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1 - 14 Role of Nucleonic Fermi Surface Depletion in Neutron Star Cooling

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The measurements on the neutron star surface temperature such as Cas A allow us to investigate the thermal evolution of NSs more deeply and hence grasp some crucial information and knowledge on the NS interior as well as some properties of dense nuclear matter^[1,2]. The Fermi surface depletion that comes from the nucleonic short-range correlation influences the level density of nucleons around the Fermi surface and controls many properties of Fermion systems related to particle-hole excitations around the Fermi energy. Thus, it affects the inputs of the neutron star cooling.

The Fermi surface depletion of beta-stable nuclear matter is calculated to study its effects on several physical properties that determine the NS thermal evolution^[3]. The neutron and proton Z factors measuring the corresponding Fermi surface depletions are calculated within the Brueckner–Hartree–Fock approach, employing the AV18 two-body force supplemented by a microscopic three-body force. The conclusion are summarized as follows: 1) The Fermi surface depletion quenches the peak value of ${}^{3}\text{PF}_{2}$ superfluidity by about one order of magnitude, and



Fig. 1 (color online) Cooling curves of a canonical neutron star.

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its effect is extremely strong at high densities. 2) The kinematic conditions giving rise to the threshold for the DU process do not change, and the neutrino emissivity for the DU process is reduced which is in complete contrast to previous expectations. In addition, the neutrino emissivities for the MU processes, the nucleon-nucleon bremsstrahlung processes, the Cooper pair breaking and formation processes are also reduced. 3) The heat capacity of beta-stable neutron star matter is reduced. 4) Based on the above results, it is found that the cooling rates of young neutron stars are significantly slowed, as shown in Fig. 1. The effect of the Fermi surface depletion of nucleons on NS cooling cannot be neglected, when an accurate theoretical study of the cooling is carried out.