HK 42: Heavy-Ion Collisions and QCD Phases VII

Time: Thursday 14:00–15:30 Location: HS 3 Chemie

Group Report HK 42.1 Thu 14:00 HS 3 Chemie

Universal critical dynamics in QCD — •Johannes Roth[1], Yunxin Ye[2], Sören Schlichting[2], and Lorenz von Smekal[1,3] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität, 35392 Giessen, Germany — [2]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld, Germany — [3]Helmholtz Research Academy Hesse for FAIR (HFHF), Campus Giessen

In this group report, I will give an overview of the universal critical dynamics at the chiral phase transition of two-flavor QCD in the chiral limit. I will review the argument by Rajagopal and Wilczek of the associated dynamic universality class being 'Model G' from the Halperin-Hohenberg classification. To extract dynamic universal quantities, we use a novel formulation of the functional renormalization group for dynamical systems with 'reversible mode couplings'. I will show results for dynamic universal quantities such as the non-trivial value $z = d/2$ of the dynamic critical exponent at the 'strong-scaling' fixed point (where d is the number of spatial dimensions) and for dynamic universal scaling functions. Finally, I will outline how the same method can be used to study the universal dynamics at the QCD critical point, with the dynamic universality class being 'Model H' in this case.

HK 42.2 Thu 14:30 HS 3 Chemie

Critical dynamics of the chiral phase transition from a 1/N expansion — •Jonas Hirsch[1], Johannes Roth[1], and Lorentz von Smekal[1,2] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität, 35392 Giessen, Germany — [2]Helmholtz Research Academy Hesse for FAIR (HFHF), Campus Giessen

The chiral phase transition of QCD in the limit of two massless quark flavors is widely believed to be of second order in the $O(4)$ universality class. Since the work of Rajagopal and Wilczek its *dynamic* universality class is then expected to be an extension of the original Model G by Halperin and Hohenberg. The characteristic feature of this dynamic model are the reversible mode couplings between the conserved iso-(axial-)vector charges and the chiral condensate as the order parameter field which all relax at equal rates due to *strong dynamic scaling*, as recently studied with the real-time FRG [1]. In this talk, I will consider a generalized version with an N-component order parameter field for large N. I will show that one can obtain exact solutions for the dynamic response functions with standard large-N counting rules from Dyson-Schwinger equations. In addition, I will discuss how the weak and strong-scaling fixed points are affected by the large-N limit.

[1] J.V. Roth, Y. Ye, S. Schlichting, L. von Smekal, *Dynamic critical behavior of the chiral phase transition from the real-time functional renormalization group*, JHEP, to be published, arXiv:2403.04573 [hep-ph].

HK 42.3 Thu 14:45 HS 3 Chemie

Critical dynamics with the analytically continued functional renormalization group — •Patrick Niekamp[1], Johannes Roth[1], and Lorenz von Smekal[1,2] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität, 35392 Giessen, Germany — [2]Helmholtz Research Academy Hesse for FAIR (HFHF), Campus Giessen, 35392 Giessen, Germany

Euclidean approaches such as the functional renormalization group (FRG) have been abundantly and successfully used to study the universal static critical behavior of various physical systems near continuous phase transitions. For the study of critical dynamics, on the other hand, one usually relies on real-time methods. Our research aims to connect and relate the two approaches by comparing analytically continued (aRG) and real-time FRG on the closed time path. In particular, we investigate the dynamic critical behavior of a dissipative open quantum system near equilibrium in the spirit of the Caldeira-Leggett model with the aFRG and compare that with real-time results for the dynamic universality class of the corresponding Model A (according to the classification by Halperin and Hohenberg). The long-term goal of this project is to understand the merits and limitations of studying more complicated critical dynamics, including conservation laws and reversible mode couplings as relevant for QCD, with analytically continued Euclidean versus real-time approaches.

HK 42.4 Thu 15:00 HS 3 Chemie

Measurement of Net-Proton Fluctuations with ALICE — •Ilya Fokin for the ALICE Germany-Collaboration — Physikalisches Institut, Universität Heidelberg

Lattice QCD (LQCD) calculations predict that chiral symmetry is restored in a smooth crossover transition between a quark-gluon plasma and a hadron resonance gas (HRG) at vanishing net-baryon density, a condition realized in heavy-ion collisions at the LHC. In this regime, the net-baryon number cumulants computed using the HRG and LQCD partition functions are in good agreement up to third order. However, starting with the fourth-order cumulants, the LQCD results are significantly lower than the corresponding HRG results. This offers a unique opportunity to experimentally verify the full QCD partition function by measuring the fourth-order cumulants of the net-proton number distributions.

In this talk, the status of the measurement of net-proton cumulants up to fourth order in Pb–Pb collisions with ALICE is presented.

HK 42.5 Thu 15:15 HS 3 Chemie

Proton and light nuclei number fluctuations measured at HADES — •Marvin Nabroth for the HADES-Collaboration — Goethe University, Frankfurt, Germany

QCD matter under extreme densities and moderate temperatures can be studied experimentally by conducting low-energy heavy-ion collisions. The HADES (High-Acceptance Dielectron Spectrometer) experiment at SIS18/GSI is specifically designed to measure the reaction products of such collisions at kinetic beam energies in the 1 AGeV regime, thereby probing the freeze-out conditions at the highest baryon-chemical potentials. Net-baryon number fluctuations are a sensitive probe for investigating critical behavior expected near the conjectured first-order phase transition and the critical endpoint of the QCD phase diagram. This report presents an analysis of proton and light nuclei multiplicity fluctuations measured in Ag+Ag collisions at $\sqrt{s_{NN}} = 2.55$ GeV and Au+Au collisions at $\sqrt{s_{NN}} = 2.4$ GeV. Advanced techniques for correcting detector inefficiencies and incomplete particle identification are discussed, including unfolding methods based on fuzzy logic and machine learning algorithms. Additionally, the effects of volume fluctuations and the corresponding correction strategies are covered. Finally, we present the reconstructed cumulants of protons and light nuclei, along with their ratios, as functions of centrality and rapidity acceptance.

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