Experimental investigation of the structure of radionuclide ^{22}Mg via ^{18}Ne(α,α)^{18}Ne measurement

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Abstract

The ^{18}Ne(α,p)^{21}Na reaction, one of the breakout reactions from hot-CNO cycle, plays a crucial role in understanding the X-ray bursts and the nucleosynthesis in the rp-process. Because this reaction rate is dominated by the energy levels of ^{22}Mg above the α-threshold at 8.14 MeV, studying the ^{22}Mg nuclide may improve our understanding of the X-ray burst. In order to study the energy level properties of the radionuclide ^{22}Mg, the ^{18}Ne(α,α)^{18}Ne scattering measurement was performed at CRIB, a radioactive-ion beam separator of Center for Nuclear Study of the university of Tokyo in inverse kinematics. By adopting a thick target method, energy levels at Ex = 9.5 - 17 MeV in ^{22}Mg were populated in a single run. Details of the experimental setup and preliminary results will be discussed in this presentation.

Portable ionization chamber for the future experiment at RAON

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Abstract

Beam current monitoring and particle identification of beams and beam-like heavy recoils are crucial for cross-section measurement in low-energy nuclear physics. Ionization chamber is one of the most popular devices for this purpose because of its sturdiness against radiation damage and relatively good energy resolution. A fast position-sensitive ionization chamber has been developed at the Sungkyunkwan University in order to overcome the count rate limitation of conventional ion counter (~100,000 pps). The ionization chamber was tested and commissioned by using heavy ion beams at the 8 MV tandem accelerator facility of the Kyushu University in Japan. By employing the multi-electrode design, the maximum count rate of about 800,000 pps was achieved. This ionization chamber will be used for the experiment at the KoBRA (KOrea Broad acceptance Recoil spectrometer and Apparatus) at RAON. Details of the design and result of performance test will be presented.

Developing interactive kinematics tool for transfer reaction measurements

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Abstract

Relativistic kinematics calculations are essential to optimize experimental settings for transfer reaction measurements, which is a very useful too in nuclear spectroscopy. Since the state populated by a transfer reaction shows a structure that can be expressed as the core with the transferred nucleon orbiting around it, the energies of shell model orbitals can be well produced by performing transfer measurements. Although lots of codes are available for various calculation such as reaction kinematics, energy loss, Gamow window calculations, using a series of codes is not always trivial since it involves iterative usage of codes. For a better user experience, a java-based relativistic kinematics program for transfer reactions has been developed. Development procedure, usage, and application of program will be discussed.

Construction and Commissioning of LAMPS neutron TOF detector

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Abstract

The LAMPS group made and built LAMPS neutron TOF detector which is one of main detectors of LAMPS experiment in 2018. We will present processes of detector constructions and commissioning of LAMPS neutron TOF detector.

LAMPS detector has two detector systems. One is consisted with Time Projection Chamber, T0 detector and TOF detector for charged particles. The another one is neutron detector to measure direction and time of flight of neutrons. With these information, full momentum information of neutron can be reconstruct. The neutron detector has 4 layers of neutron wall, and each layer has two 2 x 2 m^2 detection area with 40 neutron modules. The size of single neutron module is 10 cm x 10 cm x 200 cm with scintillation material, BC408, and two light guides and PMTs are attached two ends of the scintillator. With this configuration, neutron detector can measure hit position and hit timing of a neutron with 23 mm position resolution and 140 ps timing resolution. Signals from PMTs are recorded by 500 MHz FADC.

The neutron detector construction was done from May. 2018 to Dec. 2018. 180 detector modules in total, including 20 charged particle VETO detector were made and installed into detector frame. For systematic mass production, a gluing stage was designed for gluing scintillators and light guide. PMT holders were also designed for fixing PMTs on the light guide and easy replacing.

The commissioning is on the progress from Mar. 2019. After PMT gain adjustment and energy-timing calibration, The neutron detector will be ready for physics measurement.

Study of RI Beam speculation using LiSe++ toolkit

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Abstract

At Rare isotope Accelerator complex for ON-line experiments (RAON), high energy Rare Isotope (RI) beam will be produced by IF(In-flight Fragment) system. The produced RI beam will be delivered to Large Acceptance for Multi-Purpose (LAMPS) facility to study nuclear symmetry energy. It would be very important to understand what kind of RI beam will be exactly injected to the target inside LAMPS. For doing this, we have a plan to build Beam Profile Detector installed between IF and LAMPS. In order to determine the best detector type, we will use LiSe++ toolkit to simulate RI beam production by IF. In this poster presentation, we will introduce LiSe++ and present the results of the study for simulated RI beam.

MASS MEASUREMENT OF IMPORTANT NUCLEI IN THE rp-PROCESS

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Abstract

The rp-process is believed to be triggered from the hot CNO cycle. This process will proceed via a combination of the proton captures, (α,p) reactions and β+-decays until the photodisintegration hinders the nuclear flow of the nucleosynthesis. The reaction rates are important to investigate the equilibrium of (p,γ) – (γ,p) branches at waiting points. However, the calculations of the rates based on the X-ray burst models indicated that a series of the proton captures of the Ge, As, Se and Kr isotopes in rp-process has the variations up to a factor of 100. This uncertainty can be reduced by more accurate masses of the exotic nuclei of the reactions but they are still very uncertain. Therefore, mass measurements of those isotopes are proposed to be measured for more precision. In this work we consider the possible reactions for the production of the mentioned exotic nuclides via Isotope-Separation On-Line (ISOL) method and the feasibility of their mass measurements using future Multi-Reflection Time-of-Flight Mass Spectrometer (MR-TOF-MS) at RAON facility.

Spin-glass-like behaviours of doped breathing pyrochlores $Li(In_xGa_{1-x})Cr_4O_8$ (x = 0.2 and 0.5)

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Abstract

We performed ac and dc magnetic susceptibility, electron spin resonance (ESR), and muon spin relaxation (μSR) measurements on doped breathing pyrochlore system $Li(In_xGa_{1-x})Cr_4O_8$ (x = 0.2 and 0.5). This system realizes the alternating arrangement of small and large tetrahedra, included alternating bonds and geometrical frustrations. The magnetic phase of breathing pyrochlore is determined by "the breathing parameter $B_f = J'/ J$". By doping we elucidate the macroscopic and microscopic magnetic properties on intermediate phases of breathing pyrochlore between B_f (In) = 0.1 < B_f < B_f (Ga) = 0.6. In the different manner of the uniform pyrochlore and mother compounds, the magnetostructural phase transition is suppressed and not observed in doped compounds. The *ac* and *dc* magnetic susceptibility and μSR measurements show the magnetic transitions at T = 6 (4) K in x = 0.2 (0.5) compounds. However, the field- and frequency-dependent *ac* susceptibility shows the deviation from canonical spin-glass behavior, which χ' show the broad peaks as the magnetic field (frequency) increases. From the bandwidth of ESR, the critical exponents of the intermediate breathing pyrochlore show the values close to that of the 3D coupled spin tetrahedra $Cu_4Te_5O_{12}Cl_4$. Taken together, the modified breathing pyrochlore shows the suppression of magnetostructural transition, the survival of magnetic transition, and the spin-glass-like behavior due to geometrical frustration and complex bond alternation.

Study of the quantum criticality in the S = 1/2 square-lattice antiferromagnets $Sr_2Cu(Te_{1-x}W_x)O_6$ (x = 0.05, 0.1)

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Abstract

A square-lattice Heisenberg *J1-J2* model harbors various exotic quantum phases including Néel and columnar antiferromagnetic orders, and ferromagnetic order by controlling the ratio *J2/J1*. The B-site ordered double perovskites $Sr_2Cu(Te_{1-x}W_x)O_6$ with a tetragonal I4/*m* structure are regarded as an optimal realization of the S = 1/2 square-lattice Heisenberg J1- J2 model [1-4]. By varying the B" cations between Te^{6+} and W^{6+} ions, $Sr_2Cu(Te1\text{-}xWx)O_6$ compounds exhibit the Néel order (x = 0), columnar antiferromagnetic order (x = 1). Moreover, a quantum spin liquid state is found at x = 0.5 due to the high amount of quenched disorder in the magnetic interactions [1]. We try to clarify the true nature of a quantum spin liquid ground state with a perspective of the quantum critical behavior for the disordered Te6+ and W6+ ions.

In this presentation, we focus on the $Sr_2Cu(Te1\text{-}xWx)O_6$ (x = 0.05 and 0.1) which are located in the Néel order and quantum spin-liquid side, respectively. DC magnetic susceptibility of x = 0.05 and 0.1 exhibits a broad hump around 70 K, indicating the short-range magnetic correlations. With fitting both magnetic susceptibilities to the Curie-Weiss law, Weiss temperatures are estimated to about -90 K, suggesting the dominant antiferromagnetic exchange interaction. The magnetization curves of both compounds show a gradual, nonlinear increase up to 55 T. Furthermore, magnetic susceptibility for x = 0.05 shows a small kink at 18 K, where the muon relaxation rate at zero field displays a weak anomaly. This kink indicates the occurrence of the magnetic order. On cooling from 18 K down to 4 K, temperature dependence of the muon relaxation rate for both compounds shows a steep increase without a sharp peak. This feature points to persisting spin fluctuations in the ordered state. Especially

for the x = 0.1 compound, persistent spin fluctuations below 1 K was observed, reminiscent of a quantum spin liquid.

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Measurements of secondary neutrons from carbon target bombarded by 800 MeV/u ^{28}Si

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Abstract

Nuclear data for heavy ion reactions are needed for many purposes including studies of nuclear structures and reactions and the production of medical isotopes, etc. There is no evaluated nuclear data for heavy-ion reactions while the demand for the heavy ion reaction data is increasing. A heavy-ion facility RAON is under construction in Korea to provide radioactive ion beams. For the development of shielding design for radiation safety, it is important to measure energy spectra of secondary neutrons from heavy-ion reactions as a source term and compare the data with the results from Monte Carlo simulations. In the Monte Carlo simulations related to heavy ions, one of the physics models most often used is the quantum molecular dynamics (QMD). For the verification of various physics models, such as QMD, experimental data of heavy-ion reactions are needed. Heavy Ion Medical Accelerator in Chiba (HIMAC), which can deliver heavy ion beams with energies up to 800 MeV/nucleon, is used to measure the double differential cross sections and the thick target yield of secondary neutrons from a carbon target bombarded by 800 MeV/u silicon beams. Neutron spectra were measured at 6 different angles (15°, 30°, 45°, 60°, 75°, and 90°) by the time-of-flight technique with use of NE-213 liquid organic scintillators. Two sizes of NE-213 liquid organic scintillators were installed to cover a wide energy range of neutrons from a few MeV to several hundred MeV. To eliminate the background signals scattered by the surrounding structures, iron bars were arranged between the

carbon target and each NE-213 neutron detector. The experimental results are compared with Monte Carlo simulation results obtained by the Particle and Heavy Ion Transport code (PHITS). The PHITS code deals with heavy-ion reactions by means of JQMD (JAERI QMD) model. The simulation results were found in good agreement with our experimental data of the secondary neutrons.

Thermal neutron capture cross sections and resonance integrals of ^{185}Re and ^{187}Re using pulsed neutrons produced from the Pohang electron linac

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Abstract

In this work, we have determined the thermal neutron capture cross sections (♦0) and resonance integrals (I0) of the ^{185}Re(n,ɣ)^{186}Re and ^{187}Re(n,ɣ)^{188}Re reactions by using the method of neutron activation analysis based on the 100-MeV electron linac of the Pohang Accelerator Laboratory (PAL). The measurements were done with respect to the ^{197}Au(n,ɣ)^{198}Au reference reaction. The induced ɣ-ray activities in the irradiated foils were measured with high purity germanium (HPGe) ɣ-ray detector. The thermal neutron capture cross sections for the ^{185}Re(n,ɣ)^{186}Re and ^{187}Re(n,ɣ)^{188}Re reactions have been determined to be 108.33±2.77 barn and 75.59±2.84 barn relative to the reference value of 98.65±0.09 barn for the ^{197}Au(n,ɣ)^{198}Au reaction. The resonance integrals for the ^{185}Re(n,ɣ)^{186}Re and ^{187}Re(n,ɣ)^{188}Re and reactions have been determined to be 1650.3±98.5 barn and 317.44±18.31 barn with respect to the reference value of 1550±28 barn for the ^{197}Au(n,ɣ)^{198}Au reaction. The comparison between the present measurements and various literature values are discussed.

Keywords: Thermal neutron capture cross section; Resonance integral; Activation method and off-line ɣ-ray spectrometric technique; ^{185}Re(n,ɣ)^{186}Re and ^{187}Re(n,ɣ)^{188}Re reactions.

A Simulation Study on Antiproton Therapy with Comparison of Proton and Carbon Ion Therapy

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Abstract

To evaluate the distribution of dose depositions of antiproton beam, by using simulation method, the phantom model that includes the target volume and three interested normal volumes are constructed. The interactions for beams and phantom materials are simulated, and the dose deposition in target volume and three interested volumes are calculated. The calculation results show that the dose deposition in upstream volume is lower for antiproton beam than that for proton and carbon ion. However, for other volumes, the dose deposition of proton beams and carbon ion beams are more ideal than that for antiproton. Through this study, it can be concluded that the antiproton therapy has the advantages as a radiation therapy method. Especially for the case that lower dose is required for upstream of target.

Silencing of fused toes homolog (FTS) combined with carbon ion irradiation increases cell killing synergistically through notch mediated signaling in cervical cancer cells

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Abstract

Purpose: Fused toes homolog (FTS), a cervical oncoprotein plays a significant role in radio-resistance and involved in radiation induced EGFR and Notch signaling by X-ray irradiation. The present study investigated the regulatory role of FTS on Notch signaling and maintenance of cancer stem cells (CSC) upon carbon ion irradiation. The effect of carbon(C) ion beam alone or combined with FTS-silencing on notch signaling in human uterine cervical cancer cells were studied.

Materials and Methods: Panel of three human cervical cancer cell lines (HeLa, ME180, CaSki) were treated with C-ions in FTS intact and silenced cells. Western blot, spheroid formation assay, clonogenic assay, immunoprecipitation assay and immunofluorescence were performed. Cells were irradiated with C-ion beams of 290 MeV/n with average LET 50 keV/μm and a dose rate of 3 Gy/min.

Results: Notch 1, 2, 3 and FTS was increased after C-ion irradiation in cell line dependent manner. Protein expression of ɣ-secretase complex and Notch target Hes1 was reduced by FTS- silencing combined C-ions. Immunoprecipitation showed FTS binds with Notch1 and Hes1. Clonogenic numbers, spheroid formation and the expression of CSC markers, Nanog, Oct4A and Sox2 were reduced by FTS-silencing combined with C-ions.

Conclusion: These results suggest that C-ion irradiation combined with FTS-silencing has a potential to increases cancer cell killing by exploiting Notch signaling in cervical cancer.

Key words: Carbon ion radiation, Cervical cancer, Fused toes homolog, Notch, Cancer stem cells

Constraints on the saturation properties by using the experimental and astronomical observation data

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Abstract

We discuss the constraint on the saturation properties by using the astronomical observation and experimental data. The equation of state for nuclear matter is important for finite-nuclei and neutron star properties. The equation of state is expressed as energy which is the function of density. At the saturation density, at which the energy of symmetric nuclear matter is minimum, the binding energy, symmetry energy, slope parameter, and incompressibility are the significant physical quantity in nuclear physics. The binding energy and symmetry energy are well determined by many researches. However, the slope parameter and incompressibility have uncertainty. The recent neutron star observation (For example, Tidal deformability) could reduce this uncertainty. To do this, we employ the relativistic-mean-field- model with non-linear potential. In this work, we present how to constraint on the saturation properties.

Big bang nucleosynthesis in a weakly non-ideal plasma

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Abstract

We propose a correction of standard big bang nucleosynthesis (BBN) scenario to resolve the primordial lithium problem by considering a possibility that the primordial plasma can deviate from the ideal state. In the standard BBN, the primordial plasma is assumed to be ideal, particles and photons satisfying the Maxwell-Boltzmann and Planck distribution, respectively. We suggest that this assumption of the primordial plasma being ideal might oversimplify the early universe and cause the lithium problem. We find that deviation of photon distribution from the Planck distribution, which is parameterized with the help of Tsallis statistics, can resolve the primordial lithium problem when the particle distributions of the primordial plasma still follow the Maxwell- Boltzmann distribution. We discuss how the primordial plasma can be weakly non-ideal in this specific fashion and its effects on the cosmic evolution.

Neutrino self-interaction and MSW effects on the supernova neutrino-process

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Abstract

We investigate nuclear abundances produced from the neutrino (ν)-process in supernova explosions. For the first time, we have calculated the ν-flux propagation including both its modification by ν self-interaction (ν-SI) near the ν-sphere and the Mikheyev-Smirnov-Wolfenstein (MSW) effect in the outer O-Ne-Mg layer. The abundances of heavier isotopes ^{92}Nb, ^{98}Tc and ^{138}La are largely enhanced by the ν-SI for the inverted mass hierarchy. The ratio of ^{7}Li/^{11}B is lower in the inverted hierarchy than in the normal hierarchy. Abundance ratios of the heavy to the light neutrino isotopes such as ^{138}La/^{11}B are sensitive to the mass hierarchy by the ν-SI..

Semi-empirical model for calculating the mass distribution of fission products

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Abstract

Fission product yields (FPY) data are important for applications of nuclear technology such as the estimation of decay heat, operation of nuclear reactors and handling of spent fuels. FPY data are also important in physics: For example, the accuracy of the final abundance distribution in r-process is determined by the FPY data. However, it is difficult to measure the yields of a large part of fission products due to the short life-time and thus they need to be deduced from fission models. Although many theoretical fission models are developed, the calculation results are not necessarily accurate enough to reproduce the fission observables quantitatively. On the other hand, semi-empirical models may be useful in describing the FPY in a simple way but with a relative good accuracy. In this study, we calculated the mass distribution of fission products by using a semi-empirical method. It is assumed that the mass distribution of fission products is determined by the fission barrier to some extent whereas the effects of detailed nuclear dynamics from saddle to scission are included in our model parameters. The parameters for our empirical model are deduced by fitting the evaluated fission yields to those from the ENDF data, and we found that the parameters can be expressed in simple forms. The calculated results from our model are compared with those from other phenomenological fission models, TALYS and GEF, as well as experimental data.

Feasibility of muonium oscillation experiment in RAON and future prospect of muon beam

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Abstract

The muonium is a bound state of positive muon and electron. The muonium - antimuonium oscillation is a charged Lepton flavor violation process of muon which will be a direct signature of beyond-Standard model theories, if found. Considering the expected muon rate of RAON, it will provide a competitive chance of muonium oscillation research. In this presentation, the feasibility of muonium oscillation experiment in RAON, its technical difficulties and the possible resolutions will be discussed. A possible upgrade strategy of RAON muon beam in view of physics research will be discussed also.

Eliminating the differential decay systematic error by fitting for the g-2 phases

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Abstract

The muon g-2 experiment aims to measure the magnetic dipole moment anomaly of muons at 0.14 ppm level. The spin precession rate of the muons due to the magnetic dipole moment is a prob of getting the anomaly. Muons are stored into a ring where there is a pure magnetic field causing the muon spin precess due to the intrinsic dipole moment. Eliminating all other effects that can cause the muon spin to precess in the storage ring is necessity of the experiment. Muon spin is indirectly measured via the child positrons of the muon decay. Decay positron momentum has the same direction with the mother muon. Its energy and the time of the detection in the calorimeter are recorded. Design of the experiment targets that all muons will have one momentum and they all will follow the same orbit. In this ideal case particles will also enter the calorimeter with the same angle which is called phase. In reality, particles have different momentum and different phase. The particles with different phase will arrive at different times altough they start the journey at the same time. This lead to an error which is called the differential decay. This study tries to eliminate the systematic error caused from the differential decay in the muon g-2 data analysis with method developed by modifiying the known five parameter function.

Time-of-flight transmission measurements for ^{103}Rh at a 10m and 50m stations of GELINA

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Abstract

To study the resonance structure of neutron induced reaction cross sections, neutron spectroscopic measurements are required which determine with a high accuracy the energy of the neutron that interacts with the material under investigation. To cover a broad energy range such measurements are best carried out with a pulsed white neutron source, which is optimized for time-of-flight (TOF) measurements. The TOF-facility GELINA has been designed and built for high-resolution cross section measurements in the resonance region. Transmission measurements have been performed at the time-of-flight facility GELINA to determine neutron resonance parameters for 103Rh and the total cross section at thermal energies.

The measurements have been carried out at a 10 m and 50 m transmission station at a moderated neutron beam using a Li-glass scintillator as neutron detector and with the accelerator operating at a frequency of 50 Hz and 800Hz. The samples were metallic discs with different thicknesses, i.e. 0.075mm, 0.15mm and 0.75mm. The 0.75mm and 0.15mm thick samples were used for the measurements at 10 m and 50m, respectively, with an operation frequency of 50Hz. Additional measurements with the 0.075 mm and 0.15mm thick samples were carried at 10 m with a 800Hz operating frequency.

The results of the transmission measurements at 10 m and 50 Hz are used to determine the cross sections at thermal energy. The other measurements are carried out to study resonance parameters. By combining results obtained under different measurement conditions, i.e. sample thickness and flight path distance, systematic effects due to these conditions can be reduced. In addition, combining transmission data obtained with samples with different thickness offers the possibility to verify the spin of a resonance. Results of the 50 m transmission measurements can even be used

to determine the total resonance width. Therefore, for some of the low energy resonances the resonance energy, neutron width and radiation width can be derived.
The experimental transmission has been derived using the AGS concept. This concept is used to provide the full covariance information. This information is given such that nuclear reaction model parameters together with their covariance can be derived in a least squares adjustment to the data using e.g. the resonance shape analysis code REFIT. For a final evaluation of the resonance parameters, the transmission data will be combined in a resonance shape analysis with results from capture measurements which have been recently finalised.