HK 56: Schwerionenkollisionen und QCD Phasen VII

Time: Thursday 16:30–19:00 Location: HS AP

Group Report HK 56.1 Thu 16:30 HS AP

Polyakov-loop extended Nambu–Jona-Lasinio models meeting Schwinger-Dyson equations — •Thomas Hell, Nino Bratovic, Kouji Kashiwa, and Wolfram Weise — Physik-Department, Technische Universität München, D-85747 Garching, Germany

Given the experimental data from RHIC and upcoming results from ALICE at LHC, it is timely and important to update and improve the modeling of the QCD phase diagram. We use nonlocal extensions of the Polyakov-loop-extended Nambu–Jona-Lasinio (PNJL) [1, 2] models including momentum-dependent wave-function renormalization of the quark propagator. This approach permits to establish close contacts with results from Dyson-Schwinger and lattice-QCD calculations. Both the two and three quark-flavor cases are considered. The coupling to the Polyakov loop allows us to describe the confinement-deconfinement phase transition. Introduction of a nonlocal 't Hooft-Kobayashi-Maskawa determinant generates an interaction between the up, down and strange quarks describing the anomalous breaking of the axial U(1) symmetry. The thermodynamics of these models leads to (schematic) phase diagrams for strongly interacting matter that are compared to recent lattice data.

[1] T. Hell et al., Phys. Rev. D **79**, 014022 (2009).
[2] T. Hell et al., Phys. Rev. D **81**, 074034 (2010).

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HK 56.2 Thu 17:00 HS AP

Nonlocal PNJL model and imaginary chemical ptoential — •Kouji Kashiwa[1,2], Thomas Hell[2], and Wolfram Weise[2] — [1]Kyushu University, Fukuoka, Japan — [2]Technische Universität München, Garching, Germany

In order to get constraints for the modeling of the QCD phase diagram at real chemical potential ($\mu_{\rm R}$), we investigate the phase structure of two-flavor QCD at finite imaginary chemical potential ($\mu_{\rm I}$) and temperature (T) using the nonlocal Polyakov-loop extended Nambu–Jona-Lasinio (PNJL) model including quark wave function renormalization. We show that this nonlocal PNJL model reproduces characteristic properties of QCD such as the Roberge-Weiss (RW) periodicity and the RW transition at finite $\theta = \mu_{\rm I}/T$. To reproduce lattice QCD data of crossover lines for the chiral and deconfinement transitions near $\theta = \pi/3$, we introduce additional local and nonlocal vector-type four-quark interactions in this model. These interactions have strong influences on the thermodynamics at moderate and high $\mu_{\rm R}$. Details of wave function renormalization do not affect the crossover lines, but have a significant impact on the determination of the strength of the nonlocal vector-type four-quark interaction. This work is supported by the Japan Society for the Promotion of Science for Young Scientists, by BMFT and by DFG Excellence Cluster "Origin and Structure of the Universe".

HK 56.3 Thu 17:15 HS AP

Transporteigenschaften eines NJL-Piongases — Michael Buballa, •Klaus Heckmann und Jochen Wambach — Institut für Kernphysik, TU Darmstadt

Bei niedrigen Temperaturen und Dichten im QCD Phasendiagramm ist die Dynamik von den leichtesten Freiheitsgraden, den Pionen dominiert. Die hydrodynamischen Transportkoeffizienten eines Pion-Gases lassen sich in diesem Regime mit Hilfe einer Boltzmann-Uehling-Uhlenbeck-Gleichung berechnen. Dazu sind Massen und Wechselwirkungen der Pionen zu bestimmen. Hierzu dient in dieser Arbeit das Nambu-Jona-Lasinio-Modell (NJL), welches ein effektives Modell für Quarks ist, in dem Pionen als dynamisch generierte Quark-Antiquark-Korrelationen beschrieben werden können. Die Wechselwirkung wird aus den NJL-Rechnungen zur Pion-Pion-Streulänge bestimmt. Auf diese Weise kann die Scherviskosität eines Mesonsystems mit temperaturabhängiger effektiver Masse und Wechselwirkung berechnet werden, was auch der zusammengesetzten Natur des Hadrons Rechnung trägt. Der Einfluss der chiralen Restaurierung bei endlicher Temperatur auf das Verhältnis von Scherviskosität und Entropiedichte kann ebenfalls untersucht werden.

HK 56.4 Thu 17:30 HS AP

Critical point in the QCD phase diagram and Columbia plot: role of axial U(1) anomaly at finite chemical potential — •Nino Bratovic and Wolfram Weise — Physik Department, TU München, 85748 Garching, Germany

The Nambu-Jona-Lasinio model extended by Polyakov-loop dynamics (PNJL model) for 2 + 1 flavors is used in order to study the QCD phase diagram and associated thermodynamic quantities. In this approach, spontaneous chiral symmetry breaking as well as color singlet suppression in the hadronic phase are realized dynamically in terms of the respective order parameters.

In particular, we investigate the so-called Columbia plot for different values of the quark chemical potential. The Columbia plot is a concise way of presenting the order of the chiral transition as a function of the current quark masses ($m_{\rm u}$, $m_{\rm s}$). Our findings are compared to related results from other groups. In addition, the influence of the strength of the $\mathrm{U(1)_A}$ symmetry breaking Kobayashi-Maskawa-'t Hooft interaction is examined.

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HK 56.5 Thu 17:45 HS AP

QCD at finite temperature and density from Dyson-Schwinger equations — •Jan Lücker[1] and Christian S. Fischer[1,2] — [1]Institut für Theoretische Physik I, Justus-Liebig-Universität Gießen, Heinrich-Buff-Ring 16, 35392 Gießen — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstr. 1 64291 Darmstadt

I present results on the QCD phase diagram obtained from the Dyson-Schwinger equations (DSEs) of QCD, concentrating on the chiral and deconfinement transitions. The used truncation scheme includes a quenched gluon with full temperature dependence from lattice data, and the quark loop from the gluon DSE to account for unquenching. For the chiral transition we find the standard scenario of a crossover which turns into a first order transition at a critical endpoint. To extract the deconfinement transition line we calculate the dressed Polyakov loop and find a pseudo-critical temperature above the chiral transition in the crossover region, but coinciding transition temperatures close to the critical endpoint.

HK 56.6 Thu 18:00 HS AP

Farbsupraleitung aus Dyson-Schwinger Gleichungen — •Daniel Müller, Michael Buballa und Jochen Wambach — TU Darmstadt

Wir untersuchen das Phasendiagramm der QCD bei hohen Dichten und niedrigen Temperaturen. In diesem Bereich erwartet man farbsupraleitende Phasen, wobei wir uns auf 2SC und CFL-artige Phasen beschränken. Dazu werden die Dyson-Schwinger Gleichungen der QCD in Landau Eichung in einer geeigneten Trunkierung selbstkonsistent gelöst. Wir finden dabei eine dominante CFL-Phase, sowie bei niedrigem chemischen Potential und bei höherer Temperatur eine 2SC Phase. Die kritischen Temperaturen vom Übergang zur nicht-farbsupraleitenden Phase sind recht niedrig.

HK 56.7 Thu 18:15 HS AP

Die axiale Anomalie in Farbsupraleitern — •Hannes Basler und Michael Buballa — Institut für Kernphysik, TU Darmstadt

In einem Nambu-Jona-Lasinio-Modell untersuchen wir Effekte einer $U(1)_A$-brechenden Sechs-Punkt-Wechselwirkung in farbsupraleitenden Phasen. Üblicherweise wird die Sechs-Punkt-Wechselwirkung im NJL-Modell in Mean-Field-Näherung so behandelt, dass sie nur chiral Kondensates koppelt. Um einen Effekt im Diquark-Sektor zu erhalten, führen wir eine transformierte Sechs-Punkt-Wechselwirkung ein. Unser besonderes Interesse gilt der Abhänigkeit der Goldstone-Bosonen-Massen in der Color-Flavor-Locked-Phase von der Kopplungsstärke dieser transformierten Sechs-Punkt-Wechselwirkung.

HK 56.8 Thu 18:30 HS AP

High-density behavior of the nuclear symmetry energy — Theodoros Gaitanos[1], Massimo Di Toro[2], Vincenzo Greco[2,3], Vaia Prassa[4], and •Hermann Wolter[5] — [1]Univ. Giessen — [2]LNS, INFN, Catania — [3]Univ. of Catania — [4]Univ. of Thessaloniki — [5]Univ. München

The density dependence of the nuclear symmetry energy is rather uncertain from results of many-body theory, but is important in the physics of exotic nuclei and astrophysical processes. In particular, the behaviour at density above saturation density is very controversial. It can be investigated in relativistic heavy ion collisions; however, sensitive and robust probes have to be identified. Probes that have been discussed are pre-equilibrium nucleons, isospin flow of nucleons, or ratios of yields of isospin partners of produced particles, such as pions and kaons. In this contribution we will discuss from the point of view of simulations of heavy ion collisions the status of these investigations, and, in particlar, the situation with respect to particle probes.

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HK 56.9 Thu 18:45 HS AP

Cluster formation and dissolution in a generalized relativistic density functional approach for dense matter — •Stefan Typel[1,2,3], Maria Voskresenskaya[3], Gerd Röpke[4], David Blaschke[5], Thomas Klähn[5], and Hermann Wolter[1,6] — [1]Excellence Cluster Universe — [2]TU München — [3]GSI Darmstadt — [4]Universität Rostock — [5]Universität Wrocław — [6]LMU München

The formation and dissolution of clusters in dense matter is described by combining a microscopic quantum statistical approach with a relativistic mean-field (RMF) model with density-dependent nucleon-meson couplings. Nucleons and light clusters are treated as effective degrees of freedom with medium dependent properties. The resulting generalized relativistic density functional successfully describes the transition from clusterized matter at low densities and low temperatures to uniform neutron-proton matter at high densities and high temperatures. In addition to bound state correlations, two-body scattering correlations are included in a schematic way. The formation of heavy clusters is modeled by employing inhomogeneous calculations within the Thomas-Fermi approximation in spherical Wigner-Seitz cells. In the low-density limit, a comparison to the virial equation of state leads to new constraints on the nucleon-meson couplings of the RMF model.