QCD phase structure and conserved charge fluctuations in a chiral effective model*

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Using the well-established chiral effective model for QCD matter, which includes all known hadrons up to $m = 2.6$ GeV and quarks, this study examines the phase structure of QCD matter and fluctuations of conserved charges focussing on the chiral and deconfinement phase transition. At small baryochemical potentials the effective model shows a smooth cross over in both order parameters and, at larger potentials, does not give indications for the existence of a first order phase transition and a critical end point. Compared to lattice QCD and thermal model fits of experimental data the chiral transition from the effective model is in line with recent data (Fig. 1).

At the phase transition conserved charges show large fluctuations which can be measured by susceptibility coefficients χ. Baryon number fluctuations are largely suppressed by the finite volume of hadrons and the suppressive particle interactions with vector fields (Fig. 2). It shows that in the hadronic phase below T_c coupling strengths are of the order of the nucleon couplings. However, in the quark sector above T_c, large fluctuations found in lattice QCD restrain quark vector couplings close to zero and particles at $T > T_c$ are almost acting like an ideal gas. With this model a realistic equation of state has been compiled which can be used for studying heavy ion collisions in dynamic models as well as neutron star properties.

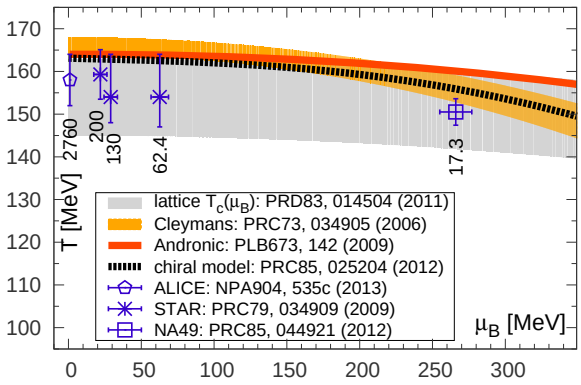

Figure 1: Chiral transition at small μ_B from lattice QCD (gray band) and from the chiral model (black line) contrasted to freeze-out curves from statistical and thermal model fits for SPS to LHC energies ($\sqrt{s_{\rm NN}}$ in GeV).

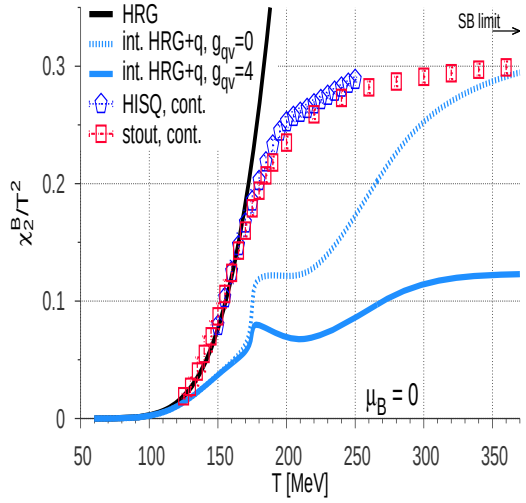

Figure 2: Second-order baryon number susceptibility of the hadron resonance gas (black line) and of the full model including hadrons and quarks (blue lines). Strong vector couplings suppress fluctuations and the Stefan-Boltzmann limit at high T may only be reached for vanishing quark vector couplings $g_{\rm qv}$ (dashed blue line).

Related publications in 2013:

1. P. Rau, J. Steinheimer, S. Schramm and H. Stöcker, *Chiral Hadronic Mean Field Model including Quark Degrees of Freedom*, J. Phys. G **40**, 085001 (2013).

2. P. Rau, J. Steinheimer, S. Schramm and H. Stöcker, *Conserved Charge Fluctuations in a Chiral Hadronic Model including Hadrons and Quarks*, arXiv:1308.4319 [hep-ph] (to be published in PLB).

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