Contribution ID: **50** Type: **not specified**

Massive Hybrid Stars with Strangeness

Sunday, 27 October 2013 17:20 (20 minutes)

Recent observations of the 2M_{sun} mass neutron stars (NSs; e.g. PSR J1614-2230, PSR J0348+0432) present a challenging problem how to explain the existence of such massive NSs. This problem is serious since massive NSs demand a very stiff equation of state (EOS) of underlying dense matter and on the contrary every transition to the exotic new phases proposed so far, including pions, kaons, hyperons or quarks in dense matter, leads to a remarkable softening of the EOS, clearly contradicting observations. In particular, the strangeness degrees of freedom (namely hyperon (Y) mixing) in NS cores causes a dramatic softening of the EOS and thereby the corresponding NS maximum-mass (M_{max}) fails to exceed even by far smaller mass, 1.44 solar mass observed for PSR 1913+16.
In this paper, we address how M_{max}\gsim2M_{sun} is made possible by introducing a new degrees of freedom, i.e., the hadron (H)-quark (Q) transition in NS cores and by a new approach not restricted to the conventional Gibbs or Maxwell condition. Our new strategy is to divide the EOS into three density (\rho) regions [1] [2], i.e., H-EOS for \rho\lsim\rho_H, HQ-EOS for \rho_H\lsim\rho\lsim\rho_Q and Q-EOS for \rho\gsim\rho_Q characterized as three-window model. This is motivated by the consideration that pure hadronic EOS becomes uncertain with increasing \rho because of finite size hadrons composed quarks and also pure quark matter EOS gets unreliable due to the deconfined-confined transition with decreasing \rho. Therefore, to discuss the HQ transition by extrapolating the pure H-EOS from lower density side and Q-EOS from higher density side is not necessarily justified. Our basic idea is to supplement the very poorly known HQ-EOS by sandwitching it in between the relatively certain H-EOS and Q-EOS and construct the HQ-EOS by a phenomenological interpolation. We use a realistic H-EOS from a G-matrix-based effective interaction including Y and take the Q-EOS from NJL model with repulsion from a vector interaction.
It is found that M_{max} ˜ (2-3)M_{sun} is possible as far as \rho_H ˜ 2\rho_0, \rho_Q ˜ (5-7)\rho_0 (\rho_0=0.17 fm^{-3} being the nuclear density) and Q-EOS is stiff. To be more realistic, we try to construct the EOS in a same manner but with a crossover HQ transition from a percolation picture, finding M_{max}\gsim 2M_{sun} is possible [2].

[1] T. Takatsuka, T. Hatsuda and K. Masuda, AIP Proceedings 1484 (NY, 2012) 406.
[2] K. Masuda, T. Hatsuda and T. Takatsuka, ApJ. 794 (2013) 12; Prog. Theor. Exp. Phys. 073D01 (2013).

Summary

1. To summarize,
   (1) The EOS with hadron-quark transition is constructed by a new approach characterized as the 3-window model (H, HQ, Q regions) and applied to hybrid stars.
   (2) The EOS brings about M_{max}\gsim2M_{sun}, almost irrespectively to the interpolation function for HQ region.
   (3) Hybrid star as massive as M\gsim2M_{sun} is possible under the condition:
   · Hadron (H)-quark (Q) transition sets on at relatively low density (about 1.5×nuclear density).
   · Strongly correlated quark matter with the repulsion from a vector type interaction is existent.
   (4) Realization of a large mass is caused by a stiffened EOS at \rho ˜ (2-5)\rho_0 due to the HQ transition.
   (5) Quite similar results are obtained by a more plausible case where the HQ transition is assumed to occur as a smooth crossover transition from a percolation picture.
2. In an extended framework of H plus Q degrees of freedom, hybrid stars based on the EOS with HQ transition are found to be as massive as M\gsim2M_{sun}, which opens the possibility to reconcile a current viewpoint of a softened EOS (due to the transition to a new phase with exotic components) with the stiff EOS demanded from observations.

Primary author: Prof. TAKATSUKA, Tatsuyuki (Nishina Center ,RIKEN)

Co-authors: Mr MASUDA, Kota (Dep.Phys.The Univ. of Tokyo); Prof. HATSUDA, Tetsuo (Nishina Center,RIKEN)

Presenter: Prof. TAKATSUKA, Tatsuyuki (Nishina Center ,RIKEN)

Track Classification: Parellel A