HK 3: Heavy-Ion Collisions and QCD Phases I

Time: Monday 15:00–16:30 Location: HS 3 Chemie

HK 3.1 Mon 15:00 HS 3 Chemie

Performance study of non-prompt J/ψ production in Pb–Pb collisions $\sqrt{s_{\rm NN}}$ = 5.36 TeV from ALICE — •YUANJING JI FOR THE ALICE GERMANY-COLLABORATION — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

Lattice QCD calculations predict that a strongly-coupled QCD matter, the quark-gluon plasma (QGP), can be formed in relativistic heavy-ion collisions at extremely high temperatures and energy densities. Due to their large masses, heavy quarks (c, b) are predominantly produced in the initial hard scattering process before the hot QCD medium forms. Their final-state dynamics, therefore, encode information about the evolution of the system, making them effective probes of the properties of the hot QCD medium. In high-energy hadronic collisions, inclusive J/ψ production consists of both prompt and non-prompt components. The prompt component includes J/ψ produced directly or from the decays of higher-mass charmonium states (e.g., ψ(2S) or χ_c), while the non-prompt component originates from the weak decays of beauty hadrons. Therefore, the study of the production and properties of non-prompt J/ψ would provide valuable insights into those of the beauty hadrons.

The Time Projection Chamber and Inner Tracking System of the ALICE detector were recently upgraded, allowing a $\sim$ 50 times increase in read-out rate in Run3 of the Large Hadron Collider (LHC). In this talk, we will present the performance of the prompt and non-prompt J/ψ measurements in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.36 GeV in ALICE during LHC Run3.

HK 3.2 Mon 15:15 HS 3 Chemie

Charmonium production at midrapidity using TRD-triggered data measured in ALICE — •JINJOO SEO for the ALICE Germany-Collaboration — Heidelberg University, Heidelberg, Germany

Quarkonium production is considered one of the golden probes of quark-gluon plasma (QGP) formation in heavy-ion collisions. Quarkonium production in small collision systems, such as pp collisions, is also important for investigating production mechanisms and providing a reference for heavy-ion collisions. Charmonium, a bound state of charm and anti-charm quark pairs, has its production mechanism described by perturbative QCD for heavy quark production and non-perturbative QCD calculations for the formation of the bound state. Measurements of J/ψ and ψ(2S) cross sections in pp collisions are crucial for studying charmonium production mechanisms and testing different QCD-based model calculations. Especially, ψ(2S) production relative to J/ψ provides strong discriminating power among quarkonium production models. Thanks to the ALICE online single-electron triggers from the Transition Radiation Detector (TRD), the ψ(2S) signal can be extracted at midrapidity via the dielectron decay channel. In this contribution, the results on $p_{\rm T}$-differential ψ(2S) production cross section at midrapidity with the TRD-triggered data measured in ALICE in pp collisions at $\sqrt{s}$ = 13 TeV will be shown, along with those for J/ψ. In addition, the excited-to-ground state yield ratio (ψ(2S)-to-J/ψ) at midrapidity will be discussed. Results will be compared to measurements at forward rapidity and available model calculations.

HK 3.3 Mon 15:30 HS 3 Chemie

Study of charm hadronization into baryons: azimuthal correlations between Λ_c^+ and charged particles in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE — •SAMRANGY SADHU for the ALICE Germany-Collaboration — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Germany

Angular correlations between prompt charm hadrons and primary charged particles in high-energy proton-proton (pp) collisions provide insights into the charm-quark hadronization process. This study presents the first measurement of Λ_c^+ baryon correlations, focusing on the azimuthal-angle difference between prompt Λ_c^+ baryons and charged particles in pp collisions at $\sqrt{s}$ = 13 TeV, using data from Run 2 taken with the ALICE detector. Λ_c^+ baryons are reconstructed in the transverse-momentum range $3 < p_T < 16$ GeV/c and correlated with charged particles having $p_T > 0.3$ GeV/c and $|\eta| < 0.8$. The correlation patterns show differences in associated particle yields compared to D mesons, particularly in the low transverse-momentum region. These results suggest that charm-quark fragmentation into baryons may differ from that into mesons. Monte Carlo simulations do not fully reproduce these discrepancies, indicating a need for refined models of charm-quark hadronization. Supported by BMBF.

HK 3.4 Mon 15:45 HS 3 Chemie

Fluid dynamics of beauty quarks at the LHC — •FEDERICA CAPELLINO — GSI Helmholtzzentrum Darmstadt, Germany

Heavy quarks (i.e. charm and beauty) are powerful tools to characterize the quark-gluon plasma (QGP) produced in heavy-ion collisions. Although they are initially produced out of kinetic equilibrium via hard partonic scattering processes, recent measurements of the anisotropic flow of charmed hadrons pose the question regarding the possible thermalization of heavy quarks in the medium. By exploiting a mapping between transport theory and hydrodynamics [1], we developed a fluid-dynamic description of heavy-quark diffusion in the QCD plasma. We will show that a fluid-dynamic description of beauty quarks at LHC energies is supported by the most recent lattice-QCD calculations. We will present results for transverse momentum distributions and integrated yields of beauty hadrons obtained with a fluid-dynamic code coupled with the conservation of a heavy-quark - antiquark current in the QGP [2,3]. This work is funded via the DFG ISOQUANT Collaborative Research Center (SFB 1225).

[1] Phys.Rev.D 106 (2022) 3, 034021
[2] Phys.Rev.D 108 (2023) 11, 116011
[3] Capellino et al., in preparation

HK 3.5 Mon 16:00 HS 3 Chemie

Study of the heavy-quark out-of-equilibrium distribution function — •ROSSANA FACEN — Physikalisches Institut Heidelberg, Heidelberg, Germany

Heavy quarks, i.e. charm and bottom, are unique probes to study the properties of the quark-gluon plasma (QGP). Due to their large masses, heavy quarks are produced at the initial stage of the collision almost exclusively via hard partonic scattering and experience the entire collision history.

Even if the heavy-quark distribution function is out of equilibrium, a fluid-dynamic approach has been demonstrated to be applicable to study the dynamics of charm quarks in the QGP [1]. However, out-of-equilibrium (ooe) corrections of the heavy-quark distribution function must be considered at the freeze-out, to correctly compute charm-hadron momentum distributions and integrated yields. In order to parameterize the ooe corrections, two different theoretical frameworks have been proposed. The Multi-Fluid description, a microscopic approach arising from kinetic theory, assumes that multiple species contribute to the diffusion of heavy quarks. On the other hand, the Maximum Entropy method is based on macroscopic considerations, and computes the ooe distribution maximizing the entropy current. In this work, we study the validity of these two approaches, focusing on their feasibility to describe heavy-quark dynamics.

This work is funded via the DFG ISOQUANT Collaborative Research Center (SFB 1225).

[1] Phys.Rev.D 106 (2022) 3, 034021

HK 3.6 Mon 16:15 HS 3 Chemie

Universal non-equilibrium scaling of cumulants across a critical point — •LEON J. SIEKE[1], MATTIS HARHOFF[3], SÖREN SCHLICHTING[3], and LORENZ VON SMEKAL[1,2] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität, 35392 Gießen, Germany — [2]Helmholtz Forschungsakademie Hessen für FAIR (HFHF), Campus Gießen, 35392 Gießen, Germany — [3]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld, Germany

We study the critical dynamics of a scalar field theory with Z_2 symmetry in the dynamic universality class of Model A in two and three spatial dimensions with classical-statistical lattice simulations. In particular, we measure the non-equilibrium behavior of the system under a quench protocol in which the symmetry-breaking external field is changed at a constant rate through the critical point. Using the well-established Kibble-Zurek scaling theory we compute non-equilibrium scaling functions of cumulants of the order parameter up to fourth order. Together with the static critical exponents and the dynamic critical exponent, these fully describe the universal non-equilibrium evolution of the system near the critical point. We further extend the analysis to include finite-size effects and observe good collapse of our data onto two-dimensional universal non-equilibrium and finite-size scaling functions.