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Data-driven analysis of the temperature and momentum dependence of the heavy quark transport coefficients

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Heavy quarks have been considered valuable probes of the quark-gluon plasma (QGP). It has been found that heavy quarks propagating through a hot and dense QGP lose energy and develop flow. The interacting strength between the heavy quarks and medium ($\hat{q}/D_s$), although not directly measurable, can be estimated by comparison of model calculations with experimental observables. Currently, most of the models are able to quantitatively either reproduce the experimental measurements of heavy quark energy loss $R_{\rm AA}$ or the collective behavior v_2. However, they still face significant challenges for simultaneously describing both together.

Commonly, an extraction of the heavy quark transport coefficient relies on manually varying the parameters of the calculation until satisfactory agreement with experimental data is obtained. Here, we propose a systematic and quantitative approach to the data-driven analysis of the heavy quark diffusion coefficient using Bayesian statistics. We apply the Bayesian analysis to an updated full space-time evolution model for heavy quarks: including a parameterized initial condition model TRENTO, an in-medium improved Langevin transport model, a hybrid hadronization model with both, fragmentation and recombination, and UrQMD for hadronic final state interactions. Note the evolution of the QGP medium is already calibrated by a state-of-the-art Bayesian analysis performed on an event-by-event hydrodynamical model VISH(2+1) with shear and bulk viscous corrections.

We demonstrate the feasibility of describing experimental data at both RHIC and LHC energies using a generalized parameterization for the temperature and momentum dependence of the heavy quark diffusion coefficients. The likelihoods of the parameters, which indicate their functional form, are obtained in an unbiased manner. We can thus quantify the most probable parameter values as well as the uncertainties and correlations among them, and obtain for the first time a proper estimation of the heavy quark transport coefficients from experimental data.

List of tracks

Heavy-flavour (open and hidden)

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