# HK 66: Heavy Ion Collision and QCD Phases XIII

Zeit: Freitag 14:00–16:00 Raum: S1/01 A04

**Gruppenbericht** HK 66.1 Fr 14:00 S1/01 A04

**The Compressed Baryonic Matter experiment at FAIR** — •David Emschermann for the CBM-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH

The Compressed Baryonic Matter experiment (CBM) will be based at the new Facility for Antiproton and Ion Research (FAIR), which will deliver heavy-ion beams up to energies of 14 A GeV. In nucleus-nucleus collisions at these beam energies strongly interacting matter with densities up to 10 times normal nuclear matter is expected to be produced. The key objective of CBM is to investigate the QCD phase diagram in the region of high baryon-densities, where a first order phase transition from hadronic to partonic matter as well as a chiral phase transition is expected to occur, representing a substantial discovery potential at FAIR energies. As a fixed-target experiment CBM is consequently designed to cope with very high interaction rates up to 10 MHz. This will allow to perform high precision measurements of extremely rare probes which have not been accessible by previous nucleus-nucleus experiments in this energy regime. To achieve the high rate capability CBM will be equipped with fast and radiation hard detectors employing with free-streaming readout electronics. A high-speed Data Aquisition system will forward data from the detector front-ends to the First Level Event Selector (FLES), providing an online event selection. We will report on the current status of the CBM experiment and its subsystems.

HK 66.2 Fr 14:30 S1/01 A04

**Effective Polyakov loop models for QCD-like theories at finite baryon density** — •Philipp Scior[1], Lorenz von Smekal[2] und Bjoern Wellegehausen[2] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]Institut für Theoretische Physik, Justus-Liebig-Universität Gießen

We study the heavy quark limit of QCD-like theories by using a three-dimensional Polyakov theory. This theory can be derived from the full QCD-like theory by a combined strong coupling expansion. In particular we investigate the cold and dense regime of the phase diagram where we expect to find the Silverblaze property realized as Bose-Einstein-condensation of diquarks or a fist order liquid-gas transition, depending on the gauge group of the theory. We find evidence for the Silverblaze property when the quark chemical potential $\mu$ reaches half the diquark mass. For even higher $\mu$ we find the deconfinement transition indicated by the rise of the Polyakov loop as well as the quark number density.

HK 66.3 Fr 14:45 S1/01 A04

**Vacuum-fluctuation effects on inhomogeneous chiral symmetry breaking** — •Michael Buballa[1], Stefano Carignano[2], and Bernd-Jochen Schaefer[3] — [1]TU Darmstadt — [2]INFN Gran Sasso — [3]Justus-Liebig-Universität Gießen

Various model studies suggest that the phase diagram of strong-interaction matter contains an inhomogeneous region where the chiral condensate is non-uniform in space. Most of these studies have been performed in the mean-field approximation. As a first step to include fluctuation effects, we investigate the phase structure of the quark-meson (QM) model in the so-called extended mean-field approximation, where the Dirac-sea contributions of the quarks are taken into account. In contrast to the frequently employed Nambu–Jona-Lasinio (NJL) model the QM model is renormalizable, so that the results eventually become independent of the cutoff parameter. Compared with the case where the Dirac sea is neglected, we find that the inhomogeneous phase shrinks, but in general does not disappear. It turns out, however, that the inhomogeneous phase is particularly sensitive to a proper choice of the renormalization conditions, fixing meson pole masses, rather than curvature masses. With that choice the Lifshitz point of the inhomogeneous phase coincides with the tricritical point if the ratio between sigma-meson and constituent quark mass in vacuum is chosen to be 2, corresponding to the fixed mass ratio in the NJL model. Finally, we uncover a general instability of the model, indicating that further improvements of the approximation scheme, in particular including bosonic fluctuations, are necessary.

HK 66.4 Fr 15:00 S1/01 A04

**Modeling chiral criticality and its consequences for heavy-ion collisions** — •Gabor Almasi[1], Bengt Friman[1,2], and Krzysztof Redlich[2,3,4] — [1]Gesellschaft für Schwerionenforschung, GSI, D-64291 Darmstadt, Germany — [2]ExtreMe Matter Institute (EMMI), D-64291 Darmstadt, Germany — [3]University of Wrocław - Faculty of Physics and Astronomy, PL-50-204 Wrocław, Poland — [4]Department of Physics, Duke University, Durham, NC 27708, USA

We explore the critical fluctuations near the chiral critical endpoint (CEP), which belongs to the Z(2) universality class, in a chiral effective model and discuss possible signals of the CEP, recently explored in nuclear collision experiments [1]. Particular attention is attributed to the dependence of such signals on the location of the phase boundary and the CEP relative to the hypothetical freeze-out conditions in nuclear collisions. We argue that in effective models freeze-out fits to heavy-ion results should not be used directly, and relevant quantities should be investigated on lines of the phase diagram, that are defined self-consistently in the framework of the model [2]. We discuss possible choices for such an approach. Additionally we discuss the effect of the repulsive vector interaction of quarks on the location of the CEP and on the structure of the baryon number cumulant ratios.

[1] L. Adamczyk, et al., Phys. Rev. Lett. **112** (2014) 032302.

[2] G. Almasi, B. Friman, and K. Redlich, Quark Matter 2015 Proceedings, to be published.

HK 66.5 Fr 15:15 S1/01 A04

**Chiral Mirror-Baryon-Meson Model and Nuclear Matter beyond Mean-Field** — •Johannes Weyrich[1,2], Nils Strodthoff[3], and Lorenz von Smekal[2] — [1]TU Darmstadt — [2]Justus-Liebig-Universität Gießen — [3]Universität Heidelberg

We consider a chiral mirror-baryon-meson model to describe the properties of nuclear matter around the liquid-gas transition in the low temperature region of the QCD phase diagram together with chiral symmetry restoration in the high density phase. In the mean-field approximation this model is known to provide a successful description of nuclear matter properties. Here, we go beyond the mean-field approximation using a functional renormalization group (FRG) framework to study this chiral mirror-baryon-meson model (or parity doublet model) at finite temperature and baryon chemical potential.

HK 66.6 Fr 15:30 S1/01 A04

**Kinetics of the chiral phase transition** — •Hendrik van Hees[1,2], Christian Wesp[1], Alex Meistrenko[1], and Carsten Greiner[1] — [1]Johann-Wolfgang-Goethe-Universität Frankfurt, Institut für theoretische Physik, Max-von-Laue-Str. 1, D-60438 Frankfurt — [2]Frankfurt Institute for Advanced Studies (FIAS), Ruth-Moufang-Str. 1, D-60438 Frankfurt

We simulate the kinetics of the chiral phase transition in hot and dense strongly interacting matter within a novel kinetic-theory approach. Employing an effective linear $\sigma$ model for quarks, $\sigma$ mesons, and pions we treat the quarks within a test-particle ansatz for solving the Boltzmann transport equation and the mesons in terms of classical fields. The decay-recombination processes like $\sigma \leftrightarrow \bar{q} + q$ are treated using a kind of wave-particle dualism using the exact conservation of energy and momentum. After demonstrating the correct thermodynamic limit for particles and fields in a "box calculation" we apply the simulation to the dynamics of an expanding fireball similar to the medium created in ultrarelativistic heavy-ion collisions.

HK 66.7 Fr 15:45 S1/01 A04

**FRG study of the chiral phase transition in a quark-meson model with (axial-)vector mesons** — •Jürgen Eser and Dirk Rischke — Institut für Theoretische Physik, Goethe-Universität, Max-von-Laue- Str. 1, 60438 Frankfurt am Main

The functional renormalization group (FRG) technique, as a non-perturbative continuum approach towards the thermodynamics of quantum chromodynamics (QCD), is complementary to lattice calculations. We use this method to investigate the chiral phase transition in a quark-meson model based on the so-called extended linear sigma model (eLSM). Besides (pseudo-)scalar degrees of freedom the latter also includes vector and axial-vector mesons, which are promising candidates in order to indicate the formation of a quark- gluon plasma (QGP) during heavy-ion collisions. Compared to previous investigations of the eLSM, the evidently significant contribution of quark fields

to the renormalization flow is now also taken into account. The chiral phase transition order within this model as well as the mass degeneracy of chiral partners occurring above the critical temperature will be discussed.