A3F-CNS Summer School 2022

Report of Contributions

https://indico3.cns.s.u-tokyo.ac.jp/e/198

Contribution ID: **1** Type: **Theoretical Nuclear Physics**

Large-scale shell-model calculations: from low-lying spectra to compound states

Saturday, 20 August 2022 09:35 (50 minutes)

Presenter: UTSUNO, Yutaka (Japan Atomic Energy Agency)

Contribution ID: **2** Type: **Theoretical Nuclear Physics**

Large-scale shell-model calculations: from low-lying spectra to compound states

Wednesday, 24 August 2022 10:40 (50 minutes)

Presenter: UTSUNO, Yutaka (Japan Atomic Energy Agency)

Contribution ID: **3** Type: **Instruments**

Scintillation counter (1/3)

Saturday, 20 August 2022 10:40 (50 minutes)

Presenter: Prof. SHUNSUKE, Kurosawa (Tohoku University)

Contribution ID: **4** Type: **Instruments**

Scintillation counter (2/3)

Sunday, 21 August 2022 09:35 (50 minutes)

Presenter: Prof. SHUNSUKE, Kurosawa (Tohoku University)

Contribution ID: **5** Type: **Instruments**

Scintillation counter (3/3)

Tuesday, 23 August 2022 10:40 (50 minutes)

Presenter: Prof. KUROSAWA, Shunsuke (Tohoku University)

Contribution ID: **6** Type: **Experimental Nuclear Physics**

Oslo Method (1/2)

Saturday, 20 August 2022 15:00 (50 minutes)

Presenter: Dr INGEBERG, Vetle (Univ. of Oslo)

Contribution ID: **7** Type: **Experimental Nuclear Physics**

Oslo method (2/2)

Saturday, 20 August 2022 16:05 (50 minutes)

Presenter: Dr INGEBERG, Vetle (Univ. of Oslo)

Contribution ID: **8** Type: **Experimental Nuclear Physics**

Experimental Level densities and Photon strength functions

Monday, 22 August 2022 16:00 (50 minutes)

Presenter: Prof. SIEM, Sunniva (Oslo University)

Contribution ID: **9** Type: **Experimental Nuclear Physics**

Medical applications of nuclear physics

Tuesday, 23 August 2022 16:00 (50 minutes)

Presenter: Prof. SIEM, Sunniva (Oslo University)

Contribution ID: **10** Type: **Theoretical Nuclear Physics**

Quantal Rotation (1/4)

Saturday, 20 August 2022 17:10 (50 minutes)

Presenter: Prof. STEFAN, Franendorf (Univ. of Notre Dome)

Contribution ID: **11**

Type: **Theoretical Nuclear Physics**

Quantal Rotation (2/4)

Monday, 22 August 2022 17:05 (50 minutes)

Presenter: Prof. STEFAN, Frauendorf (Univ. of Notre Dome)

Contribution ID: **12** Type: **Theoretical Nuclear Physics**

Quantal Rotation (3/4)

Monday, 22 August 2022 18:05 (50 minutes)

Presenter: Prof. FRUENDORF, Stefan (Univ. of Notre Dome)

Contribution ID: **13** Type: **Theoretical Nuclear Physics**

Quantal Rotation (4/4)

Tuesday, 23 August 2022 17:05 (50 minutes)

Presenter: Prof. FRAUENDORF, Stefan (Univ. of Notre Dome)

Contribution ID: **14** Type: **Experimental Nuclear Physics**

Hypernuclei (1/4)

Sunday, 21 August 2022 10:40 (50 minutes)

Presenter: Prof. NAKAMURA, Satoshi. N. (Univ. of Tokyo)

Contribution ID: **15** Type: **Experimental Nuclear Physics**

Hypernuclei (2/4)

Monday, 22 August 2022 09:35 (50 minutes)

Presenter: Prof. NAKAMURA, Satoshi. N. (Univ. of Tokyo)

Contribution ID: **16** Type: **Experimental Nuclear Physics**

Hypernuclei (3/4)

Monday, 22 August 2022 10:40 (50 minutes)

Presenter: Prof. NAKAMURA, Satoshi. N. (Univ. of Tokyo)

Contribution ID: **17** Type: **Experimental Nuclear Physics**

Hypernuclei (4/4)

Wednesday, 24 August 2022 09:35 (50 minutes)

Presenter: Prof. NAKAMURA, Satoshi N. (Univ. of Tokyo)

Contribution ID: **18** Type: **Experimental Nuclear Physics**

Physics with AGATA (TBC) (1/2)

Monday, 22 August 2022 15:00 (50 minutes)

Presenter: Prof. BRACCO, Angela (Univ. of Milano)

Contribution ID: **19** Type: **Experimental Nuclear Physics**

Physics with AGATA (TBC) (2/2)

Tuesday, 23 August 2022 15:00 (50 minutes)

Presenter: Prof. BRACCO, Angela (Univ. of Milano)

Contribution ID: **20** Type: **Experimental Nuclear Physics**

RIBF overview

Sunday, 21 August 2022 13:30 (50 minutes)

Presenter: Dr GO, Shintaro (RIKEN Nishina Center)

Contribution ID: **21** Type: **Experimental Nuclear Physics**

Spectroscopy of exotic nuclei

Tuesday, 23 August 2022 09:35 (50 minutes)

Contribution ID: **22** Type: **not specified**

Closing Ceremony

Wednesday, 24 August 2022 11:30 (20 minutes)

Contribution ID: **23** Type: **Experimental Nuclear Physics**

Background Gamma Measurement for Low Energy Astrophysical Reaction at FRENA

Monday, 22 August 2022 13:30 (15 minutes)

Facility for Research in Experimental Nuclear Astrophysics (FRENA), an upcoming tandem accelerator facility at Saha Institute of Nuclear Physics, Kolkata, India. This is a low energy (0.2-3 MV) high current facility primarily designed for nuclear astrophysical studies. Most of the astrophysical reactions have very low cross-sections with large error bars[1]. So the background studies in this region is very crucial for accurate measurements. The wall thickness of FRENA is ~1.2m thick in order to reduce the cosmic background but those walls become a source for gamma background from natural isotopes like 238U, 40 K and, 232Th [2]. In this work, a detailed background measurement is performed during beam on and off conditions. Different scintillator detectors (NaI & $LaCl_2$) are used to measure gammas at different positions of the accelerator building. With and without reduced background by Lead brick array (Pb, Z=82) and detail CPS calculation is done to understand the counts coming from a particular element. The machine parts themselves are made up of SS-304 (mainly consisting of Chromium, Nickel, and Carbon), Tantalum and copper. During beam on condition, neutrons are generated in beam dump and these neutrons interact with different isotopes present vicinity, gives gamma photon as background. Some of them have long half-life too[3]. Caen digitizer (DT5730) was used as data acquisition system. The same will be used in the future for the FRENA experiments. An experiment is planned to study the formation of ^{106,108}Cd at FRENA.

References

[1] Claus E. Rolfs & William S. Rodney. (2005). Cauldrons in the Cosmos.
[2] Glenn F. Knoll. 2001-01. Radiation Detection and Measurement.
[3] arXiv:2203.01995v1 [nucl-ex]

Primary authors: Mr SAHA, Sukhendu (Saha Institute of Nuclear Physics, HBNI, India); Mr BAR, Tanmoy (Saha Institute of Nuclear Physics, HBNI, India)

Presenter: Mr SAHA, Sukhendu (Saha Institute of Nuclear Physics, HBNI, India)

Session Classification: Young Scientist Session 2

Contribution ID: **24** Type: **Experimental Nuclear Physics**

Nuclear Structure Study of Neutron-Rich Xe Nuclei by β-γ Decay Spectroscopy

Tuesday, 23 August 2022 13:30 (15 minutes)

Shape evolution from spherical to deformed nuclear system as a function of neutron number has been studied to reveal the change of residual nuclear interactions in finite quantum many-body system. Neutron-rich Xe nuclei with A ~ 140 are located at the northeast transitional-mass region of the doubly-magic ^{132}Sn (Z = 50 and N = 82). Various nuclear structures with prolate collectivity and octupole correlation are expected to appear in these nuclei which are known in neighboring nucleus ^{144}Ba (Z = 56 and N = 88). Experiment was performed as a part of EURICA campaign based on β- and isomer-decay spectroscopy. Neutron-rich nuclei were produced at RIBF, RIKEN by in-flight fission of ^{238}U beam with energy of 345 MeV/nucleon and intensity of ~5 pnA, bombarding on a 3 mm Be target. The fragments were separated and identified through BigRIPS separator and ZeroDegree spectrometer. Ion and β ray were detected by WAS3ABi which consists of 5 DSSSD with 60 vertical and 40 horizontal strips. The parent β decaying nucleus was identified by the same detected position of ion and β ray at the WAS3ABi. Gamma ray was detected by using EURICA, a γ ray detector array consisting of 12 cluster-type Ge detectors. In this work, neutron-rich odd Xe nuclei with A ~ 140 are investigated by the β decay and the β-delayed neutron decay of I isotopes. Nuclear structure of Xe isotopes will be discussed by comparing to the theoretical calculation.

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Presenter: NURHAFIZA, M. N. (Dept. of Phys., Osaka Univ.)

Session Classification: Young Scientist Session 3

Contribution ID: **26** Type: **Experimental Nuclear Physics**

Development of a new way to measure the thickness of solid hydrogen target by using intermediate to high energy ion beams.

Monday, 22 August 2022 13:45 (15 minutes)

Background and Purpose：An efficient way to measure the nuclear radii is to measure the reaction cross section between the incident nucleus and the proton target (especially solid hydrogen). Currently, the method of measuring the length of solid hydrogen and multiplying it by the density to obtain the mass thickness is not sufficiently accurate because of the several % uncertainty in the published density of solid hydrogen. Therefore, we have developed a new method to measure the thickness of solid hydrogen with a high accuracy of about 0.several %.

Method：In our new method, the mass thickness is derived directly from the energy loss of the beam passing through solid hydrogen. Since the accuracy of the theoretical calculation of ΔE is not sufficient, the mass thickness cannot be obtained accurately by comparing it with the measured value. Therefore, we devised a method to derive the thickness of solid hydrogen by comparing the energy loss of polyethylene $(\mathrm{CH_2})$ and $(\mathrm{C}+\mathrm{H})$, carbon and solid hydrogen, and performed the measurement.

Experiment：We irradiated $(^{18}\mathrm{O}, ^{27}\mathrm{Al})$ with a primary beam of 200-300 MeV/u and a secondary beam near Ni to $\mathrm{CH_2}$ and $\mathrm{C}+\mathrm{H}$, respectively, and measured energy loss in the target at HIMAC, QST at Chiba.

Primary author: Mr TAKAYAMA, Gen (Osaka-u)

Presenter: Mr TAKAYAMA, Gen (Osaka-u)

Session Classification: Young Scientist Session 2

Contribution ID: **27** Type: **Experimental Nuclear Physics**

Measurement of $^{130}\mathrm{Sn}(d,p)$ and $^{130}\mathrm{Te}(d,p)$ reactions with TiNA for Neutron Capture Rate in r-process Nucleosynthesis

Saturday, 20 August 2022 13:30 (15 minutes)

Neutron capture rate on neutron-rich nuclei is one of the most uncertain nuclear physics parameters to understand the r-process nucleosynthesis in the universe. According to the network simulation of the nucleosynthesis, the neutron capture on $^{130}\mathrm{Sn}$ significantly affects the final abundances of the r-process. To reduce the uncertainty, we performed the experiment to study the neutron capture rate of $^{130}\mathrm{Sn}$ using the surrogate ratio method at the BigRIPS-OEDO beamline in RIKEN' s RIBF. In this experiment, we measured $^{130}\mathrm{Sn}(d,p)$ and $^{130}\mathrm{Te}(d,p)$ reactions separately in inverse kinematics to determine the ratio of the gamma emission probabilities from the respective unbound states. The protons recoiled from the CD_2 solid target were detected by a recoil particle detector array, TiNA.
The present status of the analysis will be discussed.

Primary author: HAGINOUCHI, Taiga (Tohoku University)

Presenter: HAGINOUCHI, Taiga (Tohoku University)

Session Classification: Young Scientist Session 1

Contribution ID: **28** Type: **Experimental Nuclear Physics**

Study of the contribution of the ^{7}Be(d, p) reaction to the ^{7}Li problem in the Big-Bang Nucleosynthesis

Saturday, 20 August 2022 13:45 (15 minutes)

Our research goal is to measure the cross-section of the ^{7}Be(d, p) reaction in search of a solution to the cosmological ^{7}Li problem (CLP). The CLP is the overestimation of primordial ^{7}Li abundance in the standard Big-Bang nucleosynthesis (BBN) model compared to observed abundances, a major unresolved problem in modern astrophysics. A recent theoretical BBN model emphasized the primordial ^{7}Li abundance is about three times larger than the recent precise observation [1], [2]. ^{7}Li nuclei were considered to be produced predominantly by the electron capture decay of ^{7}Be after the termination of nucleosynthesis in the standard BBN model. We focus on the ^{7}Be(d, p) reaction since it is considered one of the contributors to ^{7}Be destruction in the BBN [3]. We developed a method to produce ^{7}Be (half life = 53.22 days) target to measure the reaction cross-section in normal kinematics. The experiment was performed at the Tandem Electrostatic Accelerator, Kobe University [4]. A 2.36 MeV proton beam irradiated a natural-Li target to transmute ^{7}Li particles to ^{7}Be particles via the ^{7}Li(p, n)^{7}Be reaction [5]. We produced 3.03×10^{13} ^{7}Be particles in the target after two days of proton irradiation. After the target production, the beam ion was changed to deuterons and the ^{7}Be(d, p) reaction measured at energies 0.6, 1.0, and 1.6 MeV. The outgoing protons were measured by layered-silicon telescopes placed at 30 and 45 degrees. In this talk, I will report the experimental setup and preliminary results of this study, including the ^{7}Be(d, p) cross-section.\\
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References\par
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[2] Brian D. Fields {\it et al.}, J. Cosmol. Astropart. Phys. 03(2020)010.\par
[3] S. Q. Hou {\it et al.}, Phys. Rev. C {\bf 91}, 055802 (2015).\par
[4] "Kobe University Tandem Electrostatic Accelerator" \url{https://www.maritime.kobe-u.ac.jp/en/study/tandem_e.html} (Accessed 4th August 2022)\par
[5] K. K. Sekharan et al., Nucl. Instr. Meth. {\bf 133}, 253-257 (1976).

Primary author: INOUE, Azusa (Research Center for Nuclear Physics, Osaka university)

Co-authors: TAMII, Atsushi (Research Center for Nuclear Physics, Osaka university, Institute of Radiation Science, Osaka University); CHAN, Phaikying (Research Center for Nuclear Physics, Osaka university); HAYAKAWA, Seiya (Center for Nuclear Study, University of Tokyo); KOBAYASHI, Nobuyuki (Research Center for Nuclear Physics, Osaka university); MAEDA, Yukie (Faculty of Engineering, University of Miyazaki); NONAKA, Kotaro (Faculty of Engineering, University of Miyazaki); SHIMA, Tatsushi (Research Center for Nuclear Physics, Osaka university); SHIMIZU, Hideki (Center for Nuclear Study, University of Tokyo); TRAN, Dinh Trong (Research Center for Nuclear Physics, Osaka university, Vietnam Academy of Science and Technology); WANG, Xuan (Research Center for Nuclear Physics, Osaka university); YAMAGUCHI, Hidetoshi (Center for Nuclear Study, University of Tokyo, National Astronomical Observatory of Japan); YANG, Lei (Center for Nuclear Study, University of Tokyo, China Institute of Atomic Energy); YANG, Zaihong (Research Center for Nuclear Physics, Osaka university, School of Physics, Peking University)

Presenter: INOUE, Azusa (Research Center for Nuclear Physics, Osaka university)

Session Classification: Young Scientist Session 1

Contribution ID: **29** Type: **Experimental Nuclear Physics**

Direct measurement of the ^{26}Si(α,p)^{29}P reaction at CRIB for the nucleosynthesis in the X-ray bursts

Saturday, 20 August 2022 14:00 (15 minutes)

Nuclear reactions in the αp-process including the ^{26}Si(α, p)^{29}P are important for the nucleosynthesis in X-ray bursts. However, there are not sufficient experimental data of the reactions because radioactive-isotope (RI) beam is required to perform the experiment and the cross section is low. In order to acquire the sufficient nuclear data of the ^{26}Si(α, p)^{29}P, a direct measurement was performed at CNS RI beam separator (CRIB), located at RIKEN Nishina Center. We used inverse kinematics with a thick target method for the measurement. In this experiment, multiplexer circuit, Mesytec MUX, was used to acquire data. The details of the experimental conditions and the preliminary results of the analysis are discussed.

Primary authors: OKAWA, Kodai; KIM, Minju (Sungkyunkwan University); CHAE, Kyungyuk; HAYAKAWA, Seiya

Co-authors: ADACHI, Satoshi; CHA, Soomi; CHILLERY, Thomas; FURUNO, Tatsuya; GU, Gyungmo; HANAI, Shutaro (CNS,the university of Tokyo); IMAI, Nobu (CNS); KAHL, Daid (University of Edinburgh); KAWABATA, Takahiro; KIM, Chanhee; KIM, Dahee; KIM, Sohyun; KUBONO, Shigeru (RIKEN Nishina Center); KWAG, Minsik; LI, Jiatai (Center for Nuclear Study, University of Tokyo); MA, Nanru; MICHIMASA, Shin'ichiro (Center for Nuclear Study, the Univ. of Tokyo); NGUYEN KIM, Uyen; NGUYEN NGOC, Duy; SAKANASHI, Kohsuke; Mr SHIMIZU, Hideki (CNS, Univ. of Tokyo); SIRBU, Oana; YAMAGUCHI, Hidetoshi (Center for Nuclear Study, the University of Tokyo); YOKOYAMA, Rin; ZHANG, Qian

Presenter: OKAWA, Kodai

Session Classification: Young Scientist Session 1

Contribution ID: **30** Type: **not specified**

Greeting from the Dean

Saturday, 20 August 2022 09:30 (5 minutes)

Presenter: Prof. HOSHINO, Masahiro (The University of Tokyo)

Contribution ID: **31** Type: **Instruments**

A position sensitive Schottky cavity doublet for use in the Rare RI Ring.

Monday, 22 August 2022 14:00 (15 minutes)

Despite being proposed over half a century ago, various aspects of the r-process synthesis of heavy elements remain unknown¹. One such mystery is that of the true astrophysical site. Intense neutron flux is required to set sufficient conditions for synthesis. In order to clarify the conditions of the r-process, mass measurements of neutron rich isotopes involved in the r-process chain are crucial to constrain mass models thereby improving accuracy of simulations which rely on extrapolated values ². The Rare Radio-Isotope storage ring (R3) at RIKEN, Japan currently carries out isochronous mass spectrometry via a time-of-flight (tof) measurement over multiple revolutions. Due to low production rates, reliable beam diagnostics are essential to achieving the high yield necessary to create sufficient statistics. Currently no sophisticated beam monitor is permanently installed, therefore a novel position-sensitive Schottky cavity doublet has been developed at GSI, Darmstadt to be tested at R3. With design based on the existing successful cavities at GSI, it can additionally perform mass determination via frequency measurement; this method has been proven to provide excellent resolution³. This would remove the need to reliably extract particles to complete a tof measurement, increasing the potential yield. Position sensitivity enhances the precision of this method by correcting for velocity spread of particles offset from the isochronous condition. Moreover, it could enable measurement of the magnetic rigidity inside the ring which is used for mass determination and recorded with a thick gas based detector upstream. Removing the need for this detector would greatly reduce energy loss and increase precision. In this work, the theory and operation of the novel Schottky cavity doublet is presented.

[1] E. M. Burbidge, G. R. Burbidge, W. A. Fowler, and F. Hoyle, 'Synthesis of the Elements in Stars' , Rev. Mod. Phys., vol. 29, no. 4, pp. 547–650, Oct. 1957, doi: 10.1103/RevModPhys.29.547.

[2] J. J. Cowan et al., 'Origin of the heaviest elements: The rapid neutron-capture process', Rev. Mod. Phys., vol. 93, no. 1, p. 015002, Feb. 2021, doi: 10.1103/RevModPhys.93.015002.

[3] P. Kienle et al., 'High-resolution measurement of the time-modulated orbital electron capture and of the β+ decay of hydrogen-like 142Pm60+ ions', Physics Letters B, vol. 726, no. 4, pp. 638–645, Nov. 2013, doi: 10.1016/j.physletb.2013.09.033.

Primary author: HUDSON-CHANG, George (Riken Nishina Center)

Presenter: HUDSON-CHANG, George (Riken Nishina Center)

Session Classification: Young Scientist Session 2

Contribution ID: **32** Type: **Theoretical Nuclear Physics**

Generator coordinate method with variational basis generation

Monday, 22 August 2022 14:15 (15 minutes)

The generator coordinate method (GCM) has been utilized to describe the nuclear collective motion including the cluster structure. The GCM trial function is given by a coherent superposition of Slater determinants (SDs) fixed within some collective space, which has been a priori selected. The energy variation is then made only for the weight function. In this talk, we present a GCM with the basis SDs optimized as well according to the variational principle. With such simultaneous optimization of the basis states, one does not have to specify beforehand the relevant collective or cluster degrees of freedom covered by the set of basis SDs. We apply the method to a schematic model and discuss the difference between our method and the other beyond-mean-field methods.

Primary authors: MATSUMOTO, Moemi (Tohoku University); TANIMURA, Yusuke (Tohoku University)

Presenter: MATSUMOTO, Moemi (Tohoku University)

Session Classification: Young Scientist Session 2

Contribution ID: **33** Type: **Theoretical Nuclear Physics**

Finite range Simple effective interaction with tensor terms

Monday, 22 August 2022 14:30 (15 minutes)

The crossing of the $2p_{3/2}$ and $1f_{5/2}$ proton s.p. energy levels in neutron-rich *Ni* isotopes and the magic character of the atomic number *Z=28* in this isotopic chain is a subject of current interest from both, experimental and theoretical points of view[1,2]. The finite range Simple effective interaction(SEI) is able to reproduce the experimentally observed crossing even without requiring a tensor term. Using SEI, the crossing of the $1f_{5/2}$ and $2p_{3/2}$ s.p. proton levels in the isotopic chain of *Ni* and the spin inversion in the ground-state of *Cu*-isotopes are found to be a function of nuclear matter(NM) incompressibility. The role of the incompressibility is also noticed in the study of sd- level splitting in *Ca* isotopic chain using the SEI model. Experimental studies[3,4] establish that the proton $2s_{1/2}$ and $1d_{3/2}$ s.p. levels invert going from ^{40}Ca to ^{48}Ca. However, the observed proton gaps between the $1h_{11/2}$ and $1g_{7/2}$ shells in *Sn* and *Sb* isotopic chain, and the neutron gaps between the $1i_{13/2}$ and $1h_{9/2}$ shells in *N=82* isotones[5] require explicit consideration of a tensor part with SEI as the central contribution is not enough to initiate the required level splittings. In this work, we will analyze the observed proton and neutron single-particle energy gaps in *Sn* and *N=82* isotopic and isotonic chains respectively by adding a short-range tensor force to SEI within the Quasi-local Density Functional Theory (QLDFT) formalism and compared the results with the available experimental data[5] as well as with the predictions of other mean field models such as the SIII and SAMI-T Skyrme forces and the D1MTd Gogny interaction.

References

[1] L. Olivier, S. Franchoo, M. Niikura, Z. Vajta, D. Sohler, P. Doornenbal, A. Obertelli, Y. Tsunoda, T. Otsuka, G. Authele, et al., Phys. Rev. Lett. **119**, 192501 (2017).
[2] E. Sahin, F. L. Bello Garrote, Y. Tsunoda, T. Otsuka, G. de Angelis, A. Grgen, M. Niikura, S. Nishimura, Z. Y. Xu, H. Baba et al., Phys. Rev. Lett. **118**, 242502 (2017).
[3] P. Doll, G. J.Wagner, K. T. Knöpfle, and G. Mairle, Nucl. Phys. A **263**, 210 (1976).
[4] C. A. Ogilvie et al., Nucl. Phys. A **465**, 445 (1987).
[5] J P Schiffer, S J Freeman , J A Caggiano, C Deibel, A Heinz , et al., Phys. Rev. Lett. **92**, 162501(2004).

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Presenter: Ms BANO, Parveen (Sambalpur University)

Session Classification: Young Scientist Session 2

Contribution ID: **34** Type: **Experimental Nuclear Physics**

Direct measurement of astrophysical S(E) for the 9Be(p,a)6Li and 9Be(p,d)8Be reactions at low energy

Saturday, 20 August 2022 14:15 (15 minutes)

The p-9Be reactions play a key role in accurate prediction of primordial abundance of beryllium, and its abundance can be used to exquisitely probe the nucleosynthesis and mixing mechanism of stars. In the present work, astrophysical S(E) factors of the 9Be(p,d)8Be and 9Be(p,α)6Li reactions have been obtained from thick-target yield Yield(Ei) for proton energies from 18 to 100 keV. A full R-matrix analysis was performed to fit both the 9Be(p,d)8Be and 9Be(p,α)6Li reactions, simultaneously. The resulting astrophysical S(E) factors agree well with direct measurements, leading to S(0) = 17.3 ± 2.1 and 13.9 ± 1.8 MeV·b for the 9Be(p,d)8Be and 9Be(p,α)6Li reactions, respectively. The reaction rates were also calculated in the temperature range from 0.01 to 1 T9, which improve the precision of standard database NACRE and NACRE II.

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Co-authors: Prof. YAMAGUCHI, Hidetoshi (Center for Nuclear Study, University of Tokyo); Dr HAYAKAWA, Seiya (Center for Nuclear Study, University of Tokyo); Ms OKAWA, Kodai (Center for Nuclear Study, University of Tokyo)

Presenter: Dr ZHANG, Qian (Center for Nuclear Study, University of Tokyo, Japan)

Session Classification: Young Scientist Session 1

Contribution ID: **35** Type: **Experimental Nuclear Physics**

Study of the excited ^{9}Li core in ^{11}Li

Tuesday, 23 August 2022 13:45 (15 minutes)

^{11}Li nucleus is one of the flagship drip-line nuclei in the field of nuclear physics. A spatially extended structure of neutrons in ^{11}Li, which is now widely known as "halo"structure, opened the very active field of research with unstable nuclear beams. ^{11}Li have the nature of Borromean.[1] In many cases, ^{11}Li is considered as a 3-body system of ^{9}Li + 2 neutrons. However, recent theoretical studies pointed out that contribution of the excited ^{9}Li core can be significant. According to the interpretation of [2], the ground state of ^{11}Li has components which contain excited state of the core. In Ref [3], they showed that the E1 cluster sum rule value should be reduced by about 15% due to the ^{9}Li core excitation. Currently no experiment has succeeded in providing a direct information of the excited ^{9}Li core in ^{11}Li.

In this work, with the data of SAMURAI18 experiment, the quasi-free ^{11}Li(p,pn)^{9}Li* reaction was employed to study the excited ^{9}Li core. Because of spin-parity constraints, the first bound excited state of ^{9}Li cannot contribute much and the 2nd state, which is unbound, can give the major contribution. Therefore, the ^{9}Li excited core will decay into the ^{8}Li + neutron. Using the invariant mass spectrum and dalitz plot of ^{8}Li + 2 neutrons, we could get the direct information of the exited ^{9}Li core in ^{11}Li.

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ISGMR measurement in Kr isotope with CAT-M

Tuesday, 23 August 2022 14:15 (15 minutes)

The incompressibility in nuclear matter (K_0 and K_τ) play an important role in clarifying the equation of state (EOS) of nuclear matter in extreme environments such as neutron stars.
K_0 and K_τ can be directly determined from the nuclear incompressibility K_A measured from isoscalar giant monopole resonance (ISGMR) measurements. K_A can be expressed as follows from the nuclear droplet model,
$K_A = K_0 + K_s A^{-1/3} + \left(K_\tau + K_{\tau s} A^{-1/3}\right)\alpha^2 + K_C Z^2 A^{-4/3}$.
K_s and $K_{\tau s}$ are surface terms and K_C is the Coulomb term; K_C can be assumed to be known because the model error is very small.
In previous studies, measurements of $^{90}\mathrm{Zr}$, $^{208}\mathrm{Pb}$, Sn and Cd isotopes, which are double magic nuclei, have shown that $K_0 = 240 \pm 20$ MeV and $K_\tau = -550 \pm 100$ MeV, and The error of K_τ is as large as 20\%. Also a recent study with $A \sim 90$ reported $K_0 = 202$ MeV, which is a significant deviation from existing measurements.

The reason is that the surface effects (K_s and $K_{\tau s}$) cannot be evaluated.
Therefore, it is important to perform systematic ISGMR measurements with various nuclei, including unstable nuclei, and to quantitatively evaluate the surface effects specific to each nucleus.
The ISGMR measurement in unstable nuclei requires the measurement of low-energy recoil particles that are scattered forward angle using the RI beam.
On the other hand, there is a trade-off relation between target thickness and measurable range.
Therefore, a gas active target is best suited for systematic measurements.

We have developed an active target for systematic measurement of ISGMR, CAT-M, which consists of a small TPC for beam particle measurement (Beam TPC), a TPC for recoil particle measurement (Recoil TPC), and a dipole magnet for δ-ray removal associated with heavy-ion beam irradiation.
In this study, as a systematic measurement using Kr isotopes, we performed ISGMR measurements using $^{86}\mathrm{Kr}$ and $^{80}\mathrm{Kr}$ (d, d') reactions.
In this presentation, we report the details of the experiments and the performance of CAT-M.

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A new Silicon Array for CAT-M

Tuesday, 23 August 2022 14:00 (15 minutes)

The active target CAT-M (CNS Active Target - Medium/Manul) is being used in an experimental campaign for the study of the ISGMR (Isoscalar Giant Monopole Resonance), also called "Breathing Mode".
The experimental campaign is performed at HIMAC (Heavy Ion Medical Accelerator in Chiba), and beam time has been assigned to three different measurements. The first two experiments have been successfully carried out: the nucleus of ^{136}Xe was studied in July 2021, and the nuclei of ^{80,86}Kr in February 2022. Data are currently under analysis at RCNP.
The apparatus was improved in order to maximize the detection performance of the active target. In particular, two major upgrades will be described in this presentation which consist in the introduction of a dipole magnet inside the active target field cage, and the installation of a new silicon array on CAT-M lateral flanges (next measurement).
In the past experiments the magnet was placed inside the field cage in order to reduce the noise coming from the delta rays generated by the high-energy beam crossing the active region. Electrons resulting from the interaction of the beam with the gaseous target are confined in a thin region along the beam direction, and will not interfere with the tracking process. This is the first time a magnet was used inside an active target field cage, and the noise suppression was significant: tracks are clearly identifiable, and total trigger rate drastically reduced.
The next measurement will take place in September 2022, and the lateral flanges of CAT-M will host the DSSSD (Double-Sided Silicon Strip Detectors) array of Leuven. This array is composed by twelve Si detectors of 10cm x 10cm surface, segmented in 64 strips and with a thickness of 1000μm. It will not only guarantee a large coverage of the solid angle and a good energy resolution ($\sim$0.5% @5MeV), but also a better position sensitivity given by the high-density readout strips.

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