JINA-CEE Frontiers in Nuclear Astrophysics 2016 (Mar 28-31)

Tue, Mar 29, 16

8:00-9:00	**Registration & Coffee**
	Session 1: Chair Chris Wrede
9:00	**Opening Remarks**
9:15	**Andrew Davis**: Nuclear Astrophysics with presolar grains
	The isotopic, chemical, and petrologic properties of presolar grains from meteorites provide unique insight into nucleosynthesis in and dust formation around asymptotic giant branch (AGB) stars, core collapse supernovae, and other types of dying stars. Recent progress include Ba and Sr isotopic constraints on the distribution of carbon-13 within the carbon-13 pockets of AGB stars and Fe and Ni isotopic constraints on galactic chemical evolution.
9:45	**Michael Bennett**: ^{31}Cl β-decay and the ^{30}P(p,γ)^{31}S reaction rate in nova nucleosynthesis
	The ^{30}P(p,γ)^{31}S reaction rate is critical for identifying the origin of presolar nova grains [1], modeling the final isotopic abundances of ONe nova nucleosynthesis [2], and calibrating proposed nova thermometers [3]. Unfortunately, this rate is essentially experimentally unconstrained because the strengths of key ^{31}S proton capture resonances are not known, due to uncertainties in their spins and parities. Using a ^{31}Cl beam produced at the National Superconducting Cyclotron Laboratory, we have populated several ^{31}S states for study via beta decay and observed their radiative decay [4]. Based on isospin mixing with the nearby isobaric analog state, we have unambiguously identified a new l = 0, $J^{\pi} = 3/2^{+}$ ^{31}S resonance in the middle of the Gamow Window. Results of the study will be presented and the potential effects of this resonance on the ^{30}P(p,γ)^{31}S reaction rate will be discussed. [1] J. Jose, M. Hernanz, S. Amari, K. Lodders, and E. Zinner, Astrophys. J. 612, 414 (2004). [2] J. Jose and A. Coc, Nucl. Phys. News 15, 17 (2005). [3] L. N. Downen, C. Iliadis, J. Jose, and S. Starrfield, Astrophys. J. 762, 105 (2013). [4] M. B. Bennett et al., Phys. Rev. Lett. (Accepted 2016)
10:00	**Ian Roederer**: New observational constraints from ancient stars on the origins of heavy elements
	Understanding the origin of the elements is one of the major challenges of modern astrophysics. I will quickly highlight new observations of heavy elements in ancient stars that provide new constraints on nucleosynthesis in the earliest generations of stars. (1) The recently-discovered Reticulum 2 dwarf galaxy is unlike any other known galaxy, in that most of its stars contain three orders of magnitude more r-process material than any other low-luminosity galaxy in the Local Group. (2) New ultraviolet spectroscopy from the Hubble Space Telescope (HST) reveals possible evidence (super-solar [As/Ge] ratios, among others) for operation of the intermediate neutron-capture process (i-process) in massive stars, super-AGB stars, or low-mass AGB stars in the early Galaxy. (3) Other new observations from HST reveal new opportunities to detect phosphorus, sulfur, and zinc---elements never before detected in carbon-enhanced stars with [Fe/H] < -3.8 that may have formed from the remnants of Pop III stars. The constraints derived from these observations are central to the mission of JINA-CEE, and I am actively seeking new opportunities for collaboration in the nuclear astrophysics community.
10:15	**Iris Dillmann**: The nuclear astrophysics program at TRIUMF
	The present Nuclear Astrophysics program at TRIUMF includes the long-standing DRAGON and TUDA setups for reaction rate measurement, the TITAN Penning trap for mass measurements, and since last year also the GRIFFIN spectrometer and its auxiliary detectors for decay spectroscopy. The new EMMA recoil spectrometer is presently under construction. I will give an overview about the present and future experimental program at these facilities, and close with a look to RIKEN where the BRIKEN neutron detection setup will start to measure the beta-delayed neutron emission probabilities and half-lives of almost 100 isotopes in late 2016.
10:30-11:00	**Coffee Break**
	Session 2: Chair Brian Fields
11:00	**Terese Hansen**: Recent observational results for metal poor stars
	The first heavy elements beyond hydrogen and helium were produced by the first generations of stars to form in the Universe. These presumably massive stars, with main-sequence lifetimes of a few million years, died in supernovae explosions and can no longer be directly observed. What can be observed are the low-mass stars that formed from the gas clouds these supernovae enriched with their ejecta. These extremely ([Fe/H] < -3), ultra ([Fe/H] < -4), and hyper ([Fe/H] < -5) metal-poor stars provide a fossil record of the chemical composition of the Galaxy at the time and place of their birth. High-resolution spectroscopic observations of large samples of such stars have been analyzed in the past decades, in an effort to disentangle the chemical fingerprints of the different nucleosynthesis pathways in operation at the earliest times, such as hydrostatic burning, explosive nucleosynthesis, and neutron-capture processes. I will present a review of the recent observational results for metal-poor stars, including results from long-term radial-velocity monitoring of highly r-process-element- enhanced (r-II) stars and carbon-enhanced metal-poor (CEMP) stars with and without neutron-capture over- abundances (CEMP-s and CEMP-no stars), the discovery of numerous r-II stars in the ultra faint dwarf galaxy Recticulum II, the bimodal distribution of absolute carbon abundances among CEMP stars, and evidence for neutron-capture element production at the earliest times in our Galaxy.

11:30	**Rana Ezzeddine**: Iron abundance analysis of ultra-metal poor stars using non-LTE
	Iron abundance plays a vital role in all stellar spectroscopic studies. It is usually used as a proxy for the total metal content, due to its wealth of lines in most stellar spectra. Additionally, excitation equilibrium of FeI lines and ionization equilibrium between FeI and FeII lines is commonly used to determine the fundamental atmospheric parameters of the star. Hence accurate modelling of iron spectral lines is required to ensure an accurate characterization of the star as well as accurate chemical abundance measurements of elements other than iron. We present line-by-line non-LTE iron abundance determination for a sample of ultra metal-poor stars, using a new complete iron model atom that we built with the most up-to-date atomic data. Our results show a better agreement between FeI and FeII abundances for a chosen set of stellar parameters and a much less scatter of Fe abundances vs excitation potential than LTE values. This re-confirms the increasing need for using non-LTE spectral line synthesis in all future stellar spectroscopic studies.
11:45	**Falk Herwig**: Observations, simulations, and nuclear physics of the i-process
	I will review our present knowledge of the i-process. The I process is a neutron capture process with neutron densities of $\sim 10^{15}$cm^{-3}, in-between that of s- and r-process conditions. Possible observational manifestations have been identified in pre-solar grains, open clusters, CEMP-stars and post-AGB stars. Stellar production sites include mixing of H into He-shell flash convection zones in low-Z AGB and super-AGB stars, post-AGB stars and rapidly accreting white dwarfs as well as possibly some massive stars. Important aspects of the i-process nucleosynthesis can be studied in simple one-zone simulations and slightly more sophisticated 1D multi-zone simulations. I will discuss how recent 3D hydrodynamic simulations have shown that the astrophysical site of H- ingestion into He-convection zones defies the assumptions of conventional 1D stellar evolution simulations. Clearly more sophisticated nucleosynthesis simulation methods are needed, and are presently developed. Finally, i-process yields may be of importance on a galactic chemical evolution scale. To understand the i-process quantitatively better emerges as an important ingredient of a holistic approach to the question of how the elements rise in the early universe. The i-process proceeds very close to yet parallel to the valley of stability, which poses numerous nuclear physics challenges that may be addressed with unstable beam facilities.
12:00	**Paul Woodward:** 3D simulation of hydrogen ingestion in a very low metallicity AGB star, a potential site for i-process nucleosynthesis
	I will report on recent simulations with Stou Sandalski at Minnesota and Falk Herwig's team at the University of Victoria carried out on the Blue Waters machine at NCSA. These new simulations focus on an AGB star of the early universe, in contrast to the very late thermal pulse star, Sakurai's object, that I reported on last year. This new case has a lower driving luminosity and a larger convection zone above the helium burning shell than we find in Sakurai's object. Nevertheless, we expect the burning of hydrogen entrained into this convection zone to be a site for the i-process. The differences from the case of Sakurai's object make this simulation more challenging. Techniques that we are using to address the new computational challenges will be presented. Our simulation results show large deviations from 1-D behavior leading to burning of the ingested hydrogen-rich gas in a sequence of increasingly violent events. We have captured the flow at about 2000 time levels on a grid that is well resolved in radius but with only 80 triangular cells tessellating the sphere in the two angular dimensions. This data will be used to determine from a 3-D analysis the nucleosynthetic signature of such a hydrogen ingestion event in an AGB star of the early universe.
12:15	**Brian O'Shea:** Modelling galactic chemical evolution in a cosmological context
	In this talk, I will present results from recent efforts by the JINA galactic chemical evolution collaboration to develop chemical evolution models that take into account the dynamic nature of galaxy formation. A galaxy like the Milky Way is built by the merging together of generation after generation of galaxies -- many thousands of progenitors in total, each of which has its own unique properties, and the traces of these ancestors can be seen in the chemical abundances observed in stars in our Galaxy. Our theoretical framework combines cosmological simulations of galaxy formation, models of stellar evolution, and statistical techniques to compare to modern stellar surveys such as SEGUE, APOGEE, and Gaia-ESO. I will highlight some recent results, make connections to other projects going on within JINA (particularly nuclear experiments and astronomical observations) and talk about the capabilities of this framework and our plans for the future.
12:30-14:00	**Lunch buffet**
	Session 3: Chair Ed Brown
14:00	**Sebastian George**: Nuclear astrophysics with rings and traps
	Storage rings were primarily developed for the field of high-energy physics, while ion traps were first employed in atomic and molecular physics. Nowadays both of them are key instrumentations of nuclear astrophysics when connected to a radioactive ion beam facility. Their long storage times are perfectly suited conducting lifetime measurements as well as performing precision mass spectroscopy on astrophysical relevant nuclei and their long-lived isomers. The experimental capabilities have been successively extended to in-ring reaction studies in a quasi background-free environment. State of the art experiments and future perspectives will be discussed.
14:30	**Alex Deibel:** New Urca cooling pairs in the neutron star ocean and their effect on superbursts
	In a low-mass X-ray binary, low-level accretion onto the neutron star primary may trigger a superburst in the neutron star's ocean. Superbursts are long and energetic X-ray bursts thought to be powered by the unstable ignition of carbon approximately 100 meters below the surface. Recent reaction network calculations of nuclear burning on accreting neutron stars find that electron-capture/beta-decay cycling ``Urca" pairs are robustly produced in X-ray burst and superburst nuclear burning. When compressed deeper into the star by further accretion, Urca pairs in the neutron star's ocean and crust cool the interior through powerful neutrino emission. We find that Urca cooling pairs lower the ocean's steady state temperature in accreting neutron stars and unstable carbon ignition must occur deeper than it would in the absence of Urca pairs. In this presentation, we will discuss the newly identified Urca pairs in the neutron star's ocean and the observational consequences of Urca cooling on superbursts.
14:45	**Alessandro Roggero**: Thermal conductivity in the neutron star crust
	In this talk I will present our recent results for the thermal conductivity of electrons in the strongly-correlated multi-component plasma expected in the outer layers of neutron stars, using Path Integral Monte Carlo (PIMC) techniques, where we find an increased scattering rate compared to earlier calculations based on simple electron-impurity scattering. These findings directly impact our interpretation of thermal relaxation observed in accreting neutron stars.

15:00	**Chris Sullivan**: The sensitivity of core-collapse supernovae to nuclear electron capture
	An open source weak-rate library aimed at investigating the sensitivity of astrophysical environments to variations of electron-capture (EC) rates on medium-heavy nuclei has been developed. With this library, the sensitivity of the core-collapse and early post-bounce phases of core-collapse supernovae (CCSNe) to nuclear EC was examined. The EC rates were adjusted by factors consistent with uncertainties indicated by comparing theoretical rates to those deduced from charge-exchange and β-decay measurements. To ensure a model- independent assessment, sensitivity studies across a comprehensive set of progenitors and equations of state were performed. Variations of the protoneutron star inner-core mass and peak electron-neutrino luminosities were observed to be 5 times larger when varying the EC rates than what is observed when fixing the rates and utilizing a wide array of progenitor models. Furthermore, the simulations were found to be particularly sensitive to the reduction in rates for neutron-rich nuclei near the N = 50 closed neutron shell. As measurements for medium-heavy (A>65) and neutron-rich nuclei are sparse, and because accurate theoretical models that account for nuclear structure considerations of individual nuclei are not readily available, rates for these species may be overestimated. In this talk, I will describe the impact this overestimate may have to the core-collapse trajectory, the detailed sensitivity of the core-collapse and bounce phases of CCSNe to EC rates, and I will suggest specific areas of focus for future experimental and theoretical efforts.
15:15	**Caroline Robin**: Nuclear Response theory for spin-isospin excitations in a relativistic framework
	Nuclear spin-isospin response theory has various applications extending across the fields of nuclear structure and nuclear astrophysics. A precise description of such modes of excitation is needed to compute rates of weak interaction processes such as beta-decay, neutrino scattering or electron capture, which are important for astrophysical modeling. In this talk we present a theoretical approach to nuclear charge-exchange response. It is based on the relativistic Lagrangian that explicitly includes effective meson degrees of freedom to describe the static nucleon-nucleon interaction. At the same time, emergent collective phenomena are quantified consistently by means of an additional energy-dependent interaction induced by the nuclear medium polarization. Pion-nucleon interaction is considered with the free-space coupling constant [1,2]. The recent developments introduce pairing correlations of the superfluid type, which are needed for a correct description of open-shell nuclei. New results of calculations for Gamow-Teller resonances in medium-mass nuclei will be presented and discussed. [1] T. Marketin, E. Litvinova, D. Vretenar, P. Ring, Phys. Lett. B 706, 477 (2012). [2] E. Litvinova, B.A. Brown, D.-L. Fang, T. Marketin, R. G. T. Zegers, Phys. Lett. B 730, 307 (2014).
15:30	**Evan Scannapieco**: Modelling the pollution of pristine gas in the early universe
	The properties of Population III (Pop III) stars are thought to be very different than those of later stellar generations, because cooling is dramatically different in a media with metallicities below a critical value, Z_c. As Z_c is very small, the mixing efficiency of metals plays a crucial role in determining the Pop III transition. I will describe a comprehensive theoretical and numerical investigation of the pollution of pristine gas in turbulent flows. Our data show that the evolution of the pristine fraction of gas with $Z<Z_c$ can be well approximated by a ``self-convolution" model, with two free parameters. Carrying out a suite of numerical simulations, we are able to provide accurate fits to these parameters as a function of Mach number and the ratio between the critical metallicity and the average metallicity in the flow. I will show how these results can be used to construct subgrid models for tracking the evolution of the first stars in large cosmological numerical simulations.
15:45	**Tsung-Han Yeh**: Primordial deuterium predictions cry out for an updated $d(p,\gamma)^3He$ rate
	Big-bang nucleosynthesis (BBN) describes the dynamic interplay among lightest nuclides during early minutes of the Universe. Standard BBN has a single free parameter: the cosmic baryon density, now measured with high precision via observations of the cosmic microwave background. Using the 2015 results from Planck, we present precise BBN predictions of primordial light element abundances. The concordance between the BBN abundance predictions and astronomical observations of helium-4 and deuterium ensures the non-trivial success of the hot big-bang cosmology and probes non-standard physics scenarios. However, while the high-redshift deuterium abundance is observed with 1.6% uncertainty, we show that the theoretical uncertainty is ~5% (1σ variance), the dominant part of which comes from the uncertainty of empirical $d(p,\gamma)^3He$ rate. Moreover, the experimental data at the BBN energy range (especially 50~200 keV) are sparse and dated. Consequently, some recent studies instead adopted theoretical ab initio calculations for the crucial $d(p,\gamma)^3He$ rate. We will show that the theoretical versus experimental rate data lead to significant discrepancies in the deuterium abundance, with important implications for BBN. To settle this controversy, new and reliable $d(p,\gamma)^3He$ measurements around 100 keV are essential.
16:00-16:30	**Coffee Break**
16:30-18:00	**Poster Session (beer/wine & hors d'oeuvre)**
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8:00-9:00	**Coffee**
	Session 4: Chair Jason Clark
9:00	**Brian Grefenstette**: Nuclear astrophysics with NuSTAR: Bringing the high energy sky into focus
	Understanding the origin of supernova explosions remains one of the outstanding problems in astrophysics. This is true of both explosions resulting from the collapse of a massive star as well as the thermonuclear explosions (Type Ia) that are commonly used as "standard candles" in cosmology. X-ray and gamma-rays produced promptly during these explosions as well as those produced in the decay of radioactive elements found in supernova remnants can be used to study the energetics of the explosion. I will provide an overview of recent high energy X-ray observations of supernovae and supernova remnants using the Nuclear Spectroscopic Telescope Array (NuSTAR). The NuSTAR Small Explorer (SMEX) mission, launched June 13, 2012, is the first focusing high-energy X-ray telescope in orbit. Covering the hard X-ray band from 3–79 keV, NuSTAR provides more than a 100-fold improvement in sensitivity, more than a 10-fold improvement in angular resolution and source positioning capability, and significantly improved spectral resolution compared to previous instruments that have operated in this band. This has enabled a unique set of observation tools for studying supernovae and the ejecta left behind by the explosions. I will review recent results from NuSTAR and place them in the context of theoretical models.

9:30	**Xilu Wang**: Fermi and Swift as supernova alarms: Alert, localization, and diagnosis of future galactic Type-Ia explosions
	A Galactic SNIa event could go entirely unnoticed to us due to the large optical and near-IR extinction in the Milky Way plane, low radio and X-ray luminosities, and a weak neutrino signal. But the recent SN2014J confirms that Type Ia supernovae emit nuclear γ-ray lines, from the ^{56}Ni → ^{56}Co → ^{56}Fe radioactive decay. The energy released in these decays powers the SNIa UVOIR light curve at times after ~1 week, leading to an exponential decline. Importantly for Swift and Fermi, these decays are accompanied by γ-ray line emission, with distinct series of lines for both the ^{56}Ni and ^{56}Co decays, spanning 158 keV to 2.6 MeV. These lines are squarely within the Fermi GBM energy range and ^{56}Ni 158 keV line emission occurs within the Swift BAT energy range. The Galaxy is optically thin to γ-rays, so the SN line flux will suffer negligible extinction. Both GBM and BAT have continuous and nearly all-sky coverage. Thus GBM and BAT are ideal to serve as Galactic SNIa monitors and early warning systems. To illustrate the GBM and BAT capabilities, we use a simple model for SNIa γ-ray emission and transfer to estimate MeV light curves and spectra. Our work is constrained and calibrated by SN2014J MeV data, which suggest ~10% of the ^{56}Ni is in an optically thin shell surrounding the rest of the initially opaque ejecta. We show that the supernova signal emerges as distinct from the GBM background within days after the explosion in the SN2014J shell model. Therefore, if a Galactic SNIa were to explode, there are two possibilities of confirming and sounding the alert: 1) Swift BAT discovers the SNIa first and localizes it within arcminutes; 2) Fermi GBM finds the SNIa first and localizes it to within ~1 degree, using the Earth occultation technique, followed up by BAT to localize it within arcminutes. After the alert of either BAT or GBM, Swift localizes it to take spectra in optical, UV, soft and hard X-rays simultaneously with both XRT and UVOT instruments.
9:45	**Karen Ostdiek:** First half-life measurement of ^{60}Fe using the direct decay of ^{60m}Co and accelerator mass spectrometry
	Radioisotopes, produced in stars and ejected through core collapse supernovae (SNe), are important for constraining stellar and early Solar System (ESS) models. The presence of these isotopes, specifically ^{60}Fe, can identify progenitors of SN types, give evidence for nearby SNe, and can be a chronometer for ESS events. The ^{60}Fe half-life, which has been in dispute in recent years, can have an impact on calculations for the timing for ESS events, the distance to nearby SN, and the brightness of individual, non-steady state ^{60}Fe gamma ray sources in the Galaxy. To measure such a long half life, one needs to simultaneously determine the number of atoms in and the activity of an ^{60}Fe sample. We have undertaken a half-life measurement at Notre Dame and have successfully measured the activity of our ^{60}Fe sample using the isomeric decay in ^{60}Co rather than the traditional ^{60}Co grow-in decay. This will then be coupled with the results of the ^{60}Fe concentration measurement of our sample using Accelerator Mass Spectrometry (AMS). I will present the most recent results of both the activity and the AMS measurements.
10:00	**Olga Liliana Caballero**: Neutrino emission from neutron star mergers with microscopical equations of state
	Neutron-star mergers are interesting for several reasons: they are proposed as the progenitors of short gamma-ray bursts, they have been speculated to be a site for the synthesis of heavy elements, and they emit gravitational waves possibly detectable at terrestrial facilities. The understanding of the merger process, from the pre-merger stage to the final compact object-accreting system involves detailed knowledge of numerical relativity and nuclear physics. In particular, key ingredients for the evolution of the merger are neutrino physics and the matter equation of state. We present some aspects of neutrino emission from binary neutron star mergers showing the impact that the equation of state has on neutrinos and discuss some spectral quantities relevant to their detection such as energies and luminosities far from the source.
10:15	**Daniel Robertson**: The CASPAR facility for underground nuclear astrophysics
	The drive of low-energy nuclear astrophysics laboratories is to study the reactions of importance to stellar burning processes and elemental production through stellar nucleosynthesis, over the energy range of astrophysical interest. As laboratory measurements approach the stellar burning window, the rapid drop off of cross-sections is a significant barrier and drives the need to lower background interference. The natural background suppression of underground accelerator facilities enables the extension of current experimental data to lower energies. An example of such reactions of interest are those thought to be sources of neutrons for the s-process, the major production mechanism for elements above the iron peak. The reactions ^{13}C(α,n)^{16}O and ^{22}Ne(α,n)^{25}Mg are the proposed initial focus of the new nuclear astrophysics accelerator laboratory (CASPAR) currently under construction at the Sanford Underground Research Facility, Lead, SD.
10:30-11:00	**Coffee Break**
	Session 5: Chair Carla Fröhlich
11:00	**Almudena Arcones**: Nucleosynthesis in supernovae and neutron star mergers
	Where in the universe are heavy elements synthesized? The favored candidates are core-collapse supernovae and neutron star mergers where extreme conditions enable the rapid neutron capture process (r-process). Recent advances in hydrodynamic simulations with improved microphysics can be combined with observations of the oldest stars to bring new insights about the astrophysical sites where heavy elements are produced. In nuclear physics, a new era for extreme neutron-rich isotopes is starting with new facilities world wide. Nucleosynthesis in core-collapse supernovae and neutrino-driven winds produces elements up to silver. While neutron star mergers present an exciting possibility for the production of all r-process elements (from the first to the third peak). Moreover, the radioactive decay of neutron-rich nuclei triggers an electromagnetic signal in mergers known as kilonova. This was potentially observed in 2013 after a short gamma ray burst, associated with a neutron star merger. Only by combining nuclear physics experiment and theory, with long-time simulations of supernovae and neutron star mergers, will we be able to understand the origin of heavy elements.
11:30	**Jorge Pereira**: Theoretical uncertainty of (α,n) reaction rates relevant for the nucleosynthesis of heavy elements in neutrino-drive winds
	Neutrino-driven winds from nascent neutron stars following Supernovae explosions have been proposed as a possible source of "light" r elements (from Sr through Ag with A~88-110). In these events, (α,n) reactions involved in the so-called α-process are key to move matter beyond the iron group towards the region of heavier proton number. We have investigated the theoretical uncertainty of calculated reaction rates for the most relevant (α,n) reactions in the α-process. We will discuss the most important sources of uncertainty, including those arising from nuclear-physics inputs and from technical aspects of the reaction codes.

11:45	**Anna Frebel**: A single prolific r-process event preserved in an ultra-faint dwarf galaxy
	The heaviest elements in the periodic table are synthesized through the r-process, but the astrophysical site for r-process nucleosynthesis is still unknown. The major current candidates are ordinary core-collapse supernovae and neutron star mergers. Ancient, metal-poor ultra-faint dwarf galaxies contain a simple fossil record of early chemical enrichment that provides the means to study clean signatures of nucleosynthesis events, and thus, can yield unique information on the origin of these processes. Previously, extremely low levels of neutron- capture elements were found in the metal-poor stars in ultra-faint dwarf galaxies which supported supernovae as the r-process site. Based on Magellan/MIKE high-resolution spectroscopy, we have determined chemical abundances of nine stars in the recently discovered ultra-faint dwarf Reticulum II. Seven stars display extremely enhanced r-process abundances, comparable only to the most extreme r-process enhanced metal-poor stars found in the Milky Way's halo. The enhancement is also 2-3 orders of magnitude higher than that of stars in any of the other ultra-faint dwarfs. This implies the neutron-capture r-process material in Reticulum II was synthesized in a single prolific event that is incompatible with r-process yields from ordinary core-collapse supernovae but consistent with that of a neutron star merger. This would be the first signature of a neutron star merger in the early universe which holds the key to finally identifying the r-process production site. Furthermore, such a single r-process event is a uniquely stringent constraint on the metal mixing and star formation history of this ultra-faint dwarf galaxy. (accepted for publication in Nature, http://arxiv.org/abs/1512.01558)
12:00	**Grant Matthews**: In search of the site for r-process nucleosynthesis
	It has been known for more than half a century that about half of the elements heavier than iron are produced via rapid neutron capture in the r-process. Indeed, the basic physical conditions for the r-process are well constrained by simple nuclear physics. In spite of this simplicity, however, the unambiguous identification of the site for the r-process nucleosynthesis has remained elusive. Parametrically, one can divide current models for the r-process into three scenarios roughly characterized by the number of neutron captures per seed nucleus (n/s). This parameter, in turn is the consequence of a variety of conditions such as time-scale, baryon density, average charge per baryon, and entropy. In this talk we summarize various proposed sites for the r- process along with their short comings. Insight from a variety of nuclear physics measurements and astronomical observations is summarized. A paradigm is proposed whereby one may be able to quantify the relative contributions of each astrophysical site.
12:15	**Farheen Naqvi**: First total-absorption spectroscopy measurement on the neutron-rich Cu isotopes
	The first β-decay studies of the isotope ^{74}Cu using the Total Absorption Spectroscopy (TAS) technique will be reported. The β-decay properties of neutron-rich nuclei are one of the essential nuclear physics inputs required to simulate and understand the astrophysical r process. The region around ^{74}Cu is identified in sensitivity studies as playing an important role in weak r process and influencing the A = 80 abundance peak. Comparing the β-decay strength distributions in the daughter Zn will provide a stringent constraint to the theoretical models used in astrophysical calculations. The Cu isotopes are also good candidates to probe the single-particle structure in the region because they have one proton outside the Z = 28 shell. The experiment was performed at the National Superconducting Cyclotron Laboratory (NSCL) employing the TAS technique with the Summing NaI(Tl) detector, while β electrons were measured in the NSCL beta-counting system. The experimentally obtained total absorption spectra for ^{74}Cu will be presented and the implications of the extracted beta- feeding intensities will be discussed.
12:30-14:00	**Lunch buffet**
	Session 6: Chair Pavel Denisenkov
14:00	**Alexander Heger**: Recent advances in X-ray burst modelling
	Type I X-Ray bursts (XRBs) occur on the surface of accreting neutron stars in binary star systems. They have typical recurrence times of hours to days for the most common variety, but there are also intermediate- duration bursts and superburst with recurrence times of the order of years. The bursts, their nuclear reactions, and their nuclear physics in general are a very rich topic. In the regular type hydrogen-rich bursts, both the αp- and rp-process occur. They are hence sensitive to nuclei far from the line of stability, as they can be made with new and upcoming facilities such as FRIB. Unlike production of exotic nuclei in massive stars, supernovae, and binary neutron star mergers, the exotic nuclei play a key role in the energetics of the bursts and their observable light curves. Therefore, our understanding and modelling of these bursts depends on accurate experimental and nuclear determination of the nuclear reaction rates involving these nuclei. I will give an overview on X-ray burst simulations with special focus on time-dependent mulit-zone models and of the different outcomes based on a range of astrophysical model parameters such as accretion rates and accretion compositors, and sensitivity to nuclear reaction rate uncertainties. The results are based on a large grid of models compiled over the years. This is complemented by targeted studies for specific regimes and input physics parameters, such as heating and nuclear reaction rates.
14:30	**Yang Sun**: Shell-model study of isospin-symmetry breaking and the impact in the rp-process
	Isospin is a fundamental concept in particle and nuclear physics. In nuclei, the Coulomb force and other isospin non-conserving (INC) forces break both charge symmetry and charge independence. The Coulomb displacement energy (CDE) is a measure of charge-symmetry breaking while the triplet displacement energy (TDE) is regarded as a measure of breaking in charge independence. We show that the characteristic behavior of CDE and TDE can be reproduced if the INC nuclear force with J = 0 and T = 1 are introduced into large-scale shell model calculations [1]. Theoretical one- and two-proton separation energies are predicted for mirror nuclei with masses A = 42-95, and locations of the proton drip-line can thereby be suggested. Mirror energy differences (MED) and triplet energy differences (TED) in the T = 1 analogue states are other probes of isospin-symmetry breaking. Experimental data for excited states in mirror nuclei are valuable information [2,3]. We show that the INC nuclear forces have significant effect also on MED and TED in the upper fp-shell [4]. There are indications that isospin-symmetry breaking in CDE-TDE for masses and MED-TED for excited states may have the same origin. Possible impact of isospin-symmetry breaking on the rp-process nucleosynthesis is discussed. This work is collaborated with K. Kaneko, T. Mizusaki, and S. Tazaki. Research at SJTU is supported by the National Natural Science Foundation of China (No. 11135005) and by the 973 Program of China (No. 2013CB834401). References: [1] K. Kaneko, Y. Sun, T. Mizusaki, S. Tazaki, Phys. Rev. Lett. 110 (2013) 172505 [2] P. Ruotsalainen et al., Phys. Rev. C 88 (2013) 041308(R) [3] P. J. Davies et al., Phys. Rev. Lett. 111 (2013) 072501. [4] K. Kaneko, Y. Sun, T. Mizusaki, S. Tazaki, Phys. Rev. C 89 (2014) 031302(R)

14:45	**Melina Avila**: Measuring key α-induced reaction rates with the MUSIC detector
	Understanding stellar evolution is one of the primary objectives of nuclear astrophysics. Reaction rates involving α-particles are often key nuclear physics inputs in stellar models. For instance, there are numerous (α,p) reactions fundamental for the understanding of X-ray bursts and the production of ^{44}Ti in core-collapse supernovae. Furthermore, some (α,n) reactions are considered as one of the main neutron sources in the s- process. However, direct measurements of these reactions at relevant astrophysical energies are experimentally challenging because of their small cross section and intensity limitation of radioactive beams. The active target system MUSIC offers a unique opportunity to study (α,p) and (α,n) reactions because its segmented anode allows the investigation of a large energy range in the excitation function with a single measurement. Recent results on the direct measurement of (α,n) and (α,p) measurements in the MUSIC detector will be discussed. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under contract number DE-AC02-06CH11357. This research used resources of ANL's ATLAS facility, which is a DOE Office of Science User Facility.
15:00-18:00	**Unconference (coffee)**
18:00-20:00	**Conference banquet (beer/wine)**
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8:00-9:00	**Coffee**
	Session 7: Chair Remco Zegers
9:00	**Hye Young Lee:** Neutron-induced reaction studies at Los Alamos Neutron Science center for improving nuclear data in astrophysics
	Available experimental nuclear inputs used in nucleosynthesis network calculations are limited to the accessible measurements of stable or radioactive nuclei, leaving thousands of reactions that rely on theoretically predicted reaction rates. The Hauser-Feshbach (HF) formalism is widely used to predict these reaction rates, however difficulties like renormalizations of calculated (n,γ) cross sections to experimental data or shape disagreements of (n,p) cross sections below 6 MeV among different HF codes have arisen. At Los Alamos Neutron Science Center (LANSCE), where neutrons are produced in the energy range of thermal energies to several hundreds of MeV, the direct measurement capability of neutron-induced charged particle reactions using the LENZ instrument (Low Energy NZ) has been developed to investigate (n,p) and (n,α) cross sections in close comparison with the Monte Carlo HF calculation, CoH. We also explored the total cross section measurement capability for providing nuclear structure information, which can be complementary to other direct measurements near charged-particle thresholds. I will present the progress of these ongoing projects at LANSCE for the interest of nuclear astrophysics.
9:30	**Yong-Zhong Qian**: Neutrinos and Nucleosynthesis
	I will review the roles of neutrinos in nucleosynthesis from the big bang to supernovae and neutron star mergers. The importance of neutrino oscillations and other nuclear input will be highlighted. Implications for observations will be discussed.
9:45	**Maxime Brodeur**: High precision mass measurements for nuclear astrophysics
	I will discuss about the importance of high precision mass measurements for nuclear astrophysics, more specifically for explosive nucleosynthesis process. I will present recent and future development that will allow to extend our reach towards more exotic nuclei of relevance to the rapid neutron capture process.
10:00	**Robert Andrassy**: 3D hydrodynamic simulations of O-shell convection
	I am reporting on our team's progress in investigating fundamental properties of convective shells in the deep stellar interior during advanced stages of stellar evolution. We have performed a series of 3D hydrodynamic simulations in 4pi spherical geometry of convection in conditions similar to those in the O-shell burning phase of massive stars. We focus on characterizing the convective boundary and the mixing of material across this boundary. Results from 768^3 and 1536^3 grids are encouragingly similar (typically within 20%). Several global quantities, including the rate of mass entrainment at the convective boundary and the driving luminosity, are related by scaling laws. We characterize the fluctuations of quantities such as the velocities in the simulations and investigate the effect of several of our assumptions, including the treatment of nuclear burning that drives the convection as well as that of entrained material from above the convection zone. The latter has potentially important implications for pre-supernova nucleosynthesis.
10:15	**Michael Deaton**: The matter neutrino resonance around black hole accretion disks
	We are studying neutrino flavor transformations in typical neutron star merger environments. Here the high neutrino densities and geometric effects of the disk introduce transformation behaviors qualitatively different from those seen in supernovae. Discovered in thin disk models assuming flat space, the matter neutrino resonance (MNR) may behave differently around thick disks, or in the strongly-curved spacetime near a black hole. I'll present what we have learned about the MNR using a phenomenological model motivated by hydrodynamical simulations of post-merger disks around a black hole.
10:30-11:00	**Coffee Break**
	Session 8 : Chair
11:00	5min summaries from approx. 10 Unconference breakout groups
11:50	**Closing remarks**
	End of Conference