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Probing the deconfinement phase transition in hybrid stars with the fastest-spinning millisecond pulsars

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We study the properties of hybrid stars containing a color superconducting quark matter phase in their cores, described by the chirally symmetric formulation of the confining relativistic density functional approach. It is shown that depending on the dimensionless vector and diquark couplings of quark matter, the characteristics of the deconfinement phase transition are varied, allowing us to study the relation between those characteristics and mass-radius relations. Moreover, we show that the quark matter equation of state (EoS) can be nicely fitted by the Alford-Braby-Paris-Reddy model that gives a simple functional dependence between the most important parameters of the EoS and microscopic parameters of the initial Lagrangian. The developed approach is utilized for analyzing spinodal instability of quark matter and constructing hybrid quark-hadron EoS. Based on it, we analyze the special points of the mass-radius diagram in which several mass-radius curves intersect. Using the found empirical relation between the mass of the special point, the maximum mass of the mass-radius curve, and the onset mass of quark deconfinement, we constrain the range of vector and diquark couplings of the quark matter model. In addition, we construct a family of curves, which allow us to describe the black widow pulsar PSR J0952-0607.

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