

Research Group for Hadron Nuclear Physics

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The research objectives of the Hadron Nuclear Physics Group are 1) experimental studies of exotic hadrons and nuclei with strange and charm quarks, and hot and dense quark/hadronic matter at J-PARC and BNL-RHIC, and 2) theoretical studies of exotic hadrons, nuclear matter, and neutron stars at low and high densities, including strangeness and charm quarks. Through these topics, we study many-body problems of quarks and hadrons in relation with Quantum Chromo Dynamics (QCD).

Hadron experimental studies at J-PARC

We performed the J-PARC E07 experiment to investigate double hypernuclei in the $K^-p \rightarrow K^+\Xi^-$ reaction using the hybrid-emulsion method, where we associate tracks from Silicon Strip Detectors with trajectories in emulsions. We irradiated 118 emulsion modules with a K^- beam, which are expected to include 10^4 stopped Ξ^- [1,2]. We have already found some candidate events with a hypernucleus, as shown in Fig. 1.

The Stage-2 request to the Program Advisory Committee (PAC) of J-PARC for the H-dibaryon search experiment (J-PARC E42) was officially approved in July 2017. In preparation for the Hyperon spectrometer for the baryon spectroscopy experiment with $\pi N \rightarrow \pi\pi N$ reactions (E45), in collaboration with Research Fellow, Ken Hicks of Ohio University, we achieved 180 ps time resolution of a prototype TPC Hodoscope, which is used for two-charged particle trigger. We also designed a liquid hydrogen target system and made the TPC target holder to accommodate the target. We wrote the technical design review and undertook a review for our Stage-2 request to PAC in Jan. 2018. The technical part of E45 has been mostly approved, while we are asked for more detailed beam time estimation with further physics consideration.

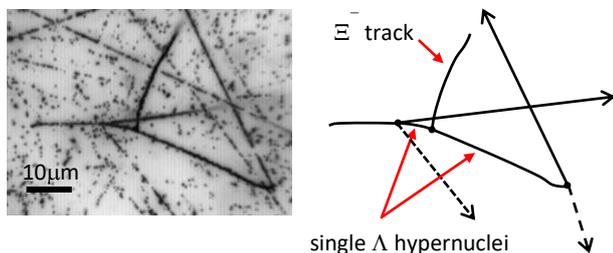


Fig.1 An event of twin single Λ hypernuclei in emulsion at J-PARC E07.

Tanida and Hicks proposed a new experiment to search for a new $\Lambda(1670)$ resonance in the $K^-p \rightarrow \Lambda\eta$ reaction. A hint for this resonance was previously observed at Belle and Crystal Ball experiments. Since this resonance does not exist in quark models, it could be an exotic hadron. The experiment (P72) was reviewed in Jan. 2018, and approved for Stage-1 (for physics importance).

Theoretical studies on exotic hadrons

We performed various theoretical studies for exotic hadrons and nuclei with strangeness and charm, such as theoretical studies for kaonic nuclei based on the J-PARC E15 experiment [3], properties of vector mesons in hot matter [4], and exotic hadrons with charm [4,5]. As activities of the Theoretical Physics Institute, we held 12 seminars, and a mini-workshop on theoretical physics with various kinds of physics topics based on the keyword of strong magnetic field. We are preparing to form a new theoretical research group in ASRC involving diverse fields such as hadron and nuclear physics, and condensed matter physics.

Other research activities

At RHIC, in p+Au collisions with polarized proton beams, we measured the left-right asymmetry of forward neutrons [6]. We obtained striking results that the asymmetry has the opposite sign to p+p data. The source of the difference has not been understood.

We are developing the design for the future heavy-ion program at J-PARC (J-PARC-HI). We are revising the spectrometer design based on a dipole magnet and Time Projection Chamber for easier implementation. We have a new international collaboration with Vinca Institute of University of Belgrade and University of Grenoble. We continue R&D for the project on Time-of-Flight detector based on Multi-Resistive Plate Chamber (MRPC), as well as a fast data acquisition system with triggerless readout.

Reimei research “Collaborative studies on baryon spectroscopy at J-PARC between theory and experiment”

In this Reimei research program, we studied baryon excited states and dense nuclear matter at J-PARC with Ken Hicks as PI. We prepared for the E45 experiment, and we proposed the P72 experiment. We held the Mini Workshop “Light baryon and hyperon spectroscopy at J-PARC” in June 2017, the and Reimei Workshop on Hadronic Resonances and Dense Nuclear Matter on Dec. 2017. The latter had 74 participants including 28 foreign participants, where we discussed hadron physics and heavy-ion physics related to J-PARC. We also held a J-PARC-HI collaboration meeting to discuss the project strategy.

References

- [1] [H. Ekawa, JPS Conf. Proc. 17, 033002 \(2017\).](#)
- [2] [S. Hayakawa, JPS Conf. Proc. 17, 033003 \(2017\).](#)
- [3] [T. Sekihara, E. Oset and A. Ramos, Acta Phys. Polon. B48, 1869 \(2017\).](#)
- [4] [P. Gubler and D. Satow, Phys. Rev. D96, 114028 \(2017\).](#)
- [5] [K. Ohtani, K-J. Araki, M. Oka, Phys. Rev. D96, 055208 \(2017\).](#)
- [6] [C. Aidala, K. Tanida, et al, Phys. Rev. Lett. 120, 022001 \(2017\).](#)