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 partonic/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 investigate many-body problems of quarks and hadrons in relation to Quantum Chromo Dynamics (QCD).

Hadron experimental studies at J-PARC

We made progress in the data analysis for the J-PARC E07 experiment to search for double hypernuclei and found 22 double hypernuclei, among which we uniquely identified a $_{\Lambda\Lambda}$Be [1], as shown in Fig. 1 (Also see the research highlight of our group).

The Stage-2 request to the Program Advisory Committee (PAC) of J-PARC for the baryon spectroscopy experiment with $\pi N \rightarrow \pi\pi N$ reactions (J-PARC E45) was officially approved in July 2018. In preparation for the Hyperon spectrometer for E42 (H-dibaryon search), E45, and E72 (search for a new Λ resonance), a high-rate beam tests up to 1 MHz at HIMAC was performed. As a result, a good efficiency, position resolution, and track reconstruction performance were achieved. We also achieved 140 ps timing resolution of a prototype TPC Hodoscope and constructed a liquid hydrogen target system. These achievements were followed by the successful performance of a 24-hour test of the superconducting dipole magnet in the summer period.

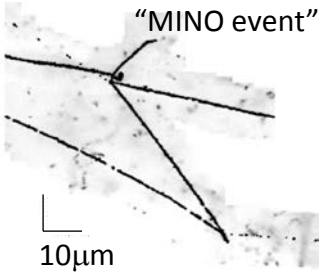

Fig.1 An event of double Λ hypernuclei (MINO event) in emulsion at J-PARC E07.

Theoretical studies on exotic hadrons

Throughout 2018, we performed various theoretical studies for exotic hadrons and nuclei with strangeness and charm, such as a nucleon-Omega dibaryon [2], production of η'd bound state in $\gamma d \rightarrow \eta d$ [3], properties of vector mesons in hot matter, and charmonium spectra at finite temperature [4]. As the Theoretical Physics Institute, we held 10 seminars and one of the lecture-series (by Y. Utsuno) on theoretical and experimental hadron nuclear physics. In Apr. 2019, we started a new theoretical research group in ASRC involving diverse fields, such as hadron, nuclear, and condensed matter physics.

Other research activities

At Belle, we were able to observe an Omega excited state for the first time [5] and two Press Releases were published on the observation. One for the discovery of the nucleus with K^- meson and two protons in Jan. 2019, and the other is for the discovery of MINO event [1] in Feb. 2019.

We proposed the future heavy-ion program at J-PARC called J-PARC-HI to Japanese Nuclear Physics Community and the Reimei Workshop “Physics of dense matter and strangeness at J-PARC-HI” was held to discuss the proposal. In Nuclear Physics Committee Meeting of Dec. 2018, large nuclear physics projects including J-PARC-HI were discussed and the committee endorsed J-PARC-HI with a high priority. We submitted the proposal for Master Plan of Science Council of Japan in Mar. 2019.

Reimei research programs

In the Reimei research program “New Aspects of Hadron Spectroscopy and Exploration of Dense Nuclear Matter at J-PARC”, we studied baryon excited states and dense nuclear matter at J-PARC with Prof. Ken Hicks (Ohio Univ.) as principal investigator (PI). We held the workshop “Physics of dense matter and strangeness at J-PARC-HI” in Dec. 2018 as described above and “Experimental and Theoretical Hadron Physics: Recent Exciting Developments on Hadronic Resonances and Dense Nuclear Matter” in Jan. 2019. The latter had 50 participants including 12 foreign participants, where we discussed hadron physics and heavy-ion physics related to J-PARC.

In another Reimei research program “Universal physics in Many-Body Quantum Systems – From Atoms to Quarks –”, we made cross-disciplinary studies of many body quantum systems with Prof. Hans-Werner Hammer (TU Darmstadt) as PI. In addition, we held the Reimei Workshop “Universal physics in Many-Body Quantum Systems - From Atoms to Quarks -” in Dec. 2018 with 54 participants including 8 foreign participants.

References

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[4] K-J. Araki, K. Suzuki, P. Gubler, M. Oka, Phys. Lett. B 780, 48 (2018).
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