Research Group for Hadron Nuclear Physics

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The research objectives of our group are 1) experimental studies of exotic hadrons and nuclei with strangeness and charm, and high-density matter at J-PARC and BNL-RHIC, 2) theoretical study of nuclear matter at low and high densities and the role of strangeness and charm in nuclear matter and neutron stars. Through these topics, we study many-body problems of quarks and hadrons in relation with Quantum Chromo Dynamics (QCD).

Hadron physics experiments at J-PARC

We measured the gamma ray emitted by the first excited state in $^{4}_{\Lambda}$He. The excitation energy of this state is found to differ from that of the mirror nucleus, $^{4}_{\Lambda}$H, by 320 keV, indicating a large charge-symmetry breaking effect [1]. Details are shown in the research highlight of this Annual Report.

We conducted pilot runs of experiments E05 (search for Ξ hypernucleus with a spectrometer) and E07 (search for a double Λ hypernucleus in emulsion) in October and November, 2015. For E05, we took preliminary data for the ^{12}C(K^-,K^+) reaction to search for Ξ hypernuclei. For E07, we tested the marking of the beam position on an emulsion with pbar and K^- beams.

We also took ^{12}C(K^-,p) reaction data in the E05 pilot run to study the $\overline{K}$-nucleus interaction. A previous study of the same reaction (KEK-E548) had an experimental bias by requiring a chaged particle in a decay detector. Our experiment measured unbiased events successfully and the analysis is underway.

We have completed the construction of the superconducting Helmholtz magnet for E42 (H-dibaryon search in (K^-,K^+) reaction) and E45 (baryon resonance spectroscopy in (π,2π) reactions) experiments in March 2016. We tested the Time Projection Chamber (TPC) for these experiments with radioactive sources and a UV laser. We developed a data acquisition system and performed readout tests of the TPC using GET (General Electronics for TPC). Our request for the second-stage approval of E42 was reviewd by the J-PARC PAC in January 2016. We were given homework on the magnet and the TPC and progress is underway to solve all remaining issues.

High energy heavy-ion physics at RHIC and J-PARC

The RHIC-PHENIX experiment aims at studies of quark-gluon plasma. In 2015, we studied the reactions p+p, p+Au, and p+Al at nucleon-nucleon center-of-mass energy of 200 GeV.

The J-PARC Heavy-Ion project (J-PARC-HI) aims to explore QCD phase structures at extremely high baryon density with the world's most intense heavy-ion beams. In the Master Plan of the Science Council of Japan, R&D for the project has been included. Design of the heavy-ion acceleration scheme with a new heavy-ion linac and a heavy-ion booster ring with existing 3-GeV RCS and 50-GeV MR has been established. Detailed simulation studies for dilepton spectra were done with a large acceptance toroidal spectrometer [2]. The white paper of J-PARC-HI has been completed in May 2016.

Hadron Theory Research and Theoretical Physics Institute

The J-PARC experimental programs are quite competitive and highly regarded internationally, and they rely on strong theoretical support. Our theorists benefit from working closely with experimentalists and have established collaborative research in multi-strange hadron/nuclear physics, charm hadron physics, and properties of dense hadronic matter. Much effort has been devoted to build a theory group to support J-PARC experiments. We started the Theoretical Physics Institute (TPI) as a (virtual) theory group at ASRC, aiming to host cross-disciplinary collaborations among the theorists in ASRC. The TPI activities include the Kick-off Meeting in August, and a series of TPI Lectures, for which we invited several guest speakers covering hadron, nuclear and condensed-matter physics.

The Reimei Program and International Collaborations

A Reimei Program on "Hadron Physics in Extreme Conditions at J-PARC" was successfully carried out with Hyun-Chul Kim (Inha Univ., Korea) as the PI. We had a fruitful research collaboration, publishing papers on heavy quark hadrons [3]. We held the 31st Reimei workshop on Hadron Physics in Extreme Conditions at J-PARC at ASRC in January 2016, with 72 participants (24 from abroad). The program consisted of a keynote talk by W. Weise (Munchen), and invited talks on the subjects of heavy quark hadrons, hypernuclear physics, hadrons in medium, exotic hadrons and heavy-ion physics.

We established international research exchange agreements with the Inha University and the European Centre for Theoretical Studies in Nuclear Physics and Related Areas (Italy), from which we invited researchers to the Reimei workshop.

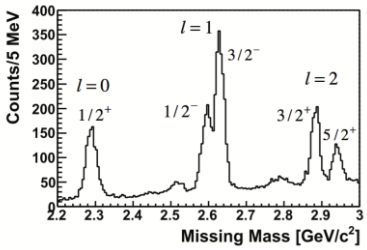

Fig. 1: Predicted missing mass spectrum of charmed baryons [3].

References

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