Contribution ID: **542** Type: **Poster**

Addressing theoretical uncertainties in Bayesian inference for heavy-ion physics

Bayesian inference in heavy-ion physics often produces varying estimates of model parameters when varying the physics model and/or the prior assumptions, reflecting a lack of accounting for theoretical uncertainties. Traditionally, a good model-to-data fit is seen as success, with inferred parameters assumed to reflect underlying physics. However, theories have limitations and extending a theory beyond its scope without including model uncertainties not only leads to incorrect parameter estimates, rendering them as mere fitting variables, but also reduces the utility of the data. To address this we propose a statistical framework that accounts for theoretical uncertainties in multistage heavy-ion models. We test this framework using "measurements" of p_T-differential observables obtained from a "true" theory - a $2+1$d hydrodynamic simulation with a known fixed value for the specific shear viscosity η/s that employs a Grad 14-moment particlization prescription. We use these observables to calibrate via Bayesian inference a different hydrodynamic simulation model that uses a parametrization of $(\eta/s)(T)$ as a function of the temperature and applies a different particlization ansatz. Our Bayesian inference framework allows for theoretical uncertainties by including model discrepancy in its statistical modeling. We compare the inferred values for the specific shear viscosity with and without the uncertainty model, demonstrating its impact on posterior inference of η/s.

Category

Theory

Collaboration (if applicable)

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Session Classification: Poster session 2

Track Classification: Collective dynamics & small systems