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A Natural Explanation for the Speed of Sound Peak in Isospin QCD via the Medium Separation Scheme

We investigate the zero-temperature equation of state at finite isospin density using the Nambu–Jona-Lasinio (NJL) model implemented within the Medium Separation Scheme (MSS), which cleanly separates medium effects from ultraviolet-divergent vacuum terms. Recent lattice QCD results reveal a nonmonotonic behavior of the speed of sound as a function of the isospin chemical potential, with a clear violation of the conformal bound. This unexpected feature, not predicted by conventional approaches—including standard NJL calculations—has drawn significant theoretical attention. We show that the NJL model, when consistently regularized via MSS, quantitatively reproduces state-of-the-art lattice data for isospin QCD, providing a natural explanation for the observed peak in and resolving artifacts typically associated with cutoff sensitivity in non renormalizable models.

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