HK 13: Schwerionenkollisionen und QCD Phasen

Zeit: Montag 16:30–19:00 Raum: HZ 7

Gruppenbericht HK 13.1 Mo 16:30 HZ 7

The Compressed Baryonic Matter (CBM) Experiment - Status Report — •Christoph Blume for the CBM-Collaboration — Goethe-Universität Frankfurt

The CBM Experiment is one of the main four scientific pillars of the new Facility for Antiproton and Ion Research (FAIR). Its main objective is the study of the QCD phase diagram in the region of high baryon-densities. With nucleus-nucleus collisions at the SIS100 accelerator at beam energies up to 14 A GeV strongly interacting matter with densities about 10 times as high as normal nuclear matter can be produced. In a second stage at the SIS300 beam energies up to 45 A GeV will be investigated. The experimental setup is designed to cope with highest interaction rates (up to 10 MHz), which for the first time will also allow to measure rare probes (open charm, light and heavy vector mesons) in the FAIR energy regime. We will report on the current status of the CBM experiment. Many detector subsystems have already completed their technical design reports, or will finalize them in 2014. The main achievements and challenges of these developments will be discussed. Also, a lot of effort is being spend on evaluating the physics performance of the experiment. An overview on the main results in the context of the CBM physics program will be given.

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HK 13.2 Mo 17:00 HZ 7

Chiral thermodynamics and fluctuations in the nuclear sector of the QCD phase diagram — •Matthias Drews[1,2] and Wolfram Weise[1,2] — [1]Technische Universität München, Germany — [2]ECT*, Trento, Italy

In order to study simultaneously the thermodynamics of nuclear matter and the question of chiral restoration, a chiral nucleon-meson model is analyzed. To describe successfully the dynamics, in particular close to the critical point of the liquid-gas phase transition, fluctuations are included within the framework of the functional renormalization group. The calculations for nuclear matter agree nicely with results obtained from in-medium chiral effective field theory. Moreover, for temperatures below 100 MeV and densities below twice the nuclear saturation density, no signs of a chiral phase transition are found.

This work is supported in part by BMBF and by the DFG Cluster of Excellence "Origin and Structure of the Universe."

HK 13.3 Mo 17:15 HZ 7

Investigations of the QCD phase diagram using Dyson-Schwinger equations — •Christian Welzbacher, Christian S. Fischer, and Jan Luecker — Institut fuer Theoretische Physik, Justus-Liebig-Universitaet Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen, Germany

The Dyson-Schwinger equations as one kind of functional methods provide us with a toolbox to investigate the structure of the QCD phase diagram. By solving the carefully truncated coupled set of equations the quark and gluon propagators at finite temperature and light-quark chemical potential are obtained. Those quantities give insights about the chiral and deconfinement phase transitions and have interesting analytic properties. We present results for the phase structure of QCD with Nf=2+1 and Nf=2+1+1 flavors and discuss the location of a potential critical endpoint.

HK 13.4 Mo 17:30 HZ 7

Hadron masses and baryonic scales in G_2-QCD at finite density — •Bjoern Wellegehausen[1], Lorenz von Smekal[1], Andreas Wipf[2], and Axel Maas[2] — [1]JLU Giessen — [2]FSU Jena

Due to the fermion sign problem, the QCD phase diagram at high baryon densities is not accessible with standard lattice Monte-Carlo methods. G_2-QCD, for which the $SU(3)$ gauge group of QCD is replaced by the exceptional Lie group G_2, does not have a sign problem and can be simulated at such densities using standard lattice techniques. It thus provides benchmarks to models and functional continuum methods, and it serves to unravel the nature of possible phases of strongly interacting matter at high densities. Instrumental in understanding these phases is that G_2-QCD has fermionic baryons, and that it can therefore sustain a baryonic Fermi surface. Because the baryon spectrum of G_2-QCD also contains bosonic diquark and probably other more exotic states, it is important to understand this spectrum before one can disentangle the corresponding contributions to the baryon density. Here we present the first systematic study of this spectrum from lattice simulations at different quark masses. This allows us to relate the mass hierarchy, ranging from scalar would-be-Goldstone bosons and intermediate vector bosons to the G_2-nucleons and deltas, to individual structures observed in the total baryon density at finite chemical potential.

HK 13.5 Mo 17:45 HZ 7

The order of the chiral phase transition in an effective model for two-flavor QCD from the Functional Renormalization Group — •Mara Grahl — Institute for Theoretical Physics, Goethe University, Max-von-Laue-Str. 1, 60438 Frankfurt am Main

Quantum chromodynamics (QCD), the theory describing the strong interaction between the building blocks of hadronic matter (quarks and gluons), predicts that at high temperature and/or density hadronic matter undergoes a transition to an exotic state of matter, called quark-gluon plasma (QGP), which is associated with a chiral phase transition. In absence of any small expansion parameter, strongly coupled systems, such as QCD near the transition to the QGP, indispensably depend on nonperturbative methods such as for example the Functional Renormalization Group (FRG) method. Very interesting to the scientific community is the order of the chiral phase transition and the critical temperature at which it takes place in effective models for QCD. The upcoming CBM experiment at GSI Darmstadt will allow to test the performance of these approaches in the near future.

Our talk is concerned with the question of which order the chiral phase transition of two-flavor QCD is. We briefly summarize the predictions as inferred from the linear sigma model and discuss our FRG results taking into account the influence of instantons which give rise to the axial anomaly.

HK 13.6 Mo 18:00 HZ 7

Thermodynamics and phase structure of the Polyakov–Quark-Meson model — Jens Braun[1,2], Eduardo S. Fraga[3,4], Lisa M. Haas[5,2], Tina K. Herbst[5], Bruno W. Mintz[6], Mario Mitter[5,4], Jan M. Pawlowski[5,2], Rudnei O. Ramos[6], Bernd-Jochen Schaefer[7,8], Jürgen Schaffner-Bielich[4], and •Rainer Stiele[5] — [1]Institut für Kernphysik (Theoriezentrum), Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI — [3]Instituto de Física, Universidade Federal do Rio de Janeiro — [4]Institut für Theoretische Physik, Goethe-Universität Frankfurt — [5]Institut für Theoretische Physik, Universität Heidelberg — [6]Departamento de Física Teórica, Universidade do Estado do Rio de Janeiro — [7]Institut für Theoretische Physik, Justus-Liebig-Universität Giessen — [8]Institut für Physik, Karl-Franzens-Universität Graz

Polyakov-loop extended chiral effective models are important tools to describe the phase structure and thermodynamics of strongly interacting matter. We show that taking into account the backreaction of quarks onto the gauge sector is crucial in such models to achieve results for the order parameters and thermodynamics that are in line with lattice calculations. Achieving a good description of lattice data at zero density, we test the reliability of those models in systems containing other control parameters besides the temperature by confronting its results with lattice data at nonzero isospin. Furthermore, we investigate the phase structure of the three-dimensional $T - \mu_{\text{isospin}} - \mu_{\text{quark}}$ phase diagram and calculate the surface tension of the first order phase transition at small temperatures and large quark densities.

HK 13.7 Mo 18:15 HZ 7

The Parity doublet model with fluctuations — •Johannes Weyrich[1], Nils Strodthoff[2], and Lorenz von Smekal[1] — [1]TU Darmstadt — [2]Universität Heidelberg

In the 1970s the Walecka model and the chiral Walecka model were developed and have since been studied intensively. It was noted early on, however, that the chiral model leads to massless Lee-Wick nuclear matter in the chirally restored phase.

A promising variant to describe nuclear matter and chiral symmetry restoration consitently is the parity doublet model (or mirror model). It has already been treated in a mean field (MF) approach with promising results. This is motivation for us to to examine this model with functional renormalization group (FRG) methods, hence including full mesonic fluctuations.

HK 13.8 Mo 18:30 HZ 7

Constraining the nuclear matter equation of state around twice the saturation density — •Arnaud Le Fèvre[1], Yvonne Leifels[1], Willibrord Reisdorf[1], Jörg Aichelin[2], Christoph Hartnack[2], and Norbert Hermann[3] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [2]SUBATECH, Université de Nantes, IN2P3/CNRS, France — [3]Physikalisches Institut der Universität Heidelberg, Heidelberg, Germany

From FOPI experimental data on elliptic flow of protons, we extract constraints for the equation of state (EOS) of compressed symmetric nuclear matter using the transport code IQMD. The best agreement with the data is obtained with the soft EOS assumption, including a momentum dependent interaction. The code predicts that the mean characteristical density related to the measured flow is around twice the saturation density. It shows how important is the interplay between the fireball and the spectator matter in the relativistic heavy-ion collisions in order to have the necessary sensitivity of the elliptic flow on the stiffness of the EOS.

HK 13.9 Mo 18:45 HZ 7

Two-loop thermodynamics of warm and dense (isospin and baryo-chemical potential) perturbative QCD — •Thorben Graf[1], Juergen Schaffner-Bielich[2], and Eduardo S. Fraga[3] — [1]Institut für Theoretische Physik, Goethe Universität, Frankfurt am Main, Germany — [2]Institut für Theoretische Physik, Goethe Universität, Frankfurt am Main, Germany — [3]Instituto de Física, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil

We present a perturbative calculation of the thermodynamical potential of quantum chromodynamics at nonvanishing temperatures for different values of the isospin and baryo-chemical potential.

A comparison to recent lattice calculations at nonvanishing isospin is performed and the region of the break-down of the perturbative calculations are delineated.

Finally, we study the thermodynamic potential at high chemical potentials and low temperatures where the perturbative scheme should be also applicable.