

# Summary

The goal of this thesis was to generate superdense star models on geometrically significant spacetimes. The nonlinear Einstein's field equations describing interior of the superdense stars were linearized by applying suitable transformation. We have constructed core-envelope models of massive stars on pseudo spheroidal spacetime, the model describing collapse of the radiating star on pseudo spheroidal spacetime. We have also examined stability of stars on paraboloidal spacetime and constructed two core-envelope models of stars on paraboloidal spacetime. Anisotropic model of superdense stars on paraboloidal spacetime is also constructed, it is shown that the model admits quadratic equation of state. All the models described in the thesis satisfy necessary physical plausibility conditions.

We now present overview of results obtained during the course of research:

- The objective of chapter 2 was to study core-envelope models of massive stars on pseudo spheroidal spacetime. We have considered isotropic pressure in the core, while the surrounding envelope has anisotropic pressure. The density profile is continuous even at the core boundary. The scheme given by Tikekar [88] is used to obtain the mass and the size of the star. The surface density is taken as  $\rho(a) = 2 \times 10^{14} \text{ gm/cm}^3$ , and density variation parameter is defined as  $\lambda = \frac{\rho(a)}{\rho(0)}$ . The model admits high degree of density variation from centre to boundary. It is observed that as the density variation parameter  $\lambda$  increases, the radius of the star increases and the thickness of the envelope decreases. The core radius is found to be  $b = \sqrt{2}R$  and for positivity of tangential pressure  $p_{\perp}$  it is required that  $\frac{a^2}{R^2} > 2$ , where  $a$  is the radius of the star. This requirement restrict the value of density variation parameter  $\lambda = \frac{\rho(a)}{\rho(0)} \leq 0.093$ .

- In chapter 3, we have studied non-adiabatic gravitational collapse of spherical distribution of matter having radial heat flux on pseudo spheroidal spacetime. The spherical distribution of matter is divided into two regions: core having anisotropic pressure distribution and envelope having isotropic pressure distribution. The exterior spacetime is taken as Vaidya metric. First and second fundamental forms are matched to guarantee the continuity of metric coefficients across the boundary of collapsing sphere. It is observed that the total luminosity for an observer at rest at infinity  $L_\infty \rightarrow 0$  as  $re^{\mu/2} \rightarrow 2m$ . That is when  $re^{\mu/2} = 2m$ , the boundary redshift becomes infinity. It is observed that for density variation parameter  $\lambda = 0.05$ , the polytropic index  $\gamma$  at the centre is less than  $\frac{4}{3}$  and at the boundary is higher than  $\frac{4}{3}$  during initial stage of collapse. Hence the central region is unstable. Assuming evolution of heat flow is governed by Maxwell-Cattaneo transport equation and following Martínez [62] we have derived equation governing temperature profile for the model under consideration.
- In Chapter 4 we investigate stability of superdense star on paraboloidal spacetime. A sufficient condition for dynamic stability of a spherical distribution of matter under small radial adiabatic perturbations have been developed by Chandrasekhar [9]. The stability of models of stars on paraboloidal spacetime is investigated by integrating Chandrasekhar's pulsation equation and it is found that the models with  $0.26 < m < 0.36$  will be stable under radial modes of pulsation. The static paraboloidal spacetime metric for its spatial section  $t = \text{constant}$  thus admits the possibility of describing spacetime of superdense star in equilibrium.
- Two core-envelope models with the feature core consisting of isotropic fluid and envelope consisting of anisotropic fluid distribution on the background of paraboloidal spacetime have been reported in Chapter 5. The nonlinear equation governing anisotropy in the envelope is converted to second order linear variable coefficient differential equation by applying suitable transformation. Tikekar's [88] scheme is used to compute mass and size of the star. Following Following Sharma *et al.* [81], we choose central density as  $\rho(0) = 4.68 \times 10^{15} \text{ gm cm}^{-3}$ . For both the models thickness of envelope increases as  $\frac{m}{a}$  increases. A noteworthy feature of these models is, they admit thin envelope, hence is significant in the study of glitches and star quakes.

- In chapter 6 a class of solution describing the interior of a static spherically symmetric compact anisotropic star based on paraboloidal spacetime is reported. We have obtained bounds on the model parameters. We have made a choice on radial pressure in such a way that the field equations are integrable and radial pressure decreases from centre to boundary. We found that radius of the star is same as the curvature parameter  $R$ . The centre pressure is found to be  $\frac{2\rho}{R}$ . The anisotropic parameter  $S$  vanishes at the centre, which also vanishes at the boundary for particular choice of  $p_0 = 1$ . The method of least square is applied to obtain equation of state for the model under consideration. We found that norm of residuals is less for quadratic equation of state compared to linear equation of state. Hence, the model admits an equation of state which is quadratic in nature. We have used Herrera's [35] overtuning method to prove the stability of the compact anisotropic star model.