September 2018

JINA-CEE

Center for the Evolution of the Elements

A note from the Director, Hendrik Schatz

Dear JINA-CEE community,

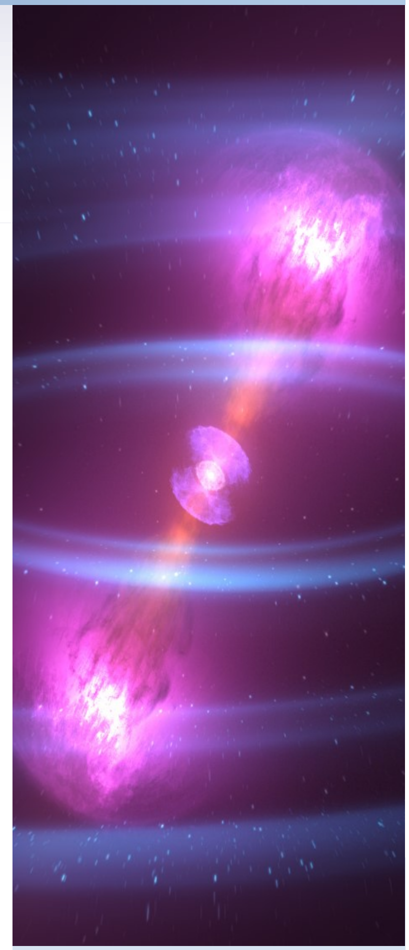
I am happy to report that after a temporary hiatus we are back with our regular JINA-CEE newsletter, published by our new JINA-CEE managing director, Dr. Ana Becerril. A lot has happened this year, and we both hope that this newsletter provides one way to catch up with at least some of the research activities and events.

Certainly last year's kilo-nova observation in the wake of the first detection of gravitational waves from two merging neutron stars has triggered a lot of activity in the field, and within JINA-CEE. Examples include the JINA-CEE Live Stream discussion last December that explored the implications of these new developments for nuclear science, various workshops and schools, and of course a lot of exciting research results that connect the astronomical observations with the physics of nuclei (see Pg. 2).

These developments coincide with JINA-CEE advances in laboratory nuclear astrophysics that address the nuclear physics of element synthesis such as the completion of the CASPAR underground accelerator and new measurements with unstable neutron rich nuclei at ANL and NSCL.

With JINA-CEE being past the midpoint of the current funding period, this is now a good time to think about how to maximize the impact and synergistic connections of the various exciting projects and developments initiated by JINA-CEE. I encourage everybody to join the discussions and activities that to that end will happen in the coming year, for example the many planned workshops and conferences, including the upcoming Frontiers meeting at MSU on May 20-24, 2019.

I hope you enjoy reading this newsletter!



Inside this issue

Image: artistic representation of a neutron star merger
Credit: NASA's Goddard Space Flight Center/CI Lab

JINA-CEE activities related to GW170817

In October 2017 the Gravitational Wave Laboratories LIGO and VIRGO announced the first observation of gravitational waves from the merger of two neutron stars on August 17, 2017 in an event called GW170817. Immediate follow-up observations revealed a short gamma-ray burst and a so-called kilo-nova associated with the same event. A kilo-nova is the weeklong afterglow of a neutron star merger and is thought to be powered by the radioactive decay of rare isotopes produced and ejected during the merger. These observations mark the beginning of a multi-messenger era in nuclear astrophysics. They have provided strong hints that heavy elements are produced in NS mergers, and confirmed the short-gamma ray burst - neutron star mergers association. In addition, simulations show that properties of the neutron star, especially its tidal polarizability and its maximum mass, are essential in interpreting the gravitational wave data. To explore the importance of these observations for nuclear science and nuclear astrophysics further, JINA-CEE organized a number of events. Two of these are highlighted in the following:

Livestream speakers and panelists discussion

More than 400 participants tuned in to a **JINA-CEE Livestream panel discussion** with experts from a wide range of backgrounds and moderated by Luke Roberts from MSU. Participants joined from Greece, China, Switzerland, Sweden, the United Kingdom, and across the United States. Speakers Ani Aprahamian of the University of Notre Dame, Andreas Bauswein of the Heidelberg Institute for Theoretical Studies in Germany, Duncan Brown of Syracuse University, Mansi Kasliwal of Caltech, Daniel Kasen of UC Berkely, Jim Lattimer of the State University of New York at Stony Brook, Jocelyn Read of California State University, Fullerton and Artemis Spyrou of Michigan State University elaborated on how significant a discovery the GW170817 event is for nuclear astrophysics. An important point made was the emphasis of the need of nuclear data for determining the actual elements produced and for linking observations with the intrinsic conditions in the neutron star merger event. You can watch the recorded event, and read about speakers and panelists, and the main conclusions, at https://jinacee1.weebly.com/

Another important event was the joint **INT/JINA-CEE workshop "First multi-messenger observations of a neutron star merger and its implications for nuclear physics"** held on March 12-14, 2018 at the University of Washington. The workshop brought together the nuclear, astronomy, and gravitational wave communities at a time when coordination between efforts in these fields is essential to interpret multi-messenger signals from explosive events in the cosmos and help answer forefront questions in nuclear astrophysics. Discussions relating to gravitational wave data analysis and the interpretation of electro-magnetic signatures, motivated further work and initiated collaborations to address the following:

1. How to obtain more stringent constraints on the equation of state of matter at supra-nuclear density by combining gravitational wave data analysis with input from nuclear theory, experiment and neutron star population studies?
2. Does the amount and composition of the ejecta pose challenges for theory and numerical relativity simulations? And what is role of neutrinos and dense matter physics in shaping this?
3. Is there evidence for the formation of a black-hole in GW170817? If so, how well can we determine the neutron star maximum mass limit and its implications for the equation of state?
4. What fraction of the r-process elements are produced in neutron star mergers and is there a need for supernovae?

Neutrinos Before Collapse

Contributed by Frank Timmes (Arizona State University)

In the hours before a star collapses and explodes as a supernova, the rapid evolution of material in its core creates a multitude of neutrinos. Observing these pre-supernova neutrinos may help us understand the final stages of a massive star's life — but they've never been looked for or detected.

Stellar neutrinos can be created through two processes: thermal processes and beta processes. Thermal processes - for example, pair production in which a particle/antiparticle pair are created - depend on the thermodynamics of the stellar core. Beta processes - where a proton converts to a neutron or vice versa - are instead linked to the isotopic makeup of the star's core. If we can observe them, beta-process neutrinos may be able to tell us about the last steps of stellar nucleosynthesis in a massive star. But observing these neutrinos is not easy. Neutrinos interact only feebly with matter; out of the ~10^{60} neutrinos released in a supernova explosion, even our most sensitive detectors record just a few of them. Can we detect the beta-process neutrinos that are released in the final few hours of a massive star's life?

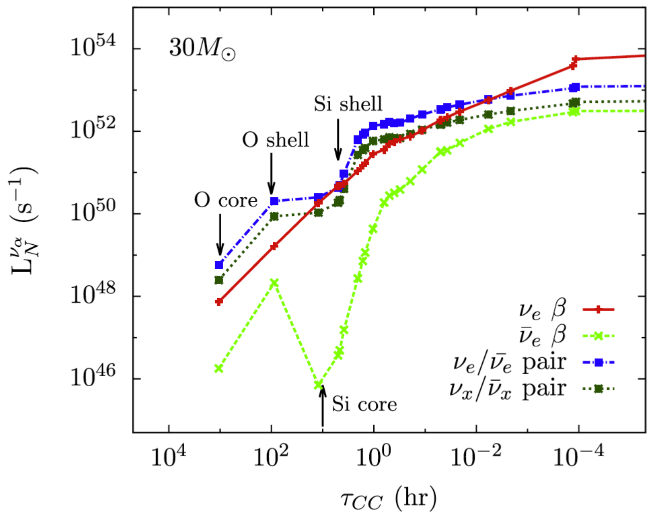


Figure 1. Neutrino luminosities leading up to core collapse. A few hours before collapse, the luminosity of beta-process neutrinos outshines that of any other neutrino flavor or origin. Credit: Patton et al. 2017

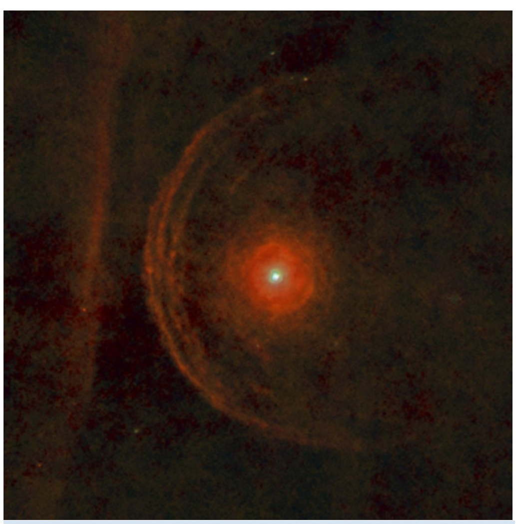


Figure 2. Composite image of Betelgeuse at 70, 100, 160 micron-wavelengths from Herschel PACS. Credit: ESA/Herschel/PACS

To help answer this question, Kelly Patton (University of Washington), Cecilia Lunardini (Arizona State University), Rob Farmer (Anton Pannekoek Institute of Astronomy), and Frank Timmes (Arizona State University, JINA-CEE) used MESA stellar evolution models to explore neutrino production in 15 and 30 solar mass stars from the onset of nuclear fusion at birth to the final moments of collapse. The team finds that in the last few hours before collapse, during which the material in the core is rapidly converted into heavier elements, the flux from beta-process neutrinos rivals that of thermal neutrinos and even exceeds it at high energies. But can we detect them? For a pre-supernova at a distance of ~3000 light-years, the team finds that the electron neutrino flux rises above the background noise from the Sun, nuclear reactors, and radioactive decay within the Earth in the final two hours before collapse. Based on these models, current and future neutrino observatories should be able to detect tens of neutrinos from a pre-supernova within ~3000 light years, about 30% of which would be beta-process neutrinos. As the distance to the star increases, the window within which neutrinos can be observed gradually narrows, until it closes at a distance of about 100,000 light-years. Are there any nearby stars expected soon to go supernova so these predictions can be tested? At a distance of only 650 light-years, the red supergiant star Betelgeuse should produce detectable neutrinos when it explodes — an exciting opportunity for multi-messenger astronomy in the future.

Further Reading: This work was highlighted by the American Astronomical Society Journals at http://aasnova.org/2018/04/20/capturing-neutrinos-from-a-stars-final-hours

Electron-captures on nuclei in astrophysical simulations

Contributed by Remco Zegers (NSCL, MSU)

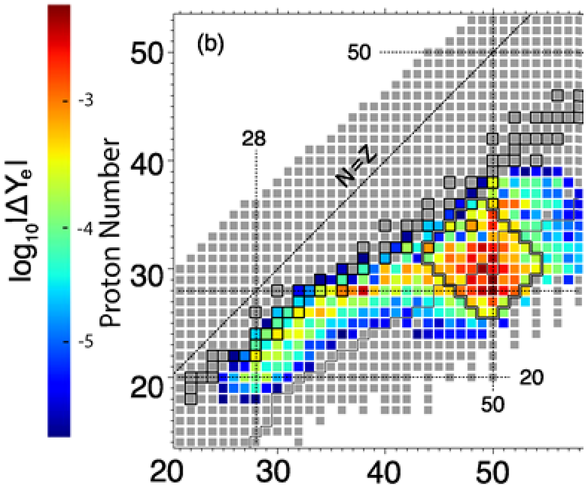


Figure 1. Nuclear chart indicating the contribution of specific isotopes to the change in electron fraction during the late stage of core-collapse supernovae. Nuclei near N=50, above ^{78}Ni are particularly important.

An important ingredient for performing many types of astrophysical simulations is an accurate set of weak-interaction rates. The charge-exchange group at NSCL has created a complete set of electron-capture rates combining the efforts by many others to provide rate sets for particular regions of the chart of nuclei. The electron-capture rate table was included in the neutrino-interaction library NuLib (http://www.nulib.org/). Recently, version 1.2 of the library was published, which includes additional sets of electron-capture rates. A plain ascii version of the table has also been created. Downloads and details about the electron-capture rate table are available at: https://groups.nscl.msu.edu/charge_exchange/weakrates.html

The electron-capture rates in the library have been used in a number of astrophysical studies. One focus has been the sensitivity of core-collapse supernovae to electron-capture rates. In particular, the charge-exchange group motivated several experiments in the region near neutron number N=50, above ^{78}Ni, based on these studies (see: R. Titus et al., J. Phys. G 45, 014004 (2017) http://iopscience.iop.org/article/10.1088/1361-6471/aa98c1). Since the electron-capture rates on these nuclei in the library are very uncertain, experiments to guide and benchmark the theoretical estimates are necessary.

The best way to test the theory relevant for electron captures on neutron-rich nuclei is by performing charge-exchange experiments. Such experiments allow for the model-independent extraction of Gamow-Teller strengths, which are the key nuclear-structure ingredient for the theoretical estimates of the electron-capture rates. (t,^{3}He+γ) charge-exchange experiments at NSCL with the S800 spectrograph and gamma-ray array GRETINA have become the favorite tool. The analysis of ^{86}Kr, ^{88}Sr, ^{93}Nb(t,^{3}He+γ) data, taken in the second S800+GRETINA campaign, is presently in progress. In the future, experiments with the (d,^{2}He) reaction in inverse kinematics are planned for studying Gamow-Teller strengths from unstable nuclei.

Figure 2. Set-up for (t,^{3}He+γ) experiments at the S800 spectrograph with GRETINA – a special target transport system was put in place to insert the volatile ^{88}Sr target (picture credit: S. Noji).

Further Reading: This work was published as part of an Special Issue, according to the editors letter "Focus on microphysics in core-collapse supernovae: 30 years since SN1987A" available at http://iopscience.iop.org/journal/0954-3899/page/Focus%20on%20core-collapse%20supernovae

This work was supported by US-NSF (PHY-1430152 and PHY-1565546) and DOE DE-AC02-05CH11231 (LBNL)

Nuclear astrophysics at rings and recoil separators

With contribution from Christoph Langer (University of Frankfurt A.M.)

Roughly 40 scientists from all over the world participated in the joint EMMI/JINA-CEE supported workshop "Nuclear Astrophysics at storage rings and recoil separators", which was held March 13 - 15, 2018 at GSI in Darmstadt, Germany. Both, recoil separators and storage rings can be used to measure astrophysical nuclear reaction rates by bombarding a target with a beam and separating the unreacted beam from the new nuclei formed whenever a reaction happened. Recoil separators discard the unreacted beam, while storage rings recycle it. Both approaches have advantages and challenges and are being developed by very different scientific communities. JINA-CEE has spearheaded the development of two major recoil separator projects – the St. George recoil separator at Notre Dame, and the SECAR recoil separator at MSU. The goal of this workshop was to bring these communities together to foster collaboration, discuss commonalities and complementarity of the different approaches, discuss common scientific interests, and explore synergies in technical developments.

During the 2.5 days long workshop, scientists from all major institutions hosting either a storage ring or a recoil separator presented their particular device and highlighted recent measurements. Students and postdocs showed details of their work and enough time was allocated for dedicated discussion sessions to address technical details. It quickly became clear, that both communities can highly profit from each other. The workshop was extremely helpful to foster new collaborations and to get to know the other community better. Especially the interaction with the atomic physics community, traditionally associated with storage rings, enabled strong discussions and new collaborations were started during the workshop.

Since many of the participants had never been to GSI before, a tour guided by the local experts complemented a very interesting, efficient and successful workshop. It was unanimous opinion, that a continuation of this kind of workshop should be planned for next year.

The talks and more information about the workshop can be found on the workshop webpage:
http://exp-astro.de/meetings/narrs/

Frontiers in Nuclear Astrophysics 2018

Contributed by Jinmi Yoon (Notre Dame)

The 2018 JINA-CEE Frontiers conference was held on May 21-25 at the University of Notre Dame, IN. This was the eighth in a series of JINA-CEE collaboration meetings that brought together members, collaborators, and other interested researchers in experimental nuclear physics, theoretical and computational nuclear astrophysics, and observational astrophysics to discuss progress and future directions related to the understanding of the origin of the elements and the matter of neutron stars.

Frontiers 2018 was composed of two separate meetings: the Junior Researchers Workshop and the main Frontiers meeting, both organized by a group of postdocs and graduate students of the JINA-CEE community. Over 130 national and international participants attended: 31% of them are faculty members, 7% research scientists, 19% postdocs, 40% graduate students, and 3% undergraduate students. The special theme of this year's main Frontiers meeting was to create cohesive snapshots of the broad variety of JINA-CEE interdisciplinary science by following a storyline of the evolution of the elements by considering *the beginning of the Universe to Now, the first stars to the neutron star mergers, and the light elements to the heavy elements*. The Junior Researchers Workshop preceded the main Frontiers meeting and was open to postdocs, graduate students, and undergraduate students. This workshop consisted of overview talks of the four JINA-CEE core disciplines (Nuclear Theory, Nuclear Experiments, Theoretical Astrophysics, and Observational Astrophysics), contributed research talks, and professional development workshops. The professional development workshops offered training in a variety of areas critical for the career development of the young researchers, such as: *Scientific writing, Grant writing, Publishing in the AAS journals, Speaking skills, Academic and non-academic career panels, and Outreach workshop.*

Some feedback from participants:

Junior Workshop: -"*very informative, got a chance to become exposed to vast areas of research and also had a nice intro/primer of the fields.*"

-"*I liked the junior conference because it didn't all go over my head.*"

Main Conference: -"*You all did a wonderful job with the conference. Everything went rather smoothly and I had a nice time. As a first time JINA-CEE participant, I found the conference to be very helpful and inclusive, and a great way to foster collaboration and discussion.*"

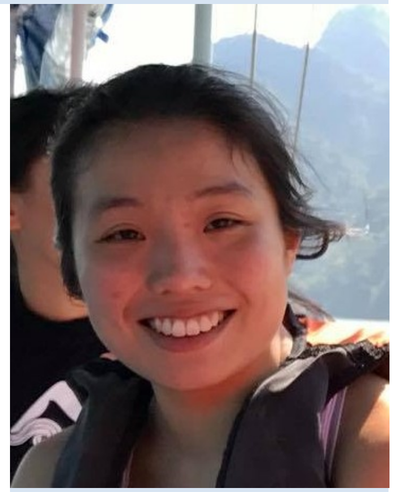
-"*Cutting-edge science. Stimulating discussions.*"

-"*Lots of opportunities for networking.*"

JINA-CEE faces:
Interview with recent PhD graduate Wei Jia Ong

Please tell us a little about yourself:

I grew up in Singapore, and moved to the US for my undergraduate studies at Washington University in St Louis. Most of my family is involved in the business/ finance sector, but my mum taught mathematics and computing for almost three decades at a local polytechnique.



JINA-CEE former grad student Wei Jia Ong (NSCL, MSU)

Education:

I studied in the Singapore public school system for 12 years before university. Then I studied physics at Wash U (although I originally started out intending to major in East Asian Studies), where I did my undergraduate research in cosmochemistry and presolar grains.

When you were younger, what did you want to be when you grew up?

This is kind of a cliché, but I wanted to be a math teacher like my mother. I really enjoyed mathematics as a kid growing up, although I did not do especially well in it in class. It was only after growing up that I realized that you have to like interacting with people to be a teacher, and I'm not really good at talking to people. I think now I mostly want to be doing something that feels challenging, and science is always challenging. I think we, as a society, place too much emphasis on children 'dreaming' about their future. I think there's something to be said about just taking it a day or week at a time and enjoying the present rather than always working towards something specific.

When did you decide to pursue physics?

As I said before, I wanted to major in East Asian Studies when I started university (which I did not tell my parents), but I took a physics class because my parents hoped I would be an engineer. One day after class I asked my professor what his research was about, and he told me that I could take a tour of the lab anytime. When I visited, it just so happened that there were two researchers looking for an undergraduate to do some work with them, and they offered me a job for the summer. I really enjoyed the work and the research group, and worked with them for another three years.

What is the focus of your research?

My research as a graduate student at MSU focused on Urca cooling in neutron star crusts, specifically on placing experimental constraints on a particular transition (^{61}V to ^{61}Cr). Though a specific transition was measured, the technique that was used is highly useful for beta decay studies in general, and my work was also to create an analytical framework and pipeline for future studies using it.

Where do you see yourself in 5 years?

I have a policy of not making career plans more than 10% of my lifespan ahead of where I am (bad for retirement planning, but good for the nerves). I would definitely like to still be working in nuclear astrophysics, because there are still so many unresolved questions, and with FRIB coming on-line in that span, there's so much that can be done.

Where do you see yourself in 20 years?

Hopefully still employed?

Want to share something else?

I like having fun while I work, so I enjoy practical jokes (only if they are harmless) and the like. My crowning glory in graduate school was giving my advisor (Hendrik Schatz) a custom-made bobble head of himself. It's hilarious, we should put it in the JINA gift store.

NASA Laboratory Astrophysics Workshop

Contributed by Artemis Spyrou (NSCL, MSU)

The 2018 NASA Laboratory Astrophysics Workshop, held on April 8—11, 2018 at the University of Georgia Center for Continuing Education and Hotel. The main goal of the workshop was to identify and prioritize critical laboratory astrophysics data needs, to meet the demands of NASA's current and near-term astrophysics missions.

The meeting attracted over 100 participants from the broader laboratory astrophysics community including representatives from NASA and the NSF, as well as researchers from atomic, molecular, plasma, nuclear physics and more. The meeting was strategically organized to include experts from NASA missions to identify lab-astro needs, lab-astro experimentalists to present current capabilities, and theorists/modelers who can build stronger connections between the two groups.

JINA-CEE members participated at the meeting with invited and contributed talks, and posters. JINA-CEE was one of the meeting's sponsors, offering student support. The single most important and valuable deliverable from LAW 2018 will be the report summarizing the recommendations from the workshop. The Scientific Organizing Committee is currently collecting input from the community on top of the discussions that took place during the workshop. For suggestions, input and needs related to Nuclear Astrophysics please contact Artemis Spyrou (spyrou@nscl.msu.edu).

UNIVERSITY OF GEORGIA
Office of Research

JINA–CEE

NASA

New International Partner: University of Oslo

The Joint Institute for Nuclear Astrophysics, Center for the Evolution of the Elements (JINA-CEE) has a new partner in its effort to foster scientific collaboration across nuclear astrophysics at institutions around the world. Recently, a memorandum of understanding (MOU) was signed with the Department of Physics and Institute of Theoretical Astrophysics at the University of Oslo, Norway.

The University of Oslo and JINA-CEE will collaborate with Ann-Cecile Larsen, Gry Merete Tveten, Signe Riemer-Sorensen, Sijing Shen, Magne Guttormsen, Sunniva Siem, and the entire Oslo group on heavy element nucleosynthesis and galactic chemical evolution models.

Oslo group. Photo credit: Victor Modamio

UNIVERSITAS OSLOENSIS MDCCCXI

Welcome to our new collaborators!

We are looking forward to strengthening existing scientific connections through new collaborations and international exchange.

Upcoming JINA-CEE Events

APS Conference for Undergraduate Women in Physics
January 18-20, 2019, Michigan State University, East Lansing, MI
https://perl.natsci.msu.edu/aps-cuwip-at-msu/

Frontiers in Nuclear Astrophysics Junior Researchers Workshop
May 20-21, 2019, Michigan State University, East Lansing, MI

Frontiers in Nuclear Astrophysics Conference
May 22-24, 2019, Michigan State University, East Lansing, MI

JINA-CEE Institutions

JINA-CEE Core Institutions:
Michigan State University, Department of Physics and Astronomy, NSCL
University of Notre Dame, Department of Physics, ISNAP
Arizona State University, SESE
University of Washington, INT

JINA-CEE Associated and Participating Institutions:
CCAPP Ohio State University, CNA Shanghai Jiao Tong University Shanghai China, EMMI-GSI Helmholtz Gemeinschaft Germany, Florida State University, INPP Ohio University, Los Alamos National Laboratory / LANSCE-3, McGill University Canada, MoCA Monash University Australia, North Carolina State University, NAVI Germany, NUCLEI LANL, Argonne National Laboratory, Princeton University, Center for Nuclear Astrophysics China, Cluster of Excellence Origin and Structure of the Universe Germany, TRIUMF Canada, University of Amsterdam Netherlands, University of Chicago, University of Minnesota, University of Sao Paulo Brazil, University of Hull UK, University of Victoria Canada, Western Michigan University, Ball State University, Hope College, Indiana University South Bend, SUNY Geneso, University of Oslo Norway

JINA-CEE also has participants from:
California Institute of Technology, Central Michigan University, Gonzaga University, Al-Balqa Applied University Jordan, LBNL, Louisiana State University, Massachusetts Institute of Technology, MPI for Extraterrestrial Physics Germany, UNAM Mexico, Ohio State University, Stony Brook University, TU Darmstadt Germany, University of Illinois, University of Michigan, Wayne State University

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

For comments or questions about:	Contact:
Outreach and Education	Micha Kilburn: mkilburn@nd.edu
Newsletter and other JINA-CEE related issues	Ana Becerril: becerril@frib.msu.edu