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Exploring Color-Superconducting Phases in Hybrid Star Models Using an RG-Consistent NJL Approach

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We present a comprehensive investigation of color-superconducting phases in compact stars using the renormalization group-consistent Nambu–Jona-Lasinio (RG-NJL) model [1]. By systematically varying vector and diquark coupling constants, we analyze their effects on the equation of state, speed of sound, and resulting mass-radius relations. Our models demonstrate that stable color-flavor-locked (CFL) phases can exist in maximum-mass star configurations, typically extending several kilometers in radius. At neutron-star densities, we observe the speed of sound squared reaching values up to $c_s^2 \approx 0.6$ and CFL gaps up to $\Delta \approx 250$ MeV [2]. The parameter constraints are derived from the $2.0\,M_\odot$ observational limit. We further explore the viability of hybrid-star configurations by combining our quark-matter model with a hadronic equation of state through Maxwell construction. Our results indicate several possible compositional scenarios for hybrid stars that remain consistent with current astrophysical constraints while demonstrating that early hadron-quark transitions can significantly affect tidal deformability measurements at $1.4\,M_\odot$ [3].

References

[1] H. Gholami, M. Hofmann, and M. Buballa, Phys. Rev. D 111, 014006 (2025).
[2] H. Gholami, I. A. Rather, M. Hofmann, M. Buballa, and J. Schaffner-Bielich, (2024), arXiv:2411.04064 [hep-ph].
[3] J. E. Christian, I. A. Rather, H. Gholami, & M. Hofmann, (2025), arXiv:2503.13626 [astro-ph.HE]

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