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Hot Neutron Stars with Hadron-Quark Crossover

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Recent observations of 2-solar-mass neutron stars (NSs) give us the problem, ''to be or not to be" for the exotic components such as deconfined quarks in dense matter of NS cores.
This is because the first-order phase transition to exotic matter leads to a softening of the equation of state (EOS) so that 2-solar-mass NSs cannot be sustained.
In our previous works [1,2], we have constructed the EOS, "CRover-C"EOS (EOS with crossover for cold NSs), assuming a hadron-quark crossover transition from a view that hadrons are not point-like particles but are composed of quarks and a quark percolation would occur when hadrons come near with each other.
We have shown this EOS can sustain the massive NSs in spite of the participation of quark degrees of freedom.
The point is that the EOS with crossover is made stiff, contrary to the conventional first-order transition, as far as the percolation begins at rather low-density.

The purpose of the present work [3] is to discuss the properties of hot NSs at birth by extending CRover-C EOS to the finite temperature case.
Hot NSs are composed of supernova matter characterized by an isentropic nature and a constant lepton fraction owing to a neutrino trapping.
In a manner analogous to the cold case, we construct a new EOS of supernova matter, ''CRover-H"(EOS with crossover for hot NSs) and obtain hot-NS models.
It is found that the crossover has important effects not only on generating the stiff EOS to sustain 2-solar-mass hot NSs, but also on lowering the internal temperature.
It is remarked that during the thermal evolution from hot to cold NSs, the gravitational energy of amount 0.04 solar-mass is released due to the contraction and the spin up of about 14% occurs, in the case of the canonical mass NSs.

[1] K.Masuda, T.Hatsuda and T.Takatsuka, Astrophys. J. 764, 12 (2013)

[2] K.Masuda, T.Hatsuda and T.Takatsuka, PTEP. no.7, 073D01 (2013)

[3] K.Masuda, T.Hatsuda and T.Takatsuka, arXiv:1506.000984[nucl-th]

On behalf of collaboration:

NONE

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