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Book of Abstracts

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Contents

Conference Day 1: 2024-09-08

0908AM-1: **2024-09-08 09:20**

s process related measurements at the deep underground Gran Sasso National Laboratory

Andreas Best

Over the recent years there has been a concerted effort to directly measure the s process neutron source cross section in the deep-underground environment of the Gran Sasso National Laboratory as part of the LUNA collaboration's experimental program. Using the 400 kV LUNA II accelerator and exploiting the ultra-low background conditions, the main s process neutron source $^{13}C(\alpha, n)^{16}O$ was measured for the first time into the Gamow energy window.

With the recent installation of the new 3.5 MV MV accelerator at the LNGS Bellotti Ion Beam facility the previously not reachable energy range of the $^{22}Ne(\alpha, n)^{25}Mg$ reaction ($Q = -478$ keV) has become accessible. As part of the SHADES ERC project a gastarget and novel detector array has been taken into operation and a first characterisation measurements were performed. In parallel preparation of a setup for the measurement of the equally important reaction channel $^{22}Ne(\alpha, \gamma)^{26}Mg$ is underway.

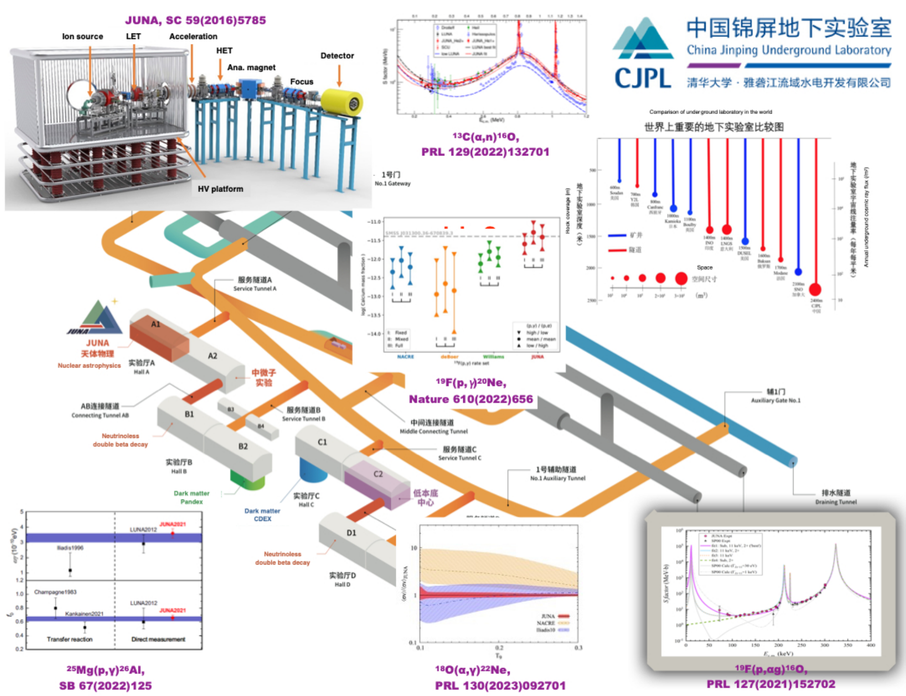
I will present an overview of the s process measurements at the LNGS, including the current status of the $^{22}Ne(\alpha, n)^{25}Mg$ campaign and an outlook on $^{22}Ne(\alpha, \gamma)^{26}Mg$.

0908AM-2: **2024-09-08 09:45**

Progress of underground nuclear astrophysics JUNA experiments

Weiping Liu

The Jinping Underground experiment for Nuclear Astrophysics (JUNA) takes advantage of the ultra-low background of the CJPL to conduct experiments for directly studying crucial reactions at stellar energies in the evolution of stars. In 2020, JUNA commissioned an mA level high current accelerator based on an ECR source, as well as high efficiency BGO and ^{3}He detectors. These combinations enabled JUNA to perform direct measurements of key nuclear reactions in 10^{-13} b sensitivity with the beam exposure of a few hundreds of Coulombs, including ^{25}Mg(p, γ)^{26}Al, ^{19}F(p, αγ)^{16}O, ^{19}F(p, γ)^{20}Ne, ^{13}C(α, n)^{16}O, ^{12}C(α, γ)^{16}O, and ^{18}O(α, γ)^{20}Ne with improved precision and closer to the Gamow window. These precise reaction rates provide valuable insights into high precision astrophysics simulation. The highlights of JUNA experiments will be presented.



0908AM-3: **2024-09-08 10:10**

New results from the LUNA collaboration at the Bellotti Ion Beam Facility

Alessandro Compagnucci

The study of many reactions of astrophysical relevance can benefit greatly from direct cross section measurements in a deep underground environment, where the low cosmic-ray background of these sites can be exploited to achieve excellent sensitivity. In this talk, I will give an overview of recent results from the LUNA collaboration with a focus on $^{14}N(p,\gamma)^{15}O$.

An accurate understanding of this reaction, that is the slowest of the CNO cycle, is essential in many astrophysical settings, from the precise estimates of the lifetimes of massive stars and globular clusters to its crucial role in determining the CNO neutrino flux emitted by the Sun. In this scenario, despite the significant efforts over the last twenty years, this reaction remains a predominant source of uncertainty when assessing the solar chemical composition.

As a pilot project at the LNGS Bellotti Ion Beam Facility, the LUNA collaboration has measured $^{14}N(p,\gamma)^{15}O$ with a focus on its angular distribution using Tantalum Nitride solid targets, developing novel approaches to limit the beam-induced background contributions. An excellent sensitivity was achieved in synergy with the high beam current provided by the new 3.5 MV accelerator in its deep-underground location.

New angular distribution data have been obtained in the energy range from 0.3 to 1.5 MeV, including also the weaker transitions, many of them not observed by previous authors. In this talk, I will present the differential cross section results that provide a novel comprehensive picture of the reaction at astrophysical energies.

0908AM-4: **2024-09-08 11:10**

Origin of r- and nu-process elements in cosmic evolution and nuclear physics

Toshitaka Kajino

There is a growing consensus in recent multi-messenger astronomy that the explosions of single massive stars, i.e. magneto-hydrodynamic jet supernovae and collapsars, dominate the r-element enrichment over the entire history of cosmic evolution, while kilonovae could partly contribute to recent epoch due to the cosmologically long time-delay of merging binary neutron stars [1,2]. We have recently found that the i- and s-processes could follow the collapsar r-process [3]. These explosive phenomena emit extremely large flux of energetic neutrinos and provide unique nucleosynthetic signals of the neutrino-nucleus interactions at high-densities [4]. We first discuss when and how these different astrophysical sites have contributed to the enrichment of the r-process elements in cosmic and Galactic chemical evolution model. We then discuss the roles of nuclear fissions, isomers, neutron-captures, beta-decays and neutrino-weak responses in these explosive nucleosyntheses.

[1] C. Kobayashi, A. Karakas, M. Lugaro, ApJ. 900 (2020), 179.
[2] Y. Yamazaki, Z. He, T. Kajino, et al., Astrophys. J. 933 (2022), 112.
[3] Z. He, T. Kajino, M. Kusakabe, et al., Astrophys. J. Lett. 966 (2024), L37.
[4] H. Sasaki, Y. Yamazaki, T. Kajino, et al., Phys. Lett. B851 (2024), 138581.

0908AM-5: **2024-09-08 11:35**

Relativistic density functional theory and the origin of the elements

Jie Meng

The relativistic or covariant density functional theory (CDFT), implemented with self-consistency and taking into account various correlations by spontaneously broken symmetries, provides an excellent description for the ground-state properties. New physics wonder may result from the strong coupling between theory and experiment perspectives. In this talk, the predictive power of PC-PK1 is demonstrated, physics around the neutron drip line and $N = Z$ nuclei are discussed, status of the DRHBc mass table collaboration is introduced as well as the effects of the continuum and deformation and the related topics. Based on the DRHBc theory, the effects of the deformation effect and the continuum effect on the nuclear energy level density, gamma intensity function, neutron capture rate and beta decay lifetime are discussed.

0908AM-6: **2024-09-08 12:00**

Reduction of ^{146}Sm-^{142}Nd chronology in the early solar system

Yibin Qian

The ^{146}Sm, as an extinct p-process isotope, plays an irreplaceable role in the time-line construction of the early solar system (ESS) and the geochemical tracing via its α decay to ^{142}Nd. However, the measured half-life of ^{146}Sm is still debated, which can result in a large uncertainty in the initial ^{146}Sm abundance in the ESS and subsequent dating of planetary events after the birth of the Sun. In this study, this half-life is reported to be 64.2 ± 10.1 million years based on a comprehensive analysis via both the state-of-the-art techniques on the α decay process and the local extrapolation from neighboring isotopes. More importantly, this procedure is actually regardless of the α-daughter potential, convincing a model-independent half-life of ^{146}Sm. The initial ^{146}Sm/^{144}Sm ratio of 0.0094-0.0003 +0.0005 at 4568 Ma, corresponding to the formation of solar system, is then determined, further leading to a reduced timescale for various planetary silicate mantle differentiation events of the ESS, paving the way for a calibrated ^{146}Sm-^{142}Nd chronometer in future studies of nucleosynthesis, earth and planetary astrophysics.

0908PM-1: **2024-09-08 13:30**

Jiangmen Underground Neutrino Observatory

Benda Xu

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20-kiloton liquid scintillator (LS) detector under construction in south China. It is designed to precisely measure the oscillation of reactor antineutrinos from two commercial nuclear power plants 53km away, with the goal of determining the neutrino mass ordering and measuring three oscillation parameters to sub-percent precisions. Upon completion in 2024, JUNO will be the world's largest and most advanced liquid scintillator detector, making it one of the best observatories for natural neutrinos from terrestrial, solar, supernovae, galactic and extragalactic sources. This talk will discuss the construction status and prospect of JUNO.

0908PM-2: **2024-09-08 13:55**

Underground nuclear astrophysics experiments: Status and Future

Giovanni Francesco CIANI

The goal of nuclear astrophysics is to measure cross sections of nuclear physics reactions of interest in astrophysics and to evaluate reaction rates for improvement knowledge of stellar evolution and synthesis of elements. At typical temperatures of stellar cores, the energy region of interest, the so-called Gamow window, is of the order of hundred keV and cross sections are very low due to the suppression of the Coulomb barrier. When these processes are studied in surface laboratories, cosmic ray induced background can strongly hamper the determination of reaction cross sections at energies relevant to astrophysical processes and experimental setups should be arranged in order to improve the signal-to-noise ratio. Placing experiments in underground sites, however, reduces this background opening the way towards ultra low cross section determination. LUNA (Laboratory for Underground Nuclear Astrophysics) was pioneer in this sense. Two accelerators are actually mounted at the INFN National Laboratories of Gran Sasso (LNGS) allowing to study nuclear reactions in several stellar scenario. Forefront Underground nuclear astrophysics projects include CASPAR and JUNA experiments, installed in Sanford Underground Research Facility (SURF) and in China Jinping Underground Laboratory (CJPL), respectively.

Recent results and future perspectives at Underground experiments will be described in this talk.

0908PM-3: **2024-09-08 14:20**

Mystery of Calcium production in the first generation stars

Jianjun HE

The origin of calcium production in the first stars (Pop III stars), which formed out of the primordial matter of the Big Bang, and their fates, remain most fascinating mysteries in astrophysics. Advanced nuclear burning and supernovae were thought to be the dominant source of the Ca production seen in all stars. Here we report on a qualitatively different path to Ca production through break-out from the "warm" carbon-nitrogen-oxygen (CNO) cycle. We extend direct measurement of the ^{19}F(p,γ)^{20}Ne break-out reaction down to an unprecedentedly low energy point of 186 keV and discover a key resonance at 225 keV. In the domain of astrophysical interest, at around 0.1 GK, this thermonuclear ^{19}F(p,γ)^{20}Ne rate is up to a factor of 7.4 larger than the previous recommended rate. Our stellar models show a stronger break-out during stellar hydrogen burning than thought before, and may reveal the nature of Ca production in Pop III stars imprinted on the oldest known ultra-iron poor star, SMSS0313-6708. This result from the China Jinping Underground Laboratory, the deepest laboratory in the world, offering an environment with extremely low cosmic-ray induced background, has far-reaching implications on our understanding of how the first stars evolve and die. Our rate showcases the impact that faint Pop III star supernovae can have on the nucleosynthesis observed in the oldest known stars and first galaxies, key mission targets of the James Webb Space Telescope.

0908PM-4: **2024-09-08 14:45**

Measurement of the $^{18}O(\alpha, g)^{22}Ne$ reaction rate at JUNA

Jun SU

0908PM-5: **2024-09-08 15:00**

Deep underground measurement of the $^{12}C(\alpha, \gamma)^{16}O$ reaction at JUNA

Yangping SHEN

0908PM-6: **2024-09-08 15:15**

PandaX Dark Matter and Neutrino Physics Program

Ke HAN

Dark matter and neutrinos are essential ingredients in the evolution of the Universe. The PandaX collaboration has built a series of xenon-based time projection chambers (XeTPC) to search for dark matter particles, neutrinoless double beta decay, and astrophysical neutrino signals. PandaX-4T is currently running, and we released the second dataset in summer 2024. This talk highlights recent dark matter searches, solar axion, and solar neutrino results.

0908PM-7: **2024-09-08 15:30**

Deep learning for nuclear masses in deformed relativistic Hartree-Bogoliubov theory in continuum

Soonchul CHOI

Most nuclei are deformed and deformations play an important role in various nuclear phenomena. Modern microscopic nuclear mass models have been/are being developed based on the relativistic Hartree-Bogoliubov theory in continuum to explore exotic nuclear properties. Among them we adopt the mass models based on the relativistic continuum Hartree-Bogoliubov theory (RCHB) with spherical symmetry and deformed relativistic Hartree-Bogoliubov theory in continuum (DRHBc) with axial symmetry to study possible effects of deformation on the rapid neutron-capture process abundances. Since the DRHBc mass table is so far finished only for even-Z nuclei, we first study if a Deep Neutral Network (DNN) can be of use to fill out the DRHBc mass table focusing on nuclear binding energy. To include information about odd-odd and odd-even isotopes to the DNN we also use the binding energies in AME2020 as a training set in addition to those of even-Z nuclei from the DRHBc mass table. After we obtain a reasonable mass table through the DNN, we perform a sample sensitivity study of r-abundances to deformation or masses by using the RCHB⋆ and DRHBc⋆ mass tables. Here, ⋆ means the mass table is obtained by the DNN. To see if such effects persist in various astrophysical sites of the r-process, we use the magnetohydrodynamic jets, collapsars and neutron star mergers.

0908PM-8: **2024-09-08 15:45**

High Energy Neutrinos from Binary Neutron Star Mergers and Rare Core-Collapse Supernovae

Gang GUO

Binary neutron star mergers and collapsars are potential sources of both high-energy (HE) neutrinos and r-process nuclei. In this talk, I will first discuss the HE neutrinos produced by jet-induced shocks. Then, I will explore the possibility that HE neutrinos can be annihilated with low-energy (LE) neutrinos, either emitted from the accretion disk around a black hole or from the beta decay of newly synthesized heavy nuclei within the same source. We suggest that these effects could be tested through precise measurements of the HE neutrino spectrum and flavor composition. Such measurements could play a unique role in identifying binary neutron star mergers and/or collapsars as sources of HE neutrinos and r-process nuclei.

0908PM-9: **2024-09-08 16:20**

Equation of state of dense matter from multi-messenger observations of neutron stars

Ang LI

The understanding of neutron star equation of state hinges on a comprehensive analysis of multi-messenger, multi-wavelength data. The recent scrutiny of PSR J0030+0451 data by NICER introduces complexities, unveiling a tension with another X-ray observation of the central compact object in HESS J1731-347, specifically concerning the mass-radius constraint of low-mass neutron stars. This tension persists when integrating NICER's updated data with LIGO/Virgo's gravitational-wave data from the GW170817 binary neutron star merger. Despite attempts to reconcile these disparate observations, the current combined data still can not distinguish different types of neutron stars − whether they are pure neutron stars or hybrid stars. Bayesian inference indicates only modest changes in the posterior ranges of parameters related to the nuclear matter and deconfinement phase transition. This ongoing exploration underscores the intricate challenges in precisely characterizing neutron stars. It also points out that it is possible to probe the equation of state at different density regimes from future more accurate radii of neutron stars with various masses.

0908PM-10: **2024-09-08 16:45**

Pulsars Discovered by FAST

JinLin HAN

Pulsars are fast-spinning neutron stars widely spread in our Milky Way. We are using the FAST to carry out the FAST Galactic Plane Pulsar Snapshot (GPPS) survey, and have discovered about 700 pulsars, including more than 160 millisecond pulsars. These discoveries have significantly extended our knowledge of how many weak pulsars exist in our Milky Way. In this talk, we show how we do the survey, and present the highlights of the survey results, especially the excellent measurements of relativistic effects of compact pulsar binary systems.

0908PM-11: **2024-09-08 17:10**

Nuclear β-decay half-life and its impact on r-process nucleosynthesis

Yifei NIU

Nuclear β-decay half-lives are basic nuclear physics inputs for rapid neutron-capture process (r-process) simulation. Since r-process path is far from the stability line, the accurate description of β-decay half-lives is important for r-process study. In this talk, I will introduce the improvement of β-decay half-life description by including the deformation degree of freedom and beyond mean-field effect, respectively, based on relativistic density functionals. By the sensitivity study of β-decay half-lives, the most impactful nuclei for r-process rare-earth peak are identified. The impact of β-decay rate of an individual nucleus on the rare-earth peak abundances is analyzed.

0908PM-12: **2024-09-08 17:25**

Theoretical descriptions of nuclear masses and β-decay half-lives in the r-process studies

Zhongming NIU

The origin of heavy elements in the universe is an important problem in basic science. The r-process is responsible for about half of the elements heavier than iron. Accurate theoretical predictions of nuclear masses and β-decay half-lives are crucial for understanding the r-process. This talk reports on recent progress in the development of various theoretical models and machine learning methods for predicting nuclear masses and β-decay half-lives. It is found that the accuracies for the description of nuclear masses and β-decay half-lives are remarkably improved. The uncertainties in the r-process abundances introduced by the nuclear mass uncertainties are found to be mainly induced by the variation of the neutron-capture rates, while the β-decay half-lives play an important role in determining the time scale of r-process.

0908PM-13: **2024-09-08 17:40**

Effective lifetime of potential waiting-point ^{68}Se in rp-process

Xing XU

Effective lifetime of a nuclide is the key parameter that can quantitatively estimate the degree of passing this nuclide in rp-process. The mass of neutron-deficient isotope ^{70}Kr, which has been directly measured by using $B\rho$-defined isochronous mass spectrometry, allows us to re-evaluate the effective stellar half-life of the potential waiting point ^{68}Se in rp-process under typical type-I x-ray bursts conditions. With the more accurate mass data of ^{70}Kr, the effective stellar half-life of ^{68}Se at both low (typically below 1.5 GK to 2 GK) and high (above 1.5 GK to 2 GK) temperatures are calculated. The results show that ^{68}Se would not be a strong waiting point since its effective lifetime shorter than typical burst time scale of 10 s to 100 s at low temperature, while poses a considerable delay at high temperature where the photodisintegration of ^{70}Kr can not be negligible in rp-process.

0908PM-14: **2024-09-08 17:55**

Conceptual design of a neutron detector for (α, n) cross section measurement

Jianqi CHEN

Polyethylene-moderated ^{3}He neutron detectors are widely used in the neutron flux monitor, fission neutron multiplicity measurement, (α, n), (γ, n), and (n, xn) reaction cross-section measurements. However, this kind of detector faces a problem that their detection efficiency strongly depends on neutron emission angle and neutron energy when neutron energy rises above 1 MeV. Therefore, we proposed a novel conceptual design of the neutron detector to address these problems that basically consists of a large spherical heavy water tank, a layer of "$^{3}He + CF_4$" gas, and surrounding photo-multiplier tubes. We used the MCNPX code to calculate detection efficiency dependencies with the neutron energy and neutron emission angle under different configurations, and obtained an optimal configuration (6 cm ^{11}B + 0.2 cm Be + 70 cm D_2O) that can offer a high detection efficiency (75%) and relatively good efficiency flatness (1.02) in the interest energy region. To reduce costs, the present study also proposed two new configurations (10 cm natCu + 0.6 cm Be + 50 cm D_2O, 10 cm natCu + 1 cm Be + 65 cm C), both of which can have fairly flat detection efficiencies when the neutron energy exceeds 1 MeV. The newly designed neutron detector may be able to substitute the conventional polyethylene-moderated ^{3}He detector and solve the long-standing problems of efficiency energy and angular dependence.

0908PM-15: **2024-09-08 18:10**

Direct reaction studies and opportunities in astrophysics

Jie CHEN

Conference Day 2: 2024-09-09

0909AM-1: **2024-09-09 09:00**

Explosive Nucleosynthesis in Core-collapse Type II Supernovae: Constraints from isotopic compositions of presolar supernova grains

Nan LIU

The chemical composition of our Solar System reflects Galactic chemical evolution (GCE) in the local interstellar medium (ISM) over the past ~ 9 Ga. While the incorporated ISM dust was mostly destroyed during the Solar System formation, a small fraction of the ISM dust, known as presolar grains, is preserved in pristine extraterrestrial materials and identified by their exotic isotopic compositions, pointing to their formation in gas outflows or explosions of ancient stars. Since their stellar birth at more than 4.6 Ga, presolar grains have borne witness to a huge array of astrophysical and cosmochemical processes. Presolar grain analysis has become an important component of the study of nuclear astrophysics as it allows for isotope analysis of bona fide stellar material in the laboratory at a precision that far exceeds what can be achieved by spectrographic measurements using state-of-the-art telescopes (Zinner 2014; Nittler & Ciesla 2016; Liu 2024).

The talk will discuss how we can leverage the isotopic compositions of presolar grains to refine our understanding of physical mixing processes within stars, stellar nucleosynthesis, and dust formation. Specifically, I will focus on the unique role of presolar grains derived from Type II core-collapse supernovae (CCSNe) in constraining explosive nucleosynthesis and the dynamic mixing processes occurring during the explosion. Drawing from our recent studies, I will present new isotope data for presolar CCSN silicon carbon (SiC) and silicon nitride (Si_3N_4) grains. Our new isotope data specifically point to the contributions of materials from distinct regions within a CCSN, including the Fe/Ni core, inner Si/S zone, and He/C zone, to the CCSN ejecta for the SiC and Si_3N_4 grain formation. This inferred mixing scenario, as suggested by the CCSN grain data, aligns with recent 3D hydrodynamic model simulations of CCSN explosions. The incorporation of materials from distinct supernova regions into these grains thus enables the investigation of a variety of nucleosynthesis processes, including alpha-rich freezeouts, neutrino-nucleus reactions, and neutron burst process. Detailed comparisons of the grain data with CCSN model calculations will be presented at the meeting.

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Liu N. (2024) Presolar Grains. Chapter in the Book Treatise on Geochemistry (Third Edition), *in press* (arXiv preprint arXiv:2406.14694).

Nittler & Ciesla (2016) Astrophysics with Extraterrestrial Materials. *Ann. Rev. Astron. Astrophys.* **54**, 53.

Zinner, E. (2014) Presolar Grains. Chapter in the Book Treatise on Geochemistry (Second Edition), 181.

0909AM-2: **2024-09-09 09:25**

Recent advances in the modeling and nucleosynthesis of classical novae and X-ray bursts

Jordi JOSE

Classical novae are a class of thermonuclear explosions that involve mass-accreting white dwarfs. The low-mass, main sequence companion (or a red giant, particularly for recurrent novae) overfills its Roche lobe and matter flows through the inner Lagrangian point of the system. While most nova simulations have focused on the early stages of the explosion and ejection, it is clear that a fraction of the ejecta will collide, first with the accreting disk that orbits the white dwarf, and later with the secondary star. As a result, part of the ejecta is expected to mix with the outermost layers of the secondary star. The resulting chemical contamination may have potential implications for the next nova cycle, once mass transfer from the secondary resumes. I will present recent advances on possible mixing mechanisms at the core-envelope interface, and will present new hydrodynamic models of recurrent novae, with emphasis on T CrB, a system that should undergo an explosion likely this year.

Type I X-ray bursts are another class of thermonuclear explosions that involve neutron stars rather than white dwarfs. These events constitute the most frequent type of thermonuclear stellar explosion in our Galaxy (the third, in terms of total energy output after novae and supernovae). To date, most of the efforts undertaken in the modeling of XRBs have relied on non-rotating, 1D hydrodynamic simulations. I will present pioneering XRB models computed with different angular velocities (up to 80% of the critical value) and discuss the differences obtained in the lightcurves and in the associated nucleosynthesis with respect to non-rotating models.

It is worth noting that, while all XRB hydro simulations performed to date report that ejection from a neutron star is unlikely, radiation-driven winds during photospheric radius expansion have been suggested to lead to the ejection of a tiny fraction of the accreted envelope. Here, we will report our results of the coupling of a non-relativistic, radiative wind model with a series of XRB hydrodynamic simulations, quantifying the expected contribution of XRBs to the Galactic abundances.

0909AM-3: **2024-09-09 09:50**

^{7}Be electron and proton capture in astrophysical conditions.

Lucio GIALANELLA

^{7}Be plays an important role in several astrophysical scenarios. In stellar hydrogen burning, the competition of its proton and electron captures determines the high-energy component of the solar neutrino spectrum. In BBN, its ultimate abundance determines the amount of ^{7}Li observed in primordial matter. Its $^{3}\mathrm{He}(^{4}\mathrm{He},\gamma)^{7}\mathrm{Be}$ and $^{7}\mathrm{Be}(\mathrm{p},\gamma)^{8}\mathrm{B}$ production and destruction processes have been studied by the ERNA collaboration using a recoil mass separator. Recently, a new project was initiated to study the electron capture decay of ^{7}Be in different charge states for the first time under controlled conditions.

A review of this topic will be presented, with illustrations of recent experiments.

0909AM-4: **2024-09-09 10:15**

The ^{12}C + ^{12}C fusion reaction at stellar energies

Xiaodong TANG

The ^{12}C + ^{12}C fusion reaction plays a pivotal role in the process of stellar evolution. Despite six decades of studies, there is still a large uncertainty in the reaction rate which limits our understanding of various stellar objects, such as massive stars, type Ia supernovae, and superbursts. In this talk, I will review the experimental and theoretical studies of the carbon fusion reaction at sub-barrier energies. I will also present the preliminary results from the direct measurement of the $^{12}\mathrm{C}(^{12}\mathrm{C},\alpha_0)^{20}\mathrm{Ne}$ reaction, obtained by the CARFUSE (CARbon FUsion study at Stellar Energies) collaboration, using a novel detection system consisting of Time Project Chamber and silicon array and the intense carbon beam provided by the Low Energy high-intensity heavy-ion Accelerator Facility (LEAF) at IMP. An outlook for future studies is also presented.

0909AM-5: **2024-09-09 11:00**

Cosmic radioactivities and gas dynamics in the Milky Way

Roland DIEHL

Observations of gamma rays from radioactive decay of ^{26}Al have been accumulated from over 20 years with the SPI spectrometer aboard ESA's INTEGRAL mission. ^{26}Al decay occurs with a lifetime of one million years. This decay time is longer than the typical luminosity of supernova remnants, and allows to trace the late propagation and dynamics of ejecta from nucleosynthesis in massive stars and their supernovae. From analysis of SPI data, it has been concluded that typical environments of these sources are superbubbles with extents up to kpc. This provides new insights into the processes that characterise feedback of star formation onto the morphology of the interstellar medium in our Galaxy. We discuss how these inferences were made, and what they may tell us about galactic structure and evolution.

0909AM-6: **2024-09-09 11:25**

Radio observations of fast variations in microquasars

Wei WANG

Microquasars are the compact objects generally including accreting black holes which produce relativitic jets. The physical mechanisms of jet launching, collimation, and acceleration are poorly understood. Microquasars show strong variability in multi-wavelength observations. In X-rays, the sources show the fast variation features up to millisecond time scales, with the prominant quasiperiodic oscillations (QPOs) around 1 Hz - tens of Hz in light curves, however, physical origin of QPOs is still uncertain. FAST as the largest radio telescope provide the opportunity to study fast variability of both radio flux and polarization in microquasars. Firstly, we reported the first evidence of subsecond quasi-periodic oscillations of GRS 1915+105 in the radio band, providing the direct link between QPOs and the special dynamics of relativistic jets. In addition, we also at first time discover the similar oscillation beharviors of both flux and polarization in jets, which should provide a clear picture on the inner engine and magnetic configuration of relativistic jets. In near future, high time resolution radio monitoring of microquasars is expected to discover more new phenomena in black hole systems.

0909AM-7: **2024-09-09 11:50**

Half-life of the one-proton emitter ^{149}Lu with microscopic description of nuclear deformation

Shisheng Zhang

0909PM-1: **2024-09-09 13:30**

Neutrino Oscillations and Nucleosynthesis of Heavy Elements

Meng-Ru WU

Neutrinos play key roles in supernova explosions and neutron star mergers, which are important sites of heavy element production in the universe. The flavor oscillations of neutrinos in these environments, particularly the collective oscillations due to the nonlinear coupling of neutrino forward scattering among themselves, have been shown to potentially impact the nucleosynthesis yield prediction. In this talk, I will discuss the recent progress in understanding the impact of collective neutrino oscillations on the nucleosynthesis yields in supernovae and mergers. I will also highlight developments aiming for consistently including collective oscillations in hydrodynamical simulations of supernoave and mergers, which are crucial for providing robust theory predictions of these events.

0909PM-2: **2024-09-09 13:55**

Improved proton capture reaction rates in the rp-process

Suqing HOU

Accurate proton capture reaction rates are pivotal for a comprehensive understanding of the rp-process. However, the uncertainties of some proton capture rates are influenced significantly by the relevant nuclear masses, especially for those proton-rich nuclei along the rp-process path. Using the high-precision nuclear masses of ^{27}S, ^{29}S, ^{27}P, and ^{43}V isotopes measured at the Heavy Ion Research Facility in Lanzhou, we updated the respective proton capture rate and derived the associated rate uncertainties. The influences of these new rates in the rp-process are explored by a series of postprocessing nucleosynthesis calculations. The specific astrophysical implications for each new rate will be discussed.

0909PM-3: **2024-09-09 14:10**

Stellar weak-interaction rates of nuclei by angular-momentum projection theory

Long-Jun WANG

Nuclear weak-interaction processes, including beta minus and plus decays, electron capture (EC) etc., play important roles for understanding Nucleosynthesis. Recently we developed a nuclear-structure model based on angular-momentum projection techniques, to calculate stellar weak-interaction rates of nuclei, where both allowed Gamow-Teller and first-forbidden transitions [1] are taken into account simultaneously. I will show some of our calculations for related processes. For the s-process, I will talk about the branching-point nuclei, paying attention to the first-forbidden transitions [2] and bound-state beta decay [3]. For the rp-process, I will talk about the Urca cooling mechanism of accreting neutron star [4], as well as the waiting-point nuclei [5]. For the r-process, I will talk about the stellar EC rates of nuclei for the core-collapse supernova [6]. We are now working on the strong magnetic-field effect for stellar weak rates, as well as the chiral two-body currents effect for nuclear Gamow-Teller transitions, which will be finished soon in the near future.

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0909PM-4: **2024-09-09 14:25**

r-process Nucleosynthesis in the Common Envelop Jet Supernovae

Shilun JIN

The common envelop jet supernovae (CEJSN) r-process scenario has been proposed as an r-process nucleosynthesis site in the past decade. Jets launched by a neutron star that spirals-in inside the core of a red supergiant star in a common envelope evolution supply the proper conditions for the formation of elements heavier than iron through the rapid neutron capture process.

This talk unveils the r-process abundance patterns that result from the density profile in the relatively long-lived jets. The CEJSN r-process scenario can produce the largest ratio of the third r-process peak elements to Lanthanides among current r-process scenarios, and in addition can form quite an amount of Lanthanides in a single event. The comparison of the ratio of the third peak elements to the Lanthanides with a number of observed r-enhanced metal-poor stars and with other r-process scenarios suggests that a high mass of third peak elements is anti-correlated with high fraction of Lanthanides, both in observations and theory.

0909PM-5: **2024-09-09 14:40**

Radiative α capture on ^{12}C in cluster effective field theory

Shung-Ichi Ando

Radiative α capture on ^{12}C, $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$, is studied within the framework of cluster effective field theory (EFT). We constructed a low energy EFT for the $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ reaction and studied the related reactions to fix the parameters of the reaction amplitudes and estimate the astrophysical S factors of $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ at the Gamow-peak energy, $E_G = 0.3$ MeV; it is known that $E1$ and $E2$ transitions of $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ are dominant because of the sub-threshold 1_1^- and 2_1^+ states of ^{16}O. The theory was applied to the studies of elastic α-^{12}C scattering at low energy, β delayed α emission from ^{16}N, and the $E1$ transition of $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ in which the S_{E1} factor was deduced at E_G. We report the study of $E2$ transition of $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ to estimate the S_{E2} factor at E_G and discuss the uncertainties of estimate of the S factors at E_G in the cluster EFT.

0909PM-6: **2024-09-09 14:55**

Calibrated Atomic Data and 3D Radiative Transfer Modelling of Kilonova

Andreas FLOERS

With the detection of multiple neutron-star merger events in the last few years, the need for a more comprehensive understanding of nuclear and atomic properties as well as radiative transfer has become increasingly important. Despite our current understanding, there are still large discrepancies in the opacities obtained from different codes and methods. These discrepancies lead to variations in the location and strength or absorption and emission features in radiative transfer models and prevent a firm identification of r-process products. We report on converged large-scale atomic structure calculations of all singly and doubly ionised lanthanides with greatly improved transition wavelength accuracy compared to previous works. We present three-dimensional radiative transfer calculations for the ejecta from a neutron star merger that include line-by-line opacities for tens of millions of bound-bound transitions, composition from an r-process nuclear network, and time-dependent thermalization of decay products from individual and decay reactions. We demonstrate the importance of wavelength-calibration of atomic data using a model with calibrated Sr, Y, and Zr data, and find major differences in the resulting spectra, including a better agreement with AT2017gfo. We also show that 1D models obtained by spherically averaging the 3D ejecta lead to dramatically different direction-integrated luminosities and spectra compared to full 3D calculations.

0909PM-7: **2024-09-09 15:10**

The impact of supernova ejecta on their companion stars and pollution of the synthesized elements at the companion surface

Zhengwei LIU

The progenitors of many supernovae are expected to be in binary systems. After the supernova explosion in a binary system, the companion star may suffer from mass stripping and be shock heated and polluted with heavy elements as a result of the impact of the supernova ejecta. If the binary system is disrupted by the supernova explosion, the companion star is ejected as a runaway star, and in some cases as a hypervelocity star. This talk will present the results of three-dimensional hydrodynamical simulations of the interaction between supernova ejecta and their companion stars, as well as pollution of the synthesized elements at the surface of companion stars during the interaction.

0909PM-8: **2024-09-09 15:25**

Two-flavor color superconducting quark stars may not exist

Wen-Li YUAN

Large uncertainties in the determinations of the equation of state of dense stellar matter allow the intriguing possibility that the bulk quark matter in beta equilibrium might be the true ground state of the matter at zero pressure. And quarks will form Cooper pairs very readily since the dominant interaction between quarks is attractive in some channels. As a result, quark matter will generically exhibit color superconductivity, with the favored pairing pattern at intermediately high densities being two-flavor pairing. In the light of several possible candidates for such self-bound quark stars, including the very low-mass central compact object in supernova remnant HESS J1731-347 reported recently, we carry out one field-theoretic model, the NambuJona-Lasinio model, of investigation on the stability of beta-stable two-flavor color superconducting (2SC) phase of quark matter, nevertheless find no physically-allowed parameter space for the existence of 2SC quark stars.

0909PM-9: **2024-09-09 15:40**

An approach to constrain neutron-star structure from Clocked bursters

Akira DOHI

Type-I X-ray bursts are rapidly brightening phenomena triggered by the nuclear burning of light elements near the surface of accreting neutron stars. Most X-ray bursters behave very irregularly, but some of them show quite regular activity, i.e., constant recurrence time and the similar shape of light curves in the burst sequence. They are called Clocked bursters, which help contain many model parameters, such as accretion rate, the composition of accreted matter, reaction rates relevant to proton-rich nuclei, neutron-star structure, and temperature. In this talk, we discuss the impact of uncertainties of the neutron-star equation of state on burst light curves. We also present an approach to probe the neutron-star structure from the observed recurrence time and light-curve shape of two Clocked bursters, GS 1826−24 and 1RXS J180408.9−342058.

0909PM-10: **2024-09-09 15:55**

Dynamic Universe: from FAST to Cosmic Antennae (CA)

Di LI

Human's perception and philosophy of the cosmos depend on our collective sensors. Modern optical sky surveys in the 20th century gave rise to the concept of dynamic Universe, the forefront of which currently is situated in radio bands and manifests itself as fast radio bursts (FRB). The discovery of FRBs was awarded the 2023 Shaw prize in astronomy. We built the largest radio telescope, namely, the Five-hundred-meter Aperture Spherical radio Telescope (FAST), which has been leading the field of characterizing repeating FRBs ever since its inception in 2020.

With close to 100 FAST-based papers on FRBs, including 5 on Nature and 2 on Science, we started to establish an evolutionary picture for FRBs. With compact objects being the leading candidate engine of FRBs, the utter lack of short-time-scale periodicity present a major mystery regarding FRBs' origin. Recently, we invented the Pincus-Lyapunov diagram to help ascertain the stochastic nature of FRBs. The P-L diagram quantify FRBs to be less chaotic than Earthquakes, but way more random, akin to a Brownian motion on the energy-time bi-variate space. This stochastic behavior presumably reflects the young ages of FRBs. To help systematically localize and discovery multi-band counterparts, we are building a next generation FRB machine, namely Cosmic Antennae (CA), the aim of which is to increase the discovery rate by orders of magnitude over all current radio telescopes.

0909PM-11: **2024-09-09 16:20**

Lithium Evolution of Giant Stars Observed by LAMOST and Kepler

Jianrong SHI

Lithium is a fragile but crucial chemical element in the Universe, and exhibits interesting and complex behaviors. Based on the LAMOST medium resolution spectra, we determined the lithium abundances for more than 450,000 stars. We use a sample of giants with known evolutionary phases and lithium abundances from the LAMOST-Kepler and LAMOST-K2 fields, we construct mass-radius diagrams to characterize the evolutionary features of lithium. The stars at red giant branch phase show natural depletion along with their stellar evolution, however, there are an obvious crowd stars with anomalously slightly higher Li abundances near the bump. Also, we found there obvious Li-rich giants near the RGB tip.

0909PM-12: **2024-09-09 16:45**

Exploring the Milky Way with LAMOST Survey

Haining LI

The formation and evolution of the Milky Way have always been cutting-edge fields in contemporary astronomy, while large-scale surveys provide us unexpected opportunities to deeply explore our home galaxy. This talk will briefly introduce the new picture of the Milky Way presented based on the huge LAMOST database. From chemical enrichment to the formation history, the LAMOST spectroscopic survey helps reveal some of our latest understandings in the field of stellar and Galactic science.

0909PM-13: **2024-09-09 17:10**

astrophysical studies with JUNO

Haining LI

0909PM-14: **2024-09-09 17:25**

Thermonuclear $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$ reaction rate and astrophysical implication in ONe nova explosion

Jinbo Liu

An accurate $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$ reaction rate is crucial to defining the nucleosynthesis products of explosive hydrogen burning in ONe novae. Using the recently released nuclear mass of $^{29}\mathrm{S}$, together with a shell model and a direct capture calculation, we reanalyzed the $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$ thermonuclear reaction rate and its astrophysical implication.

Aims. We focus on improving the astrophysical rate for $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$ based on the newest nuclear mass data. Our goal is to explore the impact of the new rate and associated uncertainties on the nova nucleosynthesis.

Methods. We evaluated this reaction rate via the sum of the isolated resonance contribution instead of the previously used Hauser-Feshbach statistical model. The corresponding rate uncertainty at different energies was derived using a Monte Carlo method. Nova nucleosynthesis is computed with the 1-D hydrodynamic code SHIVA.

Results. The contribution from the capture on the first excited state at 105.64 keV in $^{28}\mathrm{P}$ is taken into account for the first time. We find that the capture rate on the first excited state in $^{28}\mathrm{P}$ is up to more than 12 times larger than the ground-state capture rate in the temperature region of 2.5×10^7 K to 4×10^8 K, resulting in the total $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$ reaction rate being enhanced by a factor of up to 1.4 at $\sim 1 \times 10^9$ K. In addition, the rate uncertainty has been quantified for the first time. It is found that the new rate is smaller than the previous statistical model rates, but it still agrees with them within uncertainties for nova temperatures. The statistical model appears to be roughly valid for the rate estimation of this reaction in the nova nucleosynthesis scenario. Using the 1-D hydrodynamic code SHIVA, we performed the nucleosynthesis calculations in a nova explosion to investigate the impact of the new rates of $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$. Our calculations show that the nova abundance pattern is only marginally affected if we use our new rates with respect to the same simulations but statistical model rates. Finally, the isotopes whose abundance is most influenced by the present $^{28}\mathrm{P}(\mathrm{p},\gamma)^{29}\mathrm{S}$ uncertainty are $^{28}\mathrm{Si}$, $^{33,34}\mathrm{S}$, $^{35,37}\mathrm{Cl}$, and $^{36}\mathrm{Ar}$, with relative abundance changes at the level of only 3% to 4%.

0909PM-15: **2024-09-09 17:26**

Thermonuclear reaction rate of $^{57}\mathrm{Cu}(p,\gamma)^{58}\mathrm{Zn}$ in rp-process

Min Zhang

The thermonuclear reaction rate of $^{57}\mathrm{Cu(p,\gamma)}^{58}\mathrm{Zn}$, which depends exponentially on the neutron-deficient nuclide $^{58}\mathrm{Zn}$ mass, is of great importance to understand how the rp-process proceeds beyond the $^{56}\mathrm{Ni}$ waiting point in type-I X-ray bursts.

So far the uncertainty of $^{57}\mathrm{Cu(p,\gamma)}^{58}\mathrm{Zn}$ reaction rate is dominated by the 50 keV uncertainty of the proton separation energy (S_p) of $^{58}\mathrm{Zn}$ [1,2] propagated from its mass [3], which was determined indirectly by measuring the Q value of a double charge-exchange reaction $^{58}\mathrm{Ni}(\pi^+,\pi^-)^{58}\mathrm{Zn}$ nearly 40 years ago [4]. Recently, we directly measured the mass of $^{58}\mathrm{Zn}$ by using $B\rho$-defined isochronous mass spectrometry [5], resulting in a more precise proton separation energy of $S_p(^{58}\mathrm{Zn}) = 2227(36)$ keV.

With this new S_p value, the thermonuclear rate of the $^{57}\mathrm{Cu(p,\gamma)}^{58}\mathrm{Zn}$ reaction has been reevaluated to be higher than the most recently published rate [2] by a factor of up to 3 in the temperature range of $0.2\mathrm{GK} \lesssim T \lesssim 1.5\mathrm{GK}$.

The new rate is used to investigate its astrophysical impact via one-zone post-processing type-I X-ray burst calculations. It shows that the updated rate and new $S_p(^{58}\mathrm{Zn})$ value result in noticeable abundance variations for nuclei with $A = 56$-59 and a reduction in $A = 57$ abundance by up to 20.7%, compared with the results using the recently published rate.

References

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[3] M. Wang *et al.*, Chinese Physics C **45** (2021) 030003.

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0909PM-16: **2024-09-09 17:27**

Neutron-capture elements in open clusters

Sugimura Fua

Elements beyond Fe are produced through the process of neutron capture. The s-process is known to occur in a low-mass star as it evolves to an asymptotic giant branch (AGB) star. On the other hand, the r-process is believed to occur in a neutron star merger (NSM). Kolborg et al. (2023) carried out a numerical simulation of the spatial distribution of the r-process element (Eu), and they revealed the inhomogeneous distribution of Eu with a scale of 100 pc. Research into the chemical components of open clusters plays a critical role in investigating recent chemical evolution of the Solar neighborhood. According to simulation, NSMs occur one time per 300 Myr in 100 pc^3, so that we expect different abundances of the r-process elements between clusters that have a distance of more than 100 pc, and also clusters that the age difference is more than 300 Myr.

We have investigated the abundance of neutron-capture elements (Y, Zr, Ba, La, Ce, Pr, Nd, Sm, Eu, and Gd) in the Pleiades and the Hyades. Archival data of HIRES on the Keck Telescope were used. We derived the stellar parameters (effective temperature, surface gravity, microturbulent velocity, and [Fe/H]), then we measured 1-4 lines for each element. We compared the abundance between the Pleiades and the Hyades. It was found that the abundances of neutron-capture elements in two clusters are almost the same.

0909PM-17: **2024-09-09 17:28**

Observations of r-process elements including thorium in the galactic disk and halo stars

Kurumi Furutsuka

Half of the elements heavier than iron are synthesized by the r-process. The origin of the r-process is still a major matter of debate. Recent studies have shown that the origin of the r-process is neutron star mergers. On the other hand, from the studies of galactic chemical evolution, assuming neutron star mergers as the only r-process sites, it is difficult to explain stellar observations of Europium abundances. In addition, investigations of stellar abundances have found stars with high [Thorium(Th)/Europium(Eu)] (so-called actinide-boost stars). The existence of such stars suggests that the r-process has more than one origin (Holmbeck et al., 2018; Yong et al., 2021). Actinide boost stars have been mainly observed in very metal-poor stars $[Fe/H] < -2.5$. However, observations are not sufficient for mildly metal-poor stars $[Fe/H] > -2$ for the studies of galactic chemical evolution. Therefore, it is necessary to observe stellar Thorium abundances in a wide range of [Fe/H] to investigate the origin of the r-process. We obtained the spectra of 44 stars with $-2 \lesssim [Fe/H] \lesssim +0.4$ using Nayuta/MALLS, Gunma/GAOES, and Subaru/HDS, and derived the abundances of r-process elements. In $-2 \lesssim [Fe/H] \lesssim 0$, [Th/Eu] is almost constant, and no actinide boost stars were found. These results suggest that Thorium and Europium are synthesized in the same ratio, which implies a single origin. In $0 \lesssim [Fe/H]$, four stars show high [Th/Eu], and chemical evolution models cannot explain these stars. These results of Thorium observations in a wide range of metallicity could be important for the studies of the origin of the r-process.

0909PM-18: **2024-09-09 17:29**

A New Strong Urca Pair ^{63}Fe-^{63}Mn and its Impact on the Thermal Evolution and Superburst Ignition of Netrron Star

Hao Huang

The cooling effect of $^{63}\text{Fe}-^{63}\text{Mn}$ Urca pair on the neutron star surface has been evaluated based on the state-of-the-art shell model calculations which reproduced the experimental spectroscopy results in the neutron-rich $N \sim 40$ region. It is concluded that $^{63}\text{Fe}-^{63}\text{Mn}$ could be among the strongest Urca pairs in the neutron star crust. This pair has been identified as the primary contributor to the cooling of neutron stars after type-I X-ray bursts, as demonstrated by crust cooling models. When considering this pair, carbon ignition is expected to occur at a deeper shell, potentially facilitating superburst ignition with X-ray burst residues. Consideration of $^{63}\text{Fe}-^{63}\text{Mn}$ also improves the constraints that can be made on past surface nuclear burning on accreting neutron stars with observed quiescent cooling light curves.

0909PM-19: **2024-09-09 17:30**

Data analysis of the $^{26}\mathrm{Si}(\alpha, \mathrm{p})^{29}\mathrm{P}$ reaction for the nucleosynthesis in the X-ray bursts

Kodai Okawa

The αp-process, consisting of a series of (α, p) and (p, γ) reactions, plays an important role in nucleosynthesis during X-ray bursts. Among these reactions, the $^{26}\mathrm{Si}(\alpha, \mathrm{p})^{29}\mathrm{P}$ reaction is particularly significant due to its substantial impact on the light curve of X-ray bursts. Despite its importance, experimental data for this reaction remain insufficient due to technical reasons.

In this study, we performed a direct measurement of the $^{26}\mathrm{Si}(\alpha, \mathrm{p})^{29}\mathrm{P}$ reaction at the CNS RI beam separator (CRIB). We measured the reaction at energies corresponding to the high-temperature environment around $T = 3$ GK using the ^{4}He thick gas target method.

Despite numerous background events, we determined the reaction cross section, which was approximately an order of magnitude lower than the value of the NON-SMOKER statistical model.

This research represents the first experimental determination of this reaction cross section through direct measurement. Consequently, our results will provide valuable insights for estimating the reaction rate in the high-energy region and for refining the X-ray burst light curve model.

0909PM-20: **2024-09-09 17:31**

Sensitivity study on the final abundance pattern of the r-process due to fission barrier uncertainties

Bowen Jiang

The role of nuclear fission in the r-process nucleosynthesis occurring in neutron star mergers is studied. Current theoretical nuclear physics models([1][2][3]) are based on different assumptions on the fission barrier for different fission channels (spontaneous fission, neutron-induced fission, β-delayed fission, etc). In this work, the nuclear reaction network calculation based on a consistent description for different fission channels is provided. It is shown that the neutron-induced fission channel is the dominant fission channel to influence the final abundance pattern.

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0909PM-21: **2024-09-09 17:32**

In situ measurement method of positron annihilation in nuclear astrophysical experiments

Shen Lin

In thermonuclear reactions of nuclear astrophysical interest, some can produce short-lived products that emit positrons. These positrons will annihilate with electrons in the target and then produce a pair of 511 keV γ-rays, which can be used to determine the reaction yield and calculate the cross-section as well as the astrophysical S-factor. We leverage the back-to-back characteristic of 511 keV γ-ray pairs, utilizing the opposite units of the autonomously developed large modular BGO detector array LAMBDA-II for spatial coincidence measurements of positron radioactive products. The array currently supports two spatial coincidence modes: the first mode employs the front eight and rear eight modules of the inner layer for positron annihilation coincidence measurements, while the second mode uses the eight detectors directly facing the target in the inner layer, divided into four groups in symmetrical directions, for positron annihilation coincidence measurements. In both modes, the 32 modules in the outer layer serve as anti-coincidence detectors to suppress environmental background. The first mode boasts high detection efficiency, while the second mode offers a superior signal-to-background ratio. The detection efficiency of the LAMBDA-II array for $*$in situβ^+ decay of reaction products aligns with Monte Carlo simulation results. The in situ measurement of the 259 keV resonance yield from the $^{14}N(p,\gamma)^{15}O$ reaction matches the prompt γ-ray measurement, thoroughly validating the reliability of this method.

0909PM-22: **2024-09-09 17:33**

Direct measurement of the ^{15}N$(p,\gamma)^{16}$O cross sections at low energy

Lin Wang

The CNO cycle is the primary energy production mechanism in massive stars, with the $^{15}\mathrm{N(p,\gamma)}^{16}\mathrm{O}$ reaction serving as a crucial branching point connecting the CN and NO cycles. The ratio of reaction rates between $^{15}\mathrm{N(p,\gamma)}^{16}\mathrm{O}$ and $^{15}\mathrm{N(p,\alpha)}^{12}\mathrm{C}$ directly determines the nitrogen and oxygen abundances within the CNO cycle, which in turn affect stellar evolution and nucleosynthesis. However, there is significant discrepancy in the existing low-energy experimental data for the $^{15}\mathrm{N(p,\gamma)}^{16}\mathrm{O}$ reaction cross-section. This work remeasured the $^{15}\mathrm{N(p,\gamma)}^{16}\mathrm{O}$ reaction using the 350 keV accelerator at INEST (the Institute of Nuclear Energy Safety Technology), in the energy range $E_p = 110 - 260$ keV. We used the FCVA (Filter Cathodic Vacuum Arc) technology to enrich $\mathrm{Ti}^{15}\mathrm{N}$ targets and measured the target thickness by scanning the resonance of $^{15}\mathrm{N(p,\alpha\gamma)}^{12}\mathrm{C}$ at $E_{cm} = 842$ keV. The 4π-BGO detector array can effectively absorb nearly all the γ-rays produced by the reaction. The detector is shielded and counter-coincident on the outside, which significantly reduces the measurement background. We used γ-ray summing detection techniques and Bayesian analysis method to fit the single spectra and summing spectra, yielding the γ-ray transition branching ratios and the detection efficiency of the summing peak, and further calculated the S-factor. Currently, R-matrix analysis of the $^{15}\mathrm{N(p,\gamma)}^{16}\mathrm{O}$ data is in progress. In the future, we will conduct low-energy measurements of the $^{15}\mathrm{N(p,\alpha)}^{12}\mathrm{C}$ direct reaction and calculate the impact of the ratio of these reaction rates on the abundances of nitrogen and oxygen in the CNO cycle. Click here for poster details

0909PM-23: **2024-09-09 17:34**

Research on deuterium-deuterium reaction in laser-driven plasma environment below 100 keV

Xiaofeng Xi

0909PM-24: **2024-09-09 17:35**

Studying Subthreshold Resonance Using the Trojan Horse Method

Xuejian Wang

0909PM-25: **2024-09-09 17:36**

Measurement of ^{12}C neutron inelastic scattering cross section using MAIKo+ active target Time Projection Chamber

YIFAN LIN

0909PM-26: **2024-09-09 17:37**

The origin of extremely metal-poor star with weak r-process signature

Hiroko Okada

0909PM-27: **2024-09-09 17:38**

Revised reaction rate for the astrophysical reaction $^{18}O(p, \alpha)^{15}N$ via a global R-matrix analysis

Yiyang Li

0909PM-28: **2024-09-09 17:39**

Nuclear mass predictions with machine-learning and impacts on r-process

Xin-Hui Wu

0909PM-29: **2024-09-09 17:40**

The study of single-particle strength quenching effect and nuclear astrophysical ^{14}C(n, γ)^{15}C reaction using single-neutron-removal transfer reactions of ^{15}C

Yuchen Jiang

Single-particle motion of nucleons is quenched by so-called short-range and long-range correlations, which was first observed on some stable nuclei through $(e, e'p)$ and $(d, {}^3\text{He})$ transfer reactions. Systematic studies of Heavy-Ion (HI) induced single-nucleon knockout at intermediate-energy have drawn a surprising conclusion that the quenching factor R_s, simply defined as the ratio of experimental cross-section and theoretical counterpart, exhibits a strong negative dependence on the Fermi surface asymmetry ΔS. Interestingly, in proton induced knockout and transfer framework, no such dependence has been found so far. However, there is only scarce data of transfer reactions on extremely weakly bound nuclei with $\Delta S \leq -15\,\text{MeV}$, where HI induced knockout shows great discrepancy with current transfer reaction trend, so testing the quenching effect in such extreme ΔS region with different probes is crucial for understanding this longstanding issue. In this work, we analyzed the quenching factor of ^{15}C valence neutron using single-neutron-removal transfer reactions. A bridge between nuclear structure and nuclear astrophysics was constructed through this effect and radiative capture theory.

0909PM-30: **2024-09-09 17:41**

Studying the $^{12}C+^{12}C$ fusion reaction at astrophysical energies using HOPG target

Shuo WANG

Carbon fusion reaction is one of the primary reactions in massive stars. It also serves as the ignition reaction for Type Ia supernova explosions and X-ray superbursts. Accurate carbon-carbon fusion reaction rate can reduce uncertainties in massive stars and the ignition condition in Type Ia supernova. It also can resolve the ignition problem in superbursts. However, the carbon-carbon fusion reaction in stars occurs at energies below 3 MeV at center-of-mass frame, far below the Coulomb barrier at 5.8 MeV, resulting in an extremely low fusion cross-section. This is a big challenge to measure directly in experiments. Meanwhile, the extremely low cross-section also causes influence by the background. And the complex exit channels is another difficulty to determine the cross-section.

Given these difficulties, our experiment was performed at the LEAF (Low Energy high-intensity high-charge-state ion Accelerator Facility) of the Institute of Modern Physics, Lanzhou. LEAF provided a $^{12}C^{2+}$ beam intensity of up to 174 euA on target, making it the most intense ^{12}C beam for $^{12}C+^{12}C$ reaction studies.

We have developed a $\Delta E - E$ detector telescope system composed of a Time Projection Chamber (TPC) and Si array, which enables effective background subtraction and particle identification. By adjusting the voltage applied on TPC and the working gas, detection of both alpha particles and protons can be conducted within the same experimental setup.

We have measured the $^{12}C(^{12}C,\alpha)^{20}Ne$ reaction at $E_{cm} = 2.22$ MeV using HOPG target. The total accumulated charge was $3.26 \times 10^6\ \mu C$. The left picture is the original spectrum and the right is after tracking using our detection system. From the energy spectrum, it can be observed that HOPG is indeed a target with extremely low background, making it highly suitable for carbon-carbon fusion experiment measurements. However, during the experimental measurements, we encountered problems with HOPG. We find the yield of α and proton are reduced significantly under intense beam bombardment due to radiation damage of the HOPG. We can correct for the yield loss due to the radiation damage with HOPG.

0909PM-31: **2024-09-09 17:42**

R-matrix analysis for the neutron source reaction $^{13}C(\alpha,n)^{16}O$

Taoyu Jiao

The $^{13}C(\alpha,n)^{16}O$ reaction is the main neutron source for the slow-neutron-capture (s-) process in Asymptotic Giant Branch stars and for the intermediate (i-) process. Direct measurements at astrophysical energies in above-ground laboratories are hindered by the extremely small cross sections and vast cosmic-ray induced background. We performed the first consistent direct measurement in the range of $E_{c.m.} = 0.24\,\text{MeV}$ to $1.9\,\text{MeV}$ using the accelerators at the China JinPing underground Laboratory (CJPL) and Sichuan University. Our measurement covers almost the entire i-process Gamow window in which the large uncertainty of the previous experiments has been reduced from 60 % down to 15 %, and provides a more reliable reaction rate for the studies of the s- and i-processes.

A recent discovery from Notre Dame University (NDU) claims that our measurements above ground and underground have a different trend and they treat each measurement with different normalization factors. Thus, another experiment is performed at SCU and confirms that our measurement above ground and underground is consistent. With the newly performed experiment and differential cross section measurement performed by NDU, another R-matrix analysis is required for better extrapolation. In my poster, I will show the recent progress of R-matrix fitting.

0909PM-32: **2024-09-09 17:43**

Development of the pulsing beam technique to suppress the natural background in China JinPing underground Laboratory

Yihua Fan

The slow neutron capture process (s-process) and the intermediate process (i-process) play important roles in the nucleosynthesis of heavy elements from iron to uranium. As the dominant neutron source for the s- and i-processes, the reaction cross section of $^{13}C(\alpha,n)^{16}O$ reaction in the Gamow window ($E_{c.m.}$ = 140 keV to 500 keV) is critical. Limited by cosmic-ray and natural backgrounds, direct measurement of the extremely low reaction cross section in the Gamow window is very challenging.

The Jinping Underground Laboratory Nuclear Astrophysics (JUNA) team measured the $^{13}C(\alpha,n)^{16}O$ reaction cross section directly in the Gamow window with a high-current accelerator in the China Jinping Underground Laboratory (CJPL).

While nearly all the cosmic-ray background is shielded in CJPL, radiations from uranium and thorium in the rocks of CJPL limit the detection sensibility. In this thesis, we introduce a method of background suppression technique by using the pulsed beam in CJPL. This method can increase the ratio of signal to background, suppress the influences of natural radiation in CJPL, improve the detection sensibility. It provides a new experimental technique for the future challenges of measuring the even reaction lower cross section.

0909PM-33: **2024-09-09 17:44**

Direct measurement of the $^{12}C(^{12}C,\alpha_0)^{20}Ne$ cross section at stellar energies

Yunzhen Li

The direct measurement of the carbon-carbon fusion reaction cross-section has been conducted at LEAF facility at IMP. In the field of nuclear astrophysics, the carbon-carbon fusion reaction plays a crucial role in the evolution of massive stars and impacts the ignition conditions of Type Ia supernova explosions and superbursts. After decades of research, there remains considerable uncertainty in the reaction cross-section within the stellar energy range. Direct measurement experiments are limited by extremely low reaction cross-sections and background noise. Therefore, new techniques need to be advanced.

LEAF accelerator can provide the highest carbon beam intensity achieved for the known carbon-carbon fusion reaction. For background suppression, we have developed the detection systerm and high-purity carbon targets, reducing impurity background and improving statistics.

The thick-target yield data for the α_0 reaction channel has been obtained. Several resonances within this energy range were observed. We calculated the angular distribution using Legendre polynomial coefficients provided by Becker and found good agreement with our fit above 3.2 MeV. In the fit of the angular distribution below 3.2 MeV, a 4+ component was deemed.

0909PM-34: **2024-09-09 17:45**

Development of enriched ^{12}C CVD diamond targets for astrophysical $^{12}C(\alpha,\gamma)^{16}O$ reaction measurements

Jingyu Dong

The $^{12}C(\alpha,\gamma)^{16}O$ reaction is a pivotal process in nuclear astrophysics. Due to its extremely low cross section (approximately 10×10^{-17} barn) within the Gamow window, directly measuring this reaction is highly challenging. An irradiation-resistant ^{12}C-enriched target is a key technique for the direct measurement of the $^{12}C(\alpha,\gamma)^{16}O$ reaction. In this work, we developed a ^{12}C-enriched diamond target on Mo substrates using the chemical vapor deposition (CVD) method. The target demonstrates excellent stability under bombardment with a high-intensity proton beam. A 1.5 % deterioration in ^{12}C thickness was observed after bombardment by a 270 keV, 2 mA proton beam with a charge of 125 C, indicating a significant improvement over typical carbon targets. The $^{13}C/^{12}C$ ratio in the target was determined to be $(1.1 \pm 0.3) \times 10 \times 10^{-4}$, indicating no contamination was introduced during the CVD process. A method for determining the hydrogen content in coatings based on nuclear reactions is presented. The upper limit of the hydrogen content in the diamond ^{12}C-enriched target was found to be 0.075 %. The irradiation-resistance capacity and isotopic purity of the target meet the requirement for direct measurement.

0909PM-35: **2024-09-09 17:46**

Influence of Neutrino-Nuclear Reactions on the Abundance of ^{74}Se

Na Song

The p-nuclei are supposed to be produced in different astrophysical processes, such as rapid-proton capture, photonuclear reaction, and neutrino-induced reaction. To date, their abundance cannot be reasonably explained. In the present work, the cross sections of the ^{74}Ge(ν_e, e-)^{74}As reaction are calculated with the theoretical and experimental B(GT) values, respectively. The abundance ratios between ^{74}Se and ^{74}Ge produced from the neutrino process (ν-process) are estimated based on the simple hypothesis for core-collapse supernova explosions. The results show that the upper limit of the ^{74}Se and ^{74}Ge abundance ratio resulting from the ν-process is about 36 % of the value in the solar system.

0909PM-36: **2024-09-09 17:47**

Electron screening potential calculated by a new theoretical model

Jiayinghao Li

0909PM-37: **2024-09-09 17:48**

Study of the Structural Properties of Atomic Nuclei and Neutron Stars Using Elastic Scattering Angular Distributions

Zhicheng Zhang

0909PM-38: **2024-09-09 17:49**

Average lifetime of nuclei in stellar and effects on the abundance of elements

Dong Chao

In the astrophysical environment, a large number of high-energy photons will excite the nucleon, together with γ-decay to establish a balance of abundance between the various levels of nucleus. Under the combined action of the excited states and the ground state, the effective decay rate of the nucleon in the astrophysical environment may be quite different from the laboratory. The effective half-life of ^{205}Pb under different temperature and different electron densities is calculated. It is concluded that the effective half-life of ^{205}Pb in the s-process will be reduced from 17.0(9) My in the laboratory to about 100 y due to the influence of the astrophysical environment, leading to a significant decrease in the yield of ^{205}Pb during the s-process, resulting in the abundance ratio of ^{205}Pb to 204Pb in the early solar system was reduced by about 100 times.

0909PM-39: **2024-09-09 17:50**

New Maxwell distribution neutron source

Jianglin Hou

0909PM-40: **2024-09-09 17:51**

Impact parameter in single proton transfer reaction $^{56,58}Fe(^{18}O, ^{17}N)^{57,59}Co$

Runlong Liu

Impact parameter is crucial in analyzing heavy ion nuclear reactions. As the residual effect of strong interaction force, the magnitude of nuclear force can be ignored in the case of high energy, but it is not suitable for low energy. For low energy, scattering angles in center of mass coordinate can be used to deduce a general impact parameter with a classical mechanics formula. The feature of transfer reaction that single peak appears at the grazing angle, deduced a vague impact parameter of single proton transfer reaction.

0909PM-41: **2024-09-09 17:52**

Half-Life Measurement of ^{146}Eu

Changxin Guo

0909PM-42: **2024-09-09 17:53**

Fabrication of ^{17}O isotope reaction targets

Tao Tian

0909PM-43: **2024-09-09 17:54**

Synthesis of Sc, Ti, and V in Core-Collapse Supernovae toward Constraining the Explosion Mechanism

Ryota Hatami

A core-collapse supernova (CCSN) is an explosive phenomenon that occurs at the end of the life of a massive star and drives the chemical evolution of the Universe by providing metals. However, the explosion mechanism has not yet been fully understood. In this study, we utilize nucleosynthesis to investigate the explosion mechanism. Metal-poor stars are low-mass stars formed in the early Universe. Their chemical abundances reflect the result of explosive nucleosynthesis in the CCSN of first stars. Recently observations of metal-poor stars identify correlations among Sc, Ti, and V. The abundances of Sc, Ti, and V in metal-poor stars, however, have not been reproduced by CCSN nucleosynthesis based on the results of hydrodynamical simulation. This can be a clue to constrain the explosion mechanism. Therefore, (1) we perform nucleosynthesis simulations with arbitrary temperature, density, and neutrino flux to find physical conditions reproducing the chemical abundance of metal-poor stars, and (2) we conduct two-dimensional neutrino-hydrodynamical simulation to examine whether the physical conditions are realized in the CCSN explosions. As a result, we identify the conditions on temperature and neutrino flux but find that these conditions are not realized simultaneously in 2D simulations. In this presentation, we introduce the results of (1) and (2) and discuss how the required conditions are satisfied in the CCSN explosions.

0909PM-44: **2024-09-09 17:55**

Stepped-up development of AMS for the detection of ^{60}Fe with the HI-13 tandem accelerator

Zhang Yang

The Moon provides a unique environment for investigations of nearby astrophysical events such as supernovae. Lunar samples retain valuable information provided by these nearby astrophysical events, via detectable long-lived “fingerprint” radionuclides such as ^{60}Fe.

In this work, we stepped up the development of an accelerator mass spectrometry (AMS) method for detecting ^{60}Fe using the HI-13 tandem accelerator at the China Institute of Atomic Energy. Since interferences could not be sufficiently removed with the existing magnetic systems of the tandem accelerator and the following Q3D magnetic spectrograph, a Wien filter with a maximum voltage of $\pm 60\,\mathrm{kV}$ and a maximum magnetic field of $0.3\,\mathrm{T}$ was installed after the accelerator magnetic systems to lower the detection background for the low abundance nuclide ^{60}Fe. A 1 µm thick Si_3N_4 foil was installed in front of the Q3D as an energy degrader. For particle detection, a multi-anode gas ionization chamber was mounted at the center of the focal plane of the spectrograph. Finally, an ^{60}Fe sample with an abundance of 1.125×10^{-10} was used to test the new AMS system. The results indicate that ^{60}Fe was clearly distinguished from the isobar ^{60}Ni. The sensitivity was evaluated to be better than 4.3×10^{-14} based on the 5.8 hours blank sample measurements, and the sensitivity could in principle be expected to be about 2.5×10^{-15} when the data are accumulated for 100 hours which is feasible for future lunar sample measurements because the main contaminants were sufficiently separated.

0909PM-45: **2024-09-09 17:56**

A conceptual design of neutron detector for the (α, n) cross section measurement

Yongce GONG

Conference Day 3: 2024-09-10

0910AM-1: **2024-09-10 09:00**

The $^{13}C(\alpha, n)^{16}O$ reaction rate

Richard deBoer

Neutron production for the slow neutron capture process (s-process) is dominated by (α, n) reactions on light nuclei during stellar helium burning. The two most prominent are $^{13}C(\alpha, n)^{16}O$ and $^{22}Ne(\alpha, n)^{25}Mg$. New measurements of the angle integrated cross section have recently been reported by both the LUNA and JUNA underground facilities, reaching to unprecedentedly low energies and giving further constraints on the low-energy energy-dependence. However, even though these measurements have begun to reach down into the Gamow window, the cross section must still be extrapolated to lower energies to cover the full range of interest. Since these extrapolations are made using phenomenological R-matrix and the cross section is the result of broad underlying resonances, differential cross section measurements, even made at higher energies can likewise provide constraint on the extrapolated S-factor. Therefore, using the novel technique of deuterated liquid scintillators and spectrum unfolding, we have utilized the well-characterized ODeSA array to make differential cross section measurements that extend from laboratory α-particle energies of 0.8 MeV to 6.5 MeV in approximately 10 keV energy steps at 18 angles between 0° and 160°, resulting in over 700 distinct angular distributions. These measurements extend both to lower energies and have significantly greater energy coverage than any previous measurements. We have used these differential data to augment the previous state-of-the-art R-matrix fit of the low energy $^{13}C(\alpha, n)^{16}O$ reaction developed for the ENDF/B evaluations and have used Bayesian uncertainty estimation to demonstrate that this differential data can decrease the uncertainty by up to a factor of two, from approximately 10 % to 5 %, over the energy region of astrophysical interest. Further plans for a new cross section evaluation will also be discussed.

0910AM-2: **2024-09-10 09:25**

The Role of Carbon-Oxygen Shell Interactions in the Nucleosynthesis and Final Fate of Massive Stars

Lorenzo Roberti

Carbon-oxygen (C-O) shell interactions in the late evolutionary stages of massive stars play a crucial role in determining their final fate and have a significant impact on the pre-supernova and explosive nucleosynthesis. In this talk, I will explore the complex dynamics within C-O shells, and how these interactions drive the production of intermediate and heavy elements. Recent advancements in theoretical models and observational data provide new insights into how C-O shell interactions influence the synthesis of elements, shaping the chemical evolution of the star and the broader universe.

0910AM-3: **2024-09-10 09:50**

Dynamics and nucleosynthesis of neutron star mergers and collapsars

Sho Fujibayashi

The merger of two neutron stars and the collapses of rotating massive stars can form a system composed of a central object (either a neutron star or black hole) and a centrifugally supported disk. Inside the disk, a turbulent state is generated by magnetorotational instability and then induces an effective viscosity. The viscous angular momentum transport and heating can evolve the system and trigger mass ejection from the disk. In the case of the merger, the post-merger mass ejection contributes to the total ejecta in addition to the violent merger phase and to shaping the abundance pattern of heavy nuclei produced via the r-process. In the case of the collapsar, the disk outflow can contribute to the explosion of the collapsed star with a higher energy than the normal supernova. It can also provide a significant amount of radioactive nickel, which would power the luminosity of the supernova. In this talk, I will present the results of my numerical simulations of such systems and their implications.

0910AM-4: **2024-09-10 10:15**

Neutrino and Heavy-element Nucleosynthesis in Supernovae

Xilu Wang

Neutrinos can play an important role in the synthesis of nuclides in high energy astrophysical processes involving compact objects, such as core-collapse supernovae or binary neutron star mergers, where neutrinos can experience collective flavor oscillations driven by neutrino-neutrino interactions. Here, we seek to explore the possible influences of neutrino interactions on the heavy-element nucleosynthesis including νp-process and r-process in supernova environments with different astrophysical conditions and neutrino inputs. We find that the potential impact is particularly strong in high-entropy, proton-rich conditions, where neutrino interactions can nudge an initial νp process neutron rich, introducing a new neutrino-induced neutron capture process "νi process".

0910AM-5: **2024-09-10 11:00**

Studying astrophysical reactions with low-energy RI beams - the projects at CRIB

Hidetoshi Yamaguchi

The radioactive isotopes (RI) seldom exist on the earth, but they can be created in the universe and often play an important role in explosive stellar sites, contributing to the nucleosynthesis, stellar evolution and thermal dynamics.

Several experimental projects at CRIB [1-3], a low-energy RI beam separator operated by Center for Nuclear Study, the University of Tokyo and located at RIBF of RIKEN Nishina Center, are discussed as the examples of the low-energy RI beam creation and RI-involved astrophysical reaction study. Recent experiments, including a resonant scattering measurement with TTIK for the ^{22}Mg(α, p) reaction relevant in X-ray bursts [4], the study on ^{7}Be destruction reaction in the Big-Bang Nucleosynthesis with the THM [5], and the latest study on the (α, p) reactions in stellar environments are introduced and discussed.

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0910AM-6: **2024-09-10 11:25**

Measurement of the γ Decay Probability of the Hoyle State

Kosuke Sakanashi

The triple alpha (3α) reaction is one of the most important processes in nucleosynthesis. In this reaction, an α particle is captured by the 2α resonance of ^{8}Be, and forms a 3α cluster state with weakly bound α particles. Most of the 3α resonance states decay to three α particles, but a tiny fraction of them decays to the ground state in ^{12}C via radiative processes of γ decay or $e^{+}e^{-}$-pair emission. Therefore, the γ-decay probability is an important parameter that directly determines the amount of ^{12}C produced in nucleosynthesis. Many γ decay probability measurements were performed by 1976 and radiative-decay probability $\Gamma_{\rm rad}/\Gamma = 4.16(10) \times 10^{-4}$ [1] from the Hoyle state has been widely accepted.

Recently, a striking result of the γ decay probability of the Hoyle state was reported from a measurement of two γ rays from the cascade decay of the Hoyle state. The new value of $\Gamma_{\rm rad}/\Gamma = 6.2(6) \times 10^{-4}$ [2] is 50% higher than the recommended value in Ref.[1]. Most of the old data were taken by measuring ^{12}C nuclei surviving after the Hoyle state decayed. The authors of Ref.[2] claimed that such measurement might not be appropriate and the discrepancy between the new and old results should be due to the different experimental methods. In order to solve this puzzle, it is necessary to measure surviving ^{12}C nuclei and γ rays at the same time.

In this study, the experiment was performed at the tandem accelerator facility of IFIN-HH in Romania. We populated Hoyle state in ^{12}C by the $\alpha + {}^{12}$C scattering using an α particle beam at $E_{\rm beam} = 25\,\mathrm{MeV}$, and emitted charged particles are detected by a DSSD and γ rays by the ROSPHERE $\mathrm{LaBr_3}$ detector array [3]. In this talk, we will report the experimental details and results of the γ decay probability measurements.

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0910AM-7: **2024-09-10 13:30**

Impact of precise nuclear input for stellar evolution

Alexander Heger

0910AM-8: **2024-09-10 13:55**

Binary Star Evolution

Hongwei Ge

Binary stars lie at the heart of many vital astrophysical phenomena, and several types of explosive cosmic events are produced by binary objects, such as double black holes, double neutron stars, double white dwarfs, type Ia supernovae, and X-ray binaries. Despite the importance of binary evolution, there are still two long-standing unsolved fundamental questions: mass transfer stability and common envelope evolution. We briefly introduce binary star evolution, binary population synthesis fields, and recent progress in mass transfer physics. Finally, we introduce applications in related objects, such as high-mass X-ray binaries, hot subdwarf binaries, and important gravitational wave sources (double white dwarfs and double black holes).

0910AM-9: **2024-09-10 14:20**

Measurements of stellar neutron source reactions at JUNA

Bingshui Gao

0910AM-10: **2024-09-10 14:35**

The Effect of Reaction Rate on the Pre-supernovae Core Structure and Nucleosynthesis

Wenyu Xin

The gravitational wave signal GW190521 detected by LIGO/Virgo seems to originate from a binary black hole merger event, with a 99.0% probability that at least one of the black holes falls into the black hole mass gap caused by pair-instability supernova. This conclusion challenges stellar evolution theory and has motivated many attempts to examine the effects of uncertainties involved in stellar evolution. In this talk, we mainly focused on how the $^{12}C(\alpha, \gamma)^{16}O$ reaction rate affects the core structure of progenitors and nucleosynthesis. We will elaborate on the mechanism of this reaction rate's influence on the evolution of massive stars and propose a new criterion for predicting the final fate of core-collapse supernova explosions. Additionally, we also discuss the impact of this reaction rate on the evolution and nucleosynthesis of pair-instability supernovae, predicting the theoretical abundance of various elements after the explosion of first-generation pair-instability supernovae. Comparing the predicted theoretical abundance with the observed abundance of extremely metal-poor stars helps in identifying the chemical imprints left behind by first-generation supermassive stars after their explosions.

0910AM-11: **2024-09-10 14:50**

Transfer reaction measurements using proton beams for astrophysical reaction rates and proton branching ratios

Kyungyuk Chae

Transfer reaction measurements in normal kinematics using light stable beams are very powerful tools to study the properties of single-particle states of unstable nuclei important for astrophysical phenomena. The measurements are also useful to extract the proton branching ratios of populated excited states of unstable nuclei. In the presentation, we will summarize the results of proton branching ratio analysis for radionuclide ^{22}Mg which were populated through a previous $^{24}\mathrm{Mg(p,t)}^{22}\mathrm{Mg}$ reaction measurement. The measured branching ratios provide constrains on the proton partial widths, which have implications for X-ray burst nucleosynthesis. Details of the data analysis and our future plan for the $^{40}\mathrm{Ca(p,t)}^{38}\mathrm{Ca}$ reaction will be presented.

0910AM-12: **2024-09-10 15:15**

Role of neutron-rich nuclei in r-process nucleosynthesis

Shunji Nishimura

Where and how were heavy elements which contain many neutrons relative to proton, synthesized? With regards to the origin of these heavy elements, a reaction in which nuclei capture neutrons in a fast and continuous manner during the explosion of a star was proposed and named the rapid neutron capture process (r process) [1].

In 2017, a binary neutron star merger event was discovered by simultaneous observations of gravitational and electromagnetic waves, and its kilonova was also identified, suggesting the synthesis of heavy elements. Were heavy elements such as gold, platinum, and even uranium synthesized in binary neutron star mergers, supernova explosions, or collapsars [2-4]? Analysis of the unique heavy-element compositions left behind in the solar system, meteorites, and old metal-poor stars has begun. The key to deciphering the traces left behind by isotopic elements lies in the thousands of neutron-rich nuclei that disappeared in an instant.

Here, we introduce the experimental research on the explosive r-process nucleosynthesis and future perspective at RIBF [5,6].

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0910AM-13: **2024-09-10 15:40**

Study of ^{22,23}Na + p resonance scattering via thick-target inverse kinematics method

Youbao Wang

^{22,23}Na + p resonance scattering were studied via thick-target inverse kinematics method, for the exit-channel resonance parameters of compound nuclei ^{23,24}Mg. High-purity ^{22}Na secondary beam was produced by ^{1}H(^{22}Ne, ^{22}Na)n reaction at RIBLL1, excitation functions of ^{22}Na(p, p) were obtained at two angles up to 4 MeV. The deduced ^{23}Mg resonances were used for the evaluation of the reaction rates of the ^{19}Ne(α, p)^{22}Na reaction. In the case of ^{23}Na + p, the proton and alpha decay partial width of compound nucleus ^{24}Mg were deduced and applied for the astrophysical S-factor of the ^{12}C + ^{12}C fusion reaction.

0910AM-14: **2024-09-10 16:15**

Studies of nuclear properties involved in nucleosynthesis at CENS

Sunghoon (Tony) Ahn

0910AM-15: **2024-09-10 16:40**

Non destructive lifetime measurement of isomeric states in heavy ion storage rings

Shahab Sanjari

Storage rings provide a unique experimental environment for non-destructive measurements of the mass and lifetime of unstable nuclei and/or their isomeric states. With their high resolution, cavity based Schottky detectors provide the speed and sensitivity required for such measurements. In order to increase the measurement accuracy, the velocity spread of the particles has to be dealt with. In the past, the electron cooler was used for this purpose. However, since the cooling time is in the order of seconds, efforts have been made to perform mass and lifetime measurements of shorter lived states by tuning the lattice of the storage ring to the isochronous ion-optical mode. In this work, we describe the successful application of this combined method of Isochronous Schottky Mass (and lifetime) Spectroscopy (ISMS) for the recent measurement of the 2 photon decay of 72m-Ge. The experimental setup, used detectors and applied methods are described and future perspectives are discussed.

0910AM-16: **2024-09-10 17:05**

Bρ-defined isochronous mass spectrometry at CSRe-Lanzhou

Meng Wang

Accurate nuclear masses not only provide indispensable information on nuclear structure, but also deliver important input data for applications in nuclear astrophysics. The challenge today is to obtain accurate masses of nuclei located far away from the valley of stability. Recently, we have developed a brand new technique, the Bρ-defined isochronous mass spectrometry (IMS), at the cooler storage ring CSRe in Lanzhou [1,2]. Using the simultaneously determined revolution times and velocities of the stored ions, the relation between ions' magnetic rigidities and orbit lengths is established, allowing to determine the magnetic rigidity of any stored ion according to its orbit length. Consequently, m/q values of the unknown-mass nuclides are determined. High mass resolving power has been achieved covering a large m/q-range over the full Bρ-acceptance of the storage ring, starting a new era of the IMS. By using the Bρ-defined IMS, the masses of ^{70}Kr, ^{66}Se, ^{64}As, ^{62}Ge were measured for the first time and the mass precision was improved for some other nuclides. The new mass results were used to study relevant problems in nuclear structure and astrophysics [3,4].

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0910AM-17: **2024-09-10 17:30**

Construction of active target TPC in CENS

Soomi Cha

Active Target Time Projection Chamber (AT-TPC) is one of advanced particle detectors which allows a precise measurement of nuclear reactions using rare isotope beams at the present and future nuclear physics facilities. A new Active Target TPC for Multiple nuclear physics eXperiments (AToM-X) is being developed at the Center for Exotic Nuclear Studies (CENS). It consists of a highly segmented Time Projection Chamber (TPC) using a Micromegas, a field cage, and solid state detectors. It enables the high resolution measurement of the 3-dimensioinal particle tracks, energy, and position with the high detection efficiency. Details of the development status and the future plans will be presented.

0910AM-18: **2024-09-10 17:45**

Indirect measurement in CIAE

Bing Guo

Conference Day 4: 2024-09-11

0911AM-1: **2024-09-11 09:00**

Effect of coherent neutrino elastic scattering off many atoms to core-collapse supernova explosions

Tatsushi Shima

It has been a long-standing problem that the available kinetic energy is insufficient in the theoretical simulation of the core-collapse supernova explosions. In this work, the energy transfer via the coherent scattering of neutrinos with matter in outgoing shockwave is studied by numerical evaluation for the expected energy transfer. It was found that the process can be a candidate of a new source of the additional kinetic energy to the exploding matter.

0911AM-2: **2024-09-11 09:25**

"Other" Indirect Methods in Nuclear Astrophysics

Livius Trache

It is an widely accepted and used idea that when we cannot make direct measurements for nuclear reactions that are important in nuclear astrophysics due to very small cross sections and/or for impossible/difficult projectile combinations, we resort to indirect methods. There many Indirect Methods in Nuclear astrophysics, some well known. I will discuss here two less known ones: fusion of light ions at sub-coulomb energies and the nuclear breakup of unstable projectiles at intermediate energies.

0911AM-3: **2024-09-11 09:50**

Experimental studies of key resonances for explosive hydrogen and helium burning

Christopher Wrede

An experimental program to address uncertainties in the thermonuclear rates of proton and alpha induced reactions with the greatest influence on the modeling of astronomical observables from transient events including classical novae and X-ray bursts will be described. The goal is to discover and characterize key resonances in reactions on unstable reactants by measuring their energies and strengths. Resonances are populated using positron and electron-capture decays of nuclides at the proton drip line provided by the Facility for Rare Isotope Beams (FRIB), and their radiations measured using the Gaseous Detector with Germanium Tagging (GADGET) and the new Particle X-ray Coincidence Technique (PXCT) setup. Complementary data is obtained by measuring nuclear reactions with stable beams at TRIUMF and the recently upgraded Doppler Shift Lifetimes (DSL2) setup. Recent results, ongoing work, and plans for the near future will be presented.

0911AM-4: **2024-09-11 10:35**

Measurement of ^{58}Ni(^{3}He,n)^{60}Zn reaction to investigate X-ray burst light curve

Tatsuya Furuno

X-ray burst is frequently observed thermonuclear explosion events in the universe. Understanding its light curve is inevitable to unveil the properties of neutron stars. The shape of the light curve is sensitive to many nuclear reaction rates. It is shown that the ^{59}Cu(p,γ)^{60}Zn and ^{59}Cu(p,α)^{56}Ni reaction rates have the largest influence on the light curve. These reactions proceed via the ^{59}Cu+p resonance states in ^{60}Zn, thus the spin-parity and decay branch ratio of these states should be determined. We measured the ^{58}Ni(^{3}He,n)^{60}Zn reaction and determined spin-parity of three resonance states at $E_x = 6.36 - 7.13$ MeV for the first time. In the present talk, we will show the method, results, and future plan of the experiment.

0911AM-5: **2024-09-11 10:50**

Operation and Experiment Introduction of the CSNS Back-n White Neutron Facility

Ruirui Fan

The Back-n white neutron facility is a comprehensive experimental platform that serves a wide spectrum of research goals, including nuclear data measurement, experiments in nuclear physics and astrophysics, calibration of neutron detectors, investigation of neutron radiation effects, and applications in archaeology, among others. Operational since 2018, this beamline has facilitated over 300 varied experiments involving international collaborations with China, Russia, and the USA, afford more than 30,000 hours of beam time.

In 2023, the Back-n started employing boron nitride (BN) absorber sheets as a substitute for conventional cadmium sheets, thereby significantly reducing the cutoff energy for low-energy neutrons. This strategic enhancement has broadened the beamline's capacity to include accurate measurement of thermal neutron reaction cross-sections. The substantial neutron flux and extensive beam time have been crucial in securing high-quality statistical data in energy regions that were previously unattainable, leading to notable physical discoveries. These advancements are highlighted by the recently published measurements of the 232Th fission cross-section, which illustrate the improved capabilities of the beamline.

Moreover, Back-n's involvement in the NOPTREX international collaboration has facilitated the conduct of advanced polarized neutron physics experiments, leveraging the SEOP neutron polarization apparatus. The use of polarized neutrons in the eV energy range has enabled a series of fundamental physics experiments, including CP violation experiment etc.

The facility has also experienced significant enhancements in its detection technology. Recent developments include the commissioning of leading-edge detection systems such as a BaF2 detector array (GTAF) for capture cross-section measurements, a Multipurpose Time Projection Chamber (MTPC) for the charged particles and fission cross-sections, and a boron-doped Microchannel Plate detector (BMCP) for total cross-section measurements and neutron resonance radiography. These detectors are among the most advanced neutron detection technologies in the world. Their integration into the Back-n beamline is expected to lead to a wave of pioneering scientific results from the white neutron experiments.

0911AM-6: **2024-09-11 11:05**

Electron scattering for online-produced unstable nucleus at the RIKEN SCRIT facility

Toshimi Suda

Electron scattering is the gold standard for probing nuclear structures, consistently playing an essential role in revealing the internal structures of atomic nuclei and in establishing modern pictures of their structures. To date, its application, however, has been strictly limited to stable nuclei (with some exceptions such as 3H), leaving short-lived unstable nuclei unexplored*.

Following nearly two decades of development, we have successfully achieved a groundbreaking milestone: the first electron scattering experiment on an online-produced radioactive isotope at the SCRIT electron-scattering facility of RIKEN RI Beam Factory in Japan**.

The SCRIT facility, designed to explore the internal structures of short-lived exotic nuclei by electron scattering, employs a novel ion-trapping technique, SCRIT (Self-Confining Radioactive Isotope Ion Target) ***. Using only $\sim 10^7$ ions of an exotic nucleus, the SCRIT technique enables us to achieve a luminosity of approximately $10^{27}\,\mathrm{cm}^2/\mathrm{s}$, which is the minimum required for realizing elastic electron scattering for medium-heavy nuclei.

I will present the recent achievements and the current status of the SCRIT facility, and outline many research possibilities awaiting exploration at the SCRIT facility as well.

If time allows, I will also provide an overview of the ongoing low-energy electron scattering project, ULQ2 (Ultra-Low Q2), in Sendai. This project aims to determine precise proton charge radius by low-energy electron scattering covering the lowest-ever momentum transfer, Q2.

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0911AM-7: **2024-09-11 11:20**

Measurement of the ^{159}Tb(n,γ) cross section at the CSNS Back-n facility

SuYaLaTu Zhang

We report the measurement of ^{159}Tb(n,γ) cross sections up to 1 MeV neutron energy with the TOF method at the back streaming white neutron facility of the China Spallation Neutron Source (CSNS), which is the only high intense pulsed spallation reaction neutron source in China at present. The resonance kernels of ^{159}Tb(n,γ) are obtained up to 1.2 keV, and the MACS for the astrophysical interest energy region from kT = 5 $\sim$ 100 keV are calculated. The sensitivity analysis of ^{159}Tb(n,γ)^{160}Tb reaction rate is studied for the stellar evolution and nucleosynthesis of the 2$M_{\odot}$ star model using the MESA code. We believe it will be of interest to both nuclear astrophysics and nuclear technology applications.

0911PM-1: **2024-09-11 13:30**

Direct measurement of the cross section for ^{102}Pd(p,γ)^{103}Ag reaction in the p-process

Fulong Liu

The study of the p-process is of paramount importance in unraveling the origin of heavy elements in the universe. To describe the entire p-nuclei nucleosynthesis process, a comprehensive reaction network involving over ten thousand nuclear reactions is required, and accurate measurements of some key reaction cross sections are essential for determining reaction rates. ^{102}Pd is one of the more than 30 p-nuclei, and the ^{102}Pd(p,γ)^{103}Ag reaction is one of its significant destruction reactions. Experimental studies for the p-nucleus ^{102}Pd indicate that the reaction rate for ^{102}Pd(p,γ)^{103}Ag is significantly higher than HF predictions. There are significant discrepancies in the available data on the ^{102}Pd(p,γ)^{103}Ag reaction cross section in the low-energy regime relevant to nuclear astrophysics. In light of these discrepancies, a direct measurement was carried out to determine the reaction cross section of ^{102}Pd(p,γ)^{103}Ag within the energy range of 1.9-2.8 MeV. The measurement was conducted utilizing the 2*1.7 MV tandem accelerator at China Institute of Atomic Energy (CIAE). The latest cross section data were obtained using offline activation measurement technique based on the low background anti-muon and anti-Compton spectrometer in CIAE.

The latest results have extended the cross section of ^{102}Pd(p,γ)^{103}Ag to the lowest energy range of proton down to 1.9 MeV. The newly measured cross section data provide valuable experimental references for the calculation of statistical models, particularly in the low-energy regime of interest in nuclear astrophysics. These results contribute to a better understanding of the p-process and its implications for the nucleosynthesis of heavy elements in the universe.

0911PM-2: **2024-09-11 13:45**

Study of νp-process nucleosynthesis in core collapse supernovae via ^{56}Ni(d,p) reaction

Jiatai Li

Understanding the origin of elements in our universe is an inevitable mission for modern nuclear physics. It is known that neutron-deficient stable isotopes, referred to as $p-$nuclei, are synthesized through the p-process (or γ-process) triggered by photo-disintegration in supernovae. One of the major issues that remain unresolved is the anomalously large abundances for certain lighter $p-$nuclei in the current astrophysical scenario, such as ^{92,94}Mo and ^{96,98}Ru. A new scenario to account for the production of lighter $p-$nuclei is the neutrino driven rapid-proton capture (νp) process, which is predicted to occur in the core collapse supernovae. While the $\nu p-$process has been well-understood theoretically for the past decade, large uncertainties remain due to the lack of experimental data, especially for the neutron capture rate of the most critical waiting point in the $\nu p-$process: ^{56}Ni, which has a long β decay lifetime of 6 days and thus dominates the abundance of heavier $p-$nuclei. Since direct determination of the reaction cross section of ^{56}Ni$(n,p)^{56}$Co is rather challenging, we have applied the surrogate method instead by measuring the (d,p) reaction.

The experiment was performed at OEDO-SHARAQ beamline at RIBF, RIKEN. The secondary ^{56}Ni beam was produced by the projectile fragementation of ^{78}Kr beam, purified by BigRIPS separator and energy-degraded by OEDO. Recoiled protons were measured to establish the missing mass spectroscopy. Decay channels were identified by measuring projectile-like nuclei transporting through the high-resolution spectrometer SHARAQ. In this presentation, details of the experimental setup and preliminary results will be presented.

0911PM-3: **2024-09-11 14:00**

Narrow-band metal-poor star surveys with Subaru/Hyper Suprime Cam and Tomo-e Gozen Camera

Nozomu Tominaga

The first metal enrichment in the Universe was made by a supernova explosion of a population III star. Second generation stars were formed from the mixture of the pristine gas and the supernova ejecta. Metal-poor stars were survivors of second-generation stars in the Galactic halo. Their abundance pattern records the metal abundance at their formation and tell us the chemical evolution in the early Universe. Therefore, large programs to survey metal-poor stars are performed and provide metal-poor star candidates and high-resolution spectroscopic follow-ups measure the metallicities and abundances of the metal-poor stars. These intensive observations constrain the chemical evolution and the nature of supernovae in the early Universe. To enhance this study, we are performing narrow-band metal-poor star surveys using Subaru/Hyper Suprime Cam and Tomo-e Gozen Camera. The former is the Zero Enrichment Rare Objects (ZERO) survey currently covering 30deg2 down to g$\sim$12. This increases the statistical significance in studying EMP stars and obtain their properties in the distant volume of the Galaxy to understand star formation at lowest metallicities. The latter aims the discovery of all bright metal-poor stars in the northern hemisphere, for which the high-resolution spectroscopic follow-up is easy. The pilot survey currently covers 5000deg2 down to g$\sim$12. We report the status of these surveys and the future plan.

0911PM-4: **2024-09-11 14:25**

Exploring the Early Galactic Formation through Chemodynamics of Very Metal-poor Stars

Ruizhi Zhang

Very metal-poor (VMP) stars record the signatures of early accreted galaxies, making them essential tools for unraveling the early Galaxy formation. Meanwhile, understanding the origin of VMP stars requires comprehensive studies of their chemical compositions and kinematics, which are currently lacking. We cluster the dynamically tagged groups for 6000 VMP stars and conduct a chemodynamical analysis on 352 of them with uniform detailed chemical abundances derived from the high-resolution spectra. We find stars associated with Gaia-Sausage-Enceladus (GSE), Thamnos, Helmi streams, Sequoia, Wukong/LMS-1, Pontus, and the very metal-poor disk (VMPD). In general, there is little significant difference in the abundance trends for different elements between VMP substructures and non-clustered VMP halo stars. However, several interesting features are found: (i) a subgroup in GSE exhibits a very high fraction of r-process enhanced stars, with four out of five showing [Eu/Fe] $> +1.0$, providing us an opportunity to unveiling the r-process nucleosynthesis in GSE; (ii) the VMPD shows lower Zn abundances than the rest, which indicates that it could be a relic of small stellar systems; (iii) Helmi streams show deficiencies in carbon and light neutron-capture elements, suggesting a potential lack of rotating massive stars; and (iv) the fraction of carbon-enhanced metal-poor stars with no enhancement in heavy elements (CEMP-no stars) seems low in the VMPD and the Helmi streams, which can be used to constrain the properties of their progenitor dwarf galaxies.

0911PM-5: **2024-09-11 14:40**

Uncovering the origin of Galactic ancient accretion relics

Renjing Xie

In the paradigm of hierarchical structure formation, we expect that numerous low-mass galaxies had been accreted to the Milky Way and leave their stellar debris throughout the stellar halo, which can be identified through searching for stellar substructures of similar orbital properties among metal-poor stars. However, only with the help of analyzing the detailed elemental abundances of their members, we are able to confirm the origin of these substructures and study the chemical evolution of their progenitors. Based on the huge LAMOST database, a number of dynamical tagged groups (DTGs) of very metal-poor stars have been identified by Yuan+2020, and high-resolution follow-up observations have been obtained for a number of interesting DTGs. This talk will present the abundance analysis of one new retrograde substructure, which provides valuable information on the origin of the most ancient components in the Galactic halo. Moreover, we have for the first time identified an extremely r-process enhanced (r-II) star in the relics of Gaia-Sausage-Enceladus (GSE), which provides us a great opportunity to compare the r-process pattern in different stellar systems, and may shed some light concerning the astrophysical condition of different site of r-process nucleosynthesis.

0911PM-6: **2024-09-11 14:55**

Origin and evolution of the satellite system of Milky-Way-like galaxies

Guobao Tang

The satellite galaxies of the Milky Way and other galaxies are important probes of the early evolution and nucleosynthesis in the cosmos. As such, an understanding of their formation and evolution is crucial in any study of the origin and evolution of matter. In this regard, there is a decades-old dilemma in our understanding of dwarf-galaxy evolution known as the Disks of Satellites (DoS) problem. In galaxies such as the Milky Way and Andromeda, the DoS problem is the observation that the satellite galaxies align to form a thin and coherent plane. It has been noted in the literature that this observation contrasts with predictions from simulations within ΛCDM cosmology framework, which anticipates a more isotropic distribution of satellite galaxies. This discrepancy raises fundamental questions about galaxy formation dynamics and challenges the standard cosmological model. Recent findings from the SAGA survey complicate this narrative by suggesting that Milky-Way-like DoS systems might not be as rare as previously assumed. In response to this ongoing debate, we have undertaken a study utilizing the high-resolution simulation suites from the IllustrisTNG project. In addition to high mass resolution, this study is distinguished by its comprehensive integration of dark matter and baryonic physics. In our initial survey of 186 Milky-like systems, only two exhibit a thin disk similar to that observed in the Milky Way, and none is rotationally supported. Further, our ongoing time series analysis of satellite catalogues, enabled by TNG's advanced merger tree features, tracks how these DoS form and evolve across various redshifts. Our study indicates that these structures tend to manifest at very low redshifts, suggesting that DoS may be transient phenomena, possibly arising under specific environmental or dynamical conditions. Moreover, our ongoing work applies a segmentation code to discern and quantify the large-scale structures surrounding these galaxies, assessing their potential role in shaping the formation of satellite disks.

0911PM-7: **2024-09-11 15:10**

The evolution low metallicity of very massive single stars

Norhasliza YUSOF

Very massive stars (VMS) just like massive stars, have great impact on their enviroment and cosmic evolution. Low metallicity VMS models are highly sensitive to rotation, while the evolution of higher metallicity models is dominated by mass loss effects. In this talk, I will explore the impact of low metallicty VMS models using GENEC and how does their evolution and their predicted fate will provide us more understanding in the formation of the universe. We also explore the possibility if we could able to predict the VMS will die either as pair instability supernovae or just directly collapse as black hole.

0911PM-8: **2024-09-11 15:45**

The impact of stellar helium content and recent measurement effort

Mingjie Jian

Stellar helium content is one of the most important but mysterious factors that play an essential role in the evolution of our Universe. As the main product of the stellar nucleosynthesis process, helium produced by stars serves as the raw material for the next generation of stars. Stars with enriched helium are known to be hotter, brighter, and evolve faster; thus, our estimation of stellar ages would be biased if we do not consider helium content. Furthermore, stellar helium content also affects the measurement of the initial mass function by altering the mass-luminosity relation. Evidence shows that the relationship between stellar helium abundance and metallicity is more complex than the widely-used helium enrichment law. However, measuring stellar helium abundance remains difficult. I will introduce the current understanding of helium content from stars to galaxies and present our recent results on its measurement in open cluster stars.

0911PM-9: **2024-09-11 16:00**

Li-enriched low mass giants: Single star evolution vs binary interaction

Raghubar Singh

Li, being susceptible to high temperature, expected to deplete below 1.5 dex in low mass (M < 2 solar mass) evolved stars. Still 1% of red giants are discovered with Li abundance 4-5 order more than expected value. To understand this anomaly, we used data from LAMOST spectroscopic survey, photometric survey of Kepler space telescope, and Gaia astrometry. Our work discovered several red clump super-Li rich giants and all in the red clump phase determined unambiguously based on asteroseismology. Another key result that emerged from this study is the location of the Li enrichment site during the He-flash, the transition phase between the evolution of stars from the end of RGB tip to the quiescent He-core burning at red clump. Based on the analysis of the spectroscopic and photometric data and comparison with stellar models, we provided first-of-its-kind evidence in the form of a correlation between lithium abundance in giants and period spacing of g-mode oscillations derived using asteroseismology. The evidence being that all the super Li-rich giants are almost exclusively young red clump giants compared to Li - poor red clump giants suggesting the direct connection between the He-flash occurrence and the presence of Li in red clump giants. Some of the super-Li-rich giants has active atmosphere revealed in the form of flares, IR excess and high rotation. These observational signature suggest physical mechanism connected with rotation for Li-production in the low mass stars. Further I will present our recent work on discovery of excess Li in the binary merger stars.

0911PM-10: **2024-09-11 16:15**

Heavy Sterile Neutrinos from Core-collapse Supernovae

Kanji Mori

Core-collapse supernovae can be a copious source of sterile neutrinos, hypothetical particles that mix with active neutrinos. We develop two-dimensional stellar core-collapse models that incorporate the mixing between tau neutrinos and heavy sterile neutrinos—those with the mass of 150–200 MeV—to investigate signatures of sterile neutrinos in supernova observables. We find that the decay channel of a sterile neutrino into a pion and a tau neutrino can enhance the explosion energy and the synthesized nickel mass. Although the inclusion of sterile neutrinos considered in this study slightly reduce the neutrino and gravitational-wave signals, we find that they are still detectable for a Galactic event. Furthermore, we point out that if sterile neutrinos are as massive as $\sim$ 200 MeV, they produce high-energy tau antineutrinos with energies of $\sim$ 80 MeV, the detection of which can be a smoking signature of the sterile neutrinos and where Hyper-Kamiokande should play a pivotal role.

0911PM-11: **2024-09-11 16:30**

Impacts of the ^{12}C(α,γ)^{16}O reaction rate on 56Ni nucleosynthesis in pair-instability supernovae

Hiroki Kawashimo

Pair-instability supernovae (PISNe) are the final fates of massive stars with an initial mass ranging from 140-260 $M_{\odot}$. Unlike other supernovae, PISNe do not leave behind compact objects. Stellar evolution theory predicts a gap in the distribution of black hole masses due to PISNe. Recent works suggested that the uncertainty may influence the location of this gap in the ^{12}C$(\alpha,\gamma)^{16}$O reaction rate. In our study, we investigate how the ^{12}C$(\alpha,\gamma)^{16}$O reaction rate affects PISNe profiles, particularly in terms of nucleosynthesis and explosion energy. We find a correlation between the ^{12}C$(\alpha,\gamma)^{16}$O reaction rate and the amount of radioactive ^{56}Ni, which determines the peak luminosity of supernovae. This correlation is attributed to the intensity of burning during the carbon burning phase, which changes the structure of the star. In this presentation, We will provide a detailed report of our findings focusing on emissions.

0911PM-12: **2024-09-11 16:45**

Strong magnetic field impact on the neutrino transportation inside the core-collapse supernova

Yudong Luo

Strong magnetic fields could exist in the inner regions of a supernova. Inside these magnetic fields, the phase space of the electrons becomes quantized. As a result, the rates of weak interaction processes can deviate from the field-free case. This talk focuses on the absorption and emission process of (anti)neutrinos in such strong fields. This process is crucial, as it determines the opacity of the neutrinos and the position of the (anti)neutrino sphere within the supernova. Such impacts of the strong magnetic field could ultimately leave an imprint on the nucleosynthesis yields produced during the supernova event.

0911PM-13: **2024-09-11 17:00**

The impacts of nuclear reaction uncertainties on explosive nucleosynthesis of core-collapse supernovae

Nobuya Nishimura

Massive stars ($> 10M_\odot$) undergo core-collapse supernova explosions at the end of their evolution. These explosions release elements ranging from helium to the iron peak, which are (produced during the stellar evolution) to iron peak elements (synthesized in explosive nucleosynthesis near the supernova core region). Although the explosion mechanism of core-collapse supernovae is not fully understood, 1D spherically symmetric explosion models have been constructed that relatively well reproduce the observed elemental abundances. Such models are ideal to systematically study the impact of nuclear reaction rates on the nucleosynthesis. Some of the nuclear reactions in explosive nucleosynthesis, certain nuclear reactions can be accessed through accelerator experiments, offering the potential to investigate undetermined reaction rates that are important in astrophysics.

We have developed a nucleosynthesis code with Monte-Carlo framework that accounts for the uncertainties in nuclear reaction rates and applied it to processes beyond iron. Given its general applicability, our framework is naturally suited for studying explosive nucleosynthesis in supernovae. In this study, we investigate 1D explosion models using the "PUSH" method, which simulates explosions by mimicking the enhanced neutrino heating observed in multi-dimensional simulations. We focus on nucleosynthesis in progenitors with solar and sub-solar metallicity and metal-poor representatives of masses around $M_{\rm ZAMS} = 16M_\odot$. Detailed post-process nucleosynthesis calculations with Monte Carlo analysis is employed to comprehensively explore the effects of uncertainties in relevant reaction rates. Additionally, we identify "key reaction rates" for explosive nucleosynthesis based on statistical analysis of our Monte Carlo nucleosynthesis calculations.