

Supporting the existence of the QCD critical point by compact star observations

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In order to prove the existence of a critical end point (CEP) in the QCD phase diagram it is sufficient to demonstrate that at zero temperature $T = 0$ a first order phase transition exists as a function of the baryochemical potential μ , since it is established knowledge from ab-initio lattice QCD simulations that at $\mu = 0$ the transition on the temperature axis is a crossover. We present the argument that the observation of a gap in the mass-radius relationship for compact stars which proves the existence of a so-called third family (implying the existence of “mass twins”) is caused by the fact that the $T = 0$ equation of state of compact star matter exhibits a strong first order transition with a latent heat that satisfies $\Delta\epsilon/\epsilon_c > 0.6$. Since such a strong first order transition under compact star conditions will remain first order when going to symmetric matter, the observation of a disconnected branch (third family) of compact stars in the mass-radius diagram proves the existence of a CEP in QCD. Modeling of such compact star twins is based on a QCD motivated NJL quark model with high order interactions together with the hadronic DD2-MEV model fulfilling nuclear observables. Furthermore we show results of a Bayesian analysis (BA) using disjunct M-R constraints for extracting probability measures for cold, dense matter equations of state. In particular this study reveals that measuring radii of the neutron star twins has the potential to support the existence of a first order phase transition for compact star matter.

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