HK 27: Heavy-Ion Collisions and QCD Phases V

Time: Friday 14:00–16:15 Location: H1

Group Report HK 27.1 Fri 14:00 H1

New developments in flow analyses techniques — •Ante Bilandzic for the ALICE-Collaboration — Technical University of Munich, Germany

With the advent of large statistics heavy-ion datasets at RHIC and LHC it is becoming feasible to study the properties of Quark–Gluon Plasma with unprecedented precision. One of the most informative probes in such studies is the collective anisotropic flow.

In this talk, we present the new developments in flow analysis techniques. We reconcile for the first time the strict mathematical formalism of multivariate cumulants with the usage of cumulants in anisotropic flow analyses. This yields to the next generation of observables to be used in flow analyses: *Event-by-event cumulants of azimuthal angles*, *Symmetric and Asymmetric cumulants of flow amplitudes*, *Cumulants of Symmetry Plane Correlations*. We show that properties of cumulants are preserved only for the stochastic observables on which the cumulant expansion has been performed directly, and if there are no underlying symmetries due to which some terms in the cumulant expansion are identically zero [1].

We derive for the first time the analytic solutions for the contribution of combinatorial background in the measured 2- and 3-particle correlations [2].

[1] A. Bilandzic, M. Lesch, C. Mordasini, S. F. Taghavi, [arXiv:2101.05619 [physics.data-an]]

[2] A. Bilandzic, [arXiv:2106.05760 [hep-ph]]

HK 27.2 Fri 14:30 H1

Tracing the emergence of collective phenomena in small systems — •Pragya Singh and Soeren Schlichting — University of Bielefeld

Event geometry and initial state correlations have been invoked as possible explanations of long-range rapidity correlations (ridge) observed in high multiplicity pp and pPb collisions. We study initial state momentum correlations and event-by-event geometry in p+Pb collisions at $\sqrt{s} = 5.02$ TeV by following the approach of extending the impact parameter dependent Glasma model (IP-Glasma) to 3D using JIMWLK rapidity evolution of the incoming nuclear gluon distribution [1].

Investigating the non-trivial rapidity dependence of the observables, we find that geometry is correlated across large rapidity intervals whereas initial state momentum correlations are relatively short range in rapidity. Based on our results, we discuss implications for the relevance of both effects in explaining the origin of collective phenomena in small systems.

[1]. B. Schenke and S. Schlichting, Phys. Rev. C 94,044907, arXiv: 1605.07158 [hep-ph]

HK 27.3 Fri 14:45 H1

Non-Equilibrium Transport of Conserved Charges in High-Energy Heavy Ion Collisions — •Philip Plaschke — Bielefeld University, Germany

Non-equilibrium Green*s functions provide an efficient way to describe the pre-equilibrium evolution of macroscopic quantities in early stages of heavy-ion collisions. Within the kinetic theory framework we derived a new method to calculate time dependent non-equilibrium Green*s functions describing the evolution of energy and momentum perturbations on top of an evolving far-from-equilibrium background. We further extend this formalism to describe the evolution of conserved charges. Within kinetic theory in relaxation time approximation we will study the pre-equilibrium evolution of the homogeneous background for non-vanishing initial charge densities and compute the Green*s functions for the charge current for initial charge perturbations around zero density on top of the background. By calculating the Green's functions, we show that only modes with long wavelength survive up into the hydrodynamic regime.

HK 27.4 Fri 15:00 H1

Exploring the Pre-Equilibrium Dynamics of Longitudinal Fluctuations in Heavy-Ion Collisions — •Stephan Ochsenfeld — Bielefeld University, Bielefeld, Germany

Non-equilibrium Green*s functions provide an efficient way to describe the pre-equilibrium evolution of macroscopic quantities in early stages of heavy-ion collisions. Within the kinetic theory framework we derive a new method to calculate time dependent non-equilibrium Green*s functions describing the evolution of energy and momentum perturbations on top of an evolving far-from-equilibrium boost invariant background. As extension to transverse perturbations we also consider fluctuations parallel to the beam direction. By calculating the Green*s functions in relaxation time approximation, we show that in both types of perturbations only modes with long wavelength survive up into the hydrodynamic regime, albeit inhibiting sightly different behavior.

HK 27.5 Fri 15:15 H1

FluiduM: fluid dynamics with mode expansion for fast simulations of relativistic heavy-ion collisions — •Andreas Kirchner[1], Federica Capellino[2], Giuliano Giacalone[1], Eduardo Grossi[3], Daniel Boness[4], Damir Devetak[8], Andrea Dubla[5], Stefan Floerchinger[1], Dhevan Gangadharan[6], Sarah Görlitz[2], Silvia Masciocchi[5,2], Ilya Selyuzhenkov[5], Christian Sonnabend[2], and Kianusch Yousefnia[7] — [1]ITP Heidelberg — [2]Physikalisches Institut, Universität Heidelberg — [3]Department of Physics, SUNY Stony Brook — [4]Fachbereich Physik, Universität Konstanz — [5]GSI Darmstadt — [6]University of Houston — [7]IPhT, Université Paris Saclay — [8]VINCA Inst. Nucl. Sci., Belgrade

We introduce FluiduM, a code to simulate the quark-gluon plasma (QGP) formed in relativistic heavy-ion collisions. Based on a background-fluctuation splitting of the QGP and its initial conditions, in FluiduM the 2+1D hydrodynamic QGP evolution is replaced with a system of de-coupled 1+1D equations, leading to a reduction of orders of magnitude in computation time compared to more traditional codes. The framework implements state-of-the-art initial conditions, second order Israel-Stuart hydrodynamics, and QGP freeze-out supplemented with viscous corrections and resonance decays. We validate the code through calculations of particle yields and average hadron momenta. FluiduM provides a new powerful tool to test our understanding of heavy-ion collisions, with potentially far-reaching consequences for the realization of the goals of the heavy-ion collision program.

HK 27.6 Fri 15:30 H1

Anisotropic flow coefficients in mode-by-mode hydrodynamics: moving towards precision in heavy-ion collision phenomenology — •Giuliano Giacalone[1], Federica Capellino[2], Andreas Kirchner[1], Eduardo Grossi[3], Daniel Boness[4], Stefan Floerchinger[1], Andrea Dubla[5], Silvia Masciocchi[2,5], and Ilya Selyuzhenkov[5] — [1]ITP Heidelberg — [2]Physikalisches Institut, Universität Heidelberg — [3]Department of Physics, SUNY Stony Brook — [4]Fachbereich Physik, Universität Konstanz — [5]GSI Darmstadt

Anisotropic flow coefficients, v_n, carry information about the transport properties of the quark-gluon plasma (QGP) formed in heavy-ion collisions, and are measured today with an amazing degree of precision at colliders. Theoretically, sophisticated models and tools of data analysis have been developed since the appearance of event-by-event (ebye) hydrodynamic simulations, but the intrinsic issue of the slowness of ebye codes remains present today, tampering with our ability of characterizing the physical properties of the QGP from experimental data. In this contribution, we overcome such an issue by means of the newly-developed FluiduM code, based on a background-fluctuation splitting of the QGP evolution, and mode-by-mode hydrodynamic equations. We show that the calculation of v_n coefficients in Fluidum is faster by orders of magnitud than in standard hydro simulations. We present, thus, results for ultra-central collisions, largely inaccessible to ebye codes, where precision data has been recently collected at LHC and RHIC. These results pave the way for future theory-to-data comparisons of unprecedented quality in the context of heavy-ion collisions.

HK 27.7 Fri 15:45 H1

Recent developments in the measurements of genuine multi-harmonic correlations in Pb–Pb collisions — •Cindy Mordasini for the ALICE-Collaboration — Technische Universität München, James-Franck-Straße 1, 85748 Garching bei München

Recently, one of the fundamental steps in constraining the transport properties of the quark–gluon plasma (QGP) was the definition of the Symmetric Cumulants (SCs), which measured the genuine correlations between two different flow amplitudes. Naturally, questions like the

existence of genuine correlations between more than two flow amplitudes arose. Quantifying them would provide new information on the properties of the QGP.

The approach shown here focuses on using the flow amplitudes in the cumulant expansion to define these new observables, contrary to the usual method based on the azimuthal angles[1]. This new formalism is illustrated for the three-harmonic SCs, with the first results obtained with ALICE in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV[2] and 5.02 TeV. Finally, the Asymmetric Cumulants, where the flow amplitudes are raised to different powers, will be introduced[3]. For all these observables, predictions from hydrodynamics models will be shown.

References.

1. C. Mordasini, A. Bilandzic, D. Karakoç, S.F. Taghavi, PRC 102, 024907 (2020)
2. ALICE Collaboration, arXiv:2021.02579 (2021) Submitted to PRL
3. A. Bilandzic, M. Lesch, C. Mordasini, S.F. Taghavi, arXiv:2101.05619 (2021)

HK 27.8 Fri 16:00 H1

Symmetry plane correlations in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV with ALICE — •Marcel Lesch for the ALICE-Collaboration — Technische Universität München, James-Franck-Straße 1, 85748 Garching bei München

The study of collective phenomena in ultra-relativistic heavy-ion collisions are nowadays to a great extent built on the so-called flow amplitudes v_n and symmetry planes Ψ_n. Both appear as two distinct degrees of freedom in the Fourier series expansion used to parametrize the distribution of azimuthal angles of produced particles. While analyses techniques for flow amplitudes v_n have advanced over the past years, observables used for measuring symmetry planes Ψ_n are often plagued by built-in biases. However, recent developments [1] in this direction introduced the so-called Gaussian Estimator (GE) which provides a new and more precise technique to measure symmetry plane correlations (SPC) in flow analyses.

In this talk, we present first experimental results of SPC measured with this newly developed GE using ALICE data for Pb–Pb at $\sqrt{s_{\rm NN}}$ = 2.76 TeV (2010). The results are compared to theoretical predictions for the initial coordinate space provided by the MC-Glauber model and for the momentum space obtained with the state-of-the-art model iEBE-VISHNU.

References:

1. A. Bilandzic, M. Lesch, S. F. Taghavi, "New estimator for symmetry plane correlations in anisotropic flow analyses", Phys. Rev. C 102, 024910 - 2020