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H-cluster stars

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The study of dense matter at ultra-high density has a very long history, which is meaningful for us to understand not only cosmic events in extreme circumstances but also fundamental laws of physics. It is well known that the state of cold matter at supranuclear density depends on the non-perturbative nature of quantum chromo-dynamics (QCD) and is essential for modeling pulsars. A so-called H-cluster matter is proposed in this paper as the nature of dense matter in reality.
In compact stars at only a few nuclear densities but low temperature, quarks could be interacting strongly with each other there. That might render quarks grouped in clusters, although the hypothetical quark-clusters in cold dense matter has not been confirmed due to the lack of both theoretical and experimental evidence. Motivated by recent lattice QCD simulations of the H-dibaryons (with structure uuddss), we are therefore considering here a possible kind of quark-clusters, H-clusters, that could emerge inside compact stars during their initial cooling, as the dominant components inside (the degree of freedom could then be H-clusters there). Taking into account the in-medium stiffening effect, we find that at baryon densities of compact stars H-cluster matter could be more stable than nuclear matter. We study the stars composed of H-clusters, i.e., H-cluster stars, and derive the dependence of their maximum mass on the in-medium stiffening effect, showing that the maximum mass could be well above 2 M_sun as observed and that the resultant mass-radius relation fits the measurement of the rapid burster under reasonable parameters. Besides a general understanding of different manifestations of compact stars, we expect further observational and experimental tests for the H-cluster stars in the future.

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