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Equation of state and neutrino emissivities with kaon condensates in hyperon-mixed matter

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Various phases in dense matter, which may be realized in the inner core of neutron stars, have been investigated from viewpoints of nuclear and particle physics and astrophysics. In particular, strangeness degrees of freedom such as kaon condensates (KC) and hyperons (Y=Λ, Ξ^-, $\cdots$) may appear in highly dense system. We have considered possible coexistence of KC and Y-mixed matter [(Y+K) phase] as multi-strangeness system and clarify equation of state (EOS) of highly dense hadronic matter with (Y+K) phase. We also discuss its relevance to extra neutrino emissivities in the presence of both KC and hyperons.
The interaction model for the description of the (Y+K) phase is based on chiral symmetry for kaon-baryon and kaon-kaon interactions, being combined with the relativistic mean-field theory for two-body baryon-baryon (B-B) interaction. In addition, universal three-baryon repulsive force (UTBR) and three-nucleon attractive force (TNA) are phenomenologically introduced, where unknown parameters are fixed to satisfy the saturation properties of symmetric nuclear matter.
It is shown that the EOS with the (Y+K) phase is stiff enough to be consistent with recent observations of massive neutron stars. We also discuss roles of main neutrino emissivities such as Kaon-induced Urca processes in the presence of nucleons and hyperons, on cooling of neutron stars, in particular, on extremely cold neutron stars recently observed.

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