Dependence of neutron star cooling on the equation of state with a possible exotic particle

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Neutron stars cool down by neutrino emission until around 10^{5-6} yr, which is highly related to their cooling processes. So as to account for the observed young and low–temperature isolated neutron stars, a rapid cooling process, such as the direct Urca process (DU), is needed. Whether DU occurs or not is determined by the interior proton fraction Y_p, or the symmetry energy. Therefore, to study the time variation of neutron star temperature we have to consider interior equation of state (EoS).

In this study, we adopt Togashi EoS [1], which has been recently constructed with use of nuclear potentials under finite temperature, and found to account for experimental and observational constraints. However, we show that Togashi EoS is inconsistent with observations of isolated neutron stars because Y_p or the symmetry energy remains low enough to prevent DU from occurring even if the baryon density reaches at sufficiently high density region over nuclear saturation density for Togashi EoS. So as to account for as many observations as possible, we consider the possibility of another strong cooling process caused by exotic particles inside neutron stars.

References

[1] H. Togashi, K. Nakazato, Y. Takehara, S. Yamamuro, H. Suzuki, and M. Takano, Nucl. Phys. A **961**, 78 (2017).