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Isentropic equation of state and speed of sound of (2+1)-flavor QCD from Taylor expansions and Pade resummation

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The quantum chromodynamics (QCD) equation of state (EoS) at finite temperature and density is of fundamental importance for the characterization of hot and dense, strongly interacting matter created in heavy ion collision experiments. It also has important applications in hydrodynamic simulations and the EoS of the early universe.

Strongly interacting dense matter created in experiments expands along trajectories of fixed s/n_B. Based on high statistics data generated by the HotQCD Collaboration we will determine these trajectories in the (T, μ_B)-plane using a Taylor series of the pressure of (2+1)-flavor QCD for several values of s/n_B and for thermal conditions met in heavy ion collisions. We compare these trajectories for fixed s/n_B with high temperature perturbation theory and the hadron resonance gas model(QMHRG2020) at low temperatures. On these trajectories we determine bulk thermodynamic observables, e.g.net baryon number, energy, and entropy densities. Earlier, we had shown that the pressure series is reliable up to $\mu_B/T \leq 2.5$ and Taylor expansion results are consistent with Pade resummed series approximants. We show that this also is the case for energy and entropy density expansions and their corresponding Pade approximants. We find that the latter seems to be more efficient in smoothening wiggles that arise from the strong T-dependence of higher order expansion coefficients. We therefore use the Pade approximants to calculate also observables involving higher order T-derivatives such as the specific heat, speed of sound and the adiabatic compressibility of strongly interacting matter.

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