# HK 30: Heavy Ion Collisions and QCD Phases VII

Zeit: Mittwoch 16:45–19:00 Raum: F 3

**Gruppenbericht** HK 30.1 Mi 16:45 F 3

**The Compressed Baryonic Matter experiment at FAIR** — •Jörg Lehnert for the CBM-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The Compressed Baryonic Matter experiment (CBM) aims to investigate the QCD phase diagram in the region of high baryon densities. In this region a rich structure is expected, which may include a first-order phase transition between hadronic and partonic matter eventually terminating in a critical point, or even exotic phases.

The CBM experiment at the future Facility for Antiproton and Ion Research (FAIR) is designed to measure nucleus-nucleus collisions at SIS100 beam energies (4-14 AGeV) where strongly interacting matter with densities about 10 times as high as normal nuclear matter is expected to be produced. For high-statistics measurements of rare probes, event rates of up to 10 MHz are needed. To meet these demands, the CBM experiment uses fast and radiation hard detectors, self-triggered detector front-ends and a free-streaming readout architecture.

In this presentation the physics program of CBM will be reviewed and the current status of the experiment and its subsystems will be reported.

HK 30.2 Mi 17:15 F 3

**Lattice simulations of Two-Colour QCD at finite density** — •Lukas Holicki, Jonas Wilhelm, Dominik Smith, and Lorenz von Smekal — Institut fuer Theoretische Physik, Justus Liebig Universitaet Giessen, 35392 Giessen, Germany

Lattice Monte Carlo simulations of QCD-like gauge theories can be performed at finite density without sign problem and by now have a long history already. Such simulations allow a direct comparison to effective theories. The physics of the bosonic diquark baryons in two-colour QCD is believed to be fairly well understood and qualitatively resembles QCD at finite isospin density with pion condensation. There is good guidance from effective field theory predictions and model studies of the BEC-BCS crossover inside the condensed phase. Lattice studies suffer from discretization artifacts when the lattice is too coarse. We therefore use an improved gauge action and lattice couplings that are somewhat larger than those of the early studies. This implies that we have to worry about additive renormalization in the chiral condensate before we can compare our results with the effective field theory predictions. We also confirm that the Polyakov-loop does not respond to the finite density in the staggered formulation. However, we find evidence that the flavour symmetry breaking pattern restores to its continuum form, which is reflected in the pseudo-Goldstone spectrum at high densities.

HK 30.3 Mi 17:30 F 3

**Influence of Van der Waals interactions between hadrons on observables from heavy-ion collisions and lattice QCD** — •Volodymyr Vovchenko[1,2], Paolo Alba[1], Mark Gorenstein[1,3], and Horst Stoecker[1,2,4] — [1]FIAS, Frankfurt, Germany — [2]ITP, Uni-Frankfurt, Frankfurt, Germany — [3]Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine — [4]GSI, Darmstadt, Germany

Extension of the ideal hadron resonance gas (HRG) model is constructed which includes attractive and repulsive van der Waals (VDW) interactions between hadrons. The VDW parameters $a$ and $b$ are fixed by the ground state properties of nuclear matter, and this VDW-HRG model yields the nuclear liquid-gas transition at low temperatures and high baryonic densities.

The predictions of the model are confronted with the lattice QCD calculations at zero chemical potential. The inclusion of VDW interactions between baryons leads to a qualitatively different behavior of cumulants of fluctuations of conserved charges, for many observables closely resembling the lattice QCD results. Calculations also suggest that strange baryons have weaker VDW interactions compared to non-strange ones. We also explore the effect of VDW interactions on the thermal fits to heavy-ion hadron yield data and find that existing agreement of ideal HRG is not spoiled in the VDW-HRG model. Finally, we find that VDW interactions have a rather substantial influence on the higher orders of fluctuations of conserved charges at finite chemical potential, in the regions where chemical freeze-out in heavy-ion collisions is expected to occur.

HK 30.4 Mi 17:45 F 3

**Freeze-out parameters of hadrons produced in Au+Au collisions at 1.23A GeV** — •Heidi Schuldes for the HADES-Collaboration — Goethe-Universität Frankfurt

The collective motion of final state hadrons reveals important information about both, the properties of the hot and dense medium created in a heavy-ion collision and the collision dynamics. The HADES collaboration has measured a comprehensive set of hadrons ($p$, $d$, $\pi^{\pm}$, $K^{\pm}$, $K^0$, $\phi$, $\Lambda$) produced in Au+Au collisions at 1.23A GeV.
The inverse slope parameters of the transverse mass spectra assuming a static thermal source show a mass dependent rise, indicating an additional radial expansion of the fireball. In this contribution we investigate the kinetic freeze-out conditions by applying simultaneous blast wave fits to the transverse mass spectra of hadrons and discuss to which extent the assumption of global freeze-out parameters can describe the observed kinematics. These results are compared to the chemical freeze-out parameters obtained by fitting the measured particle yields with a statistical hadronization model. Furthermore, the influence of resonance decays on the measured particle spectra will be addressed.
This work has been supported by BMBF (05P15RFFCA), GSI and HIC for FAIR.

HK 30.5 Mi 18:00 F 3

**Momentum anisotropy at freeze out** — •Steffen Feld and Nicolas Borghini — Universität Bielefeld, Bielefeld, Germany

The transition from a hydrodynamical modelling to a particle-based approach is a crucial element of the description of high-energy heavy-ion collisions. Assuming this "freeze out" happens instantaneously at each point of the expanding medium, we show that the local phase-space distribution of the emitted particles is asymmetric in momentum space. This suggests the use of anisotropic hydrodynamics for the last stages of the fluid evolution. We discuss how observables depend on the amount of momentum-space anisotropy at freeze out and how smaller or larger anisotropies allow for different values of the freeze-out temperature.

HK 30.6 Mi 18:15 F 3

**The Baryon Diffusion Constant of a Hot Hadron Gas** — •Jan Alexander Fotakis, Moritz Greif, and Carsten Greiner — Institut für Theoretische Physik, Goethe-Universität Frankfurt am Main, Germany

We present results for the baryon diffusion constant of a hot hadron gas which were achieved within a linear response approach in kinetic theory. We discuss the behaviour of this transport coefficient both at zero and at finite baryo-chemical potential and for temperatures underneath the critical temperature of a QGP. Furthermore, we compare to baryon diffusion constants of the QGP at the critical temperature calculated within other approaches.

HK 30.7 Mi 18:30 F 3

**Gluonic hot spots and spatial correlations inside the proton** — •Alba Soto-Ontoso[1,2], Hannah Petersen[2,3,4], and Javier L. Albacete[1] — [1]Universidad de Granada, Granada, Spain — [2]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [3]Goethe University, Frankfurt am Main, Germany — [4]GSI, Darmstadt, Germany

In this talk, based on arXiv:1605.09176, we present a microscopic realization of the *hollowness* effect observed in proton-proton scattering at $\sqrt{s} = 7$ TeV. Additionally, we show how the initial collision geometry proposed in our model influences significantly the eccentricities of p+p collisions. This is a highly debated topic as the analysis of the LHC experimental data have indicated suggestive signals of collective phenomena in high multiplicity p+p collisions.

The hollowness effect, not observed at lower energies, consists in a depletion of the inelasticity density at zero impact parameter of the collision. Our analysis is based on three main ingredients: we rely on gluonic hot spots inside the proton as effective d.o.f for the description of the scattering process. Next we assume that non-trivial correlations between the transverse positions of the hot spots inside the proton exist. Finally we build the scattering amplitude from a multiple scattering, Glauber-like series of collisions between hot spots. In our approach, the onset of the hollowness effect is naturally explained due to the diffusion of the hot spots in the transverse plane with increasing collision energy.

HK 30.8 Mi 18:45 F 3

**Studies of $\langle p_{\mathrm{T}} \rangle$ vs. $N_{\mathrm{ch}}$ in pp collisions at $\sqrt{s} = 5.02$ TeV with ALICE** — •Mario Krüger for the ALICE-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt

The ALICE experiment at CERN-LHC is designed to study the properties of a hot, deconfined QCD matter, the so called Quark-Gluon Plasma, which is created in ultrarelativistic heavy-ion collisions. This study is complemented by measurements in proton-proton and proton-lead collisions as a reference. In proton-proton collisions one can especially investigate effects of multiple-parton interactions and hadronization beyond independent string fragmentation.

The transverse-momentum spectra of particles produced in the collisions can be characterized by their mean-value $\langle p_{\mathrm{T}} \rangle$ and variance $\sigma$ as a function of event multiplicity. Due to detector effects, the measured multiplicities differ from the actual particle multiplicities $N_{\mathrm{ch}}$.

In this talk, we use a Bayesian unfolding procedure exploiting the correlation between measured and true multiplicities known from MC simulations. We present $\langle p_{\mathrm{T}} \rangle$ and $\sigma$ of inclusive charged particles as a function of the multiplicity $N_{\mathrm{ch}}$ in pp collisions at $\sqrt{s} = 5.02$ TeV within a pseudorapidity range of $|\eta| < 0.8$.

Supported by BMBF and the Helmholtz Association.