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Explosions of massive blue-supergiant stars triggered by the QCD phase transition

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Motivated from the observations of yet-unexplained explosive phenomena associated with massive blue-supergiant stars with zero-age main sequence (ZAMS) masses well above 40 $M_\odot$, we shed new light on the idea that the appearance of QCD degrees of freedom may explain such cosmic events [1]. Obeying chiral physics and taking yet-another important observation of the very existence of massive neutron stars of 2 $M_\odot$ seriously into account, puts sever constraints on the behavior of the equation of state at supersaturation density ($\rho_{\rm sat}$). In particular, sufficient stiffness with increasing density is required. Both aspects indicate rather high densities for the hadron-quark phase transition above $2 \times \rho_{\rm sat}$ (at zero temperature). As a consequence, this excludes low- and intermediate-mass stars ($\sim 10 - 30$ $M_\odot$) from the presence of 'exotic' high-density phases. On the other hand, during the evolution of very massive core-collapse supernova progenitors with ZAMS masses in excess of 40 $M_\odot$, significantly higher core temperatures and densities are reached, where the appearance of the hadron-quark phase transition triggers not only the supernova explosion onset but also a millisecond neutrino burst is released. The latter observable provides evidence not only for the presence of a $1^{\rm st}$–order phase transition at supersaturation density but contains also details about its properties. The future observation of such feature from the next galactic event will allow us to either confirm such scenario or, if not observed, rule out a (strong) $1^{\rm st}$–order phase transition at high densities encountered in astrophysics. In this talk I will review this scenario in the light of all presently known constraints from nuclear theory/experiments as well as observations, and discuss implications for astrophysics, e.g., the remnants from such supernova explosions are massive neutron stars with quark-matter core of 2 $M_\odot$ at birth.

Keywords: core-collapse supernovae – equation of state

References

[1] T. Fischer, N.-U. F. Bastian, M.-R. Wu, S. Typel, T. Klähn, and D. B. Blaschke, "High- density phase transition paves the way for supernova explosions of massive blue-supergiant stars" 2017, ArXiv *e-prints*, astro-ph.HE/1712.08788

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