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Equation of State differentials in the QCD phase diagram mapped by heavy-ion isobar collisions and theory

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Baryon (μ_B), electric charge (μ_Q) and strange quark (μ_S) chemical potentials, and temperature (T) are fundamental thermodynamic parameters characterizing QCD matter under extreme conditions. Their differentials ($\Delta\mu_B/\Delta\mu_Q$, $\Delta\mu_S/\Delta\mu_Q$) provide insight into the system's constituent correlation, response, and trajectory in the multidimensional (4D) QCD phase diagram. In this work, we report those differentials obtained from Bayesian analyses of experimental data in two isobar heavy-ion collisions ($Zr+Zr$ and $Ru+Ru$) and confront it with theory predictions for allowed trajectories in the QCD phase diagram. The chemical potentials and their differentials are derived from lattice QCD (expanded to finite net baryon chemical potential) and the Chiral Mean Field (CMF) model under the same conditions as the experiments. We find good agreement between experiment and theory, offering strong support for the theoretical modeling of QCD matter in 4D, while also identifying areas for further refinement.

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