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National Nuclear Security Administration

ACADEMIC PROGRAMS QUARTERLY

Volume 1 | Number 3 | September 2024

This issue of the *Academic Programs Quarterly* (APQ) focuses on two of our preeminent fellowship programs, the [Stewardship Science Graduate Fellowship (SSGF)] and the [Laboratory Residency Graduate Fellowship (LRGF)] both of which are part of the Stewardship Science Academic Alliances (SSAA) program. These fellowships are highly competitive and are focused to provide support to elite graduate students pursuing research in fields of critical need to the National Nuclear Security Administration (NNSA). Fellows receive tuition and fees, a generous stipend, a research or professional development allowance, and a practicum at an NNSA national laboratory, among other benefits. SSGF fellows typically complete one, 12-week practicum at an NNSA national laboratory. LRGF fellows are required to complete a minimum of two, 12-week practicums at an NNSA national laboratory. Many fellows choose to complete their dissertation research in conjunction with research staff at a national laboratory.

The NNSA Academic Programs also collaborates with the Department of Energy, Office of Science for the [Computational Sciences Graduate Fellowship (CSGF)]. CSGF is focused on elite graduate students in the disciplines of science, engineering, mathematics, statistics, computer science, or computer engineering. NNSA works in conjunction with our partner, the Krell Institute, for the administration of our fellowship programs. Please visit the [Krell Institute website] or click on the links above for more information, including how to apply.

The SSGF and LRGF 2024-2025 Classes. Meet the new Fellows on pages 3-4. Note: Two Fellows are not shown.

This issue features an article by our Academic Programs' Coordinator, Dr. Stephanie Miller, who is a graduate of the LRGF program. Dr. Miller serves as the overall Academic Programs' Coordinator as well as the Program Manager for SSAA and for the joint program in High Energy Density Laboratory Plasmas (HEDLP). A new feature by Dr. Miller, Coordinator's Corner, will be a regular feature of the APQ (see page 5).

We have an exciting change for the upcoming Stewardship Science Academic Programs (SSAP) Symposium. The 2025 SSAP Symposium will be held in June in Chicago! (Typically it would be held in February in New Mexico.) It will occur on June 10-11, 2025 at the Chicago Marriott O'Hare. On June 12, there will be tours of the Advanced Photon Source at Argonne National Laboratory for a limited number of participants. Please stay tuned for more details. We look forward to seeing you in the Spring in Chicago.

[signature]

Jahleel A. Hudson
Director
Technology and Partnerships Office

INSIDE

CALENDAR

- 10/7-11 [66th Annual Meeting of the APS Div. of Plasma Physics, Atlanta, GA]
- 11/17-22 [Supercomputing 2024 (SC'24), Atlanta, GA]
- 11/18-22 [20th Workshop on Radiative Properties of Hot Dense Matter (RPHDM2024), Paris, France]

SAVE THE DATE: 2025 Stewardship Science Academic Programs Symposium ✦ June 10-11, 2025

The Department of Energy/National Nuclear Security Administration (DOE/NNSA) is pleased to announce that the 2025 Stewardship Science Academic Programs Symposium will be held at the Chicago O'Hare Marriott in Chicago, Illinois on June 10-11, 2025. This will be an in-person only event, and we look forward to another year with record-breaking attendance.

The SSAP Symposium remains committed to providing numerous opportunities to make important connections, exchange research information, and interact with the wide range of scientific communities that SSAP encompasses. As in past years, the symposium will include presentations on current research by grantees, talks by NNSA and NNSA national laboratory staff, opportunities to connect and network with staff from NNSA, the national laboratories, the Krell Institute (which manages our fellowship programs), and a Poster Session & Reception.

We look forward to seeing you in June, so save the date!

Academic Programs Quarterly (APQ) highlights the stewardship science and academic programs supported by the Department of Energy/National Nuclear Security Administration (DOE/NNSA). APQ is published quarterly by the Defense Programs Technology and Partnerships Office. 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 Jennifer Dieudonné* | Managing Editor Terri Stone | Publication Editor & Design Millicent Mischo*

*Contractor Support

Fundamentally Curious: An Experimentalist's Approach to Career Planning *by Stephanie Miller (National Nuclear Security Administration)*

After taking what my parents and I affectionately refer to as the "Great Midwestern College Tour," I realized that I had fallen in love with Ann Arbor, Michigan—both the campus and the university. I started my time as an undergraduate at the University of Michigan thinking I wanted to become an engineer, because I am a fundamentally curious person who has always loved puzzles of any kind. I quickly found a home in the nuclear engineering department. The small department nested within a large university was a huge bonus, and the students, staff, and professors were incredibly welcoming. In my time as an undergraduate, I completed summer internships in nuclear reactors, thermodynamics, code development, and even was a camp counselor. My senior year, I took an introduction to plasma physics class, and I was hooked. I applied to graduate school and completed my graduate studies in a pulsed power laboratory.

My thesis research was focused on two main projects, both related to the Magnetized Liner Inertial Fusion (MagLIF) concept. MagLIF can be thought of as filling a small can full of fusion fuel (gas), and then smashing the can inward using current and magnetic fields so that the gas turns to plasma and, ultimately, reaches ignition. My first project was designing and executing a proof-of-concept experiment for removing a window on the top of a MagLIF target. This window is necessary to hold the fuel inside the target, but a laser is fired through the window to partially heat the fuel. To ensure the maximum amount of energy goes into the fuel and is not wasted on heating up the window material, I looked at an alternative way to open this window right before the laser would enter the target. This was a fun project for me because it focused heavily on engineering a brand-new experimental setup. My second project included experiments at the Omega Laser Facility. This project was focused on studying how the walls of a MagLIF target move once that laser enters the target and creates shocks in the fuel material that interact with the walls of the can. We used a radiography platform to study how these walls move and the implications of this on the full MagLIF concept.

Dr. Stephanie Miller
Academic Programs Coordinator
Project Manager, Stewardship Science Academic Alliances and High Energy Density Laboratory Plasmas Technology and Partnerships Office

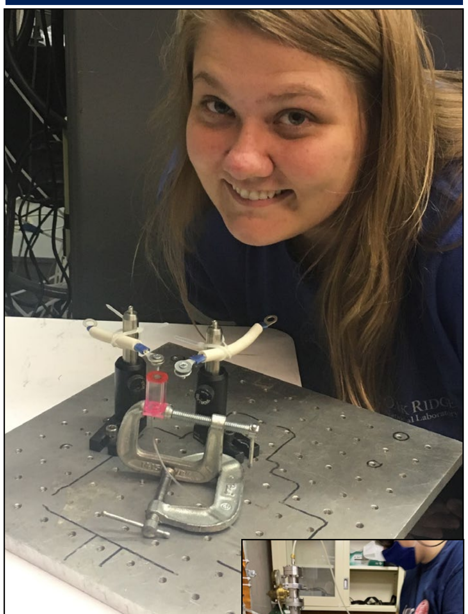
Education

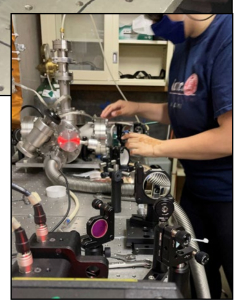
University of Michigan

- PhD, Nuclear Engineering, focus in Plasma Physics, 2024
- MSE, Nuc. Engineering, 2021
- BSE, Nuc. Engineering, minor in Physics, 2016

Fellowships

- Laboratory Residency Graduate Fellowship, 2018-2022
- NNSA Graduate Fellowship Program, 2022-2023





Dr. Miller (top) with one of the targets she built for her proof-of-concept project she worked on for her thesis and (bottom) building an interferometer.

When I was a few years into graduate school, I heard about the National Nuclear Security Administration (NNSA) Laboratory Residency Graduate Fellowship Program (LRGF) from my advisor. I was instantly excited about the residency component and getting to go work at Sandia National Laboratories (Sandia) as a graduate student. The LRGF provided me with a lot of benefits. I was able to work with amazing scientists at Sandia and to learn a great deal from them during my two residencies in Albuquerque. I had access to facilities and, therefore, research opportunities I could not have gotten from my university. The fellowship includes an annual program review that rotates between different locations. At the review meeting, I was excited to tour the different laboratories and their facilities—like the National Ignition Facility at Lawrence Livermore National Laboratory. During the annual program reviews, I was able to learn about research far different from my own, which I found fascinating. Most importantly, I developed a strong community with the other LRGF and Stewardship Science Graduate Fellowship fellows. Not only did I make professional connections, I also formed lifelong friendships through the LRGF.

I learned about the NNSA Graduate Fellowship Program (NGFP) during my time in graduate school at an LRGF annual meeting. An alum of both programs was speaking about her experiences in graduate school and about how much she enjoyed her experiences as an NGFP fellow. I was inspired by her and wanted to learn more about opportunities in policy at the NNSA. I applied for the NGFP near the end of my graduate research and ended up working as a fellow while I finished writing my dissertation. While it was a busy and hectic time, the fellowship was the perfect chance to learn about day-to-day life at the NNSA in Washington, DC. After the NGFP fellowship ended, I accepted a full-time, federal position when I completed my graduate degree.

If I could offer advice to students considering different career paths, it is "run the experiment". As I mentioned earlier, I always have been fundamentally curious and that is likely why I tried out so many different projects and opportunities, while I was in graduate school. Each opportunity expanded my understanding and challenged me to learn in different ways. This, ultimately, helped me make an informed decision about what I wanted to do after graduation. My inner experimentalist firmly believes that when it comes to figuring out your career, the easiest way to decide is to run the experiment.

Stewardship Science Graduate Fellowship and Laboratory Residency Graduate Fellowship 2024-2025 Classes

by The Krell Institute

Fourteen 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

At the University of Nevada, Reno, Matthew Armbrust will study how shocked surfaces eject large quantities of material, potentially diminishing performance in engineering applications. With SSGF alumnus and advisor Rick Kraus, Armbrust will work to close key knowledge gaps in the three stages of shallow bubble collapse, a proposed mechanism of shock-induced material ejection. For stage one, shock melting and cavitation, he will measure spall strength and track void formation. His studies on stage two, re-shock of the porous material, will investigate energy-deposition mechanisms. For stage three, vaporization, he will work to identify shock strengths needed to vaporize metals.

The Massachusetts Institute of Technology's Matthew Cufari will investigate applying an external magnetic field to inertial confinement fusion implosions to increase energy gain and nuclear fusion reactions. With Johan Frenje, he will study the effects of magnetic fields on heating and a range of ion behaviors and will obtain spatial and temporal measurements of hot spot density and temperature under such fields.

At Ohio State University, Carter Fietek is developing a single test to characterize how sheet metals used in the nuclear stockpile bend, fold, crumple, and crack under stress and strain. With Jeremy Seidt, he will probe the materials' plastic anisotropy by applying inverse analysis to an experiment in which a device expands a hole in a sheet-metal sample until it fractures. Faster and less costly than current tests, the experiment can potentially capture key stress states and offer insights into how cracks begin and propagate. Fietek will also vary the device's speed to capture failures at high rates and under impact loading.

Characteristic gamma rays from long-lived fission products hold vital data for stockpile stewardship and nuclear forensics. With Lee Bernstein, Isabel Hernandez at the University of California, Berkeley, is performing the most precise measurements to date of gamma-ray intensities from three such isotopes, aiming to reduce their absolute uncertainties to 1%. She has completed experiments on gold and is simulating the detection devices to determine their efficiencies. Her subsequent experiments on another element, terbium, point to 1% precision for the gamma-ray intensities, and she is currently preparing cadmium studies with experimental refinements, testing, calibrations, and simulations.

An electron passing through a plasma may either lose energy, emitting electromagnetic radiation, or gain energy, absorbing the radiation from an external field. These well-known phenomena, called free-free energy transport, are not well described in strongly coupled plasmas, where the plasma particles' potential energy is higher than the average plasma kinetic energy. Strongly coupled plasmas arise in inertial confinement fusion experiments, thermonuclear weapons, and some astrophysical objects. Working with Scott Baalrud at the University of Michigan, Julian Kinney has developed a mean force emission theory for the free-free emission coefficient in such plasmas, verifying the theory for repulsively interacting plasmas. He will extend the theory to include attractive interactions and to investigate free-free absorption and line broadening.

For highly compressed materials, the equations of state needed to create hydrodynamics codes can be elusive or wholly unobtainable and must be derived through quantum-mechanical methods. However, the best tool for equations of state, density functional theory (DFT), is insufficiently accurate for these materials. With Wei Cai at Stanford University, Eliana Krakovsky will focus on sharpening the accuracy of DFT methods. She plans to improve the full potential linear muffin tin orbital DFT method and use it to calculate equations of state by combining it with a free energy perturbation theory method.

At the University of Illinois Urbana-Champaign, Sean Peyres investigates basic plasma-liquid electro-chemistry in a range of potential applications. With R. Mohan Sankaran, he induces plasmas to form in contact with a liquid, creating an interface where strongly reducing and oxidizing radicals form and dissolve into the liquid. He has developed a thin-film model of the solution-phase radicals' movements and reactions, along with those of their scavengers and reactants near the interface. He'll extend this research to non-aqueous solvents and unique redox chemistries. He plans to expand his research into isotope separation and actinide radiochemistry, potentially synthesizing valuable actinide compounds.

The bladed machinery now used to mix thick blends of energetic powders and binders for munitions give low yields, low purity, and high levels of wasted material and money. Emad Renfroe of the Georgia

Institute of Technology is working to solve the problem with resonant acoustic mixing (RAM)—the use of low-frequency sound waves to mix highly viscous materials. With Blair Brettmann, he will study granule formation during RAM and the effects of raw material properties and processing conditions on the results.

Laboratory Residency Graduate Fellowship

With advisor Siegfried Glenzer, Stanford University's Danielle Brown is working to deliver new diagnostic tools and improved target design to Magnetized Linear Inertial Fusion (MagLIF) research on the Z pulsed power facility at Sandia National Laboratories, New Mexico. During her Sandia residencies with Matthias Geissel, she will develop short-pulse, X-ray backlighter radiation sources, offering more *in situ* plasma imaging options, and arrays for radiographic imaging, particle spectrometry, and to track detection of protons, neutrons, and other particles. In addition, she will continue to develop a computational technique she created to track detector particle yields. Finally, she will investigate MagLIF target designs and build a database to help researchers optimize targets to laser settings.

During indirect-drive inertial confinement fusion, plasma bubbles arise from the target cavity's, or hohlraum's, inner walls, interfering with the laser-driven implosion of nuclear fuel. Skylar Dannhoff at the Massachusetts Institute of Technology is studying the role of self-generated magnetic fields in the hohlraum, which may frustrate the use of foam linings to tamp down bubble formation. With Chikang Li, she is tackling the disconnect between experimental results and magnetohydrodynamic simulations. To close the gap, she will undertake experiments at the University of Rochester's Omega Laser Facility and incorporate magnetic fields in HYDRA simulations of foam-lined hohlraums through residencies with Chris Walsh at Lawrence Livermore National Laboratory.

Without taking flight, Tyler Nichols at the University of Colorado Boulder will study how materials endure hypersonic velocities. With Iain Boyd, he will develop ground-based approaches that replicate the extreme heat and oxidative reactions that airflow inflicts on vehicles going at least five times the speed of sound. In his residencies at Lawrence Livermore National Laboratory with Aric Rousso, Nichols will study oxidation absorption and phase change phenomena in metallic, ceramic, and composite surfaces using a wind tunnel coupled with a high-powered laser. The research is aimed at improving existing numerical models with a fuller understanding of hypersonic airflows through an alternative to costly, logistically challenging, in-flight experiments.

At Texas A&M University, Athena Padgiotis will study the shock compression responses and limits of composite materials relevant to stockpile stewardship. With Scott Jackson, she will determine the equations of state and dynamic strengths of the versatile adhesive Epon 828/DEA, granular aluminum oxide, and graphite filler materials individually, as well as composite materials made by combining those components. She will study the materials' dynamic strength using Argonne National Laboratory's Advanced Photon Source. During residencies at Sandia National Laboratories, California, with LRGF alumnus Travis Voorhees, her experiments will characterize the equation of state and dynamic fracture of Epon 828/DEA. She will incorporate her results into simulations of the materials' hydrodynamic responses.

Adria Peterkin at the Massachusetts Institute of Technology will develop a model of the potential energy within molten salts that show promise for use in nuclear fusion and fission reactors, seeking insights into how radiation increases the salts' corrosivity. She is working with Michael Short, whose group discovered that radiation has competing effects on metals in molten salt, decelerating corrosion under the direct beam but increasing salt corrosivity overall, which accelerates corrosion outside the beam. She will spend her residencies studying how radiation alters the chemical structures of FLiBe and FLiNaK in collaboration with Blas Uberuaga at Los Alamos National Laboratory. Her goal is a model that accurately predicts corrosion severity before advanced reactors come online.

In spacecraft and satellites, high-energy particles from the sun embed themselves in insulators, causing dielectric breakdown and sparks that shut down systems. At the University of Maryland, College Park, Kate Sturge studies how to prevent this type of electrostatic discharge (ESD). In Timothy Koeth's lab, her experiments on the temperature-dependence of charge trapping in dielectrics have aided a computer model of charge carrier mobility within materials. She also clocked astonishingly fast dielectric breakdown propagations, some having top speeds of almost 5% the speed of light. In residencies with Karl Smith, Jonathan Barney, David Walter, and Samuel Henderson at Los Alamos National Laboratory, she will investigate the roles of samples' geometry and temperature, searching for polymer properties that toughen up dielectrics, then use particle-matter interaction codes to characterize materials' dielectric breakdown.

COORDINATOR'S CORNER

by Stephanie Miller, Academic Programs Coordinator

Hello everyone! We are introducing a new Coordinator's Corner section to the Academic Programs Quarterly to give us a chance to highlight some of the amazing work happening in Academic Programs.

Stewardship Science Academic Alliances

The Stewardship Science Academic Alliances (SSAA) program funds collaborative Centers of Excellence and smaller individual investigator research projects, both of which conduct fundamental science and technology research of relevance to the nuclear weapons' stockpile. Faculty associated with the SSAA's Center for Additively Manufactured Complex Systems under Extremes (CAMCSE) have developed workshops, available on Youtube, in Additive Manufacturing, Static Compression of Materials, Ultrahigh-rate Mechanical Characterization via Laser-induced Projectile Impact Test (LIPIT), and First Principles and Machine Learning Methods in Materials Modeling and Discovery. If you are interested in learning more, visit the workshops page. ✦

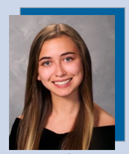
High Energy Density Laboratory Plasmas

The joint program in High Energy Density Laboratory Plasmas (HEDLP) supports high-quality multi-year research projects by academic institutions in the area of high energy density laboratory plasmas. This year, the NNSA's Technology and Partnerships Office has selected five awards:

- The **University of California, San Diego** with principal investigator (PI), Mathieu Bailly-Grandvaux, for "Driving Plasmas to Extreme Magnetizations using Strong Laser Compression and High Initial Magnetic Field"
- The **Ohio State University** with PI, Douglass Schumacher, for "Novel Plasma Optics for Relativistic Plasma Physics and New Experiments using Novel Polarization"
- The **University of California, San Diego** with PI, Farhat Beg, for "Magnetic Field Distribution in Multi-Liner, Gas Puff Z-pinches using 700 kA Linear Transformer Driver"
- The **University of Michigan** with PI, Louise Willingale, for "Direct Laser Acceleration of Electrons for Bright, Directional Radiation Sources"
- **The University of Texas at Austin** with PI, Sandra Bruce, for "Observing Quantum Effects in Hole-Boring and Photon Jet Production in Petawatt Laser-Solid."

Congratulations to the awardees! ✦

> *Thank you again for taking a chance on me early in my career. The MSIIP internship has truly been one of the biggest blessings, and I cannot express my full gratitude for this office. I am very pleased to announce that I will be working in DOE-IN starting June 17. From MSIIP, NGFP, and now to DOE, I couldn't have done it without your amazing mentorship.*
>
> –Sia Paulsen, MSIIP



Paulsen

Minority Serving Institutions Internship Program

The Minority Serving Institutions Internship Program (MSIIP) welcomed its largest cohort yet for the Class of 2025. Congratulations to all the interns! MSIIP was founded to reflect the importance of increasing diversity of thought, ideas, leadership, and experience to tackle the array of complex challenges facing the nuclear security enterprise today. This year's cohort has 153 interns, including 30 who are returning for either their second or third appointment. There is no doubt this cohort of interns will go on to do incredible things. Recently, a former MSIIP alum, Sia Paulsen, accepted a federal offer with the Department of Energy. After a summer as an MSIIP intern, she stayed on as a part-time intern through her academic year. Then, she applied for and was selected to be an NNSA Graduate Fellowship Program (NGFP) fellow. Sia is a fantastic example of how the Academic Programs work together to train the next generation of national security enterprise employees. ✦

NNSA Academic Programs Website

Visit the Academic Programs website to learn more about our programs. You'll find information about the High Energy Density Laboratory Plasmas, Minority Serving Institutions Internship Program, Predictive Science Academic Alliance Program, Stewardship Science Academic Alliances, and the three DOE/NNSA Fellowship Programs. While you're there, be sure to check out the Upcoming Events, Learning Library, Highlights & Reports, and Student Opportunities pages. ✦

Fellowship Applications

Applications for the 2025-2026 Stewardship Science Graduate Fellowship (SSGF), Laboratory Residency Graduate Fellowship (LRGF), and Computational Science Graduate Fellowship (CSGF) cohorts will be available soon. It is never too early to become familiar with the fellowship programs and the application requirements and process. NNSA fellowship programs frequently inform career trajectories and offer long-lasting, positive effects on lives. For more information and how to how to apply, click on the following programs: CSGF, SSGF, and LRGF. ✦