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Signature flip in deceleration parameter: A thermodynamic phase transition?

Under the assumption of thermal equilibrium between the horizon and the fluid inside, we conducted a thermodynamic stability analysis on a model designed to mimic the characteristics of the ΛCDM model, which is the prevailing framework for portraying the cosmic acceleration. The scale factor for this model is defined as $a \sim \sinh^{2/3}(t/t_0)$. The Hayward-Kodama temperature is opted for the evolving apparent horizon. The outcome of this analysis yielded a remarkable finding: the thermal capacity exhibited a negative value and a lack of thermodynamic stability within the cosmic matter enclosed by the horizon.

The significance of this study lies in the result indicating that the matter content experiences a phase transition precisely at the value of z where the Universe undergoes a transition from decelerated expansion to an accelerated one. Notably, this phase transition manifests characteristics akin to those of a second-order phase transition, as indicated by the discontinuity in heat capacity at constant volume (C_V). The deceleration parameter (q) serves as the order parameter and solidifies this correlation.

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