HK 57: Heavy-Ion Collisions and QCD Phases XIII

Time: Friday 11:00–12:15 Location: J-HS G

Group Report HK 57.1 Fri 11:00 J-HS G

Spectral functions and critical dynamics of the $O(4)$ model from classical-statistical lattice simulations — •Dominik Smith[1], Sören Schlichting[2], and Lorenz von Smekal[1] — [1]Justus-Liebig-Universität Gießen — [2]Universität Bielefeld

We calculate spectral functions of the relativistic $O(4)$ model from real-time lattice simulations in classical-statistical field theory. While in the low and high temperature phase of the model, the spectral functions of longitudinal (σ) and transverse (π) modes are well described by relativistic quasi-particle peaks, we find a highly non-trivial behavior of the spectral functions in the cross over region, where additional structures appear. Similarly, we observe a significant broadening of the quasi-particle peaks, when the amount explicit $O(4)$ symmetry breaking is reduced. We further demonstrate that in the vicinity of the $O(4)$ critical point, the spectral functions develop an infrared power law associated with the critical dynamics, and comment on the extraction of the dynamical critical exponent z from our simulations.

HK 57.2 Fri 11:30 J-HS G

Quark Number and Electric Flux in QCD — •Milad Ghanbarpour and Lorenz von Smekal — Institut für Theoretische Physik, Justus-Liebig-Universität Gießen, Deutschland

In pure $SU(3)$-gauge theory the free energy of a static quark in a finite volume can be rigorously defined to account for its electric flux, via suitable combinations of twisted boundary conditions relative to an enlarged ensemble with all temporal twists. In the infinite volume limit, it diverges in the confined phase and vanishes above the deconfinement phase transition. In full QCD with dynamical quarks, the situation is less clear. A straightforward definition via pseudo-canonical ensembles with quark numbers N_q that are not multiples of three fails, the corresponding partition functions vanish due to the Roberge-Weiss symmetry already in a finite volume. Such quark numbers are inconsistent with periodic boundary conditions. Therefore we first need to understand the correct boundary conditions to account for the elecrtic flux and the entanglement entropy of subsystems with $N_q \mod 3 \neq 0$. Here, we approach this problem from the heavy-dense limit of QCD at fixed quark number. The analogue system is a 3-states Potts model in three dimensions. In its naive formulation, the system suffers from a sign problem which can be solved in this case, however (see Alexandru et al., Phys. Rev. D 97 (2018) 114503). The solution consists of utilizing a cluster algorithm and improved estimators. Our first goal therefore is to adapt this scheme for non-periodic boundary conditions so that we can describe ensembles with arbitrary quark numbers in a finite volume. In this talk we review the current status of the project.

HK 57.3 Fri 11:45 J-HS G

Dynamic critical exponents from classical-statistical spectral functions — •Dominik Schweitzer[1], Sören Schlichting[2], and Lorenz von Smekal[1] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität Gießen — [2]Fakultät für Physik, Universität Bielefeld

When a thermodynamic system comes close to a critical point, large fluctuations lead to scale-invariant physics, not only in static but also dynamic observables, such as spectral functions. Such observables can be measured by a range of experiments, and will become relevant in future heavy-ion collision experiments closing in on the QCD critical point.

We investigate the dynamic critical behavior of self-interacting scalar fields with $\mathbb{Z}_2$ symmetry and hence the same static universal behavior as QCD at the critical endpoint. We calculate spectral functions of the order parameter at zero and non-vanishing momenta from classical statistical lattice simulations in real time. In the high-temperature phase, we find that the spectral functions are well described by relativistic quasi-particle peaks; at low temperatures, we find an additional mode with a different dispersion relation. Close to the transition temperature, we see a strong IR contribution building up.

Considering the equations of motion for a closed system as well as a system coupled to a heat bath, we determine the underlying universal scaling functions in the critical region, and extract the dynamic critical exponents z for two different dynamic universality classes, Model A & C.

HK 57.4 Fri 12:00 J-HS G

In-medium properties of vector and (pseudo-)scalar mesons — •Pascal Gunkel, Christian Fischer, and Philipp Isserstedt — Justus-Liebig Universität Gießen, 35392 Gießen, Deutschland

We report on recent results on the phase structure of strongly-interacting matter using the functional Dyson-Schwinger approach to QCD. We discuss results for masses, wave functions, and decay constants of (light) vector, scalar, and pseudoscalar mesons for finite chemical potentials up to the first-order phase transition. They are obtained from the corresponding homogeneous Bethe-Salpeter equations, coupled to a set of truncated Dyson-Schwinger equations for the quark and gluon propagators of Landau-gauge QCD. We confirm the Silver-Blaze property and extend previous calculations [1] to finite temperature.

[1] P. J. Gunkel, C. S. Fischer, P. Isserstedt, Eur. Phys. J. A 55 (2019) 169