# Hypernuclear and strange quark matter in compact stars *

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We have performed several studies of dense hypernuclear matter under conditions relevant to neutron stars within density dependent relativistic mean fields models [1]. Our models include the full baryon octet. One study was aimed at solving the so-called "hyperon puzzle", i.e., the fact that the observation of two solar mass neutron star virtually excludes all the models of hypernuclear matter proposed prior to this observation. We have studied the sensitivity of the equation of state on the interaction between the baryon octet and the scalar mesons. The allowed values of the hyperon-hyperon coupling via the scalar sigma meson was varied within a range admissible by the symmetries and QCD sum rules. We have demonstrated that the equation of state of hypernuclear matter can be stiffer in a certain range of parameters. This observation is a possible solution of the puzzle mentioned above. The finite temperature equation of state was studied under conditions when the neutrinos are trapped. It has been shown that the neutrino trapping stiffens the equation of state.

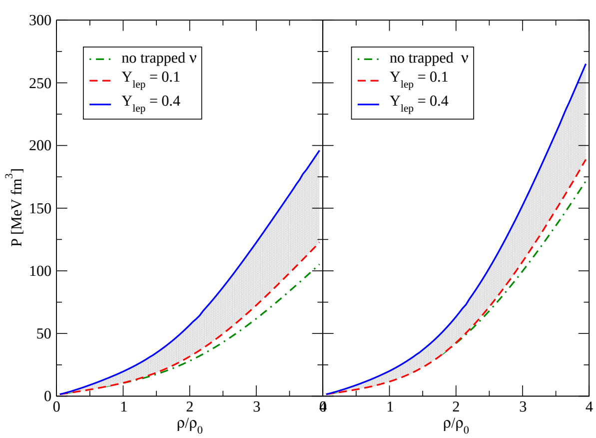


Figure 1: Equation of state in the DD-ME2 parametrization in presence of hyperons. Left panel: we fix the coupling constant $g_{\Lambda\Lambda\sigma} = 0.58 g_{NN\,\sigma}$ from NSC89 potential and we vary the couplings for the $\Sigma$ and $\Xi$ hyperons. The dashed area shows the variation of the EoS with the variation of the coupling constants of the remaining hyperons with the scalar meson. Right panel: the same as the left panel, but for a fixed coupling constant $g_{\Sigma\Sigma\sigma} = 0.448 g_{NN\sigma}$.

Compact stars with strong magnetic fields (magnetars) have been observationally determined to have surface magnetic fields of order of $10^{14} - 10^{15}$ G, the implied internal field strength being several orders larger. We have studied the equation of state and composition of dense hypernuclear matter in strong magnetic fields in a range expected in the interiors of magnetars [2]. We use the same model as above, but with density independent coupling constants. One advantage of our study is that we have implemented realistic density profiles of magnetic fields, which assume that the field decreases from the center of the star and reaches asymptotically its value at the surface $\sim 10^{15}$ G characteristic for magnetars. Thus, we have extended the previous studies of hypernuclear matter to realistic situation of density dependent field profiles and conducted a study of parameter space that defines the shape of the field profile. It should be noted that the previous studies overestimated the effects of magnetic field on the matter at low densities, simply because of the constant field Ansatz.

We have found that for sufficiently large fields $B_c \geq 10^{18}$ G the matter becomes unstable. The instability is associated with the negative contribution of the field pressure to the baryonic and leptonic pressures in the direction parallel to the magnetic field, which renders the total pressure of the system anisotropic. We have found that the onset of instability depends on the magnetic field profile (parameterized in terms of two parameters) as well as on the central field value $B_c$. The instability sets in always for critical central field values $B_{\rm cr} \approx 10^{19}$ G for any values of the parameters. This gives a natural bound for the central magnetic field of neutron stars with *homogeneously distributed magnetic field*. We have shown also that the abundances of baryons are weakly affected by the magnetic field, whereas those for the light leptons show de-Haas—van Alfven type oscillations as a function of the magnetic field.

Finally, we are conducting a study of strange quark matter in strange stars which is exposed to large magnetic fields [3]. The confinement feature is included via the phenomenological Richardson potential, which corresponds to static gluon exchange among the quarks. The model is compared to the MIT model and differences between these two confining models are discussed.

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## References

[1] G. Colucci and A. Sedrakian, *Equation of state of hypernuclear matter: impact of hyperon-scalar meson couplings.* in preparation.

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[3] M. Sinha, X.-G. Huang, and A. Sedrakian *Strange quark matter within a confining model.* in preparation.