Signature of $\Lambda(1405)$ in $K^- d \to \pi\Sigma n$ reaction

Shota Ohnishi[1], **Yoichi Ikeda**[2], **Tetsuo Hyodo**[3], **Emiko Hiyama**[2], **Wolfram Weise**[4,5]

[1] Department of Physics, Hokkaido University, Sapporo 060-0810, Japan

[2] RIKEN Nishina Center, Wako, Saitama 351-0198, Japan

[3] Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan

[4] ECT*, Villa Tambosi, I-38123 Villazzano (Trento), Italy

[5] Physik Department, Technische Universität München, D-85747 Garching, Germany

Understanding the structure of the $\Lambda(1405)$ as a $\bar{K}N$ quasibound state embedded in the $\pi\Sigma$ continuum is a long-standing issue in hadron physics. One of the possible kaon-induced processes forming the $\Lambda(1405)$ is $K^- d \to \pi\Sigma n$ reaction. This reaction have been studied by Braun *et al.* [1] in an old bubble-chamber experiment at K^- momenta between 686 and 844 MeV, and a new experiment is planned at J-PARC (E31 experiment [2]) with a 1 GeV kaon beam. Theoretical investigations of the $K^- d \to \pi\Sigma n$ reaction with this kinematics have previously been performed in simplified models assuming a two-step process [3-7].

Here we report on the results of a full three-body calculation of the scattering amplitudes, and investigate how the $\Lambda(1405)$ resonance manifests itself in the cross section of the $K^- d \to \pi\Sigma n$ reaction. The amplitudes are computed using the $\bar{K}NN$-πYN coupled-channels Alt-Grassberger-Sandhas (AGS) equations [8]. Two types of models are considered for the two-body meson-baryon interactions: an energy-independent [9] and an energy-dependent [10] version, both derived from the leading order chiral SU(3) Lagrangian. These two models have different off-shell properties that imply correspondingly different behavior in the three-body system. Baryon-exchange mechanisms and baryon-baryon interactions are treated in a consistent way so that two- and three-body unitarity is always satisfied in constructing the amplitudes.

As a key result of this investigation it is found that the cross section of the $K^- d \to \pi\Sigma n$ reaction, reflecting the $\Lambda(1405)$ mass distribution and width, depends quite sensitively on the (energy-dependent or energy-independent) model used. Hence the $K^- + d \to \pi + \Sigma + n$ reactions are useful for investigating the subthreshold behavior of the $\bar{K}N$ interaction.

[1] O. Braun et al., Nucl. Phys. B **129**, 1 (1977).

[2] H. Noumi et al., J-PARC proposal E31 [http://j-parc.jp/researcher/Hadron/en/pac_0907/pdf/Noumi.pdf].

[3] D. Jido, E. Oset, and T. Sekihara, Eur. Phys. J. A **42**, 257 (2009).

[4] D. Jido, E. Oset, and T. Sekihara, Eur. Phys. J. A **47**, 42 (2011).

[5] K. Miyagawa and J. Haidenbauer, Phys. Rev. C **85**, 065201 (2012).

[6] D. Jido, E. Oset, and T. Sekihara, Eur. Phys. J. A **49**, 95 (2013).

[7] J. Yamagata-Sekihara, T. Sekihara, and D. Jido, Prog. Theor. Exp. Phys. 043D02 (2013).

[8] E. O. Alt, P. Grassberger and W. Sandhas, Nucl. Phys. B **2**, 167 (1967).

[9] Y. Ikeda and T. Sato, Phys. Rev. C **76**, 035203 (2007).

[10] Y. Ikeda, H. Kamano and T. Sato, Prog. Theor. Phys. **124**, 533 (2010).