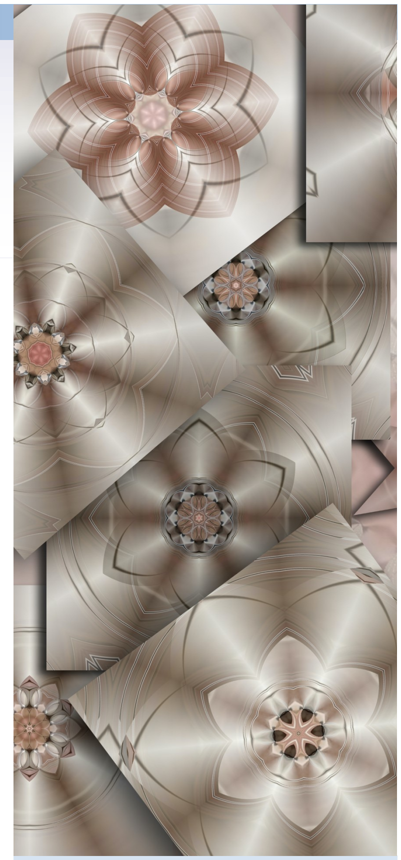
December 2020

JINA-CEE

Center for the Evolution of the Elements



A note from the Director, Hendrik Schatz

Dear Members of the JINA-CEE Community and Friends,

After a year where many in our community faced personal and professional challenges, the new year is a good opportunity to look forward towards a bright future. In that vein I hope you were able to attend the large virtual JINA-Horizons Conference we organized in December (see article in this newsletter). I certainly very much enjoyed the science and the informal interactions facilitated by virtual coffee breaks. It is clear that these are extraordinarily exciting times in nuclear astrophysics with a unique confluence of new rare isotope accelerator facilities, new deep underground accelerator laboratories, the ability to detect gravitational waves, new capabilities in astronomical observations and analysis of stardust, and advances in computation enabling unprecedented multi-D models of astrophysical environments. I was particularly struck with the large number of young scientists participating, giving overview talks, and taking on leadership roles in working groups. This bodes well for the future of our field.

It is good to see the close interactions and connections between these various subfields fostered by JINA, JINA-CEE and IReNA to come to fruition. In light of the tremendous future science and discovery opportunities, it is now more important than ever to keep our momentum and actively maintain, adapt, and expand these interdisciplinary connections as our field is rapidly evolving, driven by new capabilities and discoveries. In particular, I invite and encourage you to actively participate in JINA-CEE and IReNA events and activities, and continue to help us advocate for continued support.

As we move forward, we need to remain mindful of and continue to actively address the ongoing challenges related to equity, inclusion, and diversity. In that context I would like to remind you again of the new code of conduct we developed for JINA-CEE and IReNA collaborators and participants.

Inside this issue

Image credit: Christine Hampton

Supernova Light Curves and Spectra: Results from a Novel Modeling Pipeline

Contributed by Carla Fröhlich and Sanjana Curtis (North Carolina State University, USA)

Core-collapse supernovae are the explosive death of massive stars. The explosion that follows the gravitational collapse of these stars is an energetic event which we can observe with telescopes. These supernovae are also an important site for the synthesis of a range of chemical elements and they play an important role in the evolution of galaxies.

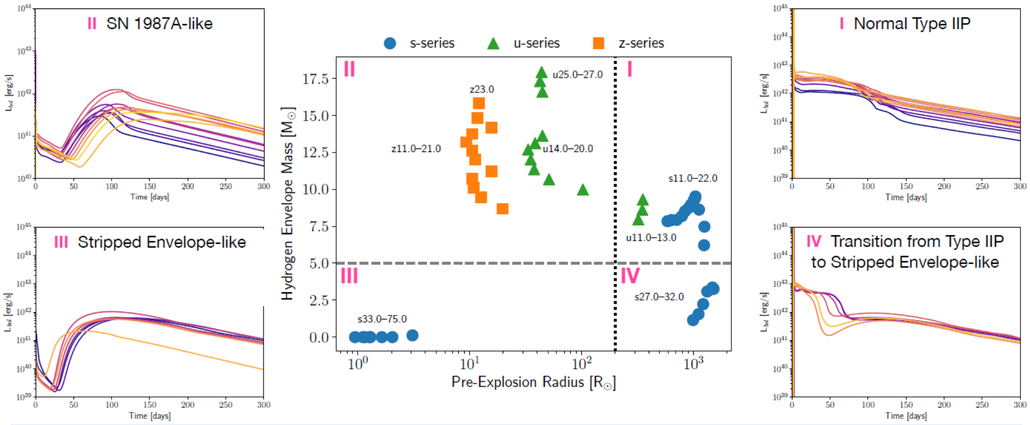
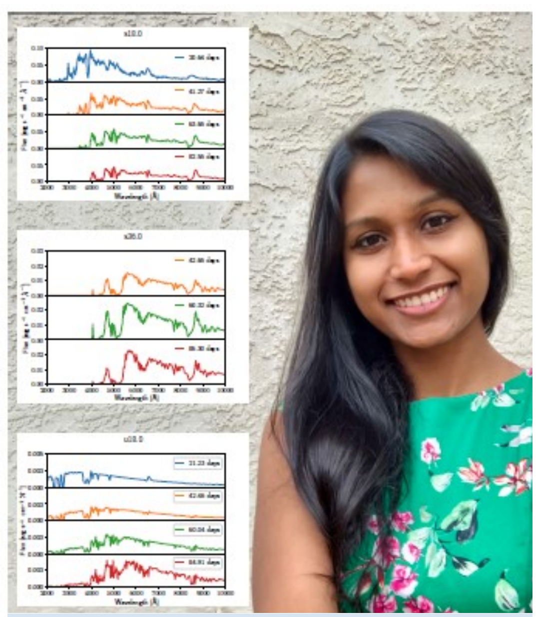


Figure 1. Bolometric light curves fall into four categories that are characterized by the stellar radius at collapse and the mass of the hydrogen envelope at collapse.

The numerical modeling of core-collapse supernovae is challenging. On the one hand, the full problem in 3D is an exascale problem, allowing for only a handful of simulations of short duration (0.5-1 sec after the explosion) - not nearly enough to predict observables such as nucleosynthesis, light curves, and spectra. On the other hand, the computationally cheaper simulations assuming spherical symmetry do not explode self-consistently, leaving researchers with a dilemma how to tackle open questions that require many exploding, long-term simulations. To fill this gap, a JINA-CEE team led by Carla Frohlich (NCSU) has developed an effective core-collapse supernova model called PUSH [1,2,3,4], which allows for consistent predictions of all observables within the model. The PUSH model mimics in spherical symmetry the increased net neutrino-heating seen in multi-dimensional simulations, via an additional heating term which is coupled to the heavy neutrinos.

In a new study, recent PhD graduate Sanjana Curtis (NCSU/LANL), along with undergraduate student Noah Wolfe (NCSU) and collaborators have developed a novel pipeline to take core-collapse supernova models from PUSH to bolometric light curves, broadband light curves, and spectra. Processing 64 models at three different metallicities and a wide range of initial masses with this pipeline has revealed interesting trends and categories. For example, the bolometric light curves fall into four categories that are characterized by the stellar radius at collapse and the mass of the hydrogen envelope at collapse (Fig 1). The spectra cover the time from photospheric to nebular phase, and show characteristic line blanketing. With this work, a large sample of theoretical predictions for core-collapse supernova observables is available for the first time without any hand-tuning beyond the initial calibration of the PUSH method. This opens an exciting perspective for analysis of collective observables from core-collapse supernova models that can be directly compared to observations.



Sanjana Curtis NCSU / LANL

Further reading: Curtis, Wolfe, et al arXiv:2008.05498 (submitted to ApJ)

References:

[1] Perego et al. ApJ 806,275 (2015) [2] Ebinger et al. ApJ 870,1 (2019)
[3] Curtis et al. ApJ 870, 2 (2019) [4] Ebinger et al. ApJ 888,91(2020)

Shocking Results: ^{44}Ti and ^{56}Ni Production Sensitivity in Core-Collapse Supernovae

Contributed by Shiv Subedi (Ohio University, USA)

Most massive stars that have exhausted the nuclear fuel at their core will undergo a violent collapse and subsequent explosion known as a core-collapse supernova. At the end of the collapse, when the core can no longer be compressed, the rebound drives an outward shock wave. The shock wave increases the temperature and density of material that was previously a part of the stellar envelope, further transmuting the elements synthesized during stellar burning. ^{44}Ti and ^{56}Ni are prominent isotopes formed by this shock-driven nucleosynthesis, as their abundances can be determined by astronomical observations of the gamma rays emitted in their radioactive decay (e.g. [1]).

^{44}Ti and ^{56}Ni are produced near the boundary where the core rebound occurs, making them ideal candidates to gain insight into the core collapse supernova explosion mechanism by comparing models to observations. Past JINA research has identified several uncertain nuclear reaction rates that influence ^{44}Ti and ^{56}Ni production in calculations [2]. However, such works have been limited to calculations using analytic temperature and density conditions or a limited set of nuclear reaction rates. Our work took the next step, by investigating a large number of nuclear reaction rates with one-dimensional models.

Our Ohio University team evolved one-dimensional models of 15, 18, 22, and 25 solar mass ($M_\odot$) stars from zero-age main sequence (when hydrogen burning begins in the stellar core) through core collapse supernova using the JINA-supported code MESA (Modules for Experiments in Stellar Astrophysics) and investigated previously identified reaction rate sensitivities of ^{44}Ti and ^{56}Ni production. We found [3] a number of reactions that have a significant impact on the nucleosynthesis of ^{44}Ti and ^{56}Ni, particularly for lower progenitor masses. Notably, the reaction rates $^{13}\mathrm{N}(\alpha,p)^{16}\mathrm{O}$, $^{17}\mathrm{F}(\alpha,p)^{20}\mathrm{Ne}$, $^{52}\mathrm{Fe}(\alpha,p)^{55}\mathrm{Co}$, $^{56}\mathrm{Ni}(\alpha,p)^{59}\mathrm{Cu}$, $^{57}\mathrm{Ni}(n,p)^{57}\mathrm{Co}$, $^{56}\mathrm{Co}(p,n)^{56}\mathrm{Ni}$, $^{39}\mathrm{K}(p,\gamma)^{40}\mathrm{Ca}$, $^{47}\mathrm{V}(p,\gamma)^{48}\mathrm{Cr}$, $^{52}\mathrm{Mn}(p,\gamma)^{53}\mathrm{Fe}$, $^{57}\mathrm{Co}(p,\gamma)^{58}\mathrm{Ni}$, and $^{39}\mathrm{K}(p,\alpha)^{36}\mathrm{Ar}$ are influential for a large number of model conditions.

Figure 1 demonstrates ^{44}Ti production sensitivities for the 15 $M_\odot$ case. Importantly, we identified high-impact reaction rate sensitivities that had not been previously highlighted as important. This suggests that the earlier list of influential reactions is likely incomplete, motivating future larger-scale sensitivity studies. These findings will also help prioritize future nuclear physics measurements at the Facility for Rare Isotope Beams, planned to come online in 2022. The SECAR recoil separator at FRIB will enable the measurement of several of these critically important capture reactions.

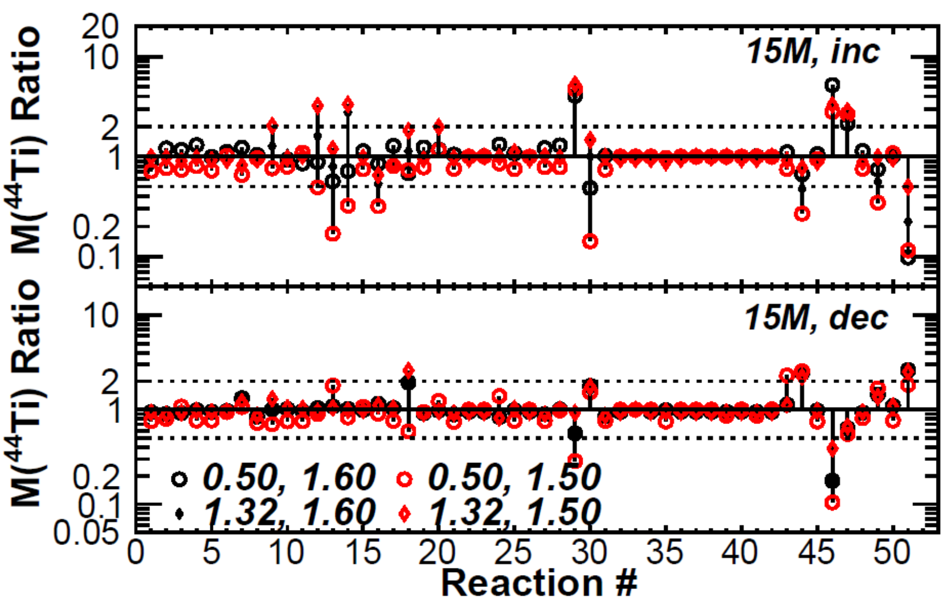


Figure 1: Ratio of the ejected ^{44}Ti mass to the baseline calculation results when varying each reaction, identified by a number, by its uncertainty factor upward (upper panel) or downward (lower panel). The legend indicates the explosion energy and cut-off point for defining ejection. The dashed lines demarcate factor of two impacts.

References:

[1] Brian W. Grefenstette et al. Nature, 506:339–342, 2014.

[2] Georgios Magkotsios et al. Astrophys. J. Suppl. Ser., 191(1):66–95, 2010.

[3] Shiv K. Subedi, Zach Meisel, and Grant Merz. Astrophys. J., 898(1):5, 2020.

Rare Isotope Studies to Understand the Cooling of Neutron Star Crusts

Contributed by Wei-Jia Ong (Lawrence Livermore National Lab) and
Hendrik Schatz (Michigan State University, USA)

The interiors of neutron stars contain the densest forms of matter found anywhere in the universe. Space-based X-ray observations make these systems unique dense matter laboratories, especially if the neutron star is located in a binary stellar system where matter from a companion star may fall onto the neutron star surface over extended periods of time, a process called accretion. One unique glimpse into the properties of dense matter is provided by observations of the surface temperature of neutron stars that were heated during an accretion episode, and cool during phases of quiescence that can last many years. Such observations can be used to determine the internal composition and structure of neutron stars, and whether they contain superfluid neutrons or nuclear pasta. Interpreting the observations requires understanding of the nuclear reactions that heat and cool the neutron star during accretion. These reactions involve neutron-rich rare isotopes that form a crust around the neutron star.

We have developed an experimental approach that takes advantage of the ability to produce these neutron-rich rare isotopes at NSCL at Michigan State University and determines the strengths of reactions that cool the neutron star crust which limit the temperature up to which accretion can heat it up. These Urca reactions have been identified theoretically in previous JINA-CEE work. They consist of alternating electron captures and beta decays, that convert a nucleus into its neighbor on the chart of nuclides, and back to the original nucleus, with the cycle repeating as long as it is hot enough. In each cycle neutrinos are emitted that escape the dense neutron star readily due to quantum effects, and carry energy away, cooling the star.

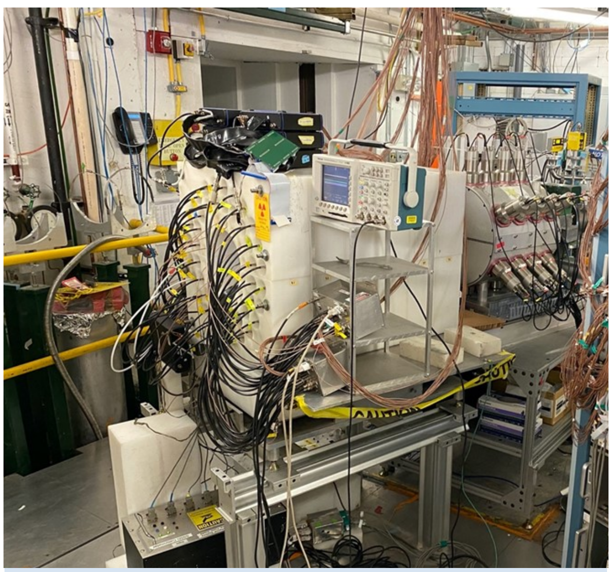


Figure 1: Experimental setup at NSCL. Incoming ^{61}V beam nuclei enter from the right. The SuN detector (right) is used for gamma-ray spectroscopy and the NERO detector (left) counts neutrons emitted following a decay.

The experiment studied the beta decay of the vanadium isotope ^{61}V, which has a short half-life of only 48 milliseconds. ^{61}V is part of a particularly prolific Urca cooling cycle for neutron stars where X-ray bursts produce heavy nuclei on the surface that are then incorporated into the neutron star crust. The nuclear quantity needed is the decay branch to the ground state. This is experimentally challenging as it is the only final state which does not lead to the subsequent emission of radiation. The experiment was conducted at NSCL in two parts – in the first part, the ^{61}V beam was stopped inside the SuN detector, a highly efficient detector for gamma-radiation that enables total absorption spectroscopy to identify all decay branches into gamma-emitting states. In the second part, the ^{61}V beam was stopped inside the NERO neutron detector to detect all decays into neutron-emitting states. With a complete set of decay branches, and the known total decay rate, the strength of the unobserved ground state decay branch could be inferred as 8.1%.

As a result, the now well-determined cooling strength is significantly lower than predicted, but significant enough to require inclusion in models that are used to interpret X-ray observations. The technique can readily be used to investigate all Urca cooling reactions. Two follow-up experiments have already been carried out at NSCL and future experiments are planned at the FRIB facility where all nuclei that form the (outer) crust of neutron stars can be produced and studied.

The work was the thesis work of JINA-CEE graduate student Wei Jia Ong, now a Lawrence Fellow at Lawrence Livermore National Laboratory. The work was performed by a JINA-CEE collaboration of multiple experimental groups to combine various detector systems, nuclear theorists, and astrophysicists.

Further Reading: W.-J. Ong et al, Phys. Rev. Lett. 125 (2020) 262701.

Fission Yields from Macroscopic-Microscopic Theory and the Universality of r-process Abundances

Contributed by Nicole Vassh (University of Notre Dame, USA)

Understanding the observed solar abundances for nuclei heavier than iron requires a disentangling of the possible contributions of various nucleosynthesis sites in our Galaxy. Metal-poor stars that are enriched in r-process elements can provide useful hints on heavy element origins since they likely probe fewer enrichment events. Comparing the abundances of such stars to the solar pattern reveals a surprising consistency from star to star, particularly for the lanthanide elements. The possible connection between fission in astrophysical scenarios and this "universality" or "robustness" of the r-process abundance pattern has been an intriguing prospect for over ten years. Since we now know that neutron star mergers produce at least lanthanide elements such as europium, can we connect such events to the r-process enrichment of metal-poor stars by considering the possible signatures of fission in merger abundance patterns?

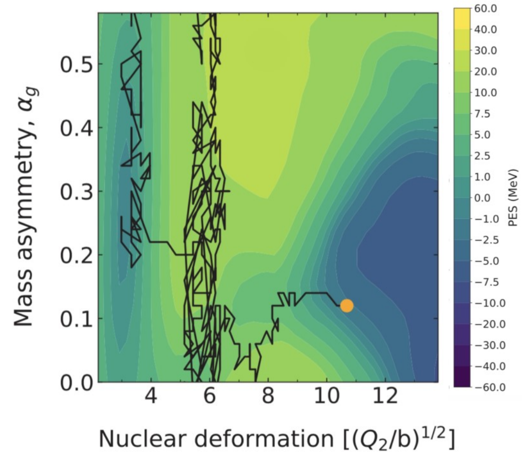


Figure 1. A calculated random walk path on the potential energy surface leading to scission of ^{236}U (see Ref. [1]).

In the future, FRIB may inform the fission data for the neutron-rich nuclei needed for r-process calculations, but it is presently well outside experimental reach as well as inaccessible by some theoretical descriptions. In recent work, fission yields were calculated across the chart of nuclides [1] using macroscopic-microscopic theory [2]. The method utilized was to perform a random walk along the nuclear potential energy surface which models the Brownian shape motion leading to scission (division into two fragments) of the nucleus (Fig. 1). The impact of these new yields in the r-process was considered by groups at the University of Notre Dame and NC State [3]. It was found that since there is late-time fission deposition from nuclei with wide, asymmetric yields, not only can universality in the lanthanides be accommodated in merger conditions, but co-production of lanthanides and the light precious metals palladium and silver is possible (Fig. 2). This demonstrated fission deposition as a previously neglected possible source of light heavy elements and showed for the first time that hints of such a co-production exist in the observational data for r-I and r-II stars.

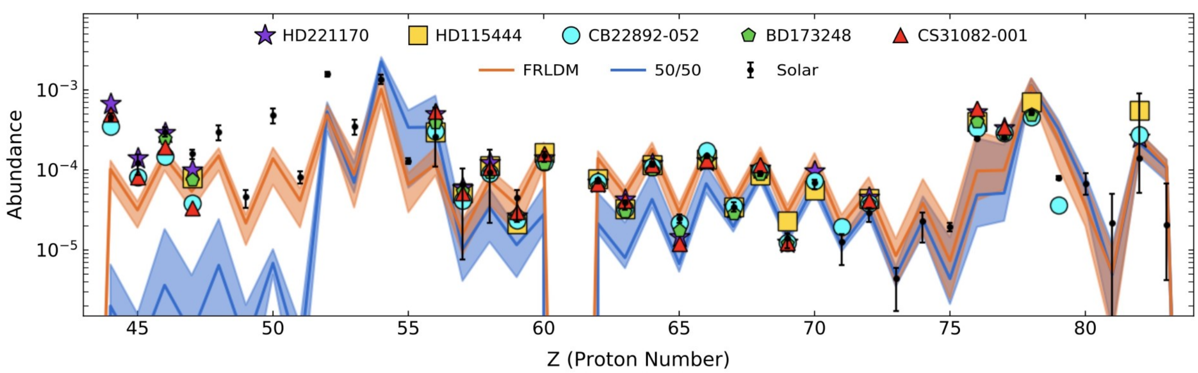


Figure 2. r-process abundances using FRLDM yields in merger dynamical ejecta as compared to elemental abundances for metal-poor, r-process enhanced stars to demonstrate the potential for fission deposition to explain the observed universality for palladium (Z=46) and heavier (see Ref. [3])

References:

[1] M. R. Mumpower, P. Jaffke, M. Verriere and J. Randrup, Phys. Rev. C 101, 054607 (2020)

[2] P. Möller, A. J. Sierk, T. Ichikawa, A. Iwamoto, and M. R. Mumpower, Phys. Rev. C 91, 024310 (2015)

[3] N. Vassh, M.R. Mumpower, G.C. McLaughlin, T.M. Sprouse and R. Surman, ApJ 896:28 (2020)

JINA-CEE Faces:
Interview with Alfredo Estrade

From arranging cables for the NERO experiment as an undergraduate student at Michigan State University, to running his own experimental campaigns at RIKEN in Japan, Alfredo Estrade has contributed to the field of nuclear astrophysics for nearly two decades. An enthusiastic reader of scientific articles and avid drinker of yerba mate, he founded the Yerba Mate Club of Astrophysics (a.k.a. YMCA) during his years as a graduate student at MSU. He then left the US to do a couple of postdocs in Germany and Scotland. Since 2014, he is an assistant professor at Central Michigan University with an adjunct appointment at Michigan State University, and he continues to foster multidisciplinary collaborations. He is one of the coordinators for IReNA's Focus Area 4 — r-process experiments.

Alfredo Estrade,
Central Michigan University

When did you decide to pursue a career in science?

I grew up in the country side of Uruguay, in a cattle ranch where the night sky is stunning and you can still see the Milky Way. Although I had always been interested in science, I never considered it as a career. I started studying agriculture in college but didn't really like it. Then I moved to Michigan to continue my undergraduate studies at MSU, undecided between engineering and physics. It was after a summer Research Experience for Undergraduates at the National Superconducting Cyclotron Lab (NSCL) that I decided to pursue physics.

What is the focus of your research?

My group studies processes that create very neutron rich isotopes, such as the r-process. We also perform experiments to study the properties of heavy nuclei that play key roles in the physics of neutron stars. We explore how nuclear masses and decay modes enter in models for the synthesis of the heavy elements by the r-process. We are also interested in nuclei that, by electron capture processes, could affect heating in the neutron star crust.

What are the main instruments you use in your research?

In the last few years I have performed a number of experiments at RIKEN, in Japan, and also at the NSCL, in Michigan. At the NSCL we developed our own technique and built fast-timing detectors to measure the time of flight of nuclei traveling in the beamline in order to determine their masses. In the near future we will be able to utilize FRIB to produce even more neutron rich nuclei in the r-process path.

How do you interact with JINA-CEE?

I have been a JINA member almost since its beginnings, so I have had many opportunities to participate, I am actually a product of the JINA educational pipeline. I now encourage my students to participate in workshops and to take every opportunity they can to learn. In particular, we find the online seminar to be very useful, as it allows small universities to have access to a broad range of expertise. Also, JINA has been instrumental in starting collaborations with astrophysicists who have developed reaction network codes that we use to understand the impact of our measurements. My students can work both at CMU and at NSCL where they have local support, partly thanks to JINA.

What's your favorite part of your job?

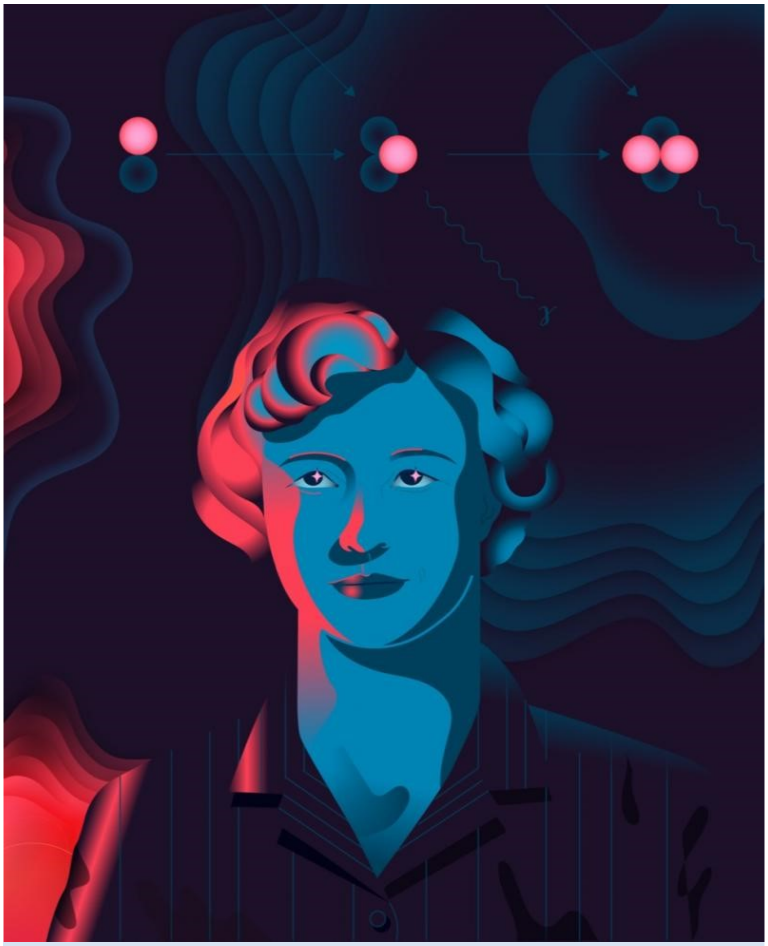
The diversity of things I get to do. Each day you have to wear a different hat and work on a different project. Teaching takes a considerable amount of time and skills are different from those used in research, but it is very fulfilling. When you work on research and get the first results it is very rewarding to see that our approach to a problem actually works.

What's your advice for junior researchers?

There are many more open questions and ideas to explore than you have time for in your career. I think it is important to be selective about how you spend your time. This may not be so easy as a grad student as you have a project to which you are committed, but it is good to be mindful about doing what is most interesting to you.

A Celebration of Margaret Burbidge

Contributed by Nicole Vassh (Notre Dame, USA) and Frank Timmes (Arizona State , USA)



Margaret Burbidge
Artwork commissioned for the event

On July 8, 2020 an online symposium was held to honor the late pioneer Eleanor Margaret Burbidge. This event celebrated her life and science through short talks from her colleagues and collaborators as well as researchers who have benefited from her trailblazing and scientific insights. Speakers included daughter Sarah Burbidge, Megan Donahue (Michigan State University, American Astronomical Society), George Fuller (University California, San Diego), Anneila Sargent (California Institute of Technology), Virginia Trimble (University California, Irvine), Fred Hamann (University California, Riverside), Vesa Junkkarinen (University California, San Diego), Amanda Karakas (Monash University), Artemis Spyrou (Michigan State University), Anna Frebel (Massachusetts Institute of Technology), and Nicole Vassh (University of Notre Dame).

Margaret was very dedicated to her work and pushed forward with grit and determination, as exemplified through a story shared by Sarah Burbidge which described a young Margaret resetting her telescope in response to bombs falling nearby during World War II. As noted by many, but emphasized by Anneila Sargent, an admirable quality of Margaret was her generally cool and collected demeanor which she maintained while balancing family with being a leading scientist in her field. Margaret's kind nature made her a warm and personable mentor, colleague, and friend, as described by Fred Hamman and Vesa Junkkarinen who were both mentored by Margaret at UCSD.

As was highlighted by George Fuller, Margaret was a driving force in two revolutions in astrophysics through her work on the origin of the elements and her work investigating the origin of supermassive black holes. In addition to her groundbreaking research, Margaret broke through many barriers associated with gender bias as the first woman to hold many important roles, including the first female president of the AAS, as was discussed by Megan Donahue and further elaborated upon by Viriginia Trimble. The closing talks given by Amanda Karakas, Artemis Spyrou, Anna Frebel, and Nicole Vassh demonstrated that Margaret's influence extends well beyond those who knew her personally and that her groundbreaking efforts in both research and combating gender bias will continue to propagate to future generations.

The event's website is http://cococubed.asu.edu/celebration_of_margret_burbidge.shtml, and a video recording of the event is available on the JINA-CEE YouTube channel.

Physics of Atomic Nuclei (PAN) Goes Online

Contributed by Zach Constan (Michigan State University, USA)

The 27th edition of the Physics of Atomic Nuclei (PAN) summer camp took place online in July 2020. This is JINA-CEE's longest running outreach program, and in its first socially-distanced edition, it was a total success! Led by Zach Constan from Michigan State University, PAN 2020 became a broad collaboration of 10 JINA-CEE institutions including Central Michigan University, Colorado School of Mines, Gonzaga University, Missouri A&T, Michigan State University, Ohio University, Rutgers University, University of Notre Dame, University of Victoria (Canada), and University of Wisconsin. JINA-CEE partners worked together to create innovative research activities that replaced the usual hands-on laboratory experience, and were carried out by students in small groups supported by JINA-CEE mentors:

A research group presents their work with EDF Theory

1. Groups at MSU and the University of Victoria leveraged the Astrohub environment created at the UVic to enable collaborative research in JINA-CEE, IReNA and other networks. The collaboration developed an Astrohub project where students could explore cutting edge computer simulations of element synthesis in stars and propose experiments for the future FRIB accelerator facility.

2. The group at Notre Dame circumvented the distance barrier by setting up a physical spectroscopy station and allowing the students to “access” it by giving instructions over video chat to the researcher on-site. Teams were challenged to determine the elemental composition of an unknown gas and/or stellar sources by carefully measuring their spectra.

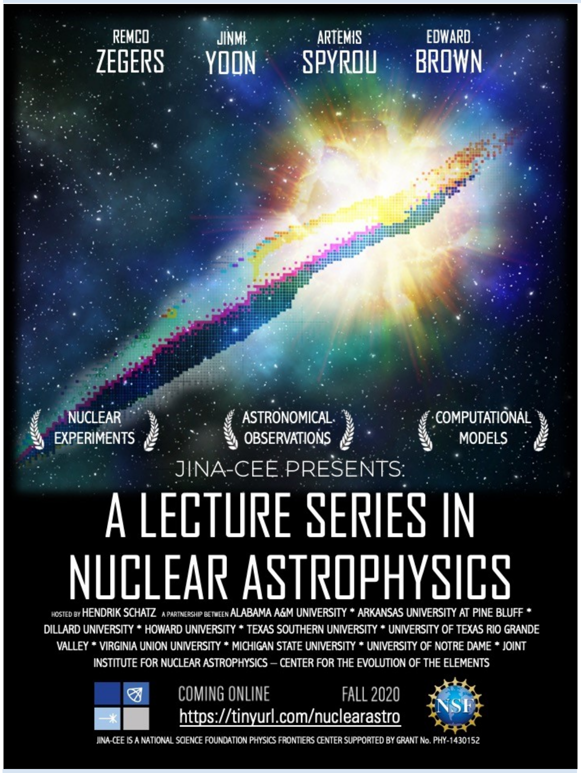
3. A nuclear Energy-Density-Functional Theory project invited students to run modelling code on their own laptops, selecting an isotope of interest to generate the energies and quantum numbers associated with the motion of one proton or neutron in the presence of other nucleons. Resulting level schemes and emergent patterns allowed them to discover the driplines, magic numbers, the valley of beta stability, and much more.

4. Recent scattering experiments at NSCL informed the fourth research project, where students calculated the probability of Rutherford scattering in a given collision. They first estimated and then measured the number of atoms in a very thin metal foil that was used in that recent experiment, then used scattering data to look for elemental impurities in the foil.


Student creates a shirt for "Dress as your favorite element day"

The absence of logistics requirements such as housing and space for activities also meant that the program was able to host more students at once: 36 compared to the usual 24, hailing from 17 different states. Student teams chose one of the above projects to pursue throughout the week, working with a JINA mentor and overseen by the faculty who developed the project. Friday saw the culmination of those projects in the presentation session where each group communicated their results. Despite the reduced social interaction among the students and with JINA-CEE researchers, post-surveys revealed that PAN Online succeeded in achieving its goals and had a very positive impact on students, many of whom expressed their motivation to pursue a scientific career. Read more at jinaweb.org.

Nuclear Astrophysics Lecture Series for Minority Serving Institutions



Poster advertising the lecture series

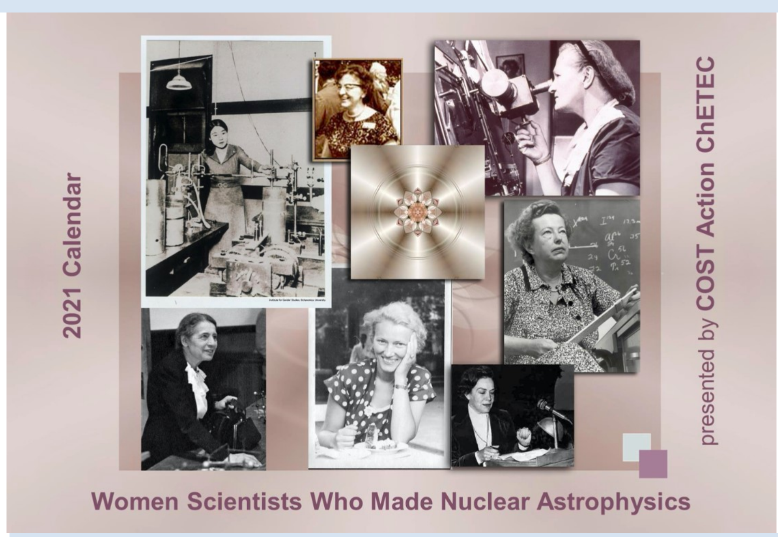
In collaboration with Paul Gueye of MSU, JINA-CEE embarked on a new collaboration with seven Minority Serving Institutions (Alabama A&M University, Arkansas University At Pine Bluff, Dillard University, Howard University, Texas Southern University, University Of Texas Rio Grande Valley, Virginia Union University) who became part of the JINA-CEE collaborative network. The goal is to build institutional relationships through overlapping research interests, introduce students to the field of nuclear astrophysics and make them part of the JINA-CEE community, and broaden participation and diversity of the JINA-CEE student community.

As a first step, an online lecture series was developed for Fall 2020 that highlighted cutting edge science in nuclear astrophysics. The series also provided information about research opportunities and paths towards graduate education and successful careers in STEM. Lecturers from different JINA-CEE institutions, Ed Brown, Artemis Spyrou, Jinmi Yoon and Remco Zegers, delivered the four lectures of the series, which was embedded into the curriculum at the various institutions. Feedback from students and MSI faculty has been positive. We plan to continue the lecture series in 2021, in addition to follow-up activities like student participation in JINA-CEE workshops and research experiences at various JINA-CEE institutions. The lectures were recorded and posted on the JINA-CEE YouTube channel. Lecture slides and materials about grad school and REU opportunities are also posted separately for easy access through the JINA website.

Calendar of Women Scientists Who Made Nuclear Astrophysics

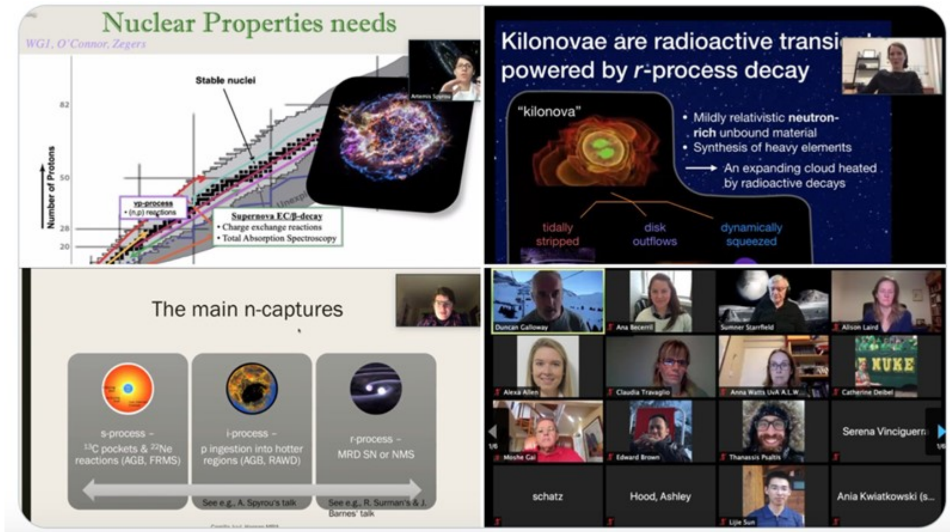
Facilitated by the IReNA framework, JINA-CEE and ChETEC members collaborated to create a beautiful 2021 calendar that celebrates the achievements of women scientists in the development of Nuclear Astrophysics.

The project, led by Maria Lugaro and Christine Hampton, highlights the biographies of twelve outstanding, inspiring women scientists. The calendar is available in more than 20 languages. You are welcome download and print your preferred version here.



Calendar cover

JINA Horizons



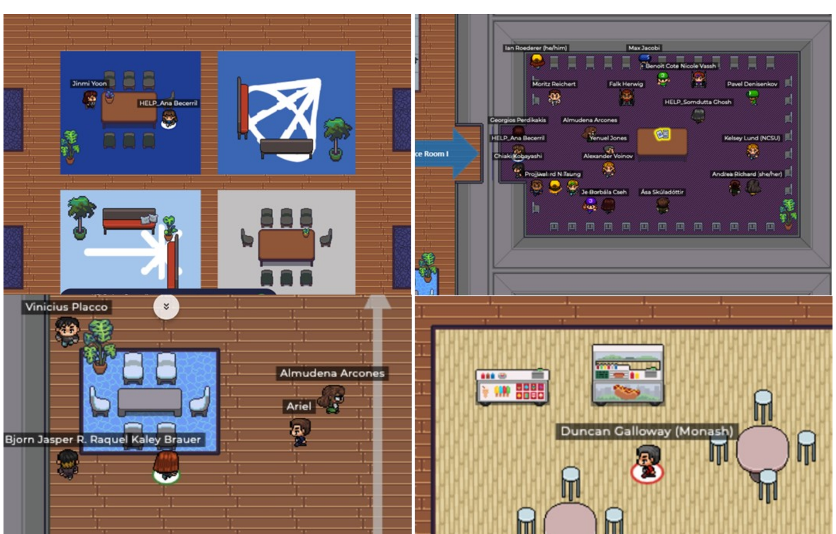
JINA-CEE and IReNA organized "JINA Horizons" on November 30 - December 4, 2020: a virtual meeting that brought together the international nuclear astrophysics community to discuss open questions and future directions of the field.

Participants came from a broad range of fields and sub-fields, including experimental rare isotope nuclear physics, experimental stable beam physics, gravitational physics, nuclear theory, computational and theoretical astrophysics, astronomy, and geophysics.

The fully online format of the meeting allowed for over 550 scientists from all over the world to actively participate. The conference featured 21 invited speakers during its plenary sessions, plus many more during the various working group sessions. JINA Horizons started with a Junior Workshop, organized by and for graduate students and postdocs for their professional development, similar to what is already a tradition at the annual JINA Frontiers Meeting. The main focus of the Junior Workshop was on communication skills and preparation for the job market and many innovative materials continue to be available through the website.

A white paper summarizing the status of nuclear astrophysics is being written based on input collected within five working groups. The working groups organized topical discussions around explosive nucleosynthesis, stellar burning, neutron stars and dense matter, thermonuclear explosions, and the need for centers and diversity. Diversity and inclusion was integrated into the meeting at the same level as the science, including plenary talks and working groups.

An innovative virtual venue was created on Gather.Town for participants to mingle during "Bring-Your-Own coffee breaks". The virtual venue was also used for a participant-driven "unconference" session where participants could form spontaneous working groups. This provided an opportunity for deeper follow-up discussions and for talking about cutting-edge topics that were not originally in the program. Attendees reported to be very pleased with the informal conversations and networking allowed by this fun 8-bit format:



- *"Had many meaningful stochastic interactions"*
- *"It was great, the closest thing to a real coffee break I have seen this year"*

Participants also connected via live tweeting using the hashtag #JINAHorizons. Slides and recorded talks from the plenary sessions are now available on the JINA Horizons website.

Thank you to the Organizing Committee, the Jr Workshop organizers, the Twitter Team, and the Gather.Town Helpers, and to all attendees for making the meeting a success!

Carl Fields Included in 30 Under 30 Forbes Magazine's List

Carl Fields, Michigan State University

JINA-CEE graduate student Carl Fields, who works on supernovae modeling with Sean Couch of Michigan State University, was named to Forbes magazine's 10th Annual Forbes 30 Under 30 list in the science category for North America.

For the 10th year, the magazine selected the 600 most influential young entrepreneurs, activists, scientists and entertainers to be featured in their 30 Under 30 list. These young innovators "provide millions of reasons to believe in a better tomorrow."

Further reading: forbes.com

JINA-CEE Institutions

JINA-CEE is supported by the National Science Foundation through the Physics Frontiers Center Program

JINA-CEE Core Institutions:
Michigan State University
University of Notre Dame
Arizona State University
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