HK 12: Heavy Ion Collisions and QCD phases

Time: Monday 16:30–19:00 Location: H-ZO 10

Invited Group Report HK 12.1 Mo 16:30 H-ZO 10

Recent lattice results on the QCD phase diagram — •Sandor Katz — Eotvos University, Budapest, Hungary

Recent results on lattice QCD thermodynamics will be reviewed. The transition temperature, equation of state and the curvature of the phase diagram will be presented. Results from different collaborations will be compared to each other.

Group Report HK 12.2 Mo 17:00 H-ZO 10

Phases of QCD, role of strangeness and PNJL model with $2+1$ flavors — •Thomas Hell, Nino Bratovic, Marco Cristoforetti, Simon Rössner, and Wolfram Weise — Physik-Department, Technische Universität München, D-85747 Garching, Germany

We investigate the QCD phase diagram within a three-flavor Nambu and Jona-Lasinio (NJL) model including the Polyakov loop as an order parameter for the confinement-deconfinement transition. Of particular interest is the impact of diquark condensation and color superconducting phases in the high-density region.

Furthermore, we present a nonlocal covariant extension [1] of the three-flavor NJL model, with built-in constraints from the running coupling of QCD at high-momentum and instanton physics at low-momentum scales. The momentum-dependent dynamical quark mass derived from this approach is in agreement with results from Dyson-Schwinger equations and lattice QCD. At finite temperature, the inclusion of the Polyakov loop and its gauge invariant coupling to quarks reproduces the dynamical entanglement of the chiral and deconfinement crossover transitions as in the (local) PNJL model, but now without the requirement of introducing an artificial momentum cutoff. Steps beyond the mean-field approximation are made including mesonic correlations through quark-antiquark ring summations.

[1] T. Hell et al., arXiv:0810.1099, Phys. Rev. **D** (2008), in print.

Work supported by BMBF, GSI, the DFG Excellence Cluster "Origin and Structure of the Universe" and by the Elitenetzwerk Bayern.

HK 12.3 Mo 17:30 H-ZO 10

Quarkyonic matter and chiral symmetry breaking in the Nambu-Jona–Lasinio model with Polyakov loops in large N_c — •Chihiro Sasaki[1], Larry McLerran[2], and Krzysztof Redlich[3] — [1]Dep. of Physics, Technische Universitaet Muenchen, Garching, Germany — [2]Dep. of Physics, Brookhaven National Laboratory, Upton, USA — [3]Institute for Theoretical Physics, University of Wroclaw, Wroclaw, Poland

The appearance of a new phase in dense QCD, quarkyonic matter, in the limit of large number of colors is studied within Nambu–Jona-Lassinio model coupled to Polyakov loops. The interplay of this novel phase with the chiral symmetry restoration and color deconfinement is discussed.

The model describes 3 phases (chirally broken, quarkyonic and chirally restored) in the confined phase. We show that in large N_c the phase diagram coincides with the one conjectured by McLerran and Pisarski. The N_c-dependence of chiral critical end point is also discussed.

The work of C. S. has been supported in part by the DFG cluster of excellence "Origin and Structure of the Universe".

HK 12.4 Mo 17:45 H-ZO 10

Shear viscosity and out of equilibrium dissipative hydrodynamics — •Andrej El, Zhe Xu, and Carsten Greiner — Goethe Universität Frankfurt am Main

We compare the solution of Israel-Stewart equations in (0+1) dimensions for a system with ongoing chemical equilibration to the results of calculations by microscopic partonic cascade BAMPS with pQCD $2 \leftrightarrow 2$ and $2 \leftrightarrow 3$ processes implemented. The shear viscosity coefficient needed to solve IS equations is calculated by an expression, which is derived from kinetic theory using Grad's method. We demonstrate an agreement between the viscous hydrodynamic calculations and the microscopic transport results on η/s, except when employing a small α_s. At $\alpha_s = 0.3$ we obtain $\eta/s \approx 0.18$. On the other hand we demonstrate that for such small α_s the gluon system is far from kinetic and chemical equilibrium, which indicates the break down of hydrodynamics. The comparison of dissipative hydrodynamic and BAMPS calculations shows the importance of chemical equilibration: without an ongoing chemical equilibration the system evolves faster to a state where hydrodynamics becomes invalid.

HK 12.5 Mo 18:00 H-ZO 10

Suppression of forward dilepton production from an anisotropic QGP — •Mauricio Martinez[1] and Michael Strickland[2] — [1]Helmholtz Reseach School and FIAS, Ruth-Moufang-Str. 1 60438, Frankfurt am Main, Germany — [2]Department of Physics, Gettysburg College, Gettysburg, PA 17325

We calculate the rapidity dependence of leading-order medium dilepton yields resulting from a quark-gluon plasma which has a local time-dependent anisotropy in momentum space. We present a phenomenological model which includes temporal evolution of the plasma anisotropy parameter, ξ, and the hard momentum scale, p_{hard}. Our model interpolates between 1+1 dimensional collisionally-broadened expansion at early times and 1+1 dimensional ideal hydrodynamic expansion at late times. Using our model, we find that at LHC energies, forward high-energy medium dilepton production would be suppressed by up to a factor of 3 if one assumes an isotropization/thermalization time of 2 fm/c. Therefore, it may be possible to use forward dilepton yields to experimentally determine the time of onset of locally isotropic hydrodynamic expansion of the quark-gluon plasma as produced in ultrarelativistic heavy-ion collisions.

HK 12.6 Mo 18:15 H-ZO 10

Role of the tetraquark in the chiral phase transition — •Achim Heinz[1], Stefan Strüber[1], Francesco Giacosa[1], and Dirk H. Rischke[1,2] — [1]Institute for Theoretical Physics, Geothe University, Max-von-Laue-Str. 1, D-60438 Frankfurt am Main, Germany — [2]Frankfurt Institute for Advanced Studies, Geothe University, Ruth-Moufang-Str. 1, D-60438 Frankfurt am Main, Germany

By using a simple chiral invariant two-flavor model, we determine the implication of a light tetraquark field on chiral symmetry restoration at nonzero temperature. The order of phase transition depends on the mixing between quarkonium and tetraquark. In order to obtain a crossover phase transition, as favored by lattice QCD studies, a large mixing between scalar quarkonium and tetraquark fields is required. To be consistent with recently advocated interpretations of spectroscopy data we chose a light ($\sim$ 0.4 GeV), predominantly tetraquark state, and a heavy ($\sim$ 1.2 GeV), predominantly quarkonium state in the vacuum. With increasing temperature the mixing increases until a interchange of roles takes place. The originally heavy, predominantly quarkonium state becomes the light state and the originally light, predominantly tetraquark state becomes the heavy state. After the interchange, as expected, the chiral symmetry is restored.

HK 12.7 Mo 18:30 H-ZO 10

The Chiral Transition in QCD: on the quark mass dependence of Goldstone fluctuations — •Wolfgang Unger — Fakultät für Physik, Universität Bielefeld

Due to fluctuations of the Goldstone pion modes, the chiral susceptibility is expected to diverge in the IR when the chiral limit is approached at temperatures which are large but below the chiral transition temperature. We summarize how this expectation is borne out of chiral perturbation theory in the continuum limit, treating the connected and disconnected contributions separately. Based on rooted staggered chiral perturbation theory we further study possible modifications due to taste violations which arise in the staggered lattice discretization scheme for the quarks. These analytic findings are then confronted with our present numerical results on the chiral susceptibility obtained from simulations with N_f=2+1 flavors at small light quark masses.

HK 12.8 Mo 18:45 H-ZO 10

QCD equation of state from a HTL quasiparticle model — •Robert Schulze — Forschungszentrum Dresden-Rossendorf, Dresden, Germany

We present a quasiparticle model based on a two-loop effective action equipped with hard thermal loop (HTL) dispersion relations and an effective running coupling strength. The model allows for an extrapolation of present QCD lattice results at small or zero chemical potential to larger baryon densities. The resulting QCD equation of

state is combined with the hadron sector to arrive at a useable form for hydrodynamical simulations of heavy-ion collisions over a large energy interval. Particular attention is paid to a tachyonic plasmino mode arising in the Landau damping regime, leading to oddities of particle densities and quark partial pressures at small temperatures and medium chemical potential. Implications for quark/neutron stars are discussed.