Study of Stellar objects with Strange Quark Matter Crust

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Introduction

The absolute stability of strange quark matter is a viable possibility and immensely effects physics at the astrophysical scale. Relativistic heavy-ion reactions offer a stage to produce this exotic state of matter and the enhanced production of strange particles during these reactions can be studied within the framework of quark-gluon plasma (QGP). We have tried to investigate the role of strangeness under the compact star phenomenology. Emphasis is laid upon the possibility of existence of a third family of strange quark stars and its study help in revealing a number of unexplored features of the cosmos. Bag model parameters have been used to determine some integral parameters for a sequence of strange stars with crust and strange dwarfs constructed out of strange quark matter crust[1]. A comparative analysis is performed between the strange and neutron stars and the strange and white dwarfs based upon these intrinsic parameters and paramount differences are observed. The intimacy between astrophysics and strange quarks depends strongly upon the strange quark matter hypothesis. It states that for a collection of more than a few hundred u, d and s quarks, the energy per baryon E/A of strange quark matter (SQM) can be well below the energy per baryon of the most stable atomic nuclei (such as iron or nickel).

Bag model parameters and the strange star phenomenology

The theory of strong interactions poses a great deal of intrinsic difficulties and thereby the quark phase is described in terms of models, with the MIT bag model being the most popular. In this section, the bag model parameters have been utilized to study strange stars with a crust and strange dwarfs. Two sets of bag model parameters have been used to determine their equations of state. The basic parameters characterizing our analysis are the bag constant B, which reflects the vacuum pressure in the volume occupied by the quarks; m_s, the mass of strange quarks; α_c, the quark-gluon coupling constant; n_s or n_{min}, the surface density and ε which is the mean energy per baryon. The mean energy per baryon essentially has negative minimum and depends upon the baryon concentration for the strange stars and ensures that SQM is bound. Realistic ranges of these parameters have been used, which generalize the phenomenological and theoretical data of hadron physics.

The first model describes normal matter in Ae(degenerate electrons) phase. We have used the tabulated data on the Baym-Pethick-Sutherland equation of state] matched to Feynman-Metropolis-Teller equation of state. The second model corresponds to strange quark matter, for which the MIT bag model has been used [2,3,4].

Table 1:- Parameters of Equation of State of Strange Quark Matter

B MeV/fm^3	m_s MeV	α_c	n_{min} fm^3	ε
50	175	0.05	0.257	-64.9
60	175	0.05	0.296	-28.6

We have utilized the calculated integral parameters for strange stars and strange dwarfs for the purpose of analysis. This is done by plotting them with the aim of pinpointing peculiarities of the strange star behaviorism in contrast to that of neutron stars and also comparing the strange dwarfs with their non-strange analogs, i.e. ordinary white dwarfs. Viable differences between them are clearly visible.

The M-R plots for compact stars have been actively studied since a long time. Their peculiar behaviorism help in differentiating the strange stars from the neutron stars (Fig1)

The M-R plot for the neutron stars is depicted in Figure 2. On comparing these two figures, we can clearly observe that the pattern of variation of mass with radius is different for the strange stars and their non-strange counterparts, i.e. the neutron stars. Thus, we can say that the M-R plots serve as a basic comparative feature for differentiating these two types of stars.

We determined the gravitational redshift Z_s at the surface of the star. This is a directly observable parameter and thus the experimental data can be compared with its theoretical counterpart. The derived values of Z_s for strange stars ($Z_{s\ min}$=9.55*10^{-6} to $Z_{s\ max}$=0.48) corresponding to different values of mass are lower than those for neutron stars ($Z_{s\ min}$ =8.34*10^{-4} to $Z_{s\ max}$ =0.649).

Similar analysis for strange and white dwarfs (both for the same mass values) was performed under the Model 1. The M-R plots clearly depict visible differences in their corresponding variations and this serves to be a basic analyzing and differentiating parameter.

The surface redshift Z_S values were calculated for both the strange and white dwarfs, but the range (1.29*10^{-6} to 3.97*10^{-4}) is almost the same for the two and thereby the plot between the redshift and mass for the two show similar behaviorism.

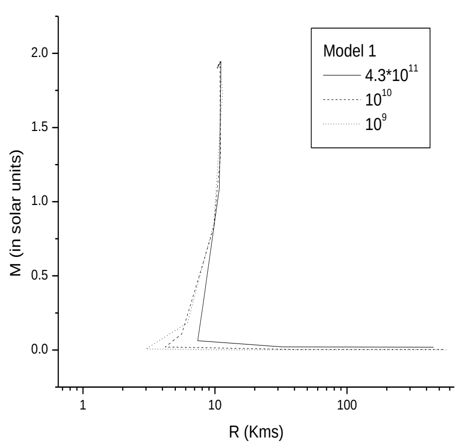

Fig 1: M-R plot for strange stars

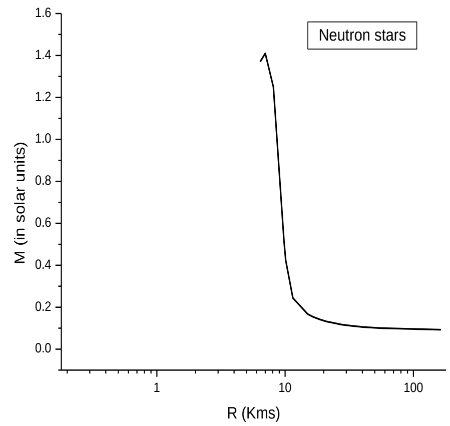

Fig 2: M-R plot for neutron stars

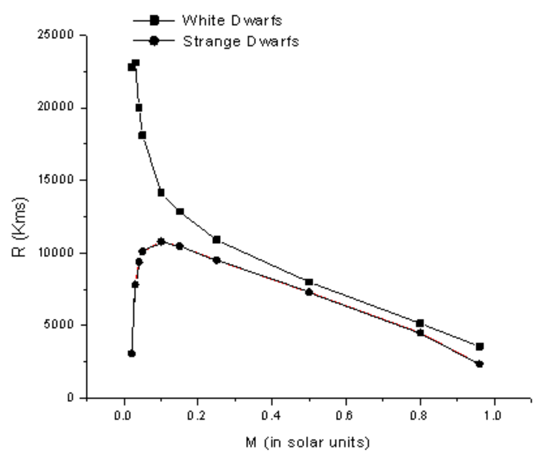

Fig 3: M-R plot for strange and white dwarfs

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