Science of the Cosmos

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Stability Criteria Assessment for Hybrid Isentropic Twin Stars Formation

We model hybrid neutron stars with color superconducting quark matter cores at finite temperatures, focusing on sequences of constant entropy per baryon (s/n_B). A nonlocal chiral quark model provides the equation of state for the quark matter phase, while a relativistic density-dependent mean field model with DD2 parametrization is used for nuclear matter. The phase transition is examined via a Maxwell construction under isothermal conditions.
Our findings show that at s/n_B 2, heating effects occur during the mixed phase, whereas at higher s/n_B, the temperature decreases. This trend is associated with color-superconducting quark matter at low temperatures and the breakdown of the diquark condensate at higher temperatures. The low s/nB branch of isentropic hybrid stars connects with the neutron star branch but separates at higher entropy, resulting in the "thermal twin" effect. Additionally, the transition from connected to disconnected hybrid star sequences can be identified using the Seidov criterion for energy density differences.
These results may enhance our understanding of the conditions required for supernova explosions in massive blue supergiant stars involving quark deconfinement, as well as the behavior of binary systems and isolated millisecond pulsars concerning accretion-induced deconfinement transitions and the formation of thermal twins.

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