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Unbiased exponential resummation in lattice QCD, a new way of exploring finite-density QCD

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Abstract - A knowledge of the QCD equation of state is crucial not only for understanding the dynamics of relativistic heavy ion collision experiments, but also for knowing the young universe. One of the familiar ways to estimate this equation of state and understand QCD thermodynamics is through Taylor series of various thermodynamic observables. Recently, exponential resummation of this Taylor series has paved to be an important alternative approach of understanding the thermodynamics. Beginning from the estimate of the QCD partition function, this method is proposed for going around the otherwise expensive computations of higher order Taylor coefficients with reliable precision in lattice QCD. However, this resummation method gives biased estimates of different correlation functions which gives wrong results and thereby leads to incorrect interpretations of the thermodynamics in finite density QCD. We analyze these biased estimates order by order in chemical potential by applying cumulant expansion and compare the same with the Taylor series results in which, the calculations involve working with only the unbiased estimates of correlation functions. Although we find that this cumulant expansion eliminates stochastic bias and gives good agreement with Taylor series results order-by-order, we also find that this happens at the expense of the vital all-order resummation form of the partition function. We consequently present a new formalism of unbiased exponential resummation which provides a novel way of eliminating stochastic bias completely up to the desired order in chemical potential without losing the form of the all-order resummation. Thus, we find a new way of determining and approaching the otherwise true QCD equation of state.

Presenter: MITRA, Sabarnya (Bielefeld University, Germany)

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