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The QCD Equation of State at order μ_B^4

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Hydrodynamic models of heavy-ion collisions have increasingly begun to rely on lattice results for the Equation of State. While the lattice has the advantage of being a first-principles approach to QCD, the notorious sign problem prevents a direct determination of the equation of state and other thermodynamic observables at finite chemical potential μ_B.

Quark number susceptibilities allow us to extrapolate the equation of state in a controlled way to small values of μ_B based on calculations at $\mu_B = 0$. Such an extrapolation is necessary in order to accurately describe the results from the beam energy scan at RHIC and from the LHC where typically $\mu_B/T = 0.1$-4, depending upon the energy of the beam.

In our talk, we will present results from a high-statistics calculation of all the Taylor coefficients upto sixth order in a (μ_B, μ_Q, μ_S)-expansion of the pressure. Our calculation allows us to extrapolate, for the first time, the equation of state on the freezeout curve upto $\mathcal{O}(\mu_B^4)$ while our sixth-order results show that the truncation error is not more than a few \% upto $\mu_B/T \sim 1.5$. Thus our equation of state should be useful in describing both the LHC results as well as results from RHIC beam energy scan down to $\sqrt{s}$ ~20 GeV. We will also use our results to construct the isentropic equation of state for strangeness-neutral systems.

Our lattice QCD calculations make use of the gauge ensembles generated using the HISQ action. Our lattices sizes range from 6×24^3 to 12×48^3 and the pion mass (~160 MeV) is nearly equal to its physical value while the strange quark is at exactly its physical value.

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