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Conference on Nuclear Astrophysics

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Organizing Committee

Mary Beard	*University of Notre Dame*
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Sunday, October 7th, 2012		
8.00am-9.00am		**Registration**
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Laurens Keek	***Michigan State University***	***Superburst ignition on neutron stars***
Jeremy Stevens	Michigan State University	Sensitivity of Carbon Synthesis in Accreting Neutron Stars to Reaction Rate and Network Parameter Variations
Andrew Steiner	INT/U. Washington	The Accreted Neutron Star Crust and the Nuclear Symmetry Energy
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10.30am-11.30am		**Chair: Richard Cyburt**
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Simin Mahmoodifar	University of Maryland	Probing the phases of dense matter using neutron star physics
Alex Deibel	Michigan State University	Magnetar Oscillations: Observing the Physics of the Magnetized Neutron Star Crust
Ernazar Abdikamalov	California Institute of Technology	Correlated gravitational wave and neutrino signals from general-relativistic rapidly rotating iron core collapse
11.30am-1.00am		**Lunch (Snyder Phillips Dining Hall)**
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Athira Menon	University of Victoria	RCB stars - the aftermath of long term post-merger nucleosynthesis of a coalesced double-degenerate (He+CO) system
Marco Pignatari	University of Basel	The slow neutron capture process in intermediate mass stars: warnings and perspectives
Thomas Rauscher	University of Basel	A solution to the gamma-process alpha-potential mystery
Grant Mathews	University of Notre Dame	Frontiers in Big Bang Cosmology and Nucleosynthesis
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Manoel Couder	***University of Notre Dame***	***Studying radiative capture with recoil separators***
Sunil Devi	Indiana University South Bend	Detection system for the St. George recoil mass separator.
Wenting Lu	University of Notre Dame	Zr-Nb isobar separation for the ^{93}Zr AMS measurement
Andreas Best	University of Notre Dame/LBNL	Neutron background characterization of deep underground laboratories
Zbigniew Chajecki	NSCL/MSU	Fission barriers for heavy exotic nuclei
Karen Ostdiek	University of Notre Dame	Complications in the measurement of the half life of Iron-60
Fang Xiao	University of Notre Dame	Experimental investigations of stellar ^{12}C+^{12}C fusion toward extremely low energies by direct and indirect methods
Yunju Li	University of Notre Dame	How to measure the total cross sections for ^{12}C + ^{12}C reaction at astrophysical energies?
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Monday, October 8th, 2012		
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Pavel Denisenkov	University of Victoria	MESA/NuGrid Models of Nova Outbursts and Nucleosynthesis
Brian O'Shea	Michigan State University	Orbital Properties of a Subset of SEGUE Stars: the halo within the Milky Way's disk.
10.00am-10.30am		**Coffee break**
10.30am-11.30am		**Chair: Thomas Rauscher**
Richard deBoer	University of Notre Dame	Comprehensive Analysis of ^{16}O Compound Nucleus Reactions
Matt Bowers	University of Notre Dame	Implications of the ^{33}S(α,p)^{36}Cl reaction on Early Solar system production
Yoav Kashiv	University of Notre Dame	A Shorter Measured ^{146}Sm Half-Life and Implications for ^{146}Sm-^{142}Nd Chronology in the Solar System
Ethan Uberseder	University of Notre Dame	First Experimental Constraint on the ^{59}Fe(n,γ)^{60}Fe Reaction via Coulomb Dissociation
11.30am-1.00am		**Lunch (Akers Hall)**
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Catherine Deibel	***Louisiana State University***	***When Stars Go BOOM: Explosive Nucleosynthesis***
Chris Wrede	MSU/NSCL	Nova nucleosynthesis via beta delayed gamma decay at NSCL
Sergio Almarez-Calderon	Argonne National Laboratory	The level structure of ^{30}S and its astrophysical implications
Christoph Langer	NSCL	Experimental investigations of important bottleneck reactions in the rp-process
Alexander Long	University of Notre Dame	Measurements of Resonance States in ^{30}S and ^{38}Ca Nuclei using the (p,t) Reaction, and Reaction Rates in the αp-Process
Justyna Marganiec	EMMI/GSI	Coulomb breakup of ^{17}Ne and the ^{15}O(2p,γ)^{17}Ne cross section.
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Stephen Quinn	Michigan State University	Cross section measurements of (p,γ) reactions using the SuN detector
Matthew Mumpower	University of Notre Dame	The Rare Earth Peak: An Overlooked r-Process Diagnostic
Jorge Pereira	NSCL	Inferring nuclear structure trends of r-process nuclei from beta-decay measurements
David Chamulak		Nucleosynthesis from Asymmetrical Explosions in Type Ia Supernovae
Yeunjin Kim	University of Chicago	Detonations in Helium Layers of White Dwarf
Rashi Talwar	University of Notre Dame	Stellar neutron sources and s-Process in Massive Stars

Abstracts

Session 1:

Laurens Keek *Superburst Ignition on Neutron Stars*

Runaway carbon fusion on an accreting neutron star produces X-ray flares that are observable for hours: superbursts. We discuss our latest multizone models of superbursts that ignite thermonuclear carbon burning as a detonation. Using a new observational analysis method we find evidence for the presence of shock heating at the onset of a superburst, supporting our detonation models. Finally we discuss the effect of superbursts on the short bursts from hydrogen and helium burning higher up in the neutron star atmosphere, and how the O15(a,g) breakout reaction determines the behavior of these bursts.

Jeremy Stevens *Sensitivity of Carbon Synthesis in Accreting Neutron Stars to Reaction Rate and Network Parameter Variations*

Superbursts from accreting neutron stars represent an opportunity for probing nuclear processes at densities ($\rho \sim 10^9$ cm^{-3}) and temperatures ($T > 10^9$ K) only available in a few other astrophysical locations. These 10^{42} erg bursts are most likely triggered by unstable ignition of carbon in an otherwise inert sea of heavy nuclei made during the rp-process of regular type I bursts (where the accumulated hydrogen and helium are burned). An open question is the origin of sufficient amounts of carbon, which is largely destroyed during the rp-process in X-ray bursts. We explore carbon production in steady state burning via the rp-process, which might occur together with unstable burning in systems showing super bursts. We determine carbon production for a range of accretion rates and helium mass fractions. We then examine the sensitivity of this production of carbon to steady state model parameters as well as reaction rate variations and identify critical nuclear reaction rates

Andrew Steiner *The Accreted Neutron Star Crust and the Nuclear Symmetry Energy*

A quasi-statistical equilibrium model is constructed to simulate the multicomponent composition of the crust of an accreting neutron star. The ashes of rp-process nucleosynthesis are driven by accretion through a series of electron captures, neutron emissions, and pycnonuclear fusions up to densities near the transition between the neutron star crust and core. A liquid droplet model which includes nuclear shell effects is used to provide nuclear masses far from stability. Reaction pathways are determined consistently with the nuclear mass model. The nuclear symmetry energy is an important uncertainty in the masses of the exotic nuclei in the inner crust and varying the symmetry energy changes the amount of deep crustal heating by as much as a factor of two.

Daniel Coupland *Density Dependence of the Symmetry energy with Emitted Neutrons and Protons*

The density dependence of the symmetry energy plays a role in many aspects of nuclear reactions, structure, and astrophysics, ranging from understanding the thickness of the neutron skins on heavy nuclei to the maximum mass and radius relationship of neutron stars. As the sign of the symmetry potential is opposite for protons and neutrons, one promising probe to study the symmetry energy is the differing spectra of protons and neutrons emitted from heavy ion collisions. Little data actually exists on this observable, however, due to the complexity of detecting neutron energy spectra. I will describe a recent experiment that measured proton and neutron spectra from Sn + Sn collisions at the NSCL. Results will be compared to theory and previous data, where available

Simin Mahmoodifar *Probing the Phases of Dense Matter Using Neutron Star Physics*

Neutron stars are the only laboratory for studying cold ultra-dense matter. Since the density at the core of a neutron star is extremely high one could expect the existence of exotic matter in the core. Studying transport properties such as viscosity, emissivity, heat capacity and etc. of different phases of dense matter that can occur in a compact star is important because they in addition to depending on the equation of state of matter, also depend on the low-energy degrees of freedom and therefore can discriminate between different phases more efficiently. In this talk I will explain how these microscopic properties of dense matter are related to the observable properties of neutron stars, specifically I will focus on how spin-down and temperature evolution of neutron stars can be used as a probe of the phases of matter at low temperatures and high densities.

Alex Deibel *Magnetar Oscillations: Observing the Physics of the Magnetized Neutron Star Crust*

Highly magnetized neutron stars, magnetars, emit irregular and extremely energetic gamma ray flares. These flares are thought to be powered by fracturing and restructuring of the neutron star crust, i.e., a starquake. During some giant flares, quasi-periodic oscillations (QPOs) are observed, and these have been identified with torsional modes excited by the starquake. We construct a new neutron star crust model which predicts nuclear masses with an accuracy very close to that of the Finite Range Droplet Model and also includes the effect of the strong magnetic field on the electrons. Torsional oscillation frequencies are computed from the crust model, and the impact of nuclear shell effects and the magnetic field on the oscillation frequencies is delineated. We make QPO predictions using several equations of state to determine the extent to which these QPOs might be used to constrain magnetar masses and radii.

Ernazar Abdikamalov *Correlated Gravitational Wave and Neutrino Signals from General-Relativistic Rapidly Rotating Iron Core Collapse*

We present results from a new set of three-dimensional general-relativistic hydrodynamic simulations of rotating iron core collapse. We focus on collapse, bounce, the early postbounce evolution, and the associated gravitational wave (GW) and neutrino signals. We demonstrate that the GW signal of rapidly rotating core collapse is practically independent of progenitor mass and precollapse structure. Moreover, we show that the effects of neutrino leakage on the GW signal are strong only in nonrotating or slowly rotating models in which GW emission is not dominated by inner core dynamics. In rapidly rotating cores, core bounce excites the fundamental quadrupole pulsation mode of the nascent protoneutron star. The resulting global oscillations lead to pronounced oscillations in the GW signal and correlated strong variations in the luminosities of antineutrino and heavy-lepton neutrinos. We find these features in cores that collapse to protoneutron stars with spin periods <2.5ms and rotational energies sufficient to drive hyperenergetic core-collapse supernova explosions. Hence, GW or neutrino observations of a core-collapse event could deliver strong evidence for or against rapid core rotation. Joint GW+neutrino observations would allow one to make statements with high confidence. Our estimates suggest that the GW signal should be detectable throughout the Milky Way by advanced laser-interferometer GW observatories, but a water-Cherenkov neutrino detector would have to be of near-megaton size to observe the variations in the early neutrino luminosities from a core collapse event at 1 kpc.

Athira Menon *RCB Stars – The Aftermath of Long Term Post-Merger Nucleosynthesis of a Coalesced Double-Degenerate (He+CO) System*

We construct post-merger 1D spherical models using a three-zone model derived from results of previous 3D hydrodynamic simulations of He+CO WD mergers (Staff etal. 2012). The initial condition of these layers has been constructed taking into account realistic models for the evolution and nucleosynthesis of the pre-merger evolution of each white dwarf, as well as the mixing and nucleosynthesis in the dynamic merger phase. We follow the evolution of this initial configuration into the giant domain of the HRD where the RCB stars are located. In this evolution we adopt a simple model of envelope mixing that represents mixing induced by differential rotation, left over from the dynamic merger phase. We perform a complete nucleosynthesis post-processing analysis of these stellar evolution tracks. Our resulting simulations show With these assumptions our models reproduce the key observed features of RCB and HdC stars, such as the [quantitatively] O16/18 ratio, the C12/13 ratio, the F enhancement, as well as enhancements of s-process elements like Zn, Ba and La.

Marco Pignatari *The Slow Neutron Capture Process in Intermediate Mass Stars: Warnings and Perspectives*

After a brief introduction to the general features of s-process nucleosynthesis in AGB stars, I will present possible perspectives on how to improve our present understanding, first of all concerning the formation of the C13-pocket. I will also introduce few warnings that mainly come from observations, which may underline limitations of theoretical predictions and help deriving relevant constraints for future s-process calculations.

Thomas Rauscher *A Solution to the Gamma-Process Alpha-Potential Mystery*

Although data are scarce close to the astrophysically relevant energy region, experiments have found low-energy deviations from predicted (alpha,gamma) reaction cross sections for the gamma-process (p-process). This spurred the development of new alpha+nucleus optical potentials suited for low energies. Despite of these efforts, no clear picture has arisen and the predictions remain challenged. A consistent solution is presented here, including the realization that the optical potential is not the (main) culprit in the apparent problems with the description of the data. Nevertheless, further measurements close to the astrophysical energy range are required.

Grant Mathews *Frontiers in Big Bang Cosmology and Nucleosynthesis*

Big bang cosmology is currently undergoing rapid evolution based upon numerous observational and theoretical developments. Nevertheless, big bang nucleosynthesis remains as one of the fundamental constraints on cosmological models must rest and is the only probe of the universe during the first few minutes of cosmic expansion. This talk will summarize the crucial role which big-bang nucleosynthesis plays in shaping some of the new cosmological paradigms. Among the topics discussed will be the limits which primordial nucleosynthesis places upon the time evolution of fundamental constants, the nature and origin of dark matter and of long-lived supersymmetric matter, the nature and origin of gravity waves and the primordial magnetic field, nature and origin of the cosmic dark energy. The crucial remaining uncertainties in nuclear reactions and the inferred primordial abundances will be also be reviewed.

Session 2:

Manoel Couder *Studying Radiative Capture with Recoil Separators*

Radiative captures of proton and alpha play a role in most stellar process reaction networks. These reactions have been an object of study since the dawn of accelerator based nuclear physics. Cross section measurements performed with standard techniques can be handicapped however, especially at low energy, by the background. Inverse kinematics techniques and recoil separators such as St. George can help to avoid such background. In particular, when the reaction of interest involves a radioactive element, recoil separators are key part of the experimental setup. SECAR is such a device for ReA3 at NSCL and FRIB.

Sunil Devi *Detection System for the St. George Recoil Mass Separator*

The St. George recoil mass separator is designed for the study of low energy (α,γ) reactions of astrophysical interest in inverse kinematics. The energy range of recoils will be 0.07 to 0.9 MeV/nucleon. A detection system is being developed for separating the recoils from the residual scattered beam at the focal plane. The detection system will consist of two position sensitive microchannel plate (MCPs) timing detectors separated by 50cm followed by a single sided silicon strip detector. Simulations were performed using the codes SIMION and GEANT4. Different designs for guiding the secondary electrons emitted from a thin carbon foil to the MCP were studied in the simulations. Good timing and position resolution and minimization of transmission loss due to grids were key factors in selecting the final design. Time of flight will be recorded between the two MCPs. The delay line technique will be used for extracting the position information from the MCPs. The energy of the recoils will be recorded by the Si detector. A dedicated vacuum chamber and the modular design of the detection system will facilitate future improvements and customization for particular experiments.

Wenting Lu *Zr-Nb Isobar Separation for the ^{93}Zr AMS Measurement*

AMS detection of the rare isotope ^{93}Zr has application potential in two fields of research: a better determination of the ^{92}Zr(n,γ)^{93}Zr cross section, which is relevant in astrophysical modeling of nucleosynthesis processes, and using this radionuclide as tracer in hydrological and radioactive waste studies. The biggest challenge in measuring ^{93}Zr at natural concentrations is adequate separation from its stable isobar ^{93}Nb. The Nuclear Science Laboratory at the University of Notre Dame is developing the capability to measure ^{93}Zr by AMS. Results are reported of first experiments, featuring the combination of a gas-filled magnet with a position-sensitive Parallel Grid Avalanche Counter and a Gas Ionization chamber in this magnet's focal plane.

Andreas Best *Neutron Background Characterization of Deep Underground Laboratories*

Low-energy (α,n) reactions in stellar helium and carbon burning provide the neutrons for the formation of elements beyond iron by the slow neutron capture process. The very low cross sections at stellar energies necessitate the use of high-efficiency detectors as well as measuring in a very low neutron background environment. By going deep underground the neutron flux can be reduced by orders of magnitude compared to surface levels, enabling the measurement of reactions for nuclear astrophysics at previously inaccessible energies. The remaining neutron flux is mostly due to spontaneous fission of ^{238}U in the cavity walls and (α, n) reactions induced by α-particles from the natural radioactivity of the underground environment. Using a portable setup consisting of 4 ^{3}He counters and polyethylene moderators the DIANA collaboration is conducting neutron background measurements at various deep underground laboratories in the US. We present first results from the Kimballton Underground Research Facility, the Soudan Underground Laboratory and the 4100 feet level of the Sanford Undeground Research Facility (SURF). Measurements at other depths in SURF and at the Waste Isolation Pilot Plant are in planning.

Zbigniew Chajecki *Fission Barriers for Heavy Exotic Nuclei*

Fission barriers for exotic nuclei and the role of fission on the r-process are intimately connected with the density dependence of the symmetry energy at the sub-saturation densities attained in the neck region at the maximum of the fission barrier. In our talk we will present the recently approved experiment to measure the fission cross sections with the Prototype Active Target Time Projection Chamber (PAT-TPC) detector at NSCL. The experiment is aimed to initiate the program at NSCL and later at FRIB to measure the fission barriers of unstable nuclei using radioactive beams. Many other interesting cases can be explored when additional stable beams with $55<Z<82$ become available.

Karen Ostdiek *Complications in the Measurement of the Half-Life of Iron-60*

The half life of Iron-60 is important to many astrophysical processes, including the interpretation of a nearby supernova that could have deposited Iron-60 on Earth several million years ago. However a recent experiment to measure the half-life differs significantly with the previously accepted value. I will discuss our efforts to remeasure the half-life, the complications we have encountered and a new method that we plan to use.

Xiao Fang *Experimental Investigations of Stellar $^{12}C+^{12}C$ Fusion Toward Extremely Low Energies by Direct and Indirect Methods*

The $^{12}C+^{12}C$ fusion reaction taking place in massive stars plays a crucial role during stellar evolution. The astrophysically important energy range, Gamow window, spans roughly from 1 MeV to 3 MeV. However, its cross section has not precisely been determined even numerous works in this topic done, due to extremely low reaction cross section and a mass of background events. To make the measurement at astrophysical interest energies possible, we have developed an efficient thick target method in the center of mass range of 3 to 5.3MeV to study the $^{12}C+^{12}C$ fusion with large area strip silicon detectors. Further measurements at even lower energies will be done with coincidence between a silicon-detector array and a Ge-detector array, coupled with a high-current accelerator being constructed, and a Helios-type solenoid spectrometer has been successfully built using the existing TWINSOL facility at University of Notre Dame. Meanwhile, we are also investigating the $^{24}Mg(\alpha,\alpha')$ reaction using the Grand Raiden Spectrometer at RCNP to search the potential resonances in the $^{12}C+^{12}C$ fusion reaction. Preliminary results from these two approaches will be presented.

Yunju Li *How To Measure the Total Cross Sections for the $^{12}C+^{12}C$ Reaction at Astrophysical Energies?*

The total fusion cross sections of 12C+12C in the energy range of 1 to 3 MeV are important for a number of astrophysical scenarios, such as the explosion of Type Ia supernovae, nucleosynthesis in massive stars and recently discovered superbursts. Since the 1960s, the carbon fusion reaction has been measured intensively at sub-barrier energies via detecting the light charged particles or characteristic gamma-rays. Because of the background and the complication of the decay schemes of the fusion residues, neither method is capable to provide the exact total cross sections. Using the statistical model, the branching ratios between several observable channels and the total fusion cross sections have been predicted. In this talk, I will present the comparison of the predicted branching ratios and the existing experimental data. According to the calculation, we plan to measure both the emitted light particles and several corresponding gamma-rays to obtain the total cross sections for the carbon fusion reaction at astrophysical energies.

Anne Sallaska *STARLIB: A Next-Generation Reaction-Rate Library for Nuclear Astrophysics*

Of the stellar reaction-rate libraries available currently, none include any information on uncertainties. Although estimates have been attempted by some rate evaluations, their uncertainties are generally not based on rigorous statistical definitions. Clearly, a common standard for deriving uncertainties is warranted. STARLIB is a new, next-generation reaction-rate library that addresses this deficiency by providing a tabular, up-to-date database that supplies not only the recommended rate and its factor uncertainty but also the rate distribution (i.e. its probability density function PDF). The foundation of this library rests on an entirely new method for calculating reaction rates: Monte-Carlo simulation, which utilizes experimental nuclear physics quantities as inputs, yields a PDF for the reaction rate at a given temperature[1]. From the cumulative distribution of rate probability densities, the low, median, and high rates are naturally defined. In addition, quantities with upper limits are seamlessly included. This library attempts to bridge the gap between experimental nuclear physics data and stellar modelers by providing a convenient tabular format with reliable uncertainties and PDFs for use in the simulation of astrophysical phenomena. We are currently preparing a paper for publication, and its submission will coincide with the unveiling of a webpage for ease of dissemination and updating.

[1] R. Longland *et al.*, Nucl. Phys., **A841**, 1 (2010).

Pavel Denisenkov *MESA/NuGrid Models of Nova Outbursts and Nucleosynthesis*

I will present the results of our 1D simulations of nova outbursts obtained with the stellar evolution code MESA and post-processing nucleosynthesis tools of NuGrid. We have explored a range of CO and ONe WD masses and accretion rates as well as the effect of different cooling times before the onset of accretion. In addition, we have studied the dependence on the elemental abundance distribution of accreted material and convective boundary mixing at the core-envelope interface. Models with such convective boundary mixing display an enrichment of the accreted envelope with C, O, and Ne from the underlying white dwarf that is commensurate with observations. We compare our results with the previous work and investigate a new scenario for novae with the ^{3}He-triggered convection.

Brian O'Shea *Orbital Properties of a Subset of SEGUE Stars: The Halo Within the Milky Way's Disk*

We examine the chemical and orbital properties of a subset of stars from the Sloan Digital Sky Survey whose three dimensional velocities are well-quantified. This is done by evolving these stars' orbits in several models of the Galactic gravitational potential. We demonstrate that the expected chemodynamical behavior of the major stellar components of the Milky Way (the thin and thick disk, as well as a galactic halo) can be reproduced by a set of purely local stars. Furthermore, stars belonging to all of the stellar components also show phase-space segregation corresponding to orbital resonances, a result that is robust to our choice of potential for the stellar disk. This lends support to the idea, inferred from the metallicity of halo stars, that they were in place before the formation of the Milky Way's disk.

Richard deBoer *Comprehensive Analysis of ^{16}O Compound Nucleus Reactions*

Over the last 60 years, a large amount of experimental nuclear data has been measured for reactions which probe the ^{16}O compound nucleus near the alpha and proton separation energies, the energy regimes most important for nuclear astrophysics. Difficulties and inconsistencies in past analysis of the individual reaction data prompt a more complete global analysis with the first aim of determining the level of consistency between the wide variety of experimental data. The global analysis has been performed using a multiple entrance/exit channel *R*-matrix framework. Over the wide range of experimental data considered, a high level of consistency is found between the many different data sets, resulting in a single consistent *R*-matrix fit which describes the broad level structure of ^{16}O below E_x= 13.5 MeV. The resulting fit is used to re-investigate our current understanding of the reaction components which contribute to the low energy cross sections of ^{15}N + p and ^{12}C + α reactions. Work has begun on establishing a better estimate of the reaction rate uncertainties by performing a Monte Carlo analysis using the many data sets considered.

Matt Bowers *Implications of the ^{33}S(α,p)^{36}Cl Reaction on Early Solar System Production*

Short-lived radionuclides, with half-lives <~ 5 Ma, are known to have been extant in the Early Solar System. These nuclides can be used as fine-tuned chronometers for dating processes during the formation of our Solar System as well as determining their nucleosynthetic origins. Excess ^{36}S measured in carbonaceous chondrite meteorites is interpreted as the result of in-situ decay of extinct ^{36}Cl. It is believed that the 36Cl was not produced in a stellar source but by spallation reactions from a young and active Sun. There is a lack of experimental nuclear cross section data on the important production reactions. We report the results of the measurement of the ^{33}S(α,p)^{36}Cl reaction cross sections and its effect on the production of ^{36}Cl in the Early Solar System.

Yoav Kashiv *A Shorter Measured ^{146}Sm Half-Life and Implications for ^{146}Sm-^{142}Nd Chronology in the Solar System*

The extinct p-process nuclide ^{146}Sm serves as an astrophysical and geochemical chronometer through measurements of isotopic anomalies of its a-decay daughter ^{142}Nd. Based on analyses of ^{146}Sm/^{147}Sm a-activity and atom ratios (the latter measured by AMS at ANL), we determined the half-life of ^{146}Sm to be 68 ± 7 (1 s.d.) million years (My), which is 34% shorter than the currently used value of 103 ± 5 My. The shorter half-life value implies a higher initial ^{146}Sm abundance in the Early Solar System, (^{146}Sm/^{144}Sm)_0 = 0.0094 ± 0.0005 (2 s.d.), than previously estimated, 0.008-0.0085. The time interval between isolation of the Solar Nebula from the ISM and formation of the Solar System is reduced by a factor of 2.5-20 to 5-100 My, depending on model. Terrestrial, lunar, and martian planetary silicate mantle differentiation events dated with the ^{146}Sm-^{142}Nd system converge to a shorter time span and in general to earlier times, due to the combined effect of the new ^{146}Sm half-life and (^{146}Sm/^{144}Sm)$_0$ values.

Ethan Uberseder *First Experimental Constraint on the ^{59}Fe(n,γ)^{60}Fe Reaction via Coulomb Dissociation*

The stellar nucleosynthesis of ^{60}Fe is presently a topic of great interest in nuclear astrophysics. The production of ^{60}Fe, and its subsequent destruction, is attributed to neutron capture reactions in massive stars, with abundances being further modified and ejected during the supernova explosion. Satellite observations of the decay signatures of both ^{26}Al and ^{60}Fe, two isotopes expected to be co-produced in massive stars, have provided a unique constraint on current stellar models. A reliable comparison between observation and theory necessitates well constrained reaction rates. Until recently, the underlying nuclear physics inputs for ^{60}Fe production have been purely based on theory. A recent activation measurement provided the first experimental determination of the destruction reaction ^{60}Fe(n,γ)^{61}Fe, though currently no experimental information exists concerning the production reaction ^{59}Fe(n,γ)^{60}Fe. To address this void, a Coulomb dissociation experiment was performed at GSI in September of 2010 to determine the inverse reaction ^{60}Fe(γ,n)^{59}Fe. The resulting photoneutron cross section provides important information concerning the gamma-ray strength function of ^{60}Fe, which serves as the predominant scaling factor in Hauser-Feshbach calculations of neutron capture. Results of the experiment, as well as new experimentally constrained values for the ^{59}Fe(n,γ)^{60}Fe cross section, will be discussed.

Session 4:

Catherine Deibel *When Stars go BOOM: Explosive Nucleosynthesis*

Many of the heavy elements we see in the Galaxy today were produced in explosive astrophysical environments. These range from relatively common explosions such as classical novae, which produce proton-rich nuclei, to more exotic scenarios that are candidates for the production sites of neutron-rich isotopes produced via the r-process. We will explore the explosive lives of stars, including novae, X-ray bursts, and supernovae, by examining the explosive environments themselves and the resulting nucleosynthesis. There will be a focus on recent experimental progress, much of which is the result of newly available radioactive ion beams that have allowed the study of some of these important reactions for the first time. The current status of our knowledge of explosive nucleosynthesis will be discussed, as well as the on-going questions that face the community and future prospects for addressing those challenges.

Chris Wrede *Nova Nucleosynthesis via Beta-Delayed Gamma Decay at the NSCL*

A classical nova is a thermonuclear runaway on the surface of a white dwarf star that is accreting hydrogen-rich material onto its surface from a binary companion. In order to model the explosion and the resulting nucleosynthesis accurately, it is essential to know the thermonuclear rates of the proton capture reactions involved. Reaction-rate sensitivity studies have revealed that uncertainties in the ^{25}Al(p,γ)^{26}Si and ^{30}P(p,γ)^{31}S reaction rates are among the most influential on nucleosynthesis in novae that occur on oxygen-neon white dwarfs. We have initiated a program at NSCL to study resonances in ^{26}Si and ^{31}S via the beta decays of ^{26}P and ^{31}Cl, respectively. Details of this program will be discussed.

Sergio Almarez-Calderon *The Level Structure of ^{30}S and its Astrophysical Implications*

The level structure of ^{30}S plays a fundamental role in understanding the nucleosynthesis processes of proton-rich nuclei in explosive hydrogen burning scenarios like Novae and X-ray-bursts. The important astrophysical reactions ^{26}Si(α,p)^{29}P and ^{29}P(p,γ)^{30}S are expected to proceed through resonance states in ^{30}S, making the reaction rates very sensitive to the level structure of ^{30}S above the charged particle threshold. In this work we present the results of our study of the level structure of ^{30}S via the ^{28}Si(^{3}He,n) and ^{32}S(p,t) reactions. Important experimental information on the energy levels, decay branching ratios and tentative spin assignments were extracted from the experiments. The correspondent reaction rates were re-evaluated and compared with previous estimates.

Christoph Langer *Experimental Investigations of Important Bottleneck Reactions in the RP-Process*

Along the reaction path of the rapid proton-capture process (rp-process), several bottleneck reactions have been identified. Nuclear structure plays a key role in explaining and determining if a reaction is a bottleneck reaction. This talk will focus on two different experimental approaches that have been used to measure the structure of isotopes in the vicinity of ^{30}S and doubly-magic ^{56}Ni. The nuclear structure of ^{31}Cl was investigated for the first time in an experiment performed at GSI. Using the method of relativistic Coulomb breakup at energies of around 600 AMeV, the energies of two low-lying resonances were extracted. These resonances constrain the rate of the ^{30}S(p,γ)^{31}Cl bottleneck reaction. In a second experiment, the level structure of ^{58}Zn was investigated at NSCL, also for the first time, via population of excited states by a (d,n) reaction. The nuclear structure of ^{58}Zn determines the rate of the ^{57}Cu(p,γ)^{58}Zn reaction, which significantly impacts the light-curve emitted in X-ray bursts and, thus, it is considered to be one of the most important reactions in the rp-process. The experiment was performed with the next-generation gamma-ray tracking device GRETINA in combination with the high-acceptance spectrometer S800. Results from both experiments will be discussed.

Alexander Long *Measurements of Resonance States in ^{30}S and ^{38}Ca Nuclei Using the (p,t) Reaction, and Reaction Rates in the αp-Process*

Thermonuclear runaway reactions in type I X-ray bursts are trigged by the breakout from the hot CNO cycles and are subsequently driven by αp- and rp-processes. These time scales for the αp- and rp-process are determined by the associated reaction rates. High precision (p,t) measurements were preformed to examine resonance states in ^{18}Ne, ^{30}S, and ^{38}Ca nuclei at iThemba Labs using the K600 spectrometer with dispersion matched beam.

Justyna Marganiec *Coulomb Breakup of ^{17}Ne and the ^{15}O(2p,γ)^{17}Ne Cross Section*

The rp-process is linked with the CNO cycle by the α-capture reaction on the ^{15}O nucleus, which is a waiting point. The CNO-break-out reaction ^{15}O(2p,γ)^{17}Ne can be an alternative way to move the initial CNO material towards heavier nuclei and continue with the rp process. The two-proton capture can proceed sequentially or directly from the three-body continuum, which can enhance the reaction rate by a few orders of magnitude (Grigorenko L V, Zhukov M V 2005 Phys. Rev. C 72 015803). The experiment was performed by means of the Coulomb dissociation of 17Ne, at LAND-R3B setup at GSI. This contribution shows first results of this experiment. This project was supported by BMBF, EU (EURONS), and EMMI.

Qian Li *The Cross Section of $^{14}N(p,\gamma)^{15}O$*

^{14}N(p,γ)^{15}O is the slowest process in the CNO cycle, thus it governs the rate of energy generation of the whole cycle. To determine the S-factor more precisely, we measured the excitation function and angular distributions. The result and preliminary R-matrix analysis will be presented.

Stephen Quinn *Cross Section Measurements of (p,γ) Reactions Using the SuN Detector*

The p-nuclei are a group of stable, neutron-deficient isotopes whose production cannot be explained by neutron capture processes. Instead, nucleosynthesis is favored to occur via the p-process, in which high stellar temperatures lead to a series of photodisintegration reactions, their inverse capture reactions, and β^+ decays on existing seed nuclei. Current p-process network calculations do not accurately reproduce the observed abundance pattern of the p-nuclei, particularly for the lightest masses. In an effort to improve our understanding of the nucleosynthesis of the lightest p-nuclei, several (p,γ) reactions were recently measured using the FN Tandem Accelerator at the University of Notre Dame in combination with the NSCL SuN detector. Cross section results at astrophysically relevant energies will be presented and compared with theoretical calculations.

Matthew Mumpower *The Rare Earth Peak: An Overlooked R-Process Diagnostic*

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.

Jorge Pereira *Inferring Nuclear Structure Trends of R-Process Nuclei from Beta-Decay Measurements*

Despite more than half a century of intensive research, the nucleosynthesis of heavy nuclei 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 around N=56.

David Chamulak *Nucleosynthesis from Asymmetrical Explosions in Type Ia Supernovae*

Type Ia supernovae (SNe Ia) are the main distance indicator for cosmological studies and a primary source of the iron peak elements in the solar system. However the progenitor systems for this type of supernovae remain loosely understood. Observational evidence suggests that if a white dwarf explodes in a SN Ia some sort of detonation must take place. Several scenarios have been proposed as to how this detonation may actually occur, but the exact mechanism remains elusive. Using the FLASH code we have performed simulations, in two dimensions, of asymmeteric detonation in white dwarfs. Detailed yields, resulting from the explosive burning of the C/O plasma in these models, are examined using post-processing of tracer particles. The reaction network includes strong as well as electroweak interactions. Results indicate that since the detonation is initiated at a point off center, there is a gradient in abundances across the explosion in regions that did not proceed to a nuclear statistical equilibrium (NSE) composition. Observations of remnants could potentially test for such gradients.

Yeunjin Kim *Detonations in Helium Layers of White Dwarf*

We re-examine the scenario of detonations in helium layers, accreted on carbon-oxygen (CO) cores. Assuming that the outburst occurs on a carbon WD that accretes helium, carbon enrichment can take place if there is dredge up mixing at the bottom of the envelope prior to the ignition of the detonation. Preliminary 1D models show that the helium envelope is indeed unstable to convection about a day before the runaway. We intend to examine this interesting possibility for the mixing process by performing 1D and 2D simulations of the pre runaway evolution.

Rashi Talwar *Stellar Neutron Sources and S-Process in Massive Stars*

Potential stellar neutron sources for the s-process in massive stars are associated with α-capture reactions on light nuclei. The capture-reaction rates provide the reaction flow for the buildup of the neutron sources ^{22}Ne, and ^{26}Mg during the helium-burning phase in stars. A critical influence on these reactions is expected to come from low-energy resonances at stellar energies between 300 keV and 1500 keV. It is possible that these resonances are characterized by a pronounced cluster structure near the α-threshold. Direct measurements of capture reactions to study the cluster structure are handicapped by the Coulomb barrier and limited detector resolutions. Hence, inelastic α-scattering on these nuclei has been used as an alternative tool to probe into the level structure. In reference to this, the experiment performed using the Grand Raiden Spectrometer at RCNP, Osaka will be discussed and preliminary results will be presented.

Poster Session:

Michael Bennett	*Beta Decay of ^{26}P for Classical Nova Studies*
Tony Battaglia	*Setting Up a Conversion Electron Array*
Richard Cyburt	*Metastable Sparticles and the Cosmological ^{7}Li Problem: Medicine for a Bitter Pill*
Juan Manfredi	*α-Decay of Excited States in ^{12}C*
Matt Meixner	*A New Equation of State for Supernovae and Neutron Star Simulations*
Matthew Mumpower	*The Rare Earth Peak: An Overlooked R-Process Diagnostic*
Darshana Patel	*Feasability of Using ^{2}H as a Probe in Studying Iso-Scalar Giant Monopole Resonance (ISGMR) in Unstable Nuclei Using Inverse Kinematics*
Carolyn Peruta	*Limitations in Modeling Galactic Chemical Evolution Due to Uncertainties in Stellar Evolution Calculations*
Sherwood Richers	*A Comparison of Neutrino Approximation Schemes in Core Collapse Supernova Simulations*
Michael Scott	*The Isovector Giant Monopole and the Nuclear Equation of State*
Rachel Showalter	*Isospin Observables from Fragment Energy Spectra*
Mallory Smith	*Decay Spectroscopy of Neutron-Rich ^{109}Ru*
Chris Sullivan	*Calculation of ^{20}Ne Electron Capture Rates, A Progenitor for Core Collapse Supernova*
Claudio Ugalde	*Fluorine Nucleosynthesis and the $^{15}N(\alpha,\gamma)^{19}F$ Reaction*
MacKenzie Warren	*The Impact of Sterile Neutrinos on Core Collapse Supernovae*
Jack Winkelbauer	*Precision Measurement of Isospin Diffusion*

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