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Repulsive Λ potential at high densities examined from heavy-ion collision and hypernuclear data

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We investigate the validity of the repulsive Λ potential at high densities which suppresses Λ in dense neutron star matter by investigating whether it reproduces the heavy-ion collision and the hypernuclear data.

In the 20th cenury, Λ baryon was predicted to appear in neutron star matter at 2-4ρ_0 from the hypernuclear spectroscopy and the phenomenology of dense neutron star matter. However, most of the hyperonic matter equations of state cannot support the observed massive neutron stars (hyperon puzzle). One of the proposed scenarios is that the ΛNN three-body force generates enough repulsion to suppress Λs in the dense nuclear matter. From chiral effective field theory, a Λ potential that satisfies this scenario has been obtained (Gerstung et al. (2020)). However, the density dependence of this potential has not been verified using experimental data.

In this talk, we will report that the above Λ potential reproduces the experimental data of heavy-ion collisions and Λ hypernuclei. We have found that the repulsive Λ potential explains both data on the Λ directed flow of heavy-ion collisions at $\sqrt{s_{NN}} = 3.0\text{–}20$ GeV within a relativistic quantum molecular dynamics implemented in JAM2 (Nara et al. (2022)), and the Λ binding energy of hypernuclei by the Skyrme-Hartree-Fock method with spherical symmetry (Jinno et al. in prep.). We conclude that the repulsive Λ potential with two- and three-body force can be a solution for the hyperon puzzle.

On the other hand, it is found that more attractive potential can also explain the both heavy-ion collision and hypernuclear data. To discriminate the repulsive Λ potentials to attractive ones, we will also examine ${}^{3}_{\Lambda}$H directed flow of heavy-ion collisions, which is recently measured by the STAR collaboration (STAR, arXiv:2211.16981) and is overestimated by the old version of JAM.

Category

Theory

Collaboration (if applicable)

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