

Abstract

In hydrostatic equilibrium, the stellar models of the static cold compact objects are obtained by determining the relativistic solutions in the framework of Einstein's general theory of relativity (GR) and different modified theories of gravity. Since the equation of state (EoS) of the internal matter composition of compact objects is not yet known, we consider the Finch-Skea geometry in this thesis, which is found useful for studying dense, compact objects. Several stellar models are constructed with isotropic fluid, anisotropic fluid, and in the presence of Maxwell's electromagnetic field in the thesis. The physical properties of a charged or uncharged static star is determined by satisfying all the criteria for a physically viable stellar object. The four-dimensional stellar model are also extended to higher dimensions to understand the effects of extra dimensions for ultra compact object in the thesis.

- **Chapter 1** presents a review of compact objects and their relevance in astrophysics, including the objective of the thesis. The methodology adopted in the thesis are also discussed.
- In four as well as higher dimensions, we derive relativistic solutions of anisotropic charged compact objects in hydrodynamical equilibrium in **Chapter 2**. The radial variations of density, pressure and other different physical features inside the stars are studied in the relativistic stellar models. It is shown that a compact star always depicts an isotropic uncharged star in four-dimensional Finch–Skea geometry, whereas higher-dimensional spacetime predicts the presence of an anisotropic star. We construct stellar models based on the known parameters of compact objects (such as mass and radius), which satisfy all the criteria for a physically viable star. The findings will help to understand some of the physical aspects of known stars. The equations of states under extreme conditions are also predicted.
- In the $f(\mathbb{T})$ gravity framework, we explore relativistic solutions of anisotropic compact stars using the Finch–Skea (FS) metric in **Chapter 3**. The equation of states (EoS) for several known stellar objects with a given mass and radius are predicted using the

modified FS geometry in the $f(\mathbb{T})$ gravity. Because the EoS inside the star is unknown, the Modified Chaplygin gas (MCG) EoS is also used to obtain stellar models. The findings are significant in both the circumstances because they help us understand features of known stars that are not observed. The physical properties of known stars are studied, and it is found that compact star formation with a repulsive core is also possible. Compact stars can be obtained with anisotropic fluid ($p_t > p_r$) in the presence of MCG in $f(\mathbb{T})$ gravity, with maximum anisotropy near the core of the star, which is different from that when MCG is absent.

- In the $f(R, T)$ - modified gravity, we find a class of anisotropic spherically symmetric relativistic solutions of compact objects in hydrostatic equilibrium in **Chapter 4**. The relativistic solutions are used to obtain realistic stellar models for compact stars. Physical features like energy density, anisotropy parameter, radial and tangential pressures and Tolman–Oppenheimer–Volkoff (TOV) equations are numerically analyzed for different model parameters. We develop anisotropic stellar models for a given mass and radius using the modified Finch-Skea ansatz in the $f(R, T)$ theory of gravity, which satisfies all the criteria for a physically realistic star. For different model parameters, the EoS of the interior matter is also predicted to be non-linear type, viz., $p = f(\rho)$.
- We obtain a new class of anisotropic relativistic solutions in Einstein Gauss-Bonnet (EGB) gravity with the Finch-Skea metric in hydrostatic equilibrium in **Chapter 5**. The relativistic solutions represents the anisotropic stellar models for strange stars using the MIT Bag equation of state. We study stellar models in higher dimensions based on the mass and radius of a known star, PSR J0348+0432. The Gauss-Bonnet coupling term is playing important role to describe the density, pressure, anisotropy profiles, and other characteristics. In EGB gravity, a star's central density and pressure are shown to be greater than those obtained in Einstein's GR. We also look at how extra dimensions affect the physical characteristics of a compact object. The best fit values of the model parameters are calculated for acceptable stellar models of several observed stars.
- In **Chapter 6**, the effect of extra dimensions is investigated on the shadow of black holes in the Lovelock gravity framework. Because of its huge gravitational field, a black hole casts an optical shadow, characterized as a dark zone surrounded by a circle for a Lovelock black hole. The null geodesic equations are computed using the directional symmetry and the Hamilton-Jacobi equation. Then we proceed to calculate the celestial coordinates (α, β) and the shadow radius (R_s) of the black hole. We also observe the effects of the mass parameter and Lovelock parameter on the shadow

radius for a particular dimension. Again, we notice that the shadow of the Lovelock black hole is a concentric circle, with the circle's radius increasing with an increase in dimensions. We also observe the change in the *silhouette* of the black hole shadow due to the presence of a plasma background. Finally, the energy emission rates are also investigated here.

- Finally in **Chapter 7** the concluding remarks and a future work plan are given.


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