DOE/NA-0168 Defense Programs | Office of Research, Development, Test, and Evaluation

National Nuclear Security Administration

ACADEMIC PROGRAMS QUARTERLY

Volume 2 | Number 3 | September 2025

Welcome to the fall issue of the *Academic Programs Quarterly* (APQ). The National Nuclear Security Administration's (NNSA) Defense Programs remains committed to streamlining its processes and workflows to increase productivity, performance, and efficiency. In a recent Defense Programs reorganization, Academic Programs moved into the Office of Research, Development, Test, and Evaluation (RDT&E) portfolio. This is a full circle moment for RDT&E because Academic Programs originated in our office. We are pleased to welcome Academic Programs back home and look forward to fostering the continued success of these programs that are so vital to the future of NNSA and the national security enterprise.

INSIDE

2025 CALENDAR

10/3	Applications close (8 pm ET) for the 2026-2027 NNSA Graduate Fellowship Program
10/26	Applications close (11:59 pm ET) for the 2026-2027 Minority Serving Institutions Internship Program
11/17-21	67th Annual Meeting of the APS Division of Plasma Physics, Long Beach, CA
12/1	Nominations deadline for The James Corones Award in Leadership, Community Building and Communication for mid-career scientists and engineers

Join us in welcoming the 2025-2026 SSGF and LRGF cohorts. Meet the new Fellows on pages 4-5.

This issue of APQ features an article about the experimental study of neutrons to better understand what happens within nuclear reactions and during nuclear explosions. Using neutron beam facilities such as the Los Alamos National Laboratory's (LANL) Los Alamos Neutron Science Center, researchers at LANL, led by experimental nuclear astrophysicist Aaron Couture and his colleague René Reifarth, measure these reactions and use them to inform and guide nuclear reaction modeling. After testing their model at low energy using proton beams to produce neutrons at the University of Notre Dame, the next step was to test their model at high energy. For this, they teamed with Sherry J. Yennello, Principal Investigator at the NNSA-funded Center of Excellence in Nuclear Training and University-based Research (CENTAUR) at Texas A&M University, to use its rare superconducting cyclotron at the Cyclotron Institute. The LANL-CENTAUR research team used cyclotron beams to produce neutrons from a beryllium target and found good agreement when they compared their model's predicted yield to the measured yield. The team's findings are significant because knowing the model is accurate makes it a reliable source for informing the development of a neutron target.

We also feature ground-breaking research led by Thomas G. White at the University of Nevada, Reno. Recently published in *Nature,* this research overturns the entropy catastrophe theory, i.e., that solids cannot remain stable above approximately three times their melting temperature without spontaneously melting. This work was funded by DOE/NNSA's High Energy Density Laboratory Plasmas program. You can read about the exciting findings of this research on page 3.

You'll meet the newest cohorts of two of our successful fellowship programs: the Stewardship Science Graduate Fellowship (SSGF) with five new fellows and the Laboratory Residency Graduate Fellowship (LRGF) with six new fellows. Fellowships require recipients to be full-time doctoral students and include an annual stipend, payment of full tuition, and a yearly professional development fee. SSGF includes one 12-week onsite research practicum at a NNSA laboratory and LRGF includes a minimum of two 12-week NNSA facility research residencies. Also, check the *2025 Calendar* in the bottom left for the application deadlines for and links to two outstanding NNSA career-building programs: the highly competitive NNSA Graduate Fellowship Program and the coveted Minority Serving Institutions Internship Program.

Everyone in RDT&E is excited to have Academic Programs back where it began. Training the next generation of stockpile stewards remains one of NNSA's core missions. We look forward to being a member of and working with this essential community again.

David A. LaGraffe

David A. LaGraffe, PhD
Principal Assistant Deputy Administrator
Office of Research, Development, Test, and Evaluation

Academic Programs Quarterly (APQ) highlights the academic programs supported by the Department of Energy/National Nuclear Security Administration. APQ is published quarterly by the Defense Programs Office of Research, Development, Test, and Evaluation. Questions and comments regarding this publication should be directed to Terri Stone at terri.stone@nnsa.doe.gov. Learn about the NNSA Academic Programs at https://www.nnsa-ap.us.

Technical Manager Stephanie Miller | Managing Editor Terri Stone | Publication Editor & Design Millicent Mischo*

*Contractor Support

Toward a Neutron Target: Lessons Learned Through Moderator Testing and Collaboration *by the Cyclotron Institute, Texas A&M University / Los Alamos National Laboratory Research Team*

For nearly two decades, experimental nuclear astrophysicist Aaron Couture has worked at Los Alamos National Laboratory's Los Alamos Neutron Science Center (LANSCE) alongside his graduate mentor and colleague René Reifarth, where they use one of the nation's most powerful linear particle accelerators to study neutrons and their impact on the evolution of elements and, in turn, our universe. Their goal is to apply that knowledge to answer mission-relevant questions, such as what happens during nuclear explosions and within nuclear reactions in general.

Couture is a Center for Excellence in Nuclear Training And University-based Research (CENTAUR)-affiliated scientist and collaborator in the Texas A&M University Cyclotron Institute's Detector Array for Photons, Protons, and Exotic Residues (DAPPER) experiments. CENTAUR is sponsored by NNSA's Stewardship Science Academic Alliances program. Couture specializes in the experimental study of neutron capture, which is responsible for the production of almost all the observed elements heavier than iron. Nuclear waste transmutation concepts rely on neutron capture to reduce long-lived radionuclide inventories, while nuclear forensics also relies on understanding neutron reaction networks. Where possible, these reactions are measured directly with neutron beam facilities such as LANSCE—measurements that are complemented by nuclear structure studies using rare isotope beams. Such structurally significant information is used to inform and guide nuclear reaction modeling that is used to predict neutron capture reaction rates as well as predictions of stability.

In recent years, Couture and Reifarth have been exploring neutron targets—a challenging yet tantalizing prospect ripe with new experimental opportunities, including potential discoveries related to nucleosynthesis, stockpile science, and reactor design.

The scientists have theorized that a neutron target intersected by an ion storage ring would allow for measurements of neutron-induced reactions on radioactive nuclides. However, because every re-scattering provides a possibility for the neutron to travel back through the target volume, neutron moderation is essential to optimizing the neutron density and energy distribution.

When Couture and Reifarth succeeded in developing a model of neutron moderation last fall, they needed a collaborator with the expertise and infrastructure required to test it. Based on Couture's CENTAUR ties, they contacted Texas A&M nuclear chemist and CENTAUR principal investigator Sherry J. Yennello. Yennello serves as director of the Cyclotron Institute, a DOE Center of Excellence that is home to one of only five K500 or larger superconducting cyclotrons worldwide.

Although their model had already been benchmarked at low energy using proton beams to produce neutrons at the University of Notre Dame, Couture and Reifarth needed a suitable facility capable of executing the next critical step in the process: testing at high energies. In December 2024, they traveled to the Cyclotron Institute, where they teamed with research scientist Alan B. McIntosh and additional members of the Yennello research group in using K150-cyclotron-generated beams to produce neutrons from a beryllium target surrounded by an 80-centimeter cube of graphite (Figure 1) to moderate the neutrons. Gold wires were arranged on a line through the center of the cube that spanned its width to account for the reaction cross sections, which are known to contain thermal and higher energy neutrons.

Following irradiation, the researchers used high-purity germanium detectors to measure gamma rays from the gold wires to determine the activity of any resulting gold products. In addition to using two beam energies, 9 and 45 megaelectron volts (MeV), the team configured the graphite cube two different ways for each respective beam energy: as a full cube and with the top half removed to increase the fast-to-thermal neutron ratio.

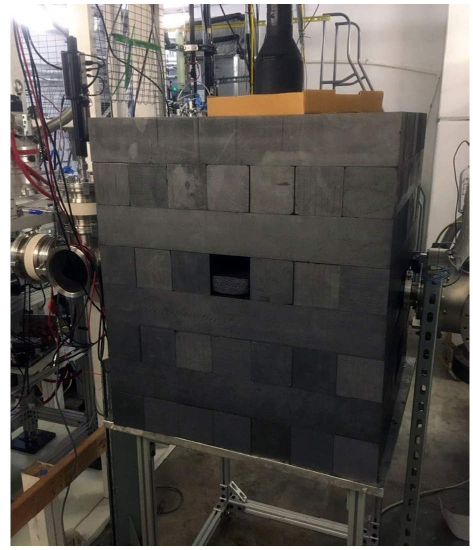


Figure 1. An 80-centimeter cube of graphite was used to moderate the neutrons produced by the Cyclotron Institute's K150 cyclotron. (Credit: Cyclotron Institute, Texas A&M University)

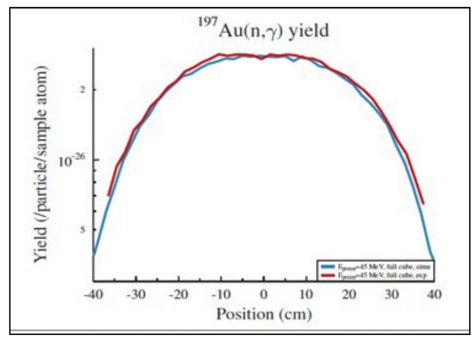


Figure 2. Preliminary simulation (blue) and experimental (red) yields of Au-197 resulting from (n, gamma) reactions at Texas A&M University. (Credit: René Reifarth, Los Alamos National Laboratory).

In comparing the model's predicted yield (calculated using knowledge of the energy-dependent neutron-induced reaction cross sections within the moderator) to the measured yield as a function of its position, the team reported "striking good agreement" using the full cube at 45 MeV, as illustrated in Figure 2.

"Agreement is also observed in preliminary analysis of the other reactions, other beam energy, and other moderator configuration," Reifarth explained. "The moderator model is accurate and can play a reliable role in the development of a neutron target."

The work was performed for the U.S. Department of Energy National Nuclear Security Administration under award numbers DE-NA0003841 and DE-NA0004150.

Surviving the Entropy Catastrophe: Superheated Gold Overturns Long-held Theory of Superheating

by Michelle Werdann and Thomas G. White (University of Nevada, Reno)

Scientists have simultaneously broken a temperature record, overturned a long-held theory, and utilized a new laser spectroscopy method for dense plasmas in a ground-breaking article published recently in the journal Nature.

In their research article, "Superheating Gold Beyond the Predicted Entropy Catastrophe Threshold," physicists revealed they were able to heat gold to over 24,300 degrees Fahrenheit, more than 14 times its melting point, without it losing its solid, crystalline structure.

"This is possibly the hottest crystalline material ever recorded," Thomas White, lead author and Clemons-Magee Endowed Professor in Physics at the University of Nevada, Reno said.

This result overturns the long-held theoretical limit known as the entropy catastrophe. The entropy catastrophe theory states that solids cannot remain stable above approximately three times their melting temperature without spontaneously melting. The melting point of gold, 1,947 degrees Fahrenheit, was far more than tripled in this experiment utilizing an extremely powerful laser at Stanford University's SLAC National Accelerator Laboratory.

"I was expecting the gold to heat quite significantly before melting, but I wasn't expecting a fourteen-fold temperature increase," White said.

To heat the gold, researchers at the University of Nevada, Reno, SLAC National Accelerator Laboratory, the University of Oxford, Queen's University Belfast, the European X-ray Free Electron Laser and the University of Warwick designed an experiment to heat a thin gold foil using a laser fired for 50 quadrillionths of a second (one millionth of a billionth). The speed with which the gold was heated seems to be the reason the gold remained solid. The findings suggest that the limit of superheating solids may be far higher—or nonexistent—if heating occurs quickly enough. The new methods used in this study opens the field of high energy density physics to more exploration, including in areas of planetary physics and fusion energy research.

White and his team expected that the gold would melt at its melting point, but to measure the temperature inside the gold foil, they would need a very special thermometer.

"We used the Linac Coherent Light Source, a 3-kilometer-long X-ray laser at SLAC, as essentially the world's largest thermometer," White said. "This allowed us to measure the temperature inside the dense plasma for the first time, something that hasn't been possible before."

"This development paves the way for temperature diagnostics across a broad range of high-energy-density environments," Bob Nagler, Staff Scientist, SLAC, said. "In particular, it offers the only direct method currently available for probing the temperature of warm dense states encountered during the implosion phase of inertial fusion energy experiments. As such, it is poised to make a transformative contribution to our understanding and control of fusion-relevant plasma conditions."

The research article is the result of a decade of work and collaboration between the University of Nevada, Reno, SLAC National Accelerator Laboratory, Queen's University Belfast, the European XFEL, Columbia University, Princeton University, the University of Padova, the University of Oxford, the University of California, Merced, and the University of Warwick.

"It's extremely exciting to have these results out in the world, and I'm really looking forward to seeing what strides we can make in the field with these new methods," White said.

White and his colleagues returned to the Linac Coherent Light Source in July 2025 to measure the temperature inside hot compressed iron in an experiment designed to replicate the interiors of planets. The campaign was highly successful, yielding promising new data as a natural extension of the newly developed temperature diagnostic.

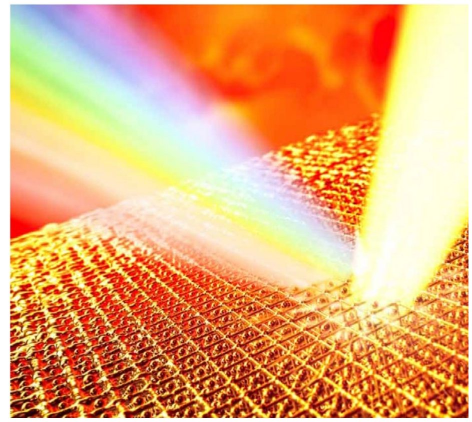


Figure 1. Researchers at SLAC's Matter in Extreme Conditions (MEC) instrument used a laser to superheat a sample of gold. Then, they sent a pulse of ultrabright X-rays from the Linac Coherent Light Source (LCLS) through the sample to measure the speed, and thus the temperature, of the atoms vibrating in the sample.

Several of White's graduate students and one undergraduate student were coauthors on the study, including doctoral student Travis Griffin, undergraduate student Hunter Stramel, Daniel Haden, a former postdoctoral scholar in White's lab, Jacob Molina, a former undergraduate currently pursuing his doctoral degree at Princeton University, and Landon Morrison, a former undergraduate student pursuing his master's degree at the University of Oxford. Jeremy Iratcabal, research assistant professor in the Department of Physics, was also a coauthor on the paper.

"I'm incredibly grateful for the opportunity to contribute to such cutting-edge science using billion-dollar experimental platforms alongside world-class collaborators," Griffin said. "This discovery highlights the power of this technique, and I'm excited by the possibilities it opens for the future of high-energy-density physics and fusion research. After graduation, I'll be continuing this work as a staff scientist at the European XFEL."

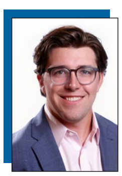
This research was funded by the U.S. Department of Energy, National Nuclear Security Administration under Award No. DE-NA0004039 and Office of Fusion Energy Sciences under Award No. DE-SC0019268.

Stewardship Science Graduate Fellowship and Laboratory Residency Graduate Fellowship 2025-2026 Classes *by The Krell Institute*

Eleven doctoral candidates will join the Department of Energy/National Nuclear Security Administration (DOE/NNSA) Stewardship Science Graduate Fellowship (SSGF) and Laboratory Residency Graduate Fellowship (LRGF) this fall. SSGF recipients research high energy density physics, nuclear science, and properties of materials under extreme conditions. Each serves a 12-week practicum at an NNSA laboratory. LRGF recipients study engineering and applied sciences, physics, materials, and mathematics and computational science. Their program includes a minimum of two residencies, and fellows are encouraged to collaborate with national lab personnel. All fellows receive tuition, a stipend, and other benefits.

Here are summaries of the new fellows' research statements.

Stewardship Science Graduate Fellowship

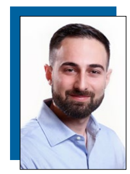


Nuclear isotopes are critical to national security. However, inefficient separation technology limits their production, and expensive measurement techniques limit their applications. With Mark Raizen at the University of Texas at Austin, **Henry Chance** will try to meet those challenges by experimentally verifying a technique proposed by Raizen called multiresonant laser isotope separation (MRLIS). Like other approaches, MRLIS uses laser energy to separate an isotope from a neutral atomic beam using shifts in the isotope's electron energy levels. MRLIS is novel in its delivery of two coordinated laser shots instead of one. The first excites the isotope to an intermediate state. The second excites it to an autoionizing state. Chance will build and optimize the necessary equipment and use it to validate MRLIS using strontium-88 and strontium-89.

At the Massachusetts Institute of Technology, **Brian Foo** will explore surprising ion behaviors observed during inertial confinement fusion (ICF) events. During fusion trials at the National Ignition Facility, Foo's advisor, Maria Gatu Johnson, and others inferred from the kinetic energy spectrum of escaping neutrons that ion velocities in the plasma, vital to increasing reactivity, did not fit the expected yardstick, called a Maxwellian curve, used in simulations. Foo will collaborate with researchers at Los Alamos National Laboratory, Lawrence Livermore National Laboratory and the Omega Laser Facility at the University of Rochester on experiments on possible non-Maxwellian ion-velocity distributions in various types of ICF implosions. He will directly probe ion-velocity distributions in ICF-like conditions and work to validate earlier findings through detailed measurements of the neutron spectrum.

Approximate methods for solving the Schrödinger equation for large numbers of interacting particles can predict atomic nuclei properties and the matter inside stars, building from the level of protons and neutrons. Working with Scott Bogner at Michigan State University, **Brandon Lem** will explore how one method, the in-medium similarity renormalization group (IMSRG), can provide microscopic calculations of the nuclear matter equation-of-state (EOS). He will incorporate a range of IMSRG extensions, enabling large-scale EOS calculations at finite temperatures and calculations of nuclear matter response functions, which would be a boon to theoretical nuclear astrophysics. He is planning a fast emulator for quantifying EOS uncertainties at low computational cost.

Bulk viscosity is a property neglected in Navier-Stokes equations, the math that describes viscous-fluid motion. To account for how such perturbed fluids return to equilibrium—or a transfer coefficient—**Jarett LeVan** will study the bulk viscosity of a plasma regime called warm dense matter. Working with Scott Baalrud at the University of Michigan, he will run density functional theory (DFT) molecular dynamics (MD) simulations, which decouple ion and electron dynamics, treating ions as classical particles while computing electron dynamics using DFT. Simulations across a variety of conditions will reveal bulk viscosity's scaling with density, temperature, and material composition. By providing physical values for the bulk viscosity's coefficient, the work will advance the understanding of transport in warm dense matter and inform hydrodynamic models in this regime.

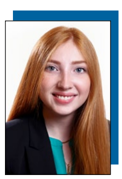


Researchers are developing high entropy alloys (HEAs) for nuclear fusion reactors that are more heat- and radiation-resistant than conventional alloys. Some HEAs are more resistant to void swelling, which occurs when neutron radiation punches holes in crystal structures, leading to embrittlement. Working with Penghui Cao at the University of California, Irvine, **Arman Ter-Petrosyan** will study HEAs' defect kinetics to understand their superior performance. He will simulate defect kinetics across various systems under different loading conditions, then develop a machine learning interatomic potential (MLIP) that accounts for crystallographic defects more accurately than existing MLIPs. The work will result in an MLIP that accurately models the potential energy surfaces of HEAs and aids materials development for fusion reactors.

Laboratory Residency Graduate Fellowship

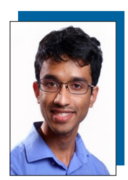
To meet a growing demand for ultrawide bandgap (UWBG) semi-conductors, **Veena Chauhan** will study how to synthesize the promising UWBG hexagonal boron nitride (h-BN) in films of necessary quality, purity, and size. Working with Joseph Gauthier at Texas Tech University, she is running electronic structure simulations to gain insights into h-BN crystal formation during chemical vapor deposition. She found that ammonia and boron trichloride appear to be ideal precursors. She will investigate other precursors, precursor concentrations, and control of gas-phase reactions. During her residencies with Joel Varley at Lawrence Livermore National Laboratory, she will use high-performance computing to simulate the reaction kinetics and thermodynamics of h-BN growth on sapphire and other substrates.

Fission gas release (FGR) from nuclear material can increase the material's porosity, changing its mechanical and thermal properties. **Kaylee Cunningham** at the University of Florida will develop mechanistic models of FGR using BISON, a finite element method nuclear fuel performance code. Working with Michael Tonks, she will construct a computational model of uranium dioxide and will build and validate models for uranium nitride, then pursue an FGR threshold for metallic uranium. Residencies with Christopher Matthews at Los Alamos National Laboratory will provide access to advanced computational resources and the laboratory's library of historical FGR experimental data.

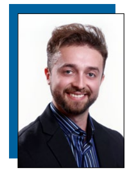


Two-photon polymerization (2PP) additive manufacturing has the potential to mass produce low-cost, high-gain targets for ICF or for high-repetition-rate inertial fusion energy. With Maria Gatu Johnson at the Massachusetts Institute of Technology, **Audrey DeVault** is characterizing 2PP-printed foams wetted with deuterium-deuterium or deuterium-tritium fuel. In DeVault's research with Marius Millot at Lawrence Livermore National Laboratory, a challenge arose when the printed foams' large pore size and regular structure imprinted on a transmitted shock front. At the University of Rochester's Omega Facility, they studied various parameters' effects on shock-front nonuniformity. In her residencies with Ryan Nora at LLNL, DeVault will develop a comprehensive 2PP-printed wetted foam target platform. She will also run 3D hydrodynamic simulations of wetted foams and work to improve EOS models.

To interpret X-ray spectra from accreting black holes, researchers simulate photoionized plasmas, those whose electrons are stripped from their nuclei by external radiation instead of heat. However, some of the models assume steady-state equilibrium between the ionizing radiation and the photoionized gases that make up the plasmas. One big unknown: as a rapidly varying radiation source waxes and wanes, does the proportion of gas atoms that are ionized also fluctuate and, if so, how closely do they follow the source over time? With Carolyn Kuranz at the University of Michigan, **Isaac Huegel** will explore time-resolved emissions from plasmas photoionized by a varying source. During residencies at Sandia National Laboratories, New Mexico, he will collaborate with Guillaume Loisel to create a powerful, rapidly varying X-radiation source on the Z machine and acquire benchmark data of the underlying physics. The results will also be relevant to ignition experiments and simulations.



At the University of California, Berkeley, **Rohith Karur** will collaborate with Andre Walker-Loud to predict the elusive proton-proton (pp) fusion rate, the backbone of stellar fusion. Due to the powerful repulsion between the protons' positive charges, pp fusion cannot be replicated in the laboratory. Also, the underlying quantum chromodynamics (QCD) has defied prediction of the pp fusion rate from first principles. However, recent advances bring the problem within reach via lattice QCD simulations. During residencies with Pavios Vranas at Lawrence Livermore National Laboratory, Karur will develop the computational-library routines and use them on the Lassen and Tuolumne supercomputers, first to compute the interaction between protons and neutrons and, on that foundation, the pp fusion rate.



Researchers need new diagnostics to resolve instabilities and degradation mechanisms in ICF reactions. Since ICF produces neutrons bearing telltale information about the implosions, **Landon Tafoya** at the University of Michigan is developing a neutron imaging diagnostic to probe the ion temperature distribution, which has never been measured. Toward this goal, working with Ryan McBride, he will combine neutron imaging, which reveals the hotspot size and symmetry, and neutron time-of-flight systems, which indicate the average ion temperature and unburned fuel ratio. Through residencies with Verena Geppert-Kleinrath at Los Alamos National Laboratory (LANl), he will run experiments at the Omega Laser Facility and National Ignition Facility and use specialized image reconstruction codes and detector systems as well as LANL radiation-hydrodynamics codes.

New Predictive Science Academic Alliance Program Centers

The National Nuclear Security Administration (NNSA) has announced the selection of the new Predictive Science Academic Alliance Program (PSAAP) Centers whose primary focus will be on the following major technical areas:

- ✧ Discipline-focused research needed to further predictive science and enabled by effective Exascale computing technologies;
- ✧ Developing and demonstrating technologies and methodologies to support effective Exascale computing in the context of science/engineering applications;
- ✧ State-of-the-art machine learning and data science technologies for predictive science and engineering;
- ✧ Predictive Science based on verification and validation and uncertainty quantification (V&V/UQ) for large-scale simulations; and
- ✧ Workforce development of the next-generation computational scientists and engineers.

(continued on page 6)

Academic Programs Highlights

New PSAAP Centers (continued from page 5)

Nine universities have been selected either as a Predictive Simulation Center (PSC), or as a Focused Investigatory Center (FIC). Each PSC will receive up to $17.5 million, and each FIC up to $5 million total over the course of five years under NNSA's PSAAP IV cooperative agreements. We congratulate the following nine universities which have been awarded cooperative agreements:

- University of Florida: Center for Multiscale Modeling of Multiphase Combustion (PSC)
- Massachusetts Institute of Technology: Center for the Exascale Simulation of Coupled High Enthalpy Fluid-Solid Interactions (PSC)
- University of Michigan: Center for Prediction Reasoning & Intelligence for Multiphysics Exploration (PSC)
- Oregon State University: Center for Advancing the Radiation Resilience of Electronics (CARRE) (PSC)
- University of Virginia: Center for Stochastic Simulations of Ablative Geometries with Error-Learning in Space and Time (PSC)
- Brown University: Center for Information Geometric Mechanics and Optimization (CIGMO) (FIC)
- University of California at San Diego: Center for Simulation and Design of Heterogeneous Architectures for Performance and Energy Absorption (FIC)
- Michigan State University: High Order Plasma Turbulence Modeling for Z-Pinch (FIC)
- University of New Mexico: Center for Optimized Modern Parallel Adaptive System Software (COMPASS) (FIC)

The PSAAP IV Centers will begin performance in September 2025 and will be funded by the NNSA Office of Research, Development, Test, and Evaluation. The program oversight will remain with the Office of Advanced Simulation and Computing & Institutional Research and Development (ASC) whose mission is to provide the simulation capabilities and computational resources to support the NNSA annual stockpile assessment and certification process, study advanced nuclear weapons design and manufacturing processes, analyze accident scenarios and weapons aging, and provide the tools to enable stockpile Life Extension Programs and the resolution of Significant Finding Investigations.

► High Energy Density Laboratory Plasmas

Strongly Coupled Coulomb Systems 2025 | PI: Thomas G. White

The Strongly Coupled Coulomb Systems (SCCS) 2025 conference,was held in South Lake Tahoe from July 27 to August 1, 2025. The conference featured six keynote talks, 14 invited talks, 35 contributed presentations, and 33 posters across seven key topic areas in plasma and condensed matter science. With 92 attendees, including 26 graduate students, 13 postdocs, and 7 undergraduates, the meeting provided an opportunity for early-career researchers to engage with leaders in the field. This level of student attendance was only made possible due to the generous travel scholarships provided by the NNSA. We also had representatives from all of the national laboratories in attendance.

Participants of SCCS 2025 hosted by the University of Nevada, Reno, Department of Physics.

► Predictive Science Academic Alliance Program

Center for Understandable, Performant Exascale Communication Systems, University of New Mexico | PI: Patrick Bridges

Center for Understandable, Performant Exascale Communication Systems (CUP-ECS) researchers collaborated with researchers at Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL) to create novel approaches for measuring irregular, dynamic communication patterns in HPC applications workloads at scale. Their new approaches, which include adding capabilities for communication pattern annotation to the LLNL Caliper Application Programming Interface (API) and creating a new scalable communication monitoring profiling system called Vernier, can reduce the overhead of collecting high-resolution communication performance data from production applications by an order of magnitude. In addition, the collected data can be replayed in standalone benchmarks also developed by CUP-ECS researchers as well as used in DOE's Structural Simulation Toolkit (SST), enabling researchers to study the impact of software and hardware changes on the performance of production communication behaviors. CUP-ECS researchers have been using these tools to examine communication optimization opportunities in multiple production codes, including studying irregular communication in the LANL xRAGE application (Figure 1).

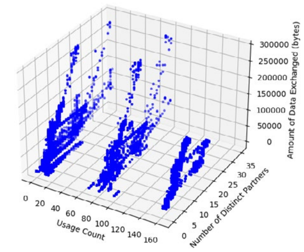


Figure 1. Visualization of irregular communication pattern behavior in the first 10 cycles of a 440 MPI process execution of the LANL xRAGE code. This graph, derived from data collected using the Vernier communication monitoring system plots the frequency of each specific pattern, how many processes are involved in communication, and how much data is exchanged in a single communication invocation.