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Merging multidimensional equations of state of strongly interacting matter via a statistical mixture

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We introduce a model-independent mechanism to merge two (or more) equations of state (EoS) by treating them as a two-fluid statistical mixture in the Grand Canonical Ensemble. The merged grand-potential density $\omega(T, \mu_B)$ is built directly from the input EoS, and the fluid fraction is fixed by minimizing ω at fixed (T, μ_B). Thermodynamic consistency is enforced across all observables. This construction satisfies the Maxwell relations and enforces convexity of the pressure $P(T, \mu_B)$. All quantities are derived from a single merged grand potential Ω as a function of T and μ_B. This yields smooth, differentiable fields over the T–μ_B plane. The method can be modified to accommodate a first-order phase transition and critical point on the phase diagram. Implementing this mechanism, we merge a van der Waals hadron resonance gas EoS with a holographic Einstein Maxwell Dilaton EoS. The result is a single EoS, spanning hadronic to deconfined matter over a broad range in (T, μ_B). It has immediate applications to heavy-ion hydrodynamics simulations. This construction may be generalized to more than two input EoSs.

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