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The impact of finite strange quark mass $m_s \neq 0$ and baryon number density n on the stability and maximum mass of strange stars

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Abstract. This study examines the effects of a non-zero strange quark mass m_s and baryon number density n on the structural properties, stability, and maximum mass of strange stars. An exact relativistic solution to the Einstein field equations is derived using the Tolman-IV metric potential and a modified MIT bag model equation of state (EoS), $p_r = \frac{1}{3}(\rho - 4B')$, where B' depends on the bag constant B , m_s , and n . Here, B represents the difference between perturbative and non-perturbative vacuum energy. According to CERN's findings, transition from hadronic matter to Quark-Gluon Plasma (QGP) can occur at high densities under favourable conditions. The standard MIT bag model, which assumes constant B , cannot adequately describe this transition. Incorporating a finite m_s and employing Wood-Saxon parametrization for B , which depends on n , provides a more realistic EoS capable of addressing this phase transition. As m_s increases, the EoS becomes softer, influencing the solutions of the TOV equations. For $m_s = 0$, the maximum mass is $2.01 M_\odot$ having radius of 10.96 Km when $n = 0.66 fm^{-3}$. For $m_s = 50$ and $100 MeV$, these values reduce to $1.99 M_\odot$ and $1.96 M_\odot$ and radii of 10.88 Km and 10.69 Km, respectively. Phase transition from hadronic to quark matter occurs at higher n values when m_s increases ($n \geq 0.482, 0.489$ and $0.51 fm^{-3}$ for $m_s = 0, 50$ and $100 MeV$ respectively). Beyond these values, the energy per baryon B drops below $930.4 MeV$, indicating a complete transition to quark matter and the stability of the system increases. The proposed model satisfies causality, energy, and stability conditions, effectively describing strange star properties.