HK 17: Heavy-Ion Collisions and QCD Phases III

Time: Wednesday 16:30–18:30 Location: H1

Group Report HK 17.1 Wed 16:30 H1

Global polarization of Λ hyperons as a probe for vortical effects in A+A collisions with HADES — •Frederic Kornas[1], Ilya Selyuzhenkov[2], and Tetyana Galatyuk[1,2] for the HADES-Collaboration — [1]TU Darmstadt, Darmstadt, Germany — [2]GSI Helmholtzzentrum, Darmstadt, Germany

Large orbital momenta occur in non-central heavy-ion collisions which might transfer to the particle spins resulting in a global polarization of the produced particles. Such a global polarization can be measured using weakly decaying particles, e.g. the Λ hyperon. The results of the Λ polarization measurement in Au+Au collisions at $\sqrt{s_{NN}} = 2.4$ GeV and Ag+Ag collisions at $\sqrt{s_{NN}} = 2.55$ GeV will be reported. For the latter, the polarization will be shown as a function of centrality, rapidity and transverse momentum. The magnitude of the measured polarization by HADES follows the increasing trend with decreasing collision energy observed by the STAR and ALICE collaborations at higher energies. In addition, directed flow v_1 measurements of the Λ will be shown. The v_1 slope at midrapidity will be compared to the protons measured in the same collision systems in HADES and put in the context of previous measurement.

HK 17.2 Wed 17:00 H1

Measurement of light (anti-)nuclei production in pp collisions at $\sqrt{s} = 13$ TeV with ALICE — •Michael Habib[1,2] and Luca Barioglio[3] for the ALICE-Collaboration — [1]GSI Helmholtzzentrum für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt — [2]Institut für Kernphysik, Technische Universität Darmstadt, Schlossgartenstr. 9, 64289 Darmstadt — [3]Physik Department, Technische Universität München, James-Franck-Straße 1, 85748 Garching bei München

Understanding the production mechanism of light (anti-)nuclei is one of the key challenges of contemporary nuclear physics. It has important consequences for astrophysics since it provides input for indirect dark matter searches with space-bound experiments. In this talk, the latest results on light (anti-)nuclei production obtained with ALICE in pp collisions at $\sqrt{s} = 13$ will be presented and compared to coalescence and thermal model predictions. In particular, the measured coalescence parameters for deuterons and helium nuclei will be compared with parameter-free theoretical predictions. The latter are constrained by femtoscopic source radius measurements and they depend directly on the nuclear wave functions.

HK 17.3 Wed 17:15 H1

Machine Learning Application for Λ Hyperon Reconstruction in CBM at FAIR — •Shahid Khan[1], Ali Imdad Khan[1], Viktor Klochkov[1], Olha Lavoryk[2], Oleksii Lubynets[3,4], Andrea Dubla[3], and Ilya Selyuzhenkov[3,5] for the CBM-Collaboration — [1]University of Tübingen — [2]University of Kyiv — [3]GSI, Darmstadt — [4]University of Frankfurt — [5]NRNU MEPhI, Moscow

The Compressed Baryonic Matter (CBM) experiment at FAIR will investigate the QCD phase diagram in the region of high net-baryon densities (B > 500 MeV) in the collision energy range of $\sqrt{s_{NN}}$ = 2.7-4.9 GeV with high interaction rate, up to 10 MHz, provided by the SIS100 accelerator. Enhanced production of strange baryons can signal a transition to a new phase of the QCD matter. Λ hyperons are the most abundantly produced strange baryons. They weakly decay, with a branching ratio of 64%, into a proton (p^+) and a pion (π^-). To reconstruct the $\Lambda \rightarrow p^+ + \pi^-$ decay kinematics, Particle-Finder Simple package is used. It uses the mathematics of the Kalman Filter Particle package and provides a convenient interface to control the reconstruction parameters. For the reduction of combinatorial background specific selection criteria need to be applied to the proton and π^- tracks and Λ-candidates decay topology.

In this work, the performance for Λ reconstruction in CBM with Machine Learning algorithms such as XGBoost will be presented. These algorithms allow efficient, non-linear and multi-dimensional selection criteria to be implemented whilst achieving high signal to background ratio in the region around the Λ candidate invariant mass peak.

HK 17.4 Wed 17:30 H1

Comparison of light (hyper-)nuclei from PHQMD simulations with experimental data from heavy-ion collisions — •Susanne Glässel[1], Christoph Blume[1,2], Elena Bratkovskaya[1,2], and Gabriele Coci[2] — [1]Goethe University Frankfurt — [2]GSI Darmstadt

Simulations of light nuclei production in heavy-ion collisions up to date have been limited to the modeling of a sudden transition from a dynamical transport model to clusterization (via coalescence or statistical model). However, a better understanding of the cluster formation and of how such weakly bound objects are formed and survive in the dense and hot environment created in heavy-ion collisions cannot be established that way. The newly developed Parton-Hadron-Quantum-Molecular-Dynamics (PHQMD) approach allows a dynamical cluster formation continuously during the time evolution of the collision. The microscopic n-body transport model describes the interactions between baryons on the basis of Quantum Molecular Dynamics (QMD) which allows to propagate n-body correlations in phase-space, essential for the cluster formation. The clusters are recognized by the Minimum Spanning Tree (MST) algorithm. Collisions among hadrons, the Quark-Gluon-Plasma formation and parton dynamics are adopted from the Parton-Hadron-String-Dynamics (PHSD) transport approach. A comparison of light nuclei and hypernuclei simulated with PHQMD and experimental data from AGS to RHIC energies will be presented, also providing valuable predictions for the upcoming CBM and NICA experiments. DFG-grant BL 982/3-1, DFG-grant BR 4000/7-1.

HK 17.5 Wed 17:45 H1

CBM performance for the measurement of Λ hyperons' directed flow in Au+Au collisions at FAIR SIS-100 energies — •Oleksii Lubynets[1,2] and Ilya Selyuzhenkov[1,3] for the CBM-Collaboration — [1]GSI, Darmstadt, Germany — [2]Goethe Universität Frankfurt, Germany — [3]NRNU MEPhI, Moscow, Russia

The main goal of the CBM experiment is to study highly compressed baryonic matter produced in collisions of heavy ions. The SIS-100 accelerator at FAIR will enable investigation of the QCD matter at temperatures up to about 120 MeV and net baryon densities 5-6 times the normal nuclear density. Hyperons produced during the dense phase of a heavy-ion collision provide information about the equation of state of the QCD matter. The measurement of their anisotropic flow is important for understanding the dynamics and evolution of the QCD matter created in the collision.

We will present the status of performance studies for Λ hyperon directed flow measurement for the CBM experiment at FAIR. Λ hyperons decay within the CBM detector volume and are reconstructed via their decay topology. The Particle-Finder Simple package, which provides an interface to the Kalman Filter Particle (KFParticle) mathematics, is used to reconstruct $\Lambda \rightarrow p\pi^-$ decay kinematics and to optimize criteria for Λ candidates selection. Directed flow of Λ hyperons is studied as a function of rapidity, transverse momentum and collision centrality. The effects on flow measurement due to non-uniformity of the CBM detector response in the azimuthal angle, transverse momentum and rapidity are corrected using the QnTools analysis package.

HK 17.6 Wed 18:00 H1

Linear and Nonlinear Kinetic Description of Momentum Anisotropies in pp and pA Collisions in RTA — •Clemens Werthmann and Sören Schlichting — Universität Bielefeld, Bielefeld, Germany

Momentum anisotropies caused by collective flow phenomena in HICs have been known to convey a rich amount of information on the collision geometry. In pp and pA collisions the system size is too small for the hydrodynamic description of these anisotropies to be applicable. Instead, a microscopic description of the non-equilibrium dynamics has to be employed. Indeed, kinetic theory simulations have reproduced the anisotropies, but detailed insight into the mechanisms of their emergence is obscured by the algorithmical implementation. This prompts attempts to complement them with analytical treatments, which is highly nontrivial. We present an in-depth study of analyitcal and numerical descriptions of the problem formulated in relaxation time approximation. The analytical description employs an opacity expansion scheme of the Boltzmann equation and a linearization in small anisotropic perturbations on top of an isotropic Gaussian background. The nonlinear numerical description allows to estimate the range of validity of these appoximations via comparison and to study how the flow behaviour evolves from the free-streaming to the hydrodynamic regime.

HK 17.7 Wed 18:15 H1

Relativistic heavy-ion collisions and multiharmonic/large-order flow cumulants — •Seyed Farid Taghavi — Physics department, Technical University of Munich, James-Franck-Straße 1, 85748 Garching bei München

In the past years, significant progress has happened in high-energy nuclear physics models. A more robust and quantitative picture has replaced the qualitative descriptions of heavy nuclei collisions in the earlier days, enabling us to have a clearer picture of different stages of a heavy-ion collision. These models typically have $O(10)$ free parameters. The free parameters are tuned by Bayesian analysis in recent years, where the ALICE measurements are used as inputs.

In this presentation, our focus is on anisotropic flow observables. We introduce a method to extract anisotropic flow cumulants systematically. Employing a Monte Carlo simulation tuned by Bayesian analysis results, we predict the value of few low-order flow harmonic cumulants with significant signals that have not been reported by the LHC so far. We address how the new observables can modify the Bayesian analysis results. The large-order flow cumulant ($v_n\{2k\}$ with large k) contains a unique piece of information about the underlying flow distribution. In particular, we discuss the relation between the nonvanishing Lee-Yang zero phase and large-order flow cumulant ratios at ultra-central, ultra-peripheral, large, and small collision systems.
Based on:
S. F. Taghavi, (2020), arXiv:2005.04742 [nucl-th] (will be appeared in Eur.Phys.J.C)