NEUTRON STARS FORMED FROM SUPERNOVA EXPLOSION AND QUARK MATTER

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We study the possibility of the existence of quark matter during the early stage of hot neutron stars. According to Walecka (1978) and Shuryak (1980), we calculate the EOS of neutron matter and quark matter at different temperatures, T, in which we take the coupling constant α_s to be 0.5 (Rafelski, 1982) and the bag constant $B^{\frac{1}{4}}$ to be 145, 170 and 190 Mev (Chin, 1978) due to a slight influence of α_s and a great influence of B on our results. Supposing that neutron matter-quark matter phase transition is the first order phase transition (Baym and Chin, 1976), we obtain the phase transition pressures and densities at T = 3×10^{10} and 10^{12} K, respectively, from the relation between the pressure and the chemical potential. Then we try to determine the existence of quark matter thru the comparison of these densities with those of stable hot neutron stars.

Our conclusions are as follows: a) There may exist a core of quark matter during the early stage of hot neutron stars as long as its temperature is higher than 10^{10} K. The higher the T is, the larger the quark core is; b) B is the important parameter affecting the size of quark core. At a given T, the quark core will become larger in the case of smaller B. When T = 10^{12} K and $B^{\frac{1}{4}}$ = 145 Mev, the whole star will almost be composed only of quark matter; c) We choose 1.4 $M_\odot$ as the mass of neutron stars at T = 10^{10} K and suppose that there is no mass ejection during the cooling from 10^{12} K to 10^{10} K. We then obtained the initial mass of neutron stars at T = 10^{12} K is equal to 1.68 $M_\odot$ for pure neutron matter and 1.51 $M_\odot$ for pure quark matter ($B^{\frac{1}{4}}$ = 145 Mev) according to the conservation of total baryon number. The total energy released by a neutron star during such a cooling process is about 5×10^{53} erg and 2×10^{53} erg, respectively. Besides, we also estimate that the neutron matter-quark matter phase transition will offer 10^{53} erg for SN explosion

References

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