evolution of neutron stars by suppressing neutrino emission from the hyperon direct Urca process [24–26]. Young neutron stars cool primarily by neutrino emission from the interior. As discussed in Refs. [27–29], the neutrino emissivity in superfluid matter is exponentially suppressed when the temperature T is much lower than the superfluid critical temperature T_c. On the other hand, superfluidity initiates a specific neutrino emission from the Cooper pair breaking and formation process, which is forbidden in nonsuperfluid matter. This process is exponentially suppressed when $T \ll T_c$, and it is much less efficient than the direct Urca process [29, 30]. Hence the presence of baryon superfluidity can drastically suppress the neutrino emission, which may play a key role in neutron star cooling. We are mainly interested in the possibility of ${}^1S_0$ superfluidity of Λ hyperons in neutron stars. So far, the ${}^1S_0$ pairing gap of Λ hyperons is still uncertain because it can be significantly influenced by both the properties of matter and the $\Lambda\Lambda$ interaction. More studies are needed to determine these uncertain factors using available information from recent developments in hypernuclear physics.

In this article, we focus on the ${}^1S_0$ superfluidity of Λ hyperons in neutron star matter, which is composed of a chemically equilibrated and charge-neutral mixture of nucleons, hyperons, and leptons. To calculate the pairing gap, we need to specify how to treat the neutron star matter and the $\Lambda\Lambda$ interaction. In this article, we use the relativistic mean field (RMF) theory to calculate the properties of neutron star matter. The RMF theory has been successfully and widely used for the description of nuclear matter and finite nuclei [31–35]. It has also been applied to providing the EOS of dense matter for use in supernovae and neutron stars [36]. In the RMF approach, baryons interact through the exchange of scalar and vector mesons. The meson-nucleon coupling constants are generally determined by fitting to some nuclear matter properties or ground-state properties of finite nuclei. To examine the influence of the RMF parameters, we employ two successful parameter sets, TM1 [37] and NL3 [38], which have been widely used in many studies of nuclear physics [11, 35–39]. As for the meson-hyperon couplings, there are large uncertainties because of limited experimental data in hypernuclear physics. Generally, one can use the coupling constants derived from the quark model or the values constrained by reasonable hyperon potentials. The meson-hyperon couplings play an important role in determining the properties of neutron star matter [8, 40]. We use the values constrained by reasonable hyperon potentials that include the updated information from recent developments in hypernuclear physics. We take into account the