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Towards first-principle hydrodynamics for heavy-ion collision phenomenology

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Heavy-ion collisions are well described by a dynamical evolution with a long hydro-dynamical phase. In this phase the properties of the strongly correlated quark-gluon plasma are reflected in the equation of state (EoS) and the transport coefficients, most prominently by the shear and bulk viscosities over entropy density ratio η/s(T) and ζ/s(T), respectively.
While the EoS is by now known to a high accuracy, the transport coefficients and in particular their temperature and density dependence are not known from first-principle computations yet. To remedy this situation we deploy a complementary QCD based approaches to compute η/s(T) using functional renormalization group to compute gluon real-time spectral functions [1]. In addition we will show the work and progresses of a novel lattice simulation prescription in non-compact imaginary time [2,3], in which the conventional analytic continuation problem is significantly improved.
In this work, these most recent QCD-based parameters are provided as input to the MUSIC framework [4]. The IP-Glasma model is used to describe the initial energy density distribution, and UrQMD the late hadronic phase. Simulations are performed for Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV, for different centrality intervals. The resulting kinematic distributions of the particles produced in the collisions are compared to data from the LHC, for several experimental observables. The high precision of the experimental results and the broad variety of observables considered allow to critically verify the quality of the description based on first-principle input to the hydro-dynamic evolution.

[1] N. Christiansen et.al. PRL 115 (2015) 112002
[2] J. M. Pawlowski and A. Rothkopf arXiv:1610.09531,
[3] J.M. Pawlowski, A. Rothkopf, F.Ziegler (in preparation)
[4] Sangwook Ryu, et al., https://arxiv.org/abs/1704.04216

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