QCD at finite density on a $24^3 \times 12$ lattice with four-flavor staggered fermions around the deconfinement phase transition line in the $(T - \mu)$-plane. While the CLM actually works at quite large values of μ, it fails in the confined phase, which appears at lower μ. This is due to the singular drift problem as one can understand through the generalized version of the Banks-Casher relation, which relates the Dirac zero modes to the chiral condensate. This problem was avoided in our previous work in the confined phase because of the chosen small spatial volume.

Primary author: Dr TSUTSUI, Shoichiro (RIKEN)

Presenter: Dr TSUTSUI, Shoichiro (RIKEN)

Session Classification: Poster session

Contribution ID: **16** Type: **Invited talk**

Lattice with external fields and rotation

Wednesday, 26 June 2019 09:00 (45 minutes)

Extreme environments, such as strong electromagnetic force and fast rotation, induce interesting quantum phenomena. They are relevant both for high energy experiments and for condensed matter experiments. From a theoretical point of view, we need reliable computational frameworks to investigate them. I would like to review such endeavors in lattice gauge theory.

Primary author: Dr YAMAMOTO, Arata (University of Tokyo)

Presenter: Dr YAMAMOTO, Arata (University of Tokyo)

Session Classification: Session 9

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

First study of $N_f = 2 + 1 + 1$ lattice QCD with physical domain-wall quarks at finite temperatures (Cancelled)

Wednesday, 26 June 2019 11:05 (25 minutes)

Using a GPU cluster consisting of 25 units of Nvidia DGX-1 (each unit having 8*V100 interconnected by the NVLink), TWQCD collaboration has generated the first gauge ensembles of $N_f = 2 + 1 + 1$ lattice QCD with physical domain-wall quarks on the $L_x^3 \times L_t = 64^3 \times (6, 8, 10, 12, 16)$ lattices, in the temperature range $T \simeq 200 - 550$ MeV. The lattice spacing $a \sim 0.064$~fm ($La > 4$ fm, and $M_\pi La > 3$) and the physical bare quark masses ($m_{u/d}a = 0.00125$, $m_s a = 0.04$, $m_c a = 0.55$) are determined with the zero temperature gauge ensemble resulting from the simulation of $N_f = 2 + 1 + 1$ QCD on the 64^4 lattice. In this talk, I will outline the HMC simulation and the generation of the gauge ensembles. Moreover, I will present the first physical results (e.g., topological susceptibility) extracting from these $N_f = 2 + 1 + 1$ gauge ensembles with physical domain-wall quarks at finite temperatures.

Primary author: Prof. CHIU, Ting-Wai (National Taiwan University)

Presenter: Prof. CHIU, Ting-Wai (National Taiwan University)

Session Classification: Session 10

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

The Kondo effect in dense QCD

Monday, 24 June 2019 14:40 (25 minutes)

We discuss Kondo effect occurring in dense QCD [1,2]. Based on the renormalization-group analysis, we show that effective coupling strengths between ungapped and gapped quarks in the two-flavor color superconducting (2SC) phase are renormalized by logarithmic quantum corrections, which drives the system into a strongly coupled regime [2]. This is a characteristic behavior observed in the Kondo effect, which has been known to occur in the presence of impurity catterings via non-Abelian interactions. We propose a novel Kondo effect emerging without doped impurities, but with the gapped quasiexcitations and the residual SU(2) color subgroup intrinsic in the 2SC phase, which we call the 2SC Kondo effect [2]. The Kondo effect is a consequence of the dimensional reduction near the Fermi surface, and an analogous dimensional reduction in a strong magnetic field is also known to induce similar phenomena [3, 4].

[1] Hattori, Itakura, Ozaki, Yasui, "QCD Kondo effect: quark matter with heavy-flavor impurities," Phys.Rev. D92 (2015) 065003.

[2] Hattori, Huang, Pisarski, "Emergent QCD Kondo effect in two-flavor color superconducting phase," [arXiv:1903.10953 [hep-ph]].

[3] Gusynin, Miransky, Shovkovy, "Dimensional reduction and dynamical chiral symmetry breaking by a magnetic field in (3+1)-dimensions," Phys.Lett. B349 (1995) 477-483.

[4] Ozaki, Itakura, Kuramoto, "Magnetically induced QCD Kondo effect," Phys.Rev. D94 (2016) 074013.

Primary author: Dr HATTORI, Koichi (Yukawa Institute, Kyoto University)

Presenter: Dr HATTORI, Koichi (Yukawa Institute, Kyoto University)

Session Classification: Session 3

Contribution ID: **19** Type: **Poster**

Topological susceptibility of two-color QCD at low temperature and high density

Monday, 24 June 2019 17:00 (20 minutes)

We study the chemical potential (μ) dependence of the topological susceptibility with two-color two-flavor QCD. We find that at temperature $T \sim T_c/2$, where Tc denotes the critical temperature at zero chemical potential, the topological susceptibility is almost constant until $\mu/m_{PS} = 1.6$, while at $T \sim T_c$, it decreases significantly from the $\mu = 0$ value in a high μ regime. In this work, we perform the simulation for $\mu/T \leq 16$, which covers even the low temperature and the high chemical potential regime. In this regime, we introduce a diquark source term, which is characterized by j, into the action. We also show our results for the phase diagram in a low temperature regime ($T \sim T_c/2$), which is obtained after taking the $j \to 0$ limit of physical observable.

Primary author: Dr ITOU, Etsuko (Keio University)

Presenter: Dr ITOU, Etsuko (Keio University)

Session Classification: Poster session

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

In-medium heavy quark potential from lattice QCD and the generalized Gauss-law

Tuesday, 25 June 2019 16:40 (25 minutes)

In this talk I report on recent progress in the determination of the complex heavy quark potential from lattice QCD simulations [1] and show how its temperature dependence can be captured in an analytic parametrization based on an improved generalized Gauss law model [2]. Prospects for in-medium quarkonium phenomenology are discussed.

[1] P. Petreczky, A.R., J.Weber, NPA982 (2019) 735 and in progress

[2] D. Lafferty, A.R. in preparation

Primary author: Dr ROTHKOPF, Alexander (University of Stavanger)

Presenter: Dr ROTHKOPF, Alexander (University of Stavanger)

Session Classification: Session 8

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

Relativistic quantum molecular dynamics approach for heavy-ion collisions at high baryon density region

Tuesday, 25 June 2019 15:45 (25 minutes)

A new N-body non-equilibrium transport model based on the relativistic quantum molecular dynamics (RQMD) is developed for the simulations of high energy heavy ion collisions at high baryon density regions. In this approach, hadrons interact via the sigma-omega fields in the mean-field approximation as well as the hard two-body scatterings which produce the strings and hadronic resonances in JAM transport code. We compare results on the beam energy dependence of the directed and elliptic flows with the E895,NA49 and STAR data. The relativistic mean-field theory predicts the density isomer state which is a strong first-order phase transition to the nucleon matter to the resonance matter. We investigate the effects of such strong first-order phase transition to the delta-matter on the directed flow. Our dynamical approach can be also applied to the event-by-event fluctuations. We also discuss the effects of delta-matter transition on the net-proton cumulant ratios.

Primary author: Prof. NARA, Yasushi (Akita International University)

Presenter: Prof. NARA, Yasushi (Akita International University)

Session Classification: Session 7

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

Axial kinetic theory and spin transport for massive fermions

Tuesday, 25 June 2019 15:20 (25 minutes)

In relativistic heavy ion collisions (HIC), not only a strong magnetic field but also strong vorticity could be generated. Recent observations of the polarization of Lambda hyperons have triggered intensive studies for vorticity-induced polarization and spin dynamics in relativistic fluids. However, more recent studies suggest that the spin polarization could be possibly led by non-equilibrium effects. It is thus desired to construct a quantum transport theory for investigating non-equilibrium dynamics of spin polarization for massive fermions. Based on the Wigner-function approach, we derive an axial kinetic theory (AKT) for massive fermions as modified Boltzmann equations involving quantum corrections associated with spin and chiral anomaly, which can be applied to track the phase-space evolution of both vector/axial charges and spin polarization in weakly coupled systems. Since spin of massive fermions is a dynamical degree of freedom, the AKT involves one scalar and one axial-vector kinetic equations with side-jump effects pertinent to the spin-orbit interaction. In the massless limit, the AKT also reproduces the chiral kinetic theory as a well-established quantum kinetic theory for Weyl fermions and manifests the spin enslavement in such a limit. The AKT could have various applications in different physical systems including the spin transport for strange quarks or for Lambda hyperons in HIC.

Primary author: Dr YANG, Di-Lun (Keio University)

Presenter: Dr YANG, Di-Lun (Keio University)

Session Classification: Session 7

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

Gluon propagator in two-color dense QCD: Massive Yang-Mills approach

Monday, 24 June 2019 17:00 (20 minutes)

We study the Landau gauge gluon propagators in dense two-color QCD at quark chemical potential. In order to take into account the non-perturbative effects in the infrared regime, we use the massive Yang-Mills theory which has successfully described the gluon and ghost propagators in the Landau gauge within the one-loop approximation measured on the lattice. We couple quarks to this theory and compute the one-loop polarization effects. Dense matter in two-color QCD should possesses the diquark condensate which is color-singlet, and hence neither electric nor magnetic screening effects appear at the scale less than the diquark gap. This infrared behavior explains the lattice results which show the insensitivity of screening masses to the quark density.

Primary author: Dr SUENAGA, Daiki (Central China Normal University)

Presenter: Dr SUENAGA, Daiki (Central China Normal University)

Session Classification: Poster session

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

Rotating neutron star in strong magnetic fields and the MR relations

Monday, 24 June 2019 12:15 (25 minutes)

Neutron stars are highly magnetized rotating compact stars. In 2010, a neutron star named PSR J1614-2230 has a mass of twice the solar mass (1.97±0.04M⊙). In 2013, a neutron star named PSR J0348+0432 with a mass of 2.01±0.04M⊙ was observed. Such massive neutron stars give strong constraints on the equation of state (EoS) of neutron star matter. In this study, we calculate radius of a neutron star using a perturbative prescription for various EoSs and relations of its total mass increased by magnetic fields. Also, we calculate the radius of the neutron star as a function of its total mass increased by rotation. As for the EoS, we use RMF theory. Moreover, we calculate mass-radius (MR) relation with both rotation and magnetic fields using 5 hadronic EoSs. We have the results of MR relation with both rotation and magnetic fields have the total mass of over twice the solar mass for all 5 hadronic EoSs.

Primary author: Ms WATANABE, Chinatsu (Saitama University)

Presenter: Ms WATANABE, Chinatsu (Saitama University)

Session Classification: Session 2

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

Lattice field theory with torsion

Monday, 24 June 2019 17:00 (20 minutes)

We formulate lattice field theory with dislocation. The dislocation realizes the spacetime torsion in the continuum limit. As the first application, we perform the numerical computation to analyze the generation of the current induced by the screw dislocation, which we call the "chiral torsional effect".

Primary author: Mr IMAKI, Shota (The University of Tokyo)

Presenter: Mr IMAKI, Shota (The University of Tokyo)

Session Classification: Poster session

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

Real-Time-Evolution of Heavy-Quarkonium Bound States

Tuesday, 25 June 2019 17:05 (25 minutes)

Elucidating the production process of heavy quark bound states is a central goal in heavy-ion collisions [1]. Two central questions exist: Do bound states of heavy quarks form in the early time evolution of the glasma? If so, in which time regime can that happen? An answer requires the development of a non-perturbative treatment of the real-time-dynamics of heavy quarkonia. To answer those questions we have developed a novel real-time formulation [2] of lattice NRQCD [3,4] to order $1/(aMq)^2$ where we employ a classical statistical simulation for the early-time dynamics of the gauge fields [5]. Here we present results from a simulation of heavy quarkonium dynamics in the glasma. By computing the time-evolution of spectral functions of heavy quarkonium channels we expect to identify the emergence of bound states and their formation time in the evolving glasma.

[1] G. Aarts et al., Eur. Phys. J. A 53 no.5, 93 (2017)

[2] A. L., A. Rothkopf (in preparation)

[3] G.P. Lepage et al., Phys.Rev. D 46, 4052 (1992)

[4] M. Berwein, N. Brambilla, S. Hwang, A. Vairo, TUM-EFT 74/15, 56 pp (2018)

[5] K. Boguslasvki, A. Kurkela, T. Lappi, J. Peuron, Phys.Rev. D98 no.1, 014006 (2018)

Primary author: Mr LEHMANN, Alexander (Heidelberg University and University of Stavanger)

Presenter: Mr LEHMANN, Alexander (Heidelberg University and University of Stavanger)

Session Classification: Session 8

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

Hydrodynamic fluctuations and fluctuation theorem in heavy-ion collisions

Tuesday, 25 June 2019 11:45 (25 minutes)

Recently the effects of hydrodynamic fluctuations, i.e., the thermal fluctuations of relativistic hydrodynamics, on flow observables in high-energy nuclear collisions are analyzed in event-by-event simulations by dynamical models. The statistics of the hydrodynamic fluctuations is usually determined by the fluctuation-dissipation theorem obtained in the global equilibrium. However, in expanding systems such as matter created in the experiments, the fluctuation-dissipation theorem is non-trivial. Fluctuation theorem is more general theorem that describes the probability distribution of the entropy production and is applicable to any non-equilibrium systems. We discuss the fluctuation-dissipation relation in expanding systems and its relation to the fluctuation theorem by performing the numerical simulations of non-linear relativistic fluctuating hydrodynamics assuming the Bjorken flow.

Primary author: Dr MURASE, Koichi (Sophia University)

Presenter: Dr MURASE, Koichi (Sophia University)

Session Classification: Session 6

Contribution ID: **30** Type: **Poster**

Nonrelativistic Nambu-Goldstone modes of generalized global symmetries and new dynamic critical phenomena in QCD

Monday, 24 June 2019 17:00 (20 minutes)

We study the effects of dynamical electromagnetic fields on the second-order chiral phase transition of QCD under a background magnetic field. We show that the interaction between the photon and the neutral pion through the quantum anomaly causes the type-B Nambu Goldstone (NG) mode associated with the spontaneous breaking of the generalized global symmetries. Furthermore, we find that such a novel NG mode leads to the new dynamic universality class beyond the conventional Hohenberg and Halperin's classification. We also argue a possible realization of this new dynamic universality class in 3-dimensional Dirac semimetals.

Primary author: Mr SOGABE, Noriyuki (Keio University)

Presenter: Mr SOGABE, Noriyuki (Keio University)

Session Classification: Poster session

Contribution ID: **31** Type: **Invited talk**

Correlations and probability distributions in high-energy nuclear collisions

Tuesday, 25 June 2019 09:45 (45 minutes)

I will discuss the present efforts to probe the QCD phase diagram with fluctuations and multi-particle correlations.

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

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

Session Classification: Session5

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

Quantum dissipation of quarkonium in quark-gluon plasma: Lindblad equation approach

Tuesday, 25 June 2019 17:30 (25 minutes)

In heavy ion collision experiments, quark-gluon plasma (QGP) is expected to be produced and its physical properties have been discussed. Survival probability of a quarkonium is sensitive to the Debye screening of color charges in QGP. The dynamics of quarkonia can be described by master equation for the density matrix in the open quantum system approach. In this approach, the effect of quantum dissipation can be discussed. In contrast, this effect cannot be described in a simple ''in-medium" Schroedinger equation approach. In our study, we derive the Lindblad master equation for the relative motion of a quarkonium in QGP and solve it numerically. From this, we analyze how the quantum dissipation and the center-of-mass motion of the quarkonium affect the relative motion between the heavy quark antiquark pair. Finally, we present the phenomenological implication of the quarkonium dynamical evolution by solving the master equation in the Bjorken expanding QGP where the temperature decreases with time.

Primary author: Mr MIURA, Takahiro (Osaka University)

Presenter: Mr MIURA, Takahiro (Osaka University)

Session Classification: Session 8

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

Tensor network study of two dimensional complex ϕ^4 theory at finite density

Wednesday, 26 June 2019 16:45 (25 minutes)

We study the complex ϕ^4 theory with finite chemical potential. To closely understand nontrivial effects such as the Silver Blaze phenomenon, experimental studies on the lattice will give some knowledge; however, on account of the finite chemical potential, there is a sign problem in Monte Carlo simulations. In this study, to overcome the problem, the tensor renormalization group approach is employed, and we give some numerical results surrounding the phenomena in the finite density system.

Primary author: Dr SAKAI, Ryo (Kanazawa University)

Presenter: Dr SAKAI, Ryo (Kanazawa University)

Session Classification: Session 12

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

Bulk quantities in nuclear collisions from Color Glass Condensate and hybrid hydrodynamic simulations

Monday, 24 June 2019 17:00 (20 minutes)

Starting from a running-coupling improved k_T-factorized formula of the Color Glass Condensate (CGC) framework, we calculate bulk observables in several heavy-ion collision systems. This is done in two ways: first the particle distribution is calculated directly as implied from the CGC model, and then it is compared to the case where it is instead used as initial conditions for a hybrid hydrodynamic simulation. In this way, it it possible to assess the effects of hydrodynamic and hadronic evolution by quantifying how much they change the results from a pure initial state approach and, therefore, to what extent initial condition models can be directly compared to experimental data. We find that although entropy production in subsequent hydrodynamic evolution can increase multiplicity by as much as 50%, the centrality, energy, and system size dependence of charged hadron multiplicity is only affected at the $\sim$5% level (disregarding a single overall - energy and system size independent - normalization) when compared to the pure initial state case. The parameter-free prediction for these dependencies then gives reasonable agreement with experimental data whether or not hydrodynamic evolution is included. On the other hand, our results are not compatible with the hypothesis that hydrodynamic evolution is present in large systems, but not small systems like p-Pb. Moreover, we find that hydrodynamic evolution significantly changes the distribution of momentum, so that observables such as mean transverse momentum are very different from the initial particle production, and much closer to measured data. Lastly, we point out that the onset of a hydrodynamic phase in heavy-ion collisions, along with viscous effects, could, perhaps, be further investigated by studying the centrality dependence of ratio of the mean p_T across different collision systems with similar collision energy.

Primary author: Dr VEIGA GIANNINI, Andre (Akita International University and University of Sao Paulo)

Presenter: Dr VEIGA GIANNINI, Andre (Akita International University and University of Sao Paulo)

Session Classification: Poster session

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

The chiral phase transition in (2+1)-flavor QCD

Wednesday, 26 June 2019 11:30 (25 minutes)

We present recent results on the pseudo-critical and critical behavior in (2+1)-flavor QCD close to the chiral phase transition temperature.

Primary author: Prof. KARSCH, Frithjof (Universitaet Bielefeld)

Presenter: Prof. KARSCH, Frithjof (Universitaet Bielefeld)

Session Classification: Session 10

Contribution ID: **36** Type: **Invited talk**

Current status and perspectives of complex Langevin calculations in finite density QCD

Monday, 24 June 2019 09:00 (45 minutes)

Monte Carlo studies of finite density QCD is difficult due to the notorious sign problem. As a promising approach that can avoid this problem, the complex Langevin method has been attracting attention. In particular, a practical criterion for correct convergence has been proposed, and it is found to be satisfied in certain parameter regions of finite density QCD. In this talk I will summarize our results obtained so far and discuss what one can do using this method.

Primary author: Prof. NISHIMURA, Jun (KEK)

Presenter: Prof. NISHIMURA, Jun (KEK)

Session Classification: Session 1

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

Partial deconfinement

Monday, 24 June 2019 17:00 (20 minutes)

We argue the existence of "partially deconfined phase" in some SU(N) gauge theories, that is in between the confined and deconfined phases. We characterize this phase in terms of the Polyakov line phases and study examples of theories in which the partially deconfined phase exists. We find that this phase is closely related to the Gross-Witten-Wadia phase transition. The partially deconfined phase is conjectured to be the counterpart of the small black hole phase in the context of the gauge/string duality. We also discuss possible applications in this context.

Primary author: Mr WATANABE, Hiromasa (University of Tsukuba)

Presenter: Mr WATANABE, Hiromasa (University of Tsukuba)

Session Classification: Poster session

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

A more powerful thimble approach to lattice field theories

Wednesday, 26 June 2019 14:45 (25 minutes)

Lefschetz thimbles regularisation of (lattice) field theories was put forward as a possible solution to the sign problem. Despite elegant and conceptually simple, it has many subtleties. Two major ones have to do with most relevant issues: how can one efficiently implement importance sampling on thimbles? how many thimbles should we take into account? As for the first question, since a few years we have been working on algorithms in which one takes into account (complete) steepest ascent paths. We discuss improvements we devised, in particular with respect to the flow equation (which in this approach is the main building block). In the original formulation of thimble regularisation, a single thimble dominance hypothesis was put forward: in the thermodynamic limit, universality arguments could support a scenario in which the dominant thimble (associated to the global minimum of the action) captures the physical content of the field theory. By now we know many counterexamples and we have been pursuing multi-thimble simulations ourselves. Still, a single thimble regularisation would be the real breakthrough. We report on ongoing work aiming at a substantial reduction of the number of thimbles to be taken into account (possibly being left with one single thimble).

Primary author: Prof. DI RENZO, Francesco (University of Parma & INFN)

Presenter: Prof. DI RENZO, Francesco (University of Parma & INFN)

Session Classification: Session 11

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

Catalytic effects of QCD monopoles on the phase transitions

Monday, 24 June 2019 17:00 (20 minutes)

The existence of monopoles has been theoretically predicted since P. A. M. Dirac introduced the magnetic monopole in quantum mechanics. Moreover, a large number of experiments to observe monopoles have been conducted. However, monopoles have not been detected yet. The purpose of this research is to find a clue to observe QCD monopoles which closely relate to the color confinement by experiments. To find the evidence, we add the classical fields of the monopole and the anti-monopole to the QCD vacuum and calculate the Dirac operator of the overlap fermion which preserves the exact chiral symmetry in the lattice gauge theory from the QCD vacuum. We then estimate catalytic effects of the additional monopole and anti-monopole on observables by the numerical calculations. In the study of the low temperature, we have shown that the value of the chiral condensate (defined as the minus value) decreases, the pion decay constant increases, and the masses of the light quarks and the mesons become heavy, by varying the values of the magnetic charges of the additional monopole and anti-monopole. Finally, we have discovered that the decay width of pion becomes wider and the lifetime of pion becomes shorter than the experimental results. These are the catalytic effects of monopoles in QCD (arXiv:1807.04808). In this research, we add the monopole and anti-monopole to the configurations of the finite temperature and investigate catalytic effects of monopoles in QCD on quark confinement-deconfinement phase transition, and chiral symmetry breaking and the restoration. We find that the additional monopole and anti-monopole increase the temperature of quark confinement-deconfinement phase transition, moreover, the restoration of chiral symmetry breaking does not occur, by varying the values of the magnetic charges of the additional monopole and anti-monopole. In this talk, we would like to present our preliminary results about the catalytic effects of QCD monopoles in the finite temperature.

Primary author: Dr HASEGAWA, Masayasu (Joint Institute for Nuclear Research)

Presenter: Dr HASEGAWA, Masayasu (Joint Institute for Nuclear Research)

Session Classification: Poster session

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

Non-Abelian vortices in dense QCD: quark-hadron continuity and non-Abelian statistics

Monday, 24 June 2019 15:05 (25 minutes)

Quark-hadron continuity was proposed as crossover between hadronic matter and quark matter without a phase transition, based on the matching of the symmetry and excitations in both phases. In the limit of a light strange-quark mass, it connects hyperon matter and the color-flavor-locked phase exhibiting color superconductivity. Here, we argue that three hadronic superfluid vortices must combine with three non-Abelian vortices with different colors with the total color magnetic fluxes canceled out through a junction called a colorful boojum. We prove this based on the Aharonov-Bohm phases of quarks around vortices. We then discuss non-Abelian statistics of non-Abelian vortices based on the Bogoliubov-de Gennes equation and possible application to the above continuity.

Primary author: Prof. NITTA, Muneto (Keio University)

Presenter: Prof. NITTA, Muneto (Keio University)

Session Classification: Session 3

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

On the multiple thimbles decomposition for the Thirring model

Monday, 24 June 2019 17:00 (20 minutes)

Lefschetz thimbles regularization is an elegant way to overcome the sign problem. By integrating over thimbles, where the imaginary part of the action stays constant and can be factored out, the sign problem disappears and observables of interest may be computed by Monte Carlo simulations. Still, many examples are known so far where the correct results can only be recovered by taking into account multiple thimbles; therefore one is left with the difficult task of collecting their contributions. The Thirring model is one of such examples: this theory has a rich thimble structure and it has been shown that one cannot reproduce the results of the full theory from the dominant thimble alone. Using the model as a test bench for the calculation techniques we have developed in Parma, we report preliminary results on reproducing the complete results from multiple thimbles simulations.

Primary author: Mr ZAMBELLO, Kevin (University of Parma and INFN, Gruppo Collegato di Parma)

Presenter: Mr ZAMBELLO, Kevin (University of Parma and INFN, Gruppo Collegato di Parma)

Session Classification: Poster session

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

Instability toward the chiral inhomogeneous phase with the functional renormalization

Monday, 24 June 2019 17:00 (20 minutes)

In this talk, we present our functional-renormalization-group (FRG) study of the collective excitations around the chiral phase transition line. In particular, we intensively investigate the sigma-mesonic and pionic collective modes around the QCD critical point (CP) by calculating the spectral functions with the FRG. Such an FRG study gives beyond-mean-field pictures of the collective modes since it incorporates the large fluctuations involved in the second-order phase transition. We find that one-particle excitation showing tachyonic instability in the sigma-mesonic channel appears as the quark chemical potential approaches that of the QCD CP from the hadronic phase with a fixed temperature. Such an unstable mode has finite momentum, which suggests the instability associated with the transition to the chiral inhomogeneous phase. We give an explanation for the origin of this phenomenon: The level repulsion between the one- and two-particle modes in the sigma-mesonic channel causes the instability in the one-particle mode. Since there is no such instability in the pionic channel, our result suggests the real kink crystal occurs.

Primary author: Dr YOKOTA, Takeru (High Energy Accelerator Research Organization)

Presenter: Dr YOKOTA, Takeru (High Energy Accelerator Research Organization)

Session Classification: Poster session

Contribution ID: **43** Type: **Poster**

String confinement in 2-form lattice gauge theory

Monday, 24 June 2019 17:00 (20 minutes)

We study the confinement between vortex strings in a 2-form gauge theory by using the lattice Monte Carlo simulation. We calculate the string-antistring potential from the surface operator of the 2-form gauge field in the abelian 2-form lattice gauge theory, which is dual of the abelian Higgs model in continuum limit. The linear confining potential appears in a confinement phase and it disappears in a deconfinement phase. The phase diagram of the theory is also studied.

Primary author: Dr HAYATA, Tomoya (RIKEN)

Presenter: Dr HAYATA, Tomoya (RIKEN)

Session Classification: Poster session

Contribution ID: **44** Type: **Oral talk**

Quark-hadron continuity beyond Ginzburg-Landau paradigm

Monday, 24 June 2019 15:30 (25 minutes)

Quark-hadron continuity [1] is a scenario that hadronic matter is continuously connected to color superconductor without phase transitions as the baryon chemical potential increases. This scenario is based on Landau's classification of phases since they have the same symmetry breaking pattern. We address the question whether this continuity is true as quantum phases of matter, which requires the treatment beyond Ginzburg-Landau description [2,3]. To examine the topological nature of color superconductor, we derive a dual effective theory for U(1) Nambu-Goldstone (NG) bosons and vortices of the color-flavor locked phase, and discuss the fate of emergent higher-form symmetries. The theory has the form of a topological BF theory coupled to NG bosons, and fractional statistics of test quarks and vortices arises as a result of an emergent Z3 two-form symmetry. We find that this symmetry is not spontaneously broken, indicating that quark-hadron continuity is still a consistent scenario.

[1] T. Schafer and F. Wilczek, Phys.Rev.Lett. 82 (1999) 3956-3959.

[2] Y. Hirono, Y. Tanizaki, Phys. Rev. Lett., in press [arXiv:1811.10608]

[3] Y. Hirono, Y. Tanizaki, [arXiv:1904.08570]

Primary author: Dr HIRONO, Yuji (Asia Pacific Center for Theoretical Physics)

Presenter: Dr HIRONO, Yuji (Asia Pacific Center for Theoretical Physics)

Session Classification: Session 3

Contribution ID: **45** Type: **Poster**

Chiral soliton lattice in dense matter under rotation

Monday, 24 June 2019 17:00 (20 minutes)

We study anomaly-induced effects on dense QCD matter under rotation. We show that the chiral perturbation theory under rotation has the topological term that accounts for the chiral vortical effect. We find that, due to the presence of this new term, the ground state of QCD under rotation is the chiral soliton lattice (CSL) for the neutral pion or η' meson. This state is a periodic array of topological solitons which spontaneously breaks parity and continuous translational symmetries. In particular, the CSL for the η' meson is energetically more favorable than the QCD vacuum and that of the neutral pion when the baryon chemical potential is much larger than the isospin chemical potentials.

Primary author: Mr NISHIMURA, Kentaro (Keio University)

Presenter: Mr NISHIMURA, Kentaro (Keio University)

Session Classification: Poster session

Contribution ID: **46** Type: **Oral talk**

Improved algorithms for generalized thimble method

Wednesday, 26 June 2019 15:10 (25 minutes)

Questions about quantum field theories at non-zero chemical potential and/or real-time correlators are often impossible to investigate numerically due to the sign problem. A possible solution to this problem is to deform the integration domain for the path integral in the complex plane. Sampling configurations on these manifolds is challenging. In this talk I will discuss some of these problems, present solutions we have found and the directions we are currently pursuing.

Primary author: Prof. ALEXANDRU, Andrei (The George Washington University)

Presenter: Prof. ALEXANDRU, Andrei (The George Washington University)

Session Classification: Session 11

Contribution ID: **47** Type: **Poster**

Relation between chirality imbalance and fermion pair-production under the parallel electromagnetic field

Monday, 24 June 2019 17:00 (20 minutes)

There has been recently an increasing interest for study of the chirality imbalance n_5, which is the difference between right- and left-handed fermions. The chirality imbalance is expected to be arised from the axial anomaly and plays a key role to understand anomalous transport phenomena in the hot/dense quark matter or the Dirac/Weyl semimetals under the magnetic field. One of interesting transport phenomena in the presence of chirality imbalance is the chiral magnetic effect(CME), appearance of electric current in direction of the external magnetic field. However, the electric field gives a crucial contribution to the emergence of the chirality imbalance in addition to the magnetic field. In the previous work, we have studied the chirality imbalance and the CME using the analytical solution of the Dirac equation in the constant magnetic and Sauter-type pulsed electric fields, and found that the time-dependence of the gauge field is essentially important for the production of n_5. Here, we try to extend our study to the general time-dependent electric field, and discuss a relation between n_5 and the fermion pair-production from the vacuum. In this talk, we study the time evolution of the chirality imbalance and the electric current under spatially-uniform and parallel electromagnetic field in the vacuum of massive fermion. For the time-dependence, we assume the constant magnetic field, but do not impose any specific form for the electric field with boundary conditions $E(t \to \pm\infty) \to 0$. We solve the Dirac equation and calculate vacuum expectation values of the currents with the gauge invariant regularization. In particular, we find that n_5 and CME at $t \to \infty$ are solely determined by the probability distributions of the fermion created non-perturbatively by the electric field. As a result, asymptotic forms of n_5 and CME consists of a constant part and an oscillating part independent of details of intermediate time-dependence of the gauge potential. The non-zero constant term is proportional to a relativistic velocity and the momentum distribution of the created particle, and understood as a classical analogue of the electric current. We discuss how the chirality imbalance arises and roles of the electromagnetic fields in detail.

Primary author: Mr AOI, Hayato (Tokyo University of Science)

Presenter: Mr AOI, Hayato (Tokyo University of Science)

Session Classification: Poster session

Contribution ID: **48** Type: **Poster**

Center symmetry and the sign problem of finite density lattice gauge theory

Monday, 24 June 2019 17:00 (20 minutes)

We study the phase transition of quantum chromodynamics (QCD) at finite temperature and density by focusing on the probability distribution function of quark density. The phase transition of QCD is expected to change its properties as the density changes, and the probability distribution function gives important information for understanding the nature of the phase transition. The numerical simulation of QCD at high density has the serious problem of "sign problem". In this study, we consider the center symmetry, which is important for understanding the phase transition of lattice gauge theory, and propose a method to avoid the sign problem using the symmetry. In this way, we aim to establish a method to calculate probability distribution functions of physical quantities such as quark density by numerical simulation.

Primary author: Dr EJIRI, Shinji (Niigata University)

Presenter: Dr EJIRI, Shinji (Niigata University)

Session Classification: Poster session

Contribution ID: **49** Type: **Oral talk**

Complex Langevin applied to chiral random matrix model in T-mu plane

Monday, 24 June 2019 09:45 (25 minutes)

We examine the $T-\mu$ phase diagram in the chiral random matrix model in $T-\mu$ plane by checking the correctness condition, i.e., the tail behavior of the ensemble distribution, with varying the matrix size and other model parameters.

Primary author: Dr FUJII, Hirotsugu (U Tokyo)

Presenter: Dr FUJII, Hirotsugu (U Tokyo)

Session Classification: Session 1

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

Extracting equation of state from neutron star observation using machine learning

Monday, 24 June 2019 17:00 (20 minutes)

First-principles evaluation of the dense matter equation of state is one of the longstanding problems in QCD. Owing to the advances in neutron star observations in last decade, it is now possible to evaluate the equation of state from the observational data. As it circumvent the problems that are inherent in the theory, it may put significant constraint on the theory. Here we discuss a novel method of machine learning to deduce the equation of state from a set of mass-radius observational data, which is alternative to the Bayesian analysis based on different principle. Using test data (mock observational data) we confirm that the equation of state is correctly reconstructed and this method works well. We use state of the art observational data of mass-radius measured from neutron star X-ray radiations as an input, and estimate the equation of state. We confirm that the speed of sound calculated from the equation of state is surpassing the conformal limit (1/3 of speed of light) as expected earlier. Our results are consistent with extrapolation from the conventional nuclear models and the experimental bound on the tidal deformability inferred from gravitational wave observation.

[1] Y. Fujimoto, K. Fukushima, K. Murase, Phys. Rev. D 98, 023019 (2018).

[2] Y. Fujimoto, K. Fukushima, K. Murase, arXiv:1903.03400 [nucl-th].

Primary author: Mr FUJIMOTO, Yuki (The University of Tokyo)

Presenter: Mr FUJIMOTO, Yuki (The University of Tokyo)

Session Classification: Poster session

Contribution ID: **51** Type: **Invited talk**

The interpolation approach to dense QCD and neutron-star phenomenology

Monday, 24 June 2019 11:05 (45 minutes)

Neutron stars (NSs) contain the densest observable matter in the universe. Within their cores lies QCD matter compressed to multiple times the density of common nuclei. Unfortunately, this matter is too dense to be studied from first-principles nuclear-physics calculations, and not dense enough to be studied using first-principles perturbative-QCD calculations. In this talk, I will detail a model-independent approach to bridge this unknown region of the equation of state (EOS) of NS matter. By using interpolating functions to parametrize our ignorance of the EOS between the extremes of nuclear and quark matter, and by demanding that a few robust astrophysical constraints hold for each interpolated EOS, we are able place bounds on the allowed region in pressure and energy density where the EOS of NS matter must lie. Furthermore, we are also beginning to be able to draw conclusions about the physical properties of this matter, and to address such questions as whether NSs are dense enough to contain quark matter in their cores.

Primary author: Dr GORDA, Tyler (University of Virginia)

Presenter: Dr GORDA, Tyler (University of Virginia)

Session Classification: Session 2

Contribution ID: **52** Type: **Poster**

Complex poles and spectral function of the Landau gauge gluon propagator: effects of quark flavors

Monday, 24 June 2019 17:00 (20 minutes)

The analytic structures of propagators have kinematic information and are important to understand the color confinement; in particular, the existence of complex poles is a signal of confinement for the corresponding particle. We derive general relationships between the number of complex poles of a propagator and the spectral function under some assumptions on the asymptotic behaviors of the propagator. We apply this relation to the massive Yang-Mills model, which is an effective model of the Landau gauge Yang-Mills theory, to show that the gluon propagator in this model has two complex poles. We consider the flavor effects on the analytic structure of the gluon propagator in the massive Yang-Mills model with quarks and also discuss effects of finite temperature and chemical potential towards understanding the QCD phases in relation with the analytic structures of the propagators in the Landau gauge QCD.

Primary author: Ms HAYASHI, Yui (Chiba University)

Presenter: Ms HAYASHI, Yui (Chiba University)

Session Classification: Poster session

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

Formulating relativistic hydrodynamics with spin polarization

Tuesday, 25 June 2019 12:10 (25 minutes)

Recently, there have been significant experimental progresses in observing and controlling spin-dependent bulk quantities in broad areas in physics such as relativistic heavy-ion collisions and spintronics. Although hydrodynamics is one of the most powerful theoretical frameworks to describe such macroscopic bulk quantities, its extension to a spinful fluid has not been fully developed, especially for relativistic systems. In this study, we formulate dissipative relativistic hydrodynamics with a dynamical spin degree of freedom based on the phenomenological entropy-current analysis [1]. With the help of the first and second laws of local thermodynamics, we constrain the possible constitutive relations for a relativistic spinful fluid. In addition, we perform the linear-mode analysis on the top of global thermal equilibrium, and clarify that spin density gives a non-hydrodynamic diffusive mode with a finite lifetime. This diffusive behavior is a consequence of the mutual convertibility between spin and orbital angular momentum.

[1] K. Hattori, M. Hongo, X.-G. Huang, M. Matsuo, H. Taya, "Fate of spin polarization in a relativistic fluid: An entropy-current analysis," arXiv:1901.06615

Primary author: Dr HONGO, Masaru (Keio University)

Presenter: Dr HONGO, Masaru (Keio University)

Session Classification: Session 6

Contribution ID: **54** Type: **Oral talk**

Schwinger-Keldysh formalism for Lattice Gauge Theories

Wednesday, 26 June 2019 17:10 (25 minutes)

It is important to compute transport coefficients in QCD at finite temperature and density. When the imaginary-time formalism of Lattice QCD is used, the spectral functions have to be reconstructed by supplementing certain Ansatze for correlation functions on the lattice. On the other hand, real-time Green's functions can be obtained directly in the Schwinger-Keldysh (SK) formalism. But the SK formalism has not been constructed so far for QCD non-perturbatively. In this work we formulate the SK formalism for Lattice QCD by constructing the transfer matrix in the direction of real time for gauge link field and Wilson fermion. We examine the spectral functions and other real-time Green's functions in weak gauge-coupling limit. We also obtain the Kubo formulae in this framework as a summation of the real-time Green's functions on the closed time path.

Primary author: Mr HOSHINA, Hiroki (The Univ. of Tokyo, Komaba)

Presenter: Mr HOSHINA, Hiroki (The Univ. of Tokyo, Komaba)

Session Classification: Session 12

Contribution ID: **55** Type: **Invited talk**

Partial deconfinement

Monday, 24 June 2019 16:15 (45 minutes)

We discuss a "partially deconfined phase" in SU(N) gauge theories. This phase is in between the confined and deconfined phases and is defined such that SU(M) in SU(N) (M < N) is deconfined and the rest of degrees of freedom are confined. We investigate some examples and find that in all the examples, the transition from the partially deconfined phase to completely deconfined phase has the same structure as the Gross-Witten Wadia transition. We also discuss an interesting relation between the partial deconfinement and black holes in string theory. When the partially deconfined phase is unstable, it corresponds to the phase with a small Schwarzschild black hole in string theory through the gauge/gravity duality.

Primary author: Prof. ISHIKI, Goro (University of Tsukuba)

Presenter: Prof. ISHIKI, Goro (University of Tsukuba)

Session Classification: Session 4

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

Chiral kinetic theory in curved spacetime

Monday, 24 June 2019 17:00 (20 minutes)

Many-body systems with chiral fermions exhibit anomalous transport phenomena originated from quantum anomalies. Based on quantum field theory, we derive the kinetic theory for chiral fermions interacting with an external electromagnetic field and a background curved geometry. The resultant framework respects the covariance under the U(1) gauge, local Lorentz, and diffeomorphic transformations. It is particularly useful to study the gravitational or non-inertial effects for chiral systems. As the first application, we study the chiral dynamics in a rotating coordinate and clarify the roles of the Coriolis force and spin-vorticity coupling in generating the chiral vortical effect (CVE). We also show that the CVE is an intrinsic phenomenon of a rotating chiral fluid, and thus independent of observer's frame.

Primary author: Dr MAMEDA, Kazuya (RIKEN)

Presenter: Dr MAMEDA, Kazuya (RIKEN)

Session Classification: Poster session

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

The sign problem in low dimensional QCD studied by using the path optimization

Wednesday, 26 June 2019 15:35 (25 minutes)

The sign problem, is a serious obstacle to perform the Monte Carlo simulations of QCD with finite chemical potential, is caused by the oscillation of the Boltzmann factor. To avoid this problem, we have proposed the path optimization method. In this method, we optimize the integral path in complex plain to decrease the cancellation in integral. In this talk, we explain the application of this method to gauge theory, and discuss the sign problem of low dimensional QCD.

Primary author: Mr MORI, Yuto (Kyoto University)

Presenter: Mr MORI, Yuto (Kyoto University)

Session Classification: Session 11

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

Dyon in pure SU(2) Yang-Mills theory with a gauge-invariant mass toward confinement-deconfinement phase transition

Monday, 24 June 2019 17:00 (20 minutes)

The KvBLL instantons (calorons) are extensively used to understand confinement-deconfinement phase transition in the Yang-Mills theory at finite temperature. The KvBLL instanton is a topological soliton solution of the self-dual equation of the SU(2) Yang-Mills theory on $S^1 \times R^3$ space with instanton charge, which consists of BPS dyons having both electric and magnetic charges with non-trivial holonomy at spatial infinity. Recently, we have found a novel dyon solution as a non-BPS solution of (non self-dual) field equations of a gauge-scalar model with the radially fixed scalar field in the adjoint representation. This dyon solution of the gauge-scalar model is identified with the topological field configuration of the Yang-Mills theory with a gauge-invariant gluon mass term without scalar field, which is regarded as the low-energy effective model of the Yang-Mills theory with mass gap. This follows from the gauge-independent Higgs mechanism which does not rely on the spontaneous breaking of gauge symmetry. Our dyon has the non-vanishing asymptotic value corresponding to the non-trivial holonomy at spatial infinity to be comparable with the KvBLL dyon. Thus we can propose another scenario for reproducing confinement-deconfinement phase transition in the Yang-Mills theory at finite temperature based on our dyon solution. In this poster we show the existence of such dyons and discuss the characteristic properties, especially the asymptotic holonomy.

Primary author: Dr NISHINO, Shogo (Chiba University)

Presenter: Dr NISHINO, Shogo (Chiba University)

Session Classification: Poster session

Contribution ID: **59** Type: **Poster**

Anomalous Casimir effect in axion electrodynamics

Monday, 24 June 2019 17:00 (20 minutes)

The Casimir effect is relevant for QCD physics in many contexts such as a possible origin of the dark energy, an extra pressure in the hadron bag model etc. In this talk we delve into the Casimir effect in (3+1)-dimensional Maxwell-Chern-Simons (MCS) theory aka axion electrodynamics. It is known that two bodies with reflection symmetry always have an attractive Casimir force, but this "no-go theorem" has been challenged recently. We demonstrate that a spatially inhomogeneous topological θ angle induces a repulsive Casimir force. This is a detectable effect in the topological insulator for which axion electrodynamics is the effective theory.

Primary author: Mr QIU, Zebin (University of Tokyo)

Presenter: Mr QIU, Zebin (University of Tokyo)

Session Classification: Poster session

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

Phase transitions in matrix models

Monday, 24 June 2019 17:00 (20 minutes)

We discuss new results in the BFSS matrix model and its bosonic variant.

Primary author: Dr RINALDI, Enrico (Riken)

Presenter: Dr RINALDI, Enrico (Riken)

Session Classification: Poster session

Contribution ID: **61** Type: **Oral talk**

Complex Langevin Simulations: Reliability and applications to full QCD at non-zero density

Monday, 24 June 2019 10:10 (25 minutes)

M. Scherzer, E. Seiler, D. Sexty and I.-O. Stamatescu Complex Langevin (Equation) is a well defined method providing a general instrument for ab initio, approximation free studies of realistic lattice models even for complex action. The latter include full QCD at finite density and CLE appears as the only method presently applied in this context. The complexification of the variable space required by a complex action introduces, however, special conditions to be satisfied in order to ensure correct convergence. Analyzing these conditions led to the development of procedures and criteria which allow to control the simulations and define physical reliability regions. We here develop one essential condition directly related to the correctness proof to a general criterion applicable on-line also to QCD and discuss its relation to other criteria. We also present full QCD CLE results for the transition from the confinement to the deconfined phase for $0 \leq \mu/T_c(\mu = 0) \leq 5$ and for observables vs μ at high temperature.

Primary author: Mr SCHERZER, Manuel (Institute for theoretical Physics, Heidelberg University)

Presenter: Mr SCHERZER, Manuel (Institute for theoretical Physics, Heidelberg University)

Session Classification: Session 1

Contribution ID: **62** Type: **Poster**

Exploring the QCD phase diagram via reweighting from isospin chemical potential

Monday, 24 June 2019 17:00 (20 minutes)

We investigate the QCD phase diagram close to the isospin chemical potential axis. Numerical simulations directly along this axis are not hindered by the sign problem and pion condensation can be observed at high enough values of the isospin chemical potential. The possibility of a crossover transition from this BEC phase to a BCS phase is investigated. We study how the BEC phase boundary evolves in the baryon and strangeness chemical potential directions via reweighting in the quark chemical potentials and discuss our results. Furthermore, we develop an alternative method to approach nonzero baryon chemical potentials. This involves simulations including auxiliary quarks of an extended isospin doublet and decoupling them by increasing their mass, again via reweighting.

Primary author: Mr SCHMALZBAUER, Sebastian (ITP, Goethe University)

Presenter: Mr SCHMALZBAUER, Sebastian (ITP, Goethe University)

Session Classification: Poster session

Contribution ID: **63** Type: **Poster**

Confinement/deconfinement phase transition for quarks in the higher representation in view of dual superconductivity

Monday, 24 June 2019 17:00 (20 minutes)

Dual superconductor picture is one of the most promising scenarios for quark confinement. We have proposed a new formulation of Yang-Mills theory on the lattice so that the so-called restricted field obtained from the gauge-covariant decomposition plays the dominant role in quark confinement. This framework improves the Abelian projection in the gauge-independent manner. For quarks in the fundamental representation, we have demonstrated some numerical evidences for the dual superconductivity. However, it is known that the expected behavior of the Wilson loop in higher representations cannot be reproduced if the restricted part of the Wilson loop is extracted by adopting the Abelian projection or the field decomposition naively in the same way as in the fundamental representation. Recentry, by virtue of the non-Abelian Stokes theorem for the Wilson loop operator, we have proposed suitable operators constructed from the restricted field only in the fundamental representation to reproduce the correct behavior of the original Wilson loop in higher representations. We have further demonstrated by the numerical simulation that the proposed operators well reproduce the expected behavior of the original Wilson loop average, which overcomes the problem that occurs in naively applying Abelian-projection to the Wilson loop operator for higher representations. In this talk, we focus on the the confinement and deconfinement phase transition for quarks in the higher representations at finite temperature in view of the dual superconductivity. By using our new formulation of lattice Yang-Mills theory and numerical simulations on the lattice, we extract the dominant mode for confinement by decomposing the Yang-Mills field, and we investigate the Polyakov loop average, static quark potential for both Yang-Mills field and decomposed restricted field in both confinement and deconfinement phase at finite temperature.

Primary author: Dr SHIBATA, Akihiro (Computing Research Center, KEK)

Presenter: Dr SHIBATA, Akihiro (Computing Research Center, KEK)

Session Classification: Poster session

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

The Schwinger mechanism with perturbative electric fields

Monday, 24 June 2019 17:00 (20 minutes)

I discuss spontaneous particle production from the vacuum (the Schwinger mechanism) in the presence of a strong slow electric field superimposed by a fast weak electric field. I analytically/numerically show that a QED analog of the Franz-Keldysh effect occurs, which significantly modifies the spectrum of the produced particles. I also show that a non-trivial spin-dependence appears in the production even without magnetic fields due to the intrinsic spin-orbit coupling in the Dirac equation if the weak electric field is transverse with respect to the strong electric field. Implications to experiments/observations (e.g. heavy ion collisions, lasers) and relations to the dynamically assisted Schwinger mechanism are also discussed.

[1] H. Taya "Franz-Keldysh effect in strong-field QED," PRD 99, 056006 (2019)

[2] X.-G. Huang, M. Matsuo, H. Taya, "Spontaneous generation of spin current from the vacuum by strong electric fields," arXiv:1904.07593

[3] X.-G. Huang, H. Taya, "Spin-dependent dynamically assisted Schwinger mechanism," arXiv:1904.08200

Primary author: Dr TAYA, Hidetoshi (Fudan University)

Presenter: Dr TAYA, Hidetoshi (Fudan University)

Session Classification: Poster session

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

The order of phase transition in three flavor QCD with background magnetic field in crossover regime

Wednesday, 26 June 2019 10:10 (25 minutes)

We investigate the order of phase transition in three flavor QCD with a background U(1) magnetic field using the standard staggered action with the plaquette gauge action. We perform simulations for three volumes $N_\sigma = 8, 16, 24$ with fixed mass $ma = 0.030$ and temporal extent $N_\tau = 4$, which is expected to show crossover for vanishing magnetic field. We apply physically same magnitude of magnetic field $\sqrt{eB} = 0.9$ for each volume. We measure the chiral condensates and Polyakov loop and calculate their susceptibility and Binder cumulant. We find that the transition becomes first order like transition with hysteresis in the Monte-Carlo history from crossover for non-zero magnetic field on the system.

Primary author: Dr TOMIYA, Akio (RIKEN-BNL)

Presenter: Dr TOMIYA, Akio (RIKEN-BNL)

Session Classification: Session 9

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

The Schwinger model in the canonical formulation

Wednesday, 26 June 2019 16:20 (25 minutes)

We consider the massive Schwinger model in the canonical formulation using transfer matrices in fixed fermion number sectors. The fermion contributions can be classified according to the discrete, local fermion occupation numbers which define specific fermion states. They can be used to expose the vacuum structure of the theory and the origin of the sign problem at finite fermion number density. We construct observables which can be used to calculate the ground state energy and the spectrum of the theory. Finally, we discuss the relation of the canonical formulation to the fermion loop and fermion bag formulation and comment on possible solutions to the fermion sign problem.

Primary author: Prof. WENGER, Urs (University of Bern)

Presenter: Prof. WENGER, Urs (University of Bern)

Session Classification: Session 12

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

Ginzburg-Landau theory for neutron 3P2 superfluidity in neutron stars

Monday, 24 June 2019 17:00 (20 minutes)

The neutron 3P2 superfluidity is one of the interesting phases inside the neutron stars. In this presentation, we will discuss their properties based on the Ginzburg-Landau theory derived from the tensor-type interaction between two neutrons. We will show the strong magnetic effect relevant to the magnetars, the boundary effect near the surface of the neutron stars, and some related topological properties.

Primary author: Dr YASUI, Shigehiro (Keio University)

Presenter: Dr YASUI, Shigehiro (Keio University)

Session Classification: Poster session

Contribution ID: **68** Type: **Invited talk**

The QCD critical point hunt: new dynamic framework and first simulation results

Tuesday, 25 June 2019 11:00 (45 minutes)

The on-going heavy-ion collision experiments at RHIC is scanning the baryon-rich regime of the QCD phase diagram with an unprecedented precision that would potentially discover the QCD critical point, the landmark point in the phase diagram. On the theory front, conventional hydrodynamic modeling would not be sufficient for the critical point hunt. Instead, I will present a novel theoretical framework, namely "hydro+", which couples critical fluctuations to bulk evolution of the "fireball" created in heavy-ion collisions. I will show the first results on the numerical simulations of "hydro+", and, if time is permitted, discuss the interesting connection of "hydro+" to other approaches of fluctuating hydrodynamics.

Primary author: Dr YIN, Yi (MIT)

Presenter: Dr YIN, Yi (MIT)

Session Classification: Session 6

Contribution ID: **69** Type: **Poster**

Shear viscosity of classical fields in Yang-Mills theory

Monday, 24 June 2019 17:00 (20 minutes)

The created matter in the initial stage of relativistic heavy ion collisions is described well by the classical Yang-Mills(CYM) fields. It has been shown that the dynamics of the CYM fields play a significant role in the realization of an local thermal equilibrium. In this work, we expect that the CYM fields itself have hydrodynamical property such as transport coefficient in equilibrium. We discuss the shear viscosity of the classical fields in the CYM theory using the Green-Kubo formula. We show that the time correlation function of energy-momentum tensor in equilibrium shows a monotonous decay with an exponential form and the shear viscosity can be well evaluated by the contribution from the exponential decay.

Primary author: Mr MATSUDA, Hidefumi (Graduate school of science, Kyoto university)

Presenter: Mr MATSUDA, Hidefumi (Graduate school of science, Kyoto university)

Session Classification: Poster session

Contribution ID: **70** Type: **Poster**

The sign problem and the Lefschetz thimbles in two dimensional Hubbard model

Monday, 24 June 2019 17:00 (20 minutes)

In the talk we discuss the sign problem and the possibility to alleviate it with the help of methods related to Lefschetz thimbles in the space of complexities field variables. In particular, we consider two-dimensional Hubbard model at finite density. We analyze the model on the square lattice combining semi-analytical study of saddle points and thimbles on a small lattice and results of test Monte-Carlo simulations. We investigate different representations of the path integral and find a particular representation which supposedly leads to the presence of a single dominating thimble even for large lattices. Finally, we derive a novel non-Gaussian representation of the four-fermion interaction term, which also exhibits decreased number of Lefschetz thimbles.

Primary author: Dr VALGUSHEV, Semeon (Brookhaven National Laboratory)

Presenter: Dr VALGUSHEV, Semeon (Brookhaven National Laboratory)

Session Classification: Poster session

Contribution ID: **71** Type: **Oral talk**

QCD energy-momentum tensor using gradient flow

Wednesday, 26 June 2019 11:55 (25 minutes)

We study the energy-momentum tensor in QCD for N_f = 2+1 dynamical quarks. In order to tame violation of the translational invariance on lattice we use the gradient flow method as a non-perturbative renormalization scheme. We adopt two values for the up and down quark mass. One is the physical mass with which we measure the one point function of the energy-momentum tensor and derive the equation of state in QCD. The other is a rather heavy mass of about $m_{ud} \simeq 59$ MeV with $m_\pi/m_\rho \simeq 0.63$. Using the latter gauge configuration we measure correlation functions of the energy-momentum tensor, from which we extract some transport coefficients. We also measure the chiral condensate and topological charge and study their temperature dependence.

Primary author: Dr TANIGUCHI, Yusuke (University of Tsukuba)

Presenter: Dr TANIGUCHI, Yusuke (University of Tsukuba)

Session Classification: Session 10

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

Measuring chiral susceptibility using gradient flow

Monday, 24 June 2019 17:00 (20 minutes)

We study the chiral susceptibility in $N_f = 2 + 1$ full QCD. In the
lattice gauge theory with Wilson fermion, chiral symmetry is explicitly broken. Therefore, we need a non-trivial additive correction to renormalize the chiral susceptibility. To avoid this problem, we use Gradient flow method. Gradient flow method makes us possible to define correctly renormalized chiral susceptibility without additive renormalization even if we use Wilson fermion. We measure not only disconnected diagram but also connected diagram for chiral susceptibility. This measurement is on finite temperature full QCD with $N_f = 2 + 1$ Wilson fermion, and for temperature range 178-348 MeV.

Primary author: Mr BABA, Atsushi (University of Tsukuba)

Presenter: Mr BABA, Atsushi (University of Tsukuba)

Session Classification: Poster session

Contribution ID: **73** Type: **Poster**

Quark mass generation by monopole condensation

Monday, 24 June 2019 17:00 (20 minutes)

We show that monopole quark interactions break flavor chiral SU(2) symmetry as well as chiral U(1) symmetry. The interactions induce quark masses when the monopoles condense even in the chiral limit (current quark masses vanish.) The masses are estimated to be approximately 20MeV. Thus, the pions are not massless even in the chiral limit.
Furthermore, the presence of the interactions leads to the fact that the chiral symmetry breaking and the quark confinement simultaneously arises. Because fluctuations of color electric fields are large in dense
quark matters, they expel the monopole condensation. Then, the deconfinement of quarks and the restoration of the chiral symmetry simultaneously arise.

Primary author: Prof. IWAZAKI, Aiichi (Nishogakusha University)

Presenter: Prof. IWAZAKI, Aiichi (Nishogakusha University)

Session Classification: Poster session

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

Heavy quark spectral and transport properties from lattice QCD

Monday, 24 June 2019 17:00 (20 minutes)

We will present recent results on thermal modifications of heavy quark spectral functions based on continuum extrapolated correlation functions in pure SU(3) plasma and discuss constraints for the heavy quark diffusion coefficients. Using the gradient flow technique for the color-electric field correlator in quenched as well as full QCD we will discuss the effects of dynamical fermions on the heavy quark momentum diffusion coefficient and provide first estimates on the thermal quarkonium mass shift of heavy quarks in the thermal medium.

Primary author: Dr KACZMAREK, Olaf (University of Bielefeld)

Presenter: Dr KACZMAREK, Olaf (University of Bielefeld)

Session Classification: Poster session