HK 6: Heavy-Ion Collisions and QCD Phases II

Time: Monday 16:30–18:00 Location: SCH/A315

Group Report HK 6.1 Mon 16:30 SCH/A315

Dielectrons with ALICE - Past, Present, Future — •Sebastian Scheid for the ALICE Germany-Collaboration — Goethe University, Frankfurt, Germany

The measurement of dielectrons is a fundamental piece in the understanding of hot and dense matter produced in ultra-relativistic heavy-ion collisions. The dielectron spectra yield information that pierce the veil of final-state hadronic interactions and give direct access to the early phases of the collision. ALICE recently started the LHC Run 3 data taking campaign after a major upgrade of the detector, which will significantly improve the capabilities to measure dileptons.

In this talk, we will give an overview of the dielectron measurements achieved so far with ALICE in different collision systems. Furthermore, the status of the Run 3 analyses together with the prospects for the Runs 3 and 4 will be presented. In particular, the impact of the detector upgrades installed during the long shut down will be explained. Finally, ultimate precision dielectron measurements in the 2030s with ALICE 3, a next-generation heavy-ion experiment at the LHC, will be discussed.

HK 6.2 Mon 17:00 SCH/A315

Thermal dileptons as a multi-messenger probe of the fireball — •Florian Seck[1], T. Galatyuk[1,2], R. Rapp[3], N. Schwarz[1], J. Steinheimer[4,5], J. Stroth[4,2], and M. Wiest[1] — [1]Technische Universität Darmstadt — [2]GSI, Darmstadt — [3]Texas A&M University, College Station, USA — [4]Universität Frankfurt — [5]FIAS, Frankfurt

As dileptons are radiated from the extreme states of matter created in heavy-ion collisions with negligible final-state interactions, they retain the information imprinted on them at the time of their creation. Multi-differential measurements of dilepton invariant mass, momentum, and angular distributions can therefore serve as a multi-messenger tool to characterize the properties of matter in the interior of the hot and dense fireball. To compute thermal dilepton spectra, we integrate in-medium dilepton rates over the space-time evolution of the collision described by a coarse-graining method of hadronic transport or hydrodynamic simulations. While the general shape of the dilepton invariant mass spectrum probes the baryon density, the slope at moderate masses measures the average temperature reached during the collision. The yield in the low-mass range is related to the fireball lifetime and is enhanced if a significant fraction of the fireball volume crosses a possible first-order phase transition. The analysis of the collective flow and polarization of dileptons can provide additional insights into the space-time evolution of the fireball in the QCD phase diagram and possible changes in the composition of the emitting source.

This work has been supported by: VH-NG-823, Helmholtz Alliance HA216/EMMI, GSI, HFHF, and the DFG through grant CRC-TR 211.

HK 6.3 Mon 17:15 SCH/A315

Dielectron Analysis for the CBM Experiment — •Adrian Meyer-Ahrens for the CBM-Collaboration — Institut für Kernphysik WWU Münster, Münster, Deutschland

The Compressed Baryonic Matter (CBM) experiment is a fixed-target heavy-ion experiment currently under construction at FAIR in Darmstadt which will explore the QCD phase diagram at high net-baryon densities. Dielectrons serve as versatile probes for the properties of the hot and dense medium created in the collisions since they do not interact strongly and escape the fireball undisturbed. Dielectron physics relies on the efficient reduction of combinatorial background, dominated by misidentified hadrons as well as electrons from photon conversions in the target or detector material.

In this talk, simulation results concerning dielectron invariant mass spectra at CBM will be presented, focussing on background rejection using conventional cut-based selections as well as machine learning methods. This work is supported by BMBF grant 05P21PMFC1.

HK 6.4 Mon 17:30 SCH/A315

Real-time methods for spectral functions — Johannes Roth[1], •Leon Sieke[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

We compare different real-time methods to calculate spectral functions in dissipative open systems based on generalized Langevin equations. These are classical-statistical lattice simulations, a quasiclassical approximation and a Gaussian state approximation (GSA) which is the main focus of this talk. Results from exact diagonalization of the quartic anharmonic oscillator with damping serve as benchmark which can be seen as a (0+1)-dimensional toy theory for self-interacting scalar fields at finite temperature. Inspired by the well-known Caldeira-Leggett model, we extend the classical Langevin dynamics for the coupling to an external heat bath to the corresponding Heisenberg-Langevin dynamics in the GSA [1]. We furthermore use the latter to compute spectral functions in a self-interacting scalar field theory in (2+1) and (3+1) dimensional spacetime. To achieve this we employ two different methods to compute the spectral functions which work particularly well in complementary temperature regimes.

[1] J. V. Roth, D. Schweitzer, L. J. Sieke and L. von Smekal, Phys. Rev. D 105 (2022) 116017.

HK 6.5 Mon 17:45 SCH/A315

Momentum dependence of thermal dilepton invariant mass spectra combining transport models and an FRG spectral function — •Maximilian Wiest[1], Tetyana Galatyuk[1,2,4], Ralf-Arno Tripolt[3], Lorenz von Smekal[3,4], and Jochen Wambach[1] — [1]Technical University of Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [3]Justus Liebig University Giessen, Germany — [4]Helmholtz Research Academy Hesse for FAIR (HFHF)

Dileptons provide a unique way to access the properties of the fireball in heavy ion-collisions. While the bulk of the detected particles stemming from heavy ion collisions are hadrons, particles heavily influenced by final state interactions, dileptons do not suffer from this disadvantage and can leave the fireball undisturbed, probing the hot and dense matter before it freezes out. We use the microscopic transport model UrQMD to simulate heavy-ion collisions at SIS18 energies in different centrality classes. Employing a Coarse Graining approach, we are able to combine the simulated microscopic dynamics with in-medium spectral functions obtained from FRG methods at finite momenta. This allows to study the impact of finite momentum effects of the spectral function on the dilepton spectra invariant mass spectra measured at SIS18 energies.

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