Exploring the Densest Objects of the Cosmos: Structure and Stability of Compact Stars in a modified Gravity

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The current work is intended to examine the structure and stability of compact stellar objects within the framework of $f(Q)$ gravity, which is a modified gravity theory where gravitational interactions emerge from nonmetricity rather than curvature or torsion. This formulation preserves second-order field equations while introducing a richer geometric description of ultra-dense astrophysical environments. By assuming a linear form of the function $f(Q) = \alpha Q + \beta$, we derive modified field equations for static, spherically symmetric anisotropic fluid distributions, ensuring regularity through the Krori-Barua metric. Our approach is applied to model compact stars—LMC X-4, SMC X-4, Cen X-3, and Vela X-1—using realistic values for central density and pressure. It turns out that the anisotropic factor is positive and increases monotonically. The model's observational viability is supported by statistical analyses that use a chi-square test to compare theoretical and observed mass values and show strong agreement. Moreover, the compact nature of these stellar configurations is confirmed by surface redshift behaviour. These results demonstrate the function of $f(Q)$ gravity in cosmological and astrophysical settings, providing a framework that is consistent with late-time cosmic acceleration scenarios and alternative to general relativity for modelling extreme gravitational systems.