HK 48: Heavy-Ion Collisions and QCD Phases XII

Time: Wednesday 17:30–19:00 Location: HBR 14: HS 1

HK 48.1 Wed 17:30 HBR 14: HS 1

Vorticity in heavy-ion reactions from a coarse-grained transport approach — •Robin Sattler[1], Nils Sass[1], and Hannah Elfner[1,2,3,4] — [1]Institute for Theoretical Physics, Goethe University, Max-von-Laue-Strasse 1, 60438 Frankfurt am Main, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt, Germany — [3]Frankfurt Institute for Advanced Studies, Ruth-Moufang-Strasse 1, 60438 Frankfurt am Main, Germany — [4]Helmholtz Research Academy Hesse for FAIR (HFHF), GSI Helmholtz Center, Campus Frankfurt, Max-von-Laue-Strasse 12, 60438 Frankfurt am Main, Germany

In 2017, the STAR collaboration at the Relativistic Heavy Ion Collider (RHIC) measured the polarization of Λ (and $\bar{\Lambda}$) hyperons and deduced an estimate for the vorticity in heavy ion collisions (HICs). Their findings suggest that the fluid produced in HICs is a highly vortical system due to the large deposition of angular momentum in the interaction medium of non-central collisions. In this work, the vortical flow structure of HICs is examined applying the hadronic transport approach SMASH (Simulating Many Accelerated Strongly-interacting Hadrons) within a coarse-grained framework. The thermal vorticity in non-central Au+Au collisions is calculated. In order to compare the results to the experimental data of the STAR collaboration, the polarization of the Λ hyperons is determined on the freeze-out hypersurface. In addition, the results are compared to a similar study within the UrQMD (Ultra-relativistic Quantum Molecular Dynamics) approach.

HK 48.2 Wed 17:45 HBR 14: HS 1

QCD topology and axions — Bastian Brandt, Gergely Endrődi, •José Javier Hernández Hernández, Gergely Markó, and Laurin Pannullo — Universität Bielefeld

A possible solution to the strong CP problem is the axion mechanism. Axions are widely studied since they are also candidates for dark matter and they are susceptible to experimental detection, e.g. through their coupling with photons. Moreover, the axion mass is a source of cosmological information during the early universe. Using Lattice QCD simulations with staggered quarks at the physical point, we explore the impact of electromagnetic fields on topological observables related to axions. Our focus is on the topological susceptibility ($\propto m_a^2$) and the axion-photon coupling. The current status in the determination of the magnetic field dependence of the axion mass at finite temperature, with a focus in the crossover region, is shown. We also present the result of the first non-perturbative calculation of the QCD corrections to the axion-photon coupling.

HK 48.3 Wed 18:00 HBR 14: HS 1

On the validity of Ohm's law in relativistic plasmas — •Ashutosh Dash, Masoud Shokri, Luciano Rezzolla, and Dirk Rischke — Goethe university, Institute for theoretical physics, 60438 Frankfurt am Main

Relativistic plasmas play a significant role in high-energy phenomena, including heavy-ion collisions, black-hole magnetospheres, relativistic jets, and the early universe. The coarse-grained framework for describing the motion of charged fluid is known as relativistic magnetohydrodynamics (MHD). The MHD equations, which comprise the particle conservation law, the energy/momentum conservation laws, and Maxwell*s equations, must also be complemented by Ohm*s law. The usual Navier-Stokes form of Ohm's law is acausal and needs to be replaced with an evolution equation of the charge diffusion current with a finite relaxation time, which ensures causality and stability.

This, in turn, leads to transient effects in the charge-diffusion current, the nature of which depends on the particular values of electrical conductivity and the charge-diffusion relaxation time. We will investigate in a simplified 1+1-dimensional setting in the context of heavy-ion collision, where matter and electromagnetic fields are assumed to be transversely homogeneous and are initially expanding according to a Björken scaling. We will see how the scale invariance is broken by the ensuing self-consistent dynamics of matter and electromagnetic fields. Implications of these findings on the recent measurement of charged particle directed flow by the STAR experiment will also be discussed.

HK 48.4 Wed 18:15 HBR 14: HS 1

Critical dynamics of non-equilibrium phase transitions — •Leon Sieke[1], Mattis Harhoff[3], Sören Schlichting[3], and Lorenz von Smekal[1,2] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — [2]Helmholtz Research Academy for FAIR (HFHF), Campus Gießen, 35392 Gießen, Germany — [3]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld, Germany

In context of the search for the QCD critical endpoint in heavy-ion collisions, a deep understanding of the out-of-equilibrium dynamics of the system is necessary to make well-grounded predictions for signatures in final states. To this end, we investigate the dynamic critical behavior of a classical scalar field theory with Z_2 symmetry in the dynamic universality class of Model A in two and three spatial dimensions. The critical dynamics of the system is studied under a linear quench protocol, where the external symmetry breaking field is changed at a constant rate through the critical point. We discuss the connection to the Kibble-Zurek mechanism and determine the dynamic critical exponent z as well as universal scaling functions. These fully describe the non-equilibrium evolution of the system near the critical point for all quench rates under consideration. We find that while the scaling functions are non-trivial, the corresponding scaling exponents are fully determined by the static critical exponents and the dynamic critical exponent. Finally, we perform a finite-size scaling analysis and observe good collapse of the data onto universal finite-size scaling functions.

HK 48.5 Wed 18:30 HBR 14: HS 1

Critical Dynamics from the Analytically Continued FRG — •Patrick Niekamp[1], Lorenz von Smekal[1,2], and Johannes Roth[1] — [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 (aFRG) 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 48.6 Wed 18:45 HBR 14: HS 1

Non-relativistic stochastic hydrodynamics — •Mattis Harhoff[1], Sören Schlichting[1], and Lorenz von Smekal[2,3] — [1]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld, Germany — [2]Institut für Theoretische Physik, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — [3]Helmholtz Research Academy for FAIR (HFHF), Campus Gießen, 35392 Gießen, Germany

Understanding dynamic critical phenomena is a crucial ingredient to finding signatures of a QCD critical endpoint in final states of non-equilibrium processes such as heavy ion collisions. If such a system exhibits the right conservation laws, its non-equilibrium dynamics in the vicinity of a critical point can be understood hydrodynamically, corresponding to Model H in the classification scheme by Halperin and Hohenberg. Since fluctuations of the order parameter diverge near a critical point, including stochastic fluctuations into the underlying hydrodynamic equations is essential to describe critical phenomena correctly. We propose a novel approach to the numerical simulation of non-relativistic stochastic hydrodynamics on a lattice in two spatial dimensions. Our method features a Metropolis-type algorithm to sample stochastic fluxes of the conserved quantities, ensuring that fluctuations follow the correct microcanonical probability distribution. Tuning input parameters using an entropy production argument generates the desired transport coefficients. We present how the algorithm can be used to simulate problems such as stochastic diffusion and give an outlook on applications in the context of non-equilibrium phase transitions.