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Physics of Neutron stars

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The underlying quark structure of hadrons suggets the possibility of a quark-hadron phase transition at high tempereature and/or density. Since a compact object like neutron star (NS) provide the natural scenario of high density, the suggestion for the existence of quark core inside such massive compact objects was put forward by Ivanenko and Kurdgelaidze in 1969 . The existence of 3-flavour quark star or strange star (QS), made up of u, d and s quarks, was suggested by Itoh in 1970. In general, the two flavour matter cannot be more stable compared to nucleonic matter. The presence of s quarks, along with u and d quarks, provides an additional Fermi well which would result in the lowering of the energy of the 3- flavour quark matter or strange quark matter (SQM) compared to 2- flavour quark matter. Since s quark has larger mass, the situation would be more favourable at higher densities. Such possibilities were recognized by Bodmer (1971) and led Witten (1984) to conjecture that SQM may be the true ground state of strongly interacting matter at high densities
One of the major difficulties in the theoretical calculations in these areas of research is the fact that the Quantum Chromodynamics (QCD) perturbative series shows poor convergence except for very small coupling at very high temperatures ($\alpha s < 0.5$, $T \sim 105$ Tc). The perturbative treatment at high density also fails. The lattice calculations are still not reliable in the high density regime applicable to NS. Hence the high density systems are studied using the QCD inspired phenomenological models. Numerous model calculations have predicted a stable quark matter system within finite parameter ranges at finite temperature and/or density.
Presently, the major technical advancements in both ground as well as satellite based observations are producing huge amounts of data. There exists a large amount of observational data on mass-radii of NS which puts a constraint on the equation of state.
The upcoming Compressed Baryonic Matter experiment at FAIR, GSI, and Germany is expected to shed some light on the nature of high density matter expected to be present in the interior of Neutron Star
The conversion of Neutron star to a stable quark star may occur through two steps: namely Neutron star to two flavour quark star and then to three flavour strange quark star through weak interactions. One of the important aspects of the physics of Neutron stars is the role of magnetic field. We have found that the presence of a high magnetic field may affect the phase transition expected to occur inside Neutron stars.
I will be discussing the various issues related to the effect of magnetic field inside Neutron Stars along with the understanding of Neutron Star physics expected from CBM experiments.

Keywords

Neutron Star, quark star, equation of state, magnetic field

Primary author: Prof. GHOSH, Sanjay K. (Bose Institute)

Presenter: Prof. GHOSH, Sanjay K. (Bose Institute)

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