Density Dependent B-parameter model of Compact object with Strange Quark Matter

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- Einstein field equations are the relations between space-time geometry & energy momentum tensor given by eqs. 1 & 2 respectively of the interior matter of a star.
- The interior space-time of a spherically symmetric, cold compact star in equilibrium is described by

$$ds^2 = -e^{2\nu(r)}dt^2 + e^{2\mu(r)}dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \tag{1}$$

- The energy momentum tensor is defined as

$$T_{ij} = \text{diag}\ (-\rho,\ p_r,\ p_\perp,\ p_\perp) \tag{2}$$

- Using eqs 1 & 2 and the ansatz $e^{2\mu} = \frac{1+\lambda r^2/R^2}{1+r^2/R^2}$ for spheroidal geometry, one can solve Einstein Field Equation

$$\mathbf{R}_{ij} - \frac{1}{2}g_{ij}\mathbf{R} = 8\pi G\ \mathbf{T}_{ij} \tag{3}$$

which leads to the following equations:

$$\rho = \frac{1}{R^2(z^2-1)}\left[1 + \frac{2}{(\lambda-1)(z^2-1)}\right] \tag{4}$$

$$p_r = -\frac{1}{R^2(z^2-1)}\left[1 - \frac{2z}{(\lambda-1)}\frac{\Psi_z}{\Psi}\right] \tag{5}$$

where Ψ is the solution.

Numerical Calculation

- In case of strange stars the interior matter content is supposed to be strange quark matter following MIT bag model EOS given below,

$$p = \frac{1}{3}(\rho - 4B) \tag{6}$$

where $'B'$ is Bag Constant.

- From Thermodynamic point of view one may established the relation that B posesses density dependence i.e $B = B(\rho)$. In this work I have studied to find out the relavence of density dependence of B from the consideration of space-time geometry in the EoS of strange matter.
- Using the values of energy density (ρ) and corresponding pressure(p_r) at different points (r) inside the star, one can express p_r as a polynomial function of ρ. I have choosen $p_r = \sum_{i=0}^{6} a_i \rho^i$, where a_is are constants to be determined from fitting.
- Again if the matter content interior to the star is supposed to be strange matter having equation of state $p_r = \frac{1}{3}(\rho - 4B)$, then p_r can be eliminated from these two expressions. This leads to the expression of B as

$$B = B(\rho) = \frac{1}{4}\left[(\frac{1}{3} - a_1) - \sum_{i=0,2}^{6} a_i \rho^i\right] \tag{7}$$

Equation of State

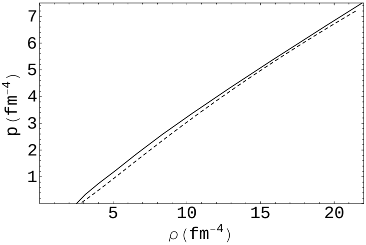

Figure 1: EoS of SQM from experimental data (Solid line) & from this model (Dotted line). $\lambda = 5.1$, $Mass = 1.435\ M_{\odot}$, $Radius = 7.07\ km$. (SAX J)

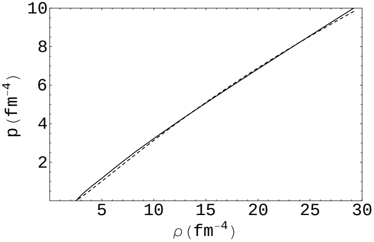

Figure 2: EoS of SQM from experimental data (Solid line) & from this model (Dotted line). $\lambda = 5.8$, $Mass = 1.435\ M_{\odot}$, $Radius = 7.07\ km$. (SAX J)

Conclusions:

- In this model EoS of matter content inside the star is similar to that obtained from the experimental data.
- Therefore EoS of matter content of compact objects may be described from the geometry of the space-time.