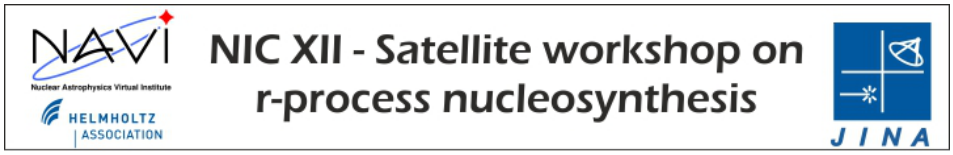
Nuclei in the Cosmos XII - Satellite Workshop



Report of Contributions

https://indico.gsi.de/e/nic12sat

Contribution ID: **1** Type: **not specified**

New UV Observations of Exotic Heavy Elements in Metal-Poor Stars

Saturday, 4 August 2012 10:45 (30 minutes)

We present new abundance determinations of the heavy elements germanium (Ge, Z=32), arsenic (As, Z=33), selenium (Se, Z=34), and tellurium (Te, Z=52) in several metal-poor stars enriched with r-process material. These recent results mark the first detection of As, Se, and Te in an r-process environment beyond the solar system. In addition, detection of the elements at the third r-process peak in some of these stars enable us to constrain the relative abundances of all three r-process peaks, which may pose a challenge to theory in some cases.

Primary author: Dr ROEDERER, Ian (Carnegie Observatories)

Presenter: Dr ROEDERER, Ian (Carnegie Observatories)

Session Classification: Observations & Data

Contribution ID: **2** Type: **not specified**

Sensitivity of the r-process to masses

Sunday, 5 August 2012 09:30 (30 minutes)

The rapid neutron capture process (r-process) is thought to be responsible for the creation of more than half of all elements beyond iron. The scientific challenges to understanding the origin of the heavy elements beyond iron lie in both the uncertainties associated with astrophysical conditions that are needed to allow an r-process to occur and a vast lack of knowledge about the properties of nuclei far from stability. There is great global competition to access and measure the most exotic nuclei that existing facilities can reach, while simultaneously building new, more powerful accelerators to make even more exotic nuclei.

I will talk about an attempt to determine the most crucial nuclei to measure using an r-process simulation code. The sensitivities are determined from various nuclear masses (mass models including FRDM, ETFSIQ, Duflo-Zuker, and F-spin). The most important nuclei to measure are determined in two ways using the changes in the resulting r-process abundances as a guide.

This work has been supported by the National Science Foundation under contract number PHY0758100 and the Joint Institute for Nuclear Astrophysics, PHY0822648.

Primary author: Prof. APRAHAMIAN, Ani (University of Notre Dame)

Co-authors: BENTLEY, Ian (Unviersity of Notre Dame); PAUL, Nancy (University of Notre Dame); SURMAN, Rebecca (University of Notre Dame); BRETT, Samuel (University of Notre Dame)

Presenter: Prof. APRAHAMIAN, Ani (University of Notre Dame)

Session Classification: Theory & Experiments

Contribution ID: **4** Type: **not specified**

Are Core-Collapse Supernovae still possible sites for the r-process?

Saturday, 4 August 2012 14:00 (30 minutes)

The problem of astrophysical site(s) for the r-process is still shrouded in mystery despite more than a half century of studies. Although neutrino driven winds have been considered to be the most likely success, recent state of the art hydrodynamic simulations show that it is seriously difficult to achieve suitable conditions for r-process by that scenario. We are reinvestigating the other astrophysical sites for the r-process, therefore, which are special types of core-collapse supernova including magnetically driven jets, compact star mergers, and so on.

In this presentation I will talk about a new idea for the r-process after I briefly reviewed recent progress of the studies. I will show the results of r-process nucleosynthesis based on special types of supernova via the Quark-hadron phase transition during the early post-bounce phase of core-collapse. We have investigated detailed properties of heavy element nucleosynthesis on the bases of one-dimensional general relativistic hydrodynamic simulations with neutrino transport and the nuclear and quark equation of states. In addition, I also want to briefly remark the progress and preliminary results
of r-process studies for magnetically driven core-collapse supernovae.

Primary author: Dr NISHIMURA, Nobuya (University of Basel)

Presenter: Dr NISHIMURA, Nobuya (University of Basel)

Session Classification: Simulations

Contribution ID: **5** Type: **not specified**

β decays of isotones with N = 126 and nuclei nearby and r-process nucleosynthesis

Saturday, 4 August 2012 17:00 (30 minutes)

β decays of the isotones with N = 126 are studied by shell-model calculations taking into account both the Gamow-Teller (GT) and first-forbidden (FF) transitions [1]. Shell-model interaction of Ref. [2] is adopted and a quenching of g_A^{eff}/g_A =0.7 is used for both the GT and FF transitions except for 0^{-} case. The FF transitions [3] are found to be important to reduce the beta-decay half-lives, by nearly twice to several times, from those by the GT contributions only. The half-lives obtained here are short compared with the standard data of FRDM [4] except for Z = 71 usually employed in nucleosynthesis network calculations. They increase monotonically as Z increases showing no odd-even staggering found in FRDM's. They are, on the other hand, longer than those of CQRPA calculations [5].
Possible implications of the short half-lives of the waiting point nuclei on the r-process nucleosynthesis during the supernova explosions are discussed. A slight shift of the third peak of the element abundances in the r process toward a higher mass region is found.
The dependence of the \beta-decay half-lives and the r-process nucleosynthesis on the magnitudes of the quenching of g_A and g_V in FF transitions is studied. Large quenchings are found to be necessary for FF transitions in ^{206}Hg [6]. FF transitions in nuclei at and near the N=126 isotones such as 204Pt, 203Pt, 202Ir and 201Ir are also investigated. Calculated half-lives of these nuclei are compared with recent experimental data [7] and the quenching of g_A and g_V are discussed.

[1] T. Suzuki, T. Yoshida, T. Kajino and T⊠Otsuka, Phys. Rev. C 85, 015802 (2012).
[2] S. J. Steer et al., Phys. Rev. C78, 061302 (2008); L. Rydstrom, J. Blomqvist, R. J. Liotta, and C. Pomar, Nucl. Phys. A 512, 217 (1990).
[3] E. K. Warburton, J. A. Becker, B. A. Brown, and D. J. Millener, Ann. Phys. 187, 471 (1988); H. Behrens and W. B¨uhring, Nucl. Phys. A 162, 111 (1971); H. Schopper, Weak Interactions and Nuclear Beta Decays (North-Holland, Amsterdam, 1966); I. S. Towner and J. C. Hardy, Nucl. Phys. A 179, 489 (1972).
[4] P.Moller, J. R. Nix, and K.-L. Kratz, At. Data Nucl. Data Tables 66, 131 (1997); P.Moller, B. Pfeiffer, and K.-L. Kratz, Phys. Rev. C 67, 055802 (2003).
[5] I. N. Borzov, Phys. Rev. C 67, 025802 (2003).
[6] E. K. Warburton, Phys. Rev. C 44, 233 (1991); ibid. 42, 2479 81990).
[7] J. Benlliure et al., ARIS 2011.

Primary author: Prof. SUZUKI, Toshio (Nihon University)

Co-authors: Prof. OTSUKA, Takaharu (University of Tokyo); Dr YOSHIDA, Takashi (University of Tokyo); Prof. KAJINO, Toshitaka (National Astronomical Observatory of Japan)

Presenter: Prof. SUZUKI, Toshio (Nihon University)

Session Classification: Simulations & Theory

Contribution ID: **6** Type: **not specified**

Direct mass measurements of stored exotic nuclei

Sunday, 5 August 2012 10:00 (30 minutes)

Ground state masses belong to the most essential nuclear quantities for our understanding of nucleosynthesis processes in stars. Particularly for the r-process, masses of very neutron-rich nuclei are needed. The need is best explained by the fact that mass differences of specific neighboring nuclei define the neutron separation energy and thus determine the pathway of the process on the chart of nuclides.
Mass-spectrometry techniques aiming at mass measurements of such exotic nuclear species have thus to be extremely efficient and fast to investigate even he most neutron-rich and thus the shortest-lived nuclides which can only be produced with low yields. Two modern techniques fulfill these requirements: Penning-trap and storage ring mass spectrometry. While the former is superior in terms of achievable mass accuracy, the latter is an ideal tool to investigate the most rare nuclides. A single particle can often be sufficient to determine its mass with a high accuracy. Furthermore, the high resolving power of these techniques makes possible the resolution of long-lived nuclear states.
In this contribution the present status of mass measurements relevant for the r-process will be outlined. It is necessary to realize that even the new-generation accelerator beam facilities will not be able to provide access to the entire r-process path. Therefore, the constraining of nuclear theories by precision mass measurements is indispensable. Such measurements allow for nuclear structure investigations such as shell closures, changes of deformations, nucleon-nucleon correlations, metastable states, etc.
Last but not least, the plans will be sketched for mass measurements at present facilities as well as future prospects related to new radioactive beam facilities which are either in construction phase, like, e.g., FAIR in Darmstadt, or being just designed, like, e.g., HIAF in Erdos/China.

Primary author: Dr LITVINOV, Yuri (GSI, Darmstadt)

Presenter: Dr LITVINOV, Yuri (GSI, Darmstadt)

Session Classification: Theory & Experiments

Contribution ID: **7** Type: **not specified**

Current status of core-collapse supernova simulations:

Saturday, 4 August 2012 13:30 (30 minutes)

In this contribution, we give overview about a current status
of multidimensional radiation hydrodynamic simulations of core-collapse supernovae. In addition to 3D hydrodynamics and general relativity, both of
which are now considered as the most important ingredients for making successful explosions, we discuss also impacts of nuclear equations of state on
the supernova dynamics. We report our recent results on
magnetohydrodynamically-driven models, which are expected to provide
possible r-process cites.

Primary author: Dr KOTAKE, Kei (National Astronomical Observatory of Japan)

Presenter: Dr KOTAKE, Kei (National Astronomical Observatory of Japan)

Session Classification: Simulations

Contribution ID: **8** Type: **not specified**

Single particle levels in Sn-131 and Sn-133 on the path of r-process nucleosynthesis

Saturday, 4 August 2012 16:30 (30 minutes)

Single-particle resonant states embedded in the continuum for ^{131,133}Sn, in the vicinity of the neutron capture threshold for ^{130,132}Sn(n,γ), are calculated by the analytical continuation of the coupling constant (ACCC) approach within the relativistic mean field (RMF) theory framework. Our fully self-consistent RMF calculations using the NL3 effective interaction,
predict single-particle bound levels near the Fermi surface, consistent with Nature report for ^{133}Sn and recent measurement for ^{131}Sn. For the first time, the level structure of single-particle resonant states in ^{131,133}Sn up to 3 $\sim$ 4 MeV above the neutron capture threshold are investigated. Our RMF+ACCC+BCS approach determines a level spacing that is too sparse for typical level density formulation used to calculate capture cross section with a Hauser-Feshbach (HF) formalism.

Primary author: Dr ZHANG, Shi-Sheng (School of Physics and Nuclear Energy Engineering, Beihang University, Beijing 100191, China)

Co-author: Dr SMITH, Michael (Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6354 USA)

Presenter: Dr ZHANG, Shi-Sheng (School of Physics and Nuclear Energy Engineering, Beihang University, Beijing 100191, China)

Session Classification: Simulations & Theory

Contribution ID: **9** Type: **not specified**

The Rare Earth Peak: An Overlooked r-Process Diagnostic

Saturday, 4 August 2012 16:00 (30 minutes)

The potential of an astrophysical environment for making r-process elements has been typically characterized by the neutron-to-seed ratio. We consider the rare earth peak as a new and independent tool for understanding the astrophysical conditions favorable for the main r-process. In the context of a high entropy r-process we discuss rare earth peak formation. We use features of a successful rare earth region to explore the types of astrophysical conditions that produce abundance patterns that best match data. This analysis allows for tighter constraints on the astrophysical conditions even after uncertainties in nuclear physics inputs such as separation energies and neutron captures are taken into account. The efficacy of this tool depends on the nuclear physics inputs and so we point out important rates in the region which have the most influence on the final abundance pattern.

Primary author: Dr MUMPOWER, Matthew (North Carolina State University)

Co-authors: Prof. MCLAUGHLIN, Gail (North Carolina State University); Prof. SURMAN, Rebecca (Union College)

Presenter: Dr MUMPOWER, Matthew (North Carolina State University)

Session Classification: Simulations & Theory

Contribution ID: **10** Type: **not specified**

Lighter element primary process (LEPP) in neutrino-driven winds

Saturday, 4 August 2012 15:30 (30 minutes)

I will discuss the origin of lighter heavy elements (Sr, Y, Zr) in neutrino-driven winds.

Primary author: ARCONES, Almudena (TU Darmstadt, GSI)

Presenter: ARCONES, Almudena (TU Darmstadt, GSI)

Session Classification: Simulations & Theory

Contribution ID: **11** Type: **not specified**

First measurment for Half-lives of Zn and Ga r-process isotopes

Sunday, 5 August 2012 10:30 (30 minutes)

The β-decays of r-process neutron rich nuclei near the doubly magic ^{78}Ni were studied at the Holifield Radioactive Ion Beam Facility (HRIBF) using an electromagnetic isobar separator. The half-lives of ^{82}Zn (228$\pm$10 ms), ^{83}Zn (117$\pm$20 ms) and ^{85}Ga (93$\pm$7 ms) were determined for the first time. These half-lives were found to be dramatically different than the predictions of established global model used in astrophysical calculations, but close to the values obtained from our new microscopic calculation. The analysis of rapid neutron capture process using our new set of calculated half-lives shows a significant redistribution of isobaric abundances particularly strong near A $>$ 140 nuclei.
The beta-delayed neutron emission of 30 r-process relevant nuclei in the Cu,Zn,Ga,Ge,Rb,Hg,Sn and Sb isotopic chains were measured for the first time using the newly developed neutron detector VANDLE. The neutron energy spectra were measured using the time-of-flight technique, achieving world leading efficiency at low energies thanks to the novel implementation of digital electronics. The spectroscopic information showed that in many cases the Gamow Teller decay occurs to neutron unbound states in the long hypothesized in this region Pygmy giant resonance. As the beta-decay will occur mainly through this resonances, the systematics across isotopic chains will provide fundamental information to refine theoretical predictions of beta decay half-lives of r-process nuclei beyond the reach of current facilities.

Primary author: Dr MADURGA, Miguel (University of Tennessee)

Co-authors: Dr GROSS, Carl (Oak Ridge National Laboratory); Dr MILLER, David (University of Tennessee); Dr BORZOV, Ivan (Joint Institute for Nuclear Research); Prof. RYKACZEWSKI, Krzysztof (Oak Ridge National Laboratory); Dr SURMAN, Rebecca (Union College); Prof. GRZYWACZ, Robert (University of Tennessee); Mr PAULAUSKAS, Stan (University of Tennessee); Dr PETERS, William (Oak ridge Associated Universities)

Presenter: Dr MADURGA, Miguel (University of Tennessee)

Session Classification: Theory & Experiments

Contribution ID: **12** Type: **not specified**

JINALIB: A new resource for nuclear astrophysics computation

Saturday, 4 August 2012 11:45 (30 minutes)

A reoccurring theme throughout nuclear astrophysics is the need for and use of the best available nuclear data as input for astrophysics calculations. Relevant nuclear data includes, but is not limited to nuclear masses, partition functions, thermonuclear reaction rates, weak interaction rates and fission fragment distributions. With the r-process reaction flow typically far from direct experimental data, we rely heavily on theoretical estimates for this nuclear data input.

To facilitate the generation of self-consistent nuclear inputs, we have started development of a new online resource for nuclear data and astrophysics validation. This resource combines and extends the capabilities of the JINA REACLIB and NUCDATALIB databases, and is tentatively called JINALIB. The new resource will continue the JINA effort in maintaining uptodate nuclear physics input, whether experimentally or theoretically based, available for download in several formats. The validation side of the database will provide the nuclear physics input and astrophysics output for several nucleosynthetic processes, so that identical data can be used in a variety of astrophysics codes, whose results can be validated against the JINA generated output.

I will present our plans and progress with the new JINALIB resource.

Primary author: Dr CYBURT, Richard (JINA/MSU)

Presenter: Dr CYBURT, Richard (JINA/MSU)

Session Classification: Observations & Data

Contribution ID: **13** Type: **not specified**

Chemical tagging and the second r-process

Saturday, 4 August 2012 11:15 (30 minutes)

The applications of stellar elemental abundances are numerous. The different groups of elements work as tracers of various formation processes, e.g. alpha-elements and odd-Z elements are created both in hydrostatic burning and supernova explosions. An abundances of every single element can trace differing features/parameters of the supernova such as mass and explosion energy.
By comparing heavy elements stemming from known neutron-capture processes to those coming from processes we still do not understand, we can learn about the similarities and differences between these formation processes.
As an example strontium is created by the weak slow neutron-capture (s-) processes, while silver is created by a weak rapid neutron-capture (r-)process. Comparing the abundances of these two elements yields anti-correlations which arise due to the different characteristics of their formation processes. This means that we can trace both process features and possible sites though a comparison of stellar abundances. Here I will focus on Sr, Y, Zr, Pd, Ag , Ba and Eu since these elements represent four different neutron-capture processes, weak and main s- and r-process, respectively.
I will furthermore show how we can use the abundance patterns of carbon to barium from stars at different evolutionary stages for chemical tagging, how we can extract information on the first stars, the formation processes as well as the chemical evolution of our Galaxy.

Primary author: Dr HANSEN, Camilla Juul (University of Heidelberg, ZAH)

Presenter: Dr HANSEN, Camilla Juul (University of Heidelberg, ZAH)

Session Classification: Observations & Data

Contribution ID: **14** Type: **not specified**

β delayed neutron emission measurements around the third r-process peak

Sunday, 5 August 2012 12:00 (30 minutes)

β delayed neutron emission measurements around the third r-process peak

Primary author: Mr CABALLERO-FOLCH, Roger (Universitat Politècnica de Catalunya (UPC))

Presenter: Mr CABALLERO-FOLCH, Roger (Universitat Politècnica de Catalunya (UPC))

Session Classification: Experiments

Contribution ID: **15** Type: **not specified**

Nuclear Dynamics of the Freezeout Phase of the r Process

Saturday, 4 August 2012 14:30 (30 minutes)

The classical (n,gamma)-(gamma,n) phase of r-process nucleosynthesis is well understood. Less well understood is the complex freezeout phase during which the last of the free neutrons are consumed. I present some calculations using simplified nuclear physics to help characterize the r-process freezeout.

Primary author: Prof. MEYER, Bradley (Clemson University)

Presenter: Prof. MEYER, Bradley (Clemson University)

Session Classification: Simulations

Contribution ID: **16** Type: **not specified**

Light Trans-Ironic Elements in Metal-Poor Stars with Low r-process Enhancement

Saturday, 4 August 2012 10:15 (30 minutes)

We extend our analysis of archival 2000A HST STIS E230H echelle spectra of five metal-poor stars with modest r-process enhancements to rare light trans-ironic elements represented by very few lines. We illustrate potential pitfalls affecting abundance determinations of isolated weak lines in the blended ultraviolet, which we minimize by analyzing all five stars simultaneously and consistently, calculating their entire visible and UV spectra from first principles.

Peterson (2011, ApJ, 742, 21) derived abundances of molybdenum and ruthenium (Mo, Ru; Z = 42, 44) in all five stars, finding extremely elevated [Mo/Fe] in two cases. Because [Ru/Fe] was also nearly as high, but not Zr (Z = 40) nor s- nor r-process elements with Z >= 56, a high-entropy wind is favored for their overproduction. Because only the low-entropy regime of the high-entropy wind yields a sharply-peaked overproduction at Z = 40 and 42, only one or a few such HEW events are implicated in the two extreme cases.

To check the range in Z over which such a low-entropy HEW wind may be effective, we present here new abundance determinations of light trans-ironic elements of both lower and higher Z, including Ge, As, Se, Cd, Sn, and Te (Z = 32, 33, 34, 48, 50, 52). We discuss the constraints this places on the yields of the low-entropy regime of a high-entropy wind, and on the subsequent incorporation of the products into subsequent stellar generations.

Primary author: Ms PETERSON, Ruth (AAdv)

Presenter: Ms PETERSON, Ruth (AAdv)

Session Classification: Observations & Data

Contribution ID: **17** Type: **not specified**

Formation of the Heaviest Elements: Necessary Conditions, Astrophysical Sites, Nuclear Input

Sunday, 5 August 2012 09:00 (30 minutes)

We give a short review on necessary conditions in order to achieve a sufficient neutron/seed ratio for an r-process to occur, what are the candidate astrophysical sites to fulfill such conditions (supernovae, magnetar-forming supernovae, quark (super-)novae, neutron star mergers,…), what is their role in the chemical evolution of galaxies, and whether there existed a chance to produce superheavy elements in nature.

Primary author: Prof. THIELEMANN, Friedrich (University of Basel)

Presenter: Prof. THIELEMANN, Friedrich (University of Basel)

Session Classification: Theory & Experiments

Contribution ID: **18** Type: **not specified**

Experimental studies of r-process nuclei at the National Superconducting Cyclotron Laboratory

Sunday, 5 August 2012 11:30 (30 minutes)

Despite more than half a century of intensive research, the nucleosynthesis of heavy nuclei remains is still an open questions in nuclear astrophysics. Besides the unknown scenario where the rapid neutron-capture process occurs, new incognita about the very synthesis mechanism are presently under study. The Puzzle will only be solved when the properties of the neutron-rich nuclei involved are well understood.
In this talk, I will discuss several NSCL r-process motivated experiments aimed at studying beta-decay and structural properties of neutron-rich nuclei. Experimental techniques and analysis methods will be presented, along with new results for nuclei in the region N=56-60. Future opportunities will be discussed in the light of the new FRIB and ReA facilities at MSU, emphasizing the type of experiments that will contribute to a deeper understanding of the R-process.

Primary author: PEREIRA, Jorge (National Superconducting Cyclotron Laboratory and Michigan State University)

Presenter: PEREIRA, Jorge (National Superconducting Cyclotron Laboratory and Michigan State University)

Session Classification: Experiments

Contribution ID: **21** Type: **not specified**

Sn(d,p) and r-process nucleosynthesis

Sunday, 5 August 2012 12:30 (30 minutes)

R. Surman and colleagues have shown how r-process nucleosynthesis abundances are affected by uncertainties in neutron capture cross sections in relatively long-lived nuclei near the r-process path, such as 130Sn. We have recently
measured the (d,p) reactions with rare isotope beams of 126,128,130,132Sn and 134Te to study the single-neutron structure in these neutron-rich nuclei and inform the direct-semi-direct (DSD) components of neutron capture cross
sections. Preliminary results from recent measurements, including DSD (n,gamma) rates, will be presented, as well as future prospects for informing (n,gamma) cross sections.

This research is a collaboration of scientists from University of Tennessee, Oak Ridge National Laboratory, and Tennessee Technological University, as well as Rutgers. Work supported in part by the U.S. Department of Energy and National Science Foundation.

Primary author: CIZEWSKI, Jolie

Presenter: CIZEWSKI, Jolie

Session Classification: Experiments

Contribution ID: **23** Type: **not specified**

Decay Spectroscopy Project at the RIBF

Sunday, 5 August 2012 13:00 (30 minutes)

Beta-decay spectroscopy of the nuclei far from the stability is one of sensitive methods to shed light on evolution of nuclear structure toward extreme neutron-to-proton ratios. The beta-decay related information is also essential to study the rapid neutron-capture process (r-process), which is responsible for producing about half of the elements heavier than Fe in the universe.
A signicant progress of beta-decay spectroscopy has been made by measuring the beta- and gamma-rays from very neutron-rich nuclei on the boundary of r-process path [1]. Recent achievement of the experiment will be presented to discuss its impact on the r-process nucleosynthesis as well as the nuclear structure. In addition, a new project of utilizing an EUroball-RIKEN-Cluster-Array (EURICA) launched for high precision gamma-ray spectroscopy will be introduced with its perspective at the RIBF.

[1] S.Nishimura, et al., Phys. Rev. Lett. 106, 052502 (2011).

Primary author: NISHIMURA, Shunji (RIKEN)

Presenter: NISHIMURA, Shunji (RIKEN)

Session Classification: Experiments