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Structure and Reaction
of Mesic Nuclei and Neutron-Rich Nuclei
with Strangeness

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In this thesis, we have studied the following two subjects: (1) We have studied the production reaction of the $\Lambda(1405)$ and the strange dibaryon resonances, by solving the $\bar{K}NN$-$\pi\Sigma N$-$\pi\Lambda N$ coupled channel Alt-Grassberger-Sandhas (AGS) equations. (2) We have investigated the possibility to have a bound state in neutron-rich light hypernuclei, the ${}^{3}_{\Lambda}n$ and the ${}^{6}_{\Lambda}$H, by using a Gaussian expansion method (GEM).

We have investigated the $\Lambda(1405)$ and strange dibaryon resonances production reactions within the framework of the coupled-channel AGS equations. We have performed full three-body calculations for the $\bar{K}NN - \pi YN$ amplitudes on the physical real energy axis, and investigated how the signature of the resonances appears in the observables of the reactions. Two types of meson-baryon interaction models have been considered: an energy-dependent interaction and an energy-independent one, both derived from the leading term of the chiral effective field theory. We have studied how the difference of the potential models shows up in the reactions.

For the $K^- + d \to \pi + \Sigma + n$ reaction, we have found peak and bump structures in the differential cross sections at the resonance energy of the $\Lambda(1405)$ for each of E-dep. model and E-indep model. Therefore it is possible to observe the signal of the $\Lambda(1405)$ resonance in the physical cross sections. Since the magnitude and the interference patterns with backgrounds of the cross section are significantly different between E-dep. model and E-indep. model, the $K^-d \to \pi\Sigma n$ reactions are useful to obtain the information on the dynamical origin of the $\bar{K}N$-$\pi\Sigma$ coupled systems with the $\Lambda(1405)$. Furthermore, we have also shown that the channel dependence of the cross section is quite large in the forward neutron scattering, so that we may also obtain the crucial information on the $I = 1$ $\bar{K}N$-$\pi\Sigma$ interaction.

For the strange dibaryons production reactions, we have found clear bump structures appear in the quasi-two-body scattering amplitudes and the transition probabilities for the $Y_{K(I=0)} + N \to \pi{+}\Sigma{+}N$ reaction. We have also shown that the amplitudes and the transition probabilities for the E-dep. and E-indep. models have quite different energy dependencies. Because this difference is closely related to the different nature of $\Lambda(1405)$ between these two models, the strange dibaryon resonance production reaction could be useful for study of the dynamical models of the $\Lambda(1405)$. We have also estimated the transition probability of the ΛN final state, and found the signature of the strange dibaryon resonances in the ΛN mass spectrum was less significant than that of the $\pi\Sigma N$ final state due to the strong contribution of the background amplitudes.

Recently, the epoch-making observations of the bound states in light neutron-rich Λ hypernuclei ${}^{3}_{\Lambda}n$ and ${}^{6}_{\Lambda}$H are reported by the HypHI Collaboration and by the FINUDA Collaboration, respectively. Motivated by observed data, we have investigated the structure of the ${}^{3}_{\Lambda}n$ and ${}^{6}_{\Lambda}$H with the GEM. For the ${}^{3}_{\Lambda}n$, we have performed the calculation of the ΛNN-ΣNN three-body coupled systems by employing the simulated NSC97f YN interactions. These interactions reproduce the observed binding energies of the ${}^{3}_{\Lambda}$H, ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He. For the ${}^{6}_{\Lambda}$H, we have studied the structure within the framework of a $tnn\Lambda$ four-body model. In the calculation of the ${}^{6}_{\Lambda}$H binding energy, it is important to reproduce the binding energy of the core nucleus ^{5}H. To reproduce the binding energy of ^{5}H, we have employed the tnn three-body force as well as the tn two-body interaction.

As a result for the structure of the ${}^{3}_{\Lambda}n$, we have not found any bound state in the ${}^{3}_{\Lambda}n$ system, by using simulated NSC97f YN and AV8$'$ NN potentials. We have also investigated the possibility to produce such a bound state in ${}^{3}_{\Lambda}n$ by tuning the strength of the YN and

NN potential. However, we have not found any possibility to have a bound state in ${}^{3}_{\Lambda}n$, while maintaining consistency with the observed data.

As for the ${}^{6}_{\Lambda}$H, when the tnn three-body force has been tuned to reproduce the central value of the observed ^{5}H resonance energy, we have had the ${}^{6}_{\Lambda}$H ground state as a resonance. We have not obtained any bound state for ${}^{6}_{\Lambda}$H, even if the tnn three-body force have been tuned to reproduce the lower bound based on the error of the observed ^{5}H resonance energy. We have generated a shallow bound state of ${}^{6}_{\Lambda}$H ,whose Λ separation energy is consistent with the FINUDA data within the error, if the tnn three-body force has been adjusted to have the ^{5}H at 0.23 MeV below the lower bound of the error on the observed resonance energy.