Title of the thesis: Some Spherically Symmetric Astrophysical Objects in General Relativity

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Abstract

The present thesis is concerned with spherically symmetric astrophysical objects in GR and modified gravity theories. We organize the whole thesis into ten chapters as follow:

The **first chapter** is introductory in which the contents of the certain relevant topics concerning the problems in the subsequent chapters are briefly described. This chapter presents an overview of general relativity (GR), extended theories, supporting evidences of GR, physics of compact stars, basics of wormhole geometry etc.

In the **second chapter** we have presented a static anisotropic solution of stellar compact objects for self-gravitating system by using minimal geometric deformation techniques in the framework of embedding class one space-time. We deform this system into two separate system through the geometric deformation of radial components for the source function $\lambda(r)$ by mapping: $e^{-\lambda(r)} \rightarrow e^{-\bar{\lambda}(r)} + \beta\, g(r)$, where $g(r)$ is deformation function. The first corresponds to Einstein's system and other quasi-Einstein system.

The **third chapter** employed Tolman VII solution with exotic matter that may be present in the extremely dense core of compact objects. For our purpose we use generalized non-linear equation of state which may incorporate exotic matter along with dust, radiation and dark energy. The amount of exotic matter contain can be modify by a parameter n which can be linked to adiabatic index. The $M - R$ relation is constructed analytically and the maximum mass and its corresponding radius is determined using the exact solutions and is shown to satisfy various observed stellar compact stars.

In **fourth chapter**, we will explore new relativistic anisotropic solutions of the Einstein field equation for compact stars under embedding class one condition. For this purpose, we use the embedding class one methodology by employing the *Karmarkar* condition. By using this methodology we obtain a particular differential equation that connects both gravitational potentials e^{λ} and e^{ν}. We have also discussed thermodynamical observable like radial and tangential pressures, matter density, etc. Further, we discussed the moment of inertia and $M - R$ curve for rotating and non-rotating stars.

The **fifth chapter** discuss relativistic anisotropic solutions of the Einstein field equation for the spherically symmetric line element under the class one condition. To do so we apply the embedding class one technique using *Eisland* condition. Once the space-time geometry is specified we obtain the matter density, the radial, and tangential pressures respectively. The $M - R$ diagram suggest that the solution yields stiffer EoS as parameter n increases. The $M - I$ graph is in agreement with the concepts of Bejgar et al. that the mass at I_{max} is lesser by

few percent (for this solution ~ 3% from M_{max}. This suggest that the EoSs is without any strong high-density softening due to hyperonization or phase transition to an exotic state.

In the **sixth chapter**, we present a physically plausible solution representing Einstein's cluster mimicking the behaviors of compact star in the context of $f(\mathbb{T})$ −gravity. We chose both diagonal and off-diagonal tetrads in linear and quadratic functions of $f(\mathbb{T})$. However, we have found that Einstein clusters exist only in the case of Teleparallel Equivalent of General Relativity. The system also gain its stability when a small net electric is introduced.

The aim of the **seventh chapter** is to explore exact solutions in linear and Starobinsky−$f(\mathcal{R},\mathcal{T})$ gravity theory. Further, we employ embedding class one condition. We then compare the cases when $\xi = \chi = 0$ [GR], $\xi = 0, \chi = 0.5$ [$f_L(\mathcal{R},\mathcal{T})$], $\xi = 0.5$, $\chi = 0$ [$f_S(\mathcal{R},\mathcal{T})$] and $\xi = \chi = 0.5$ [$f_{L+S}(\mathcal{R},\mathcal{T})$]. The $M - R$ and $M - I$ curves from our solution are well fitted with observational data.

The **eighth chapter** focuses on strange star hydrostatic equilibrium assuming a maximally symmetric phase of homogeneous superconducting quark matter called the *color-flavor-locked* (CFL) phase in the energy-momentum squared gravity (EMSG). We explored the structure of stellar objects in EMSG, which allows a correction term $T_{\mu\nu}T^{\mu\nu}$ in the action. Interestingly, EMSG may be effective to resolve the problems at high energy densities without invoking some new forms of fluid stress. Finally, we solve the complicated field equations numerically to obtain the mass-radius relations for strange stars in CFL equation of state.

In **ninth chapter**, we consider wormhole geometries in the context of Teleparallel Equivalent of General Relativity (TEGR) as well as $f(\mathbb{T})$ −gravity. We present the analytical solutions under the assumption of spherical symmetry and the existence of *Conformal Killing Vector*. In addition, a wide variety of solutions are deduced by considering a linear equation of state relating the density and pressure, for the isotropic and anisotropic pressure, independently of the shape functions, and various phantom wormhole geometries are explored.

The summary and future scopes for all the above chapters are presented in the **tenth chapter**.

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