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Calendar

10/1/2021
2022 HED Science Center Postdoctoral Fellowship applications due

10/11-14/2021
2021 Fall Meeting of the APS Division of Nuclear Physics, Boston, MA

11/8-12/2021
63rd Annual Meeting of the APS Division of Plasma Physics,Pittsburgh, PA

12/12-16/2021
IEEE Pulsed Power Conference & Symposium on Fusion Engineering, Denver, CO

Inside

*National Laboratory Detailee **Contractor Support

Welcome to the latest issue of *Stewardship Science Today*. RDT&E and its laboratory partners continue to reach milestones, break records, and produce impactful work for our mission as we navigate the ever-present challenges posed by the pandemic. Kudos and congratulations to the team at the National Ignition Facility at Lawrence Livermore National Laboratory (LLNL) for the record-breaking inertial confinement fusion (ICF) implosion yield on August 8. The data is still being analyzed; however, this momentous shot has numerous implications for the future of ICF and will be featured in the December issue of SST. We also congratulate our colleagues at Sandia National Laboratories and were honored to celebrate with them the 25th anniversary of the first shot on the Z machine. The photo on the right was taken during the formal program.

Sandia National Laboratories celebrated the 25th anniversary of the first shot on Z in September 1996. To commemorate the event, former directors of the Pulsed Power Sciences Center at Sandia shared remembrances and stories. From left to right are Gerry Yonas, Pace VanDevender, Don Cook, Jeff Quintenz, Keith Matzen, and Dan Sinars (current director). Former director Mark Herrmann was unable to attend due to Sandia business.

Our commitment to future generations of stockpile stewards continues to grow. You'll read about the first two alumni of the DOE/NNSA Laboratory Residency Graduate Fellowship (LRGF) program as well as the newest LRGF and Stewardship Science Graduate Fellowship classes. Also highlighted in this issue is pivotal work being conducted by Los Alamos National Laboratory and LLNL that is helping to improve the safety of explosives.

As always, keep yourselves and your loved ones safe.

Dr. Mark C. Anderson
Assistant Deputy Administrator
for Research, Development, Test, and Evaluation

The Next Generation of Stockpile Stewards
DOE/NNSA Laboratory Residency Graduate Fellowship Alumni

Dane M. Sterbentz, PhD
Lawrence Livermore National Laboratory

Sterbentz

The DOE/NNSA Laboratory Residency Graduate Fellowship (LRGF) allowed me to closely collaborate with world-class researchers at Lawrence Livermore National Laboratory (LLNL) while providing me with the funding and resources necessary to complete my PhD work. The LRGF also provided many great opportunities to meet and network with students and researchers affiliated with universities and DOE national laboratories from across the country. Through the on-site laboratory residencies at LLNL (provided by the LRGF), I was able to experience firsthand what a career at a DOE national laboratory might be like. Between the many exciting research opportunities and the ability to work with some of the top experts in the field of high energy density physics, I am now convinced that a national laboratory is one of the best places to start a career for a PhD graduate.

After completing my PhD, I started a postdoctoral research position in the Design Physics Division at LLNL. My postdoctoral research project involves the suppression of perturbation growth from Richtmyer-Meshkov instability (RMI) in shock-compressed materials. This instability, caused by shock-wave acceleration, leads to the propagation of spike growth at an interface between two materials of different densities. RMI is prevalent in inertial confinement fusion capsule implosions, where asymmetries caused by RMI reduce the energy yield of the compressed fuel target. For my postdoctoral research, I use hydrodynamic simulations of impactor

(continued on page 4)

Research on Transition Phenomena to Aid in Improving Safety of Explosives *by Laura Smilowitz (Los Alamos National Laboratory)*

"It is almost certain that shortly after the first successful demonstration of a black powder rocket in China circa 900 AD, a test blew up on the pad killing the inventor," says Bryan Henson, of the Thermal Kinetics and Dynamics team at Los Alamos National Laboratory (LANL). The problem of explosive stability is as old as explosives themselves and continues to plague them, as evidenced by the recent explosion of the Starship SN10 Spacecraft on landing (March 3, 2021 in South Padre Island, TX). The rocket appeared to have landed safely, but minutes later, underwent a violent explosion, the cause of which is under investigation.

Explosive materials derive their utility from the ability to release stored energy on the nanosecond timescale of detonation. The safety of explosives depends on being able to handle them without triggering a detonation. The feat of safely handling explosives rests on being able to trigger the ultrafast release of energy when desired but not accidentally. Understanding what might cause that transition is critically important to both safe handling of explosives and their ability to function as intended.

Groups at LANL and Lawrence Livermore National Laboratory (LLNL) have recently added to our understanding of the phenomenon of transitioning from a slow energy release to a detonation, also known as a deflagration to detonation transition (DDT). The phenomenon of DDT has been historically difficult to study, due in part to the vast disparity in timescales involved in the release of energy during an explosion and the difficulties in observing phenomena under such extreme conditions. "An explosion begins with heating or impact lasting seconds to minutes.

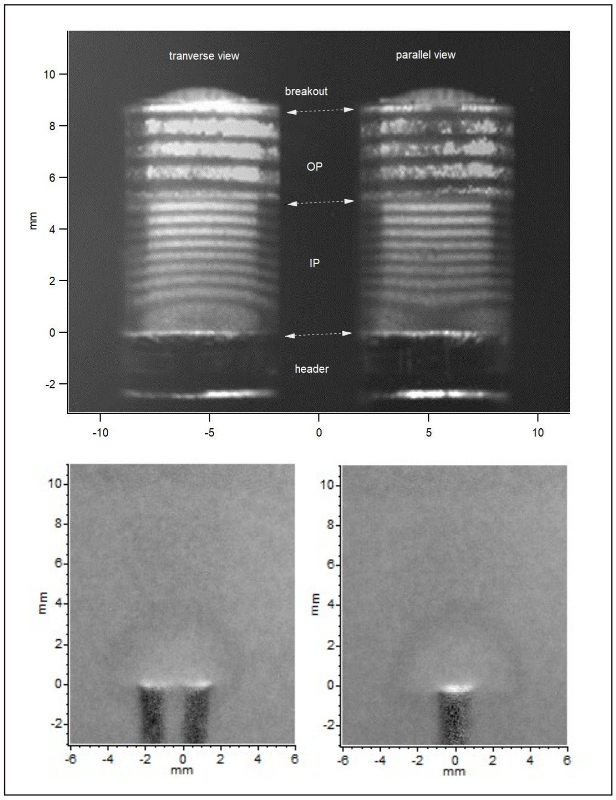


Figure 1. Simultaneous visible and X-ray transmission images of detonation initiation. Top panels - visible light emission collected during detonation propagation showing the asymmetry of the wave. Bottom panels are x-ray frames collected during detonation showing the symmetry of the shock wave.

Timescales then quickly accelerate after ignition to microseconds and can accelerate further if detonation occurs with reaction at the leading edge of the shock wave occurring in nanoseconds. The challenge in exploring the DDT phenomenon is to be able to see within the evolving explosion with a dynamic range in time sufficient to capture the whole event," said Laura Smilowitz, LANL co-author of a recent work on DDT appearing in the *Journal of Applied Physics* and pioneer in laboratory-scale X-ray radiographic techniques for viewing inside such explosions.

In that paper, larger scale experiments on porous explosive powder in clear polycarbonate tubes were conducted by combining timing and diagnostic techniques developed at LANL with LLNL's High Explosives Application Facility. These experiments have revealed key insights about the transient phenomena that occurs during the DDT process. "We were able to image this DDT transition process as it happened with both light and X-rays at the same time," said principal investigator and LLNL engineer Joe Tringe. "We characterized the three-dimensional nature of the process using a surrogate for damaged explosives. We think our observations will be important to help predict when and under what circumstances these transitions might happen in the future. While our research doesn't overturn previous theories of how the process works, it provides a new way of understanding this process that was previously inaccessible."

"Throughout the previous decades, experimental results from many research groups have been interpreted differently and the mechanisms derived for DDT have been debated. In many instances, each group in the debate put forth plausible interpretations because there was often ambiguity in the older data records," said LANL's High Explosives Thermal and Mechanical Response Team leader and paper co-author Gary Parker. "The methods employed in this work, however, provide us with insight into how certain elements of the process evolve and these new observations should help settle some of the debate within our community. We look forward to exploring the impact and breadth of applicability of this new avenue in DDT research."

The interdisciplinary team included co-authors at LLNL David Stobbe, Martin De Haven, Aaron Ruch, Bradley White, John Reaugh, and Kevin Vandersall. LANL's Gary Parker, Laura Smilowitz, Matthew Holmes, Larry Vaughn, and Bryan Henson assisted with experimental design and analysis.

This work was performed by Los Alamos National Laboratory, operated by Triad National Security, LLC, and Lawrence Livermore National Laboratory, operated by Lawrence Livermore National Security, LLC, for the U.S. Department of Energy/ National Nuclear Security Administration. The NNSA Office of Experimental Sciences supported this work through its Dynamic Materials Properties subprogram. ◆

The 2021-2022 DOE/NNSA Stewardship Science Graduate Fellowship and Laboratory Residency Graduate Fellowship Classes

by the Krell Institute

Five doctoral students will join the Department of Energy/National Nuclear Security Administration (DOE/NNSA) Stewardship Science Graduate Fellowship (SSGF), and four will join the Laboratory Residency Graduate Fellowship (LRGF) this fall. Stewardship Science fellows research subjects in high energy density physics, nuclear science, and materials under extreme conditions and hydrodynamics. They serve a 12-week practicum at an NNSA national laboratory. Laboratory Residency fellows study engineering and applied sciences, physics, materials, and mathematics and computational science. They perform at least two practicums and are encouraged to collaborate on their thesis research with lab scientists. All fellows receive tuition, a stipend and other benefits. Summaries of the new fellows' research statements follow.

Stewardship Science Graduate Fellowship

With dynamic diamond anvil cell technology, **John Copley** of Princeton University induces phase transformation, focusing on the rate dependence of the B3 to B1 transition in zinc sulfide. With advisor Thomas Duffy, Copley will adopt the time cone analytical approach, which is able to distinguish effects of overpressure on the nucleation and growth rates individually rather than in combination. Validating time cone method results requires knowing the post-transformation grain size, so Copley will measure that property before and after pressurization. Because the time-cone method can independently assess growth rates as a function of overpressure, initial experiments that observe transformation at fixed overpressures can predict transformation behavior at changing overpressures. He will compare the simulations with experiments for further validation.

At Washington University in St. Louis, **Garrett King** uses quantum Monte Carlo to probe theoretical descriptions of nuclei with mass up to A=13 and calculate nuclear electroweak observables over a range of energy and momentum transfer. With Zohan Nussinov, he's evaluated matrix elements relevant to beta decay to validate their model. He's now calculating beta-decay spectra to further substantiate it at low momentum transfer and predict an observable with precision measurements. King also is calculating muon capture rates to validate responses at moderate momentum transfer. The validated responses will let him compute nuclear matrix elements relevant to neutrino scattering and neutrinoless double decay. The goal: identifying relevant physics to include in approximations in models of heavy nuclei. He also plans to extend QMC to additional processes.

University of Colorado Boulder student **River Leversee** will study the aromatic hydrocarbons benzene and hexafluorobenzene under hydrostatic pressure. Previous studies found that the materials form nanothreads and later polymerize when under uniaxial pressure. Using apparatus at Argonne National Laboratory or in the lab of his advisor, Jorg Weber, Leversee plans to create an environment closer to true hydrostatic pressure, removing a motivating factor for nanothread formation and delaying polymerization, allowing study of the unpolymerized materials at previously unobserved high pressures. Leversee also plans to research void collapse in polymer bonded explosives, building on research he did while interning at Lawrence Livermore National Laboratory.

With Chikang Li, **Ben Reichelt** of the Massachusetts Institute of Technology concentrates on two inertial confinement fusion (ICF) areas. First, he studies mechanisms that enhance effective stopping of charged particles in relevant plasmas, focusing on trajectory deviations that cause them to travel paths with longer arc lengths. Second, he examines kinetic effects of mix on particle transport in implosions. Fully kinetic plasma descriptions are becoming feasible with new computer technology, and Reichelt has worked with codes to diagnose how important these considerations are in ICF. He'll also perform experiments on the OMEGA laser to examine those effects.

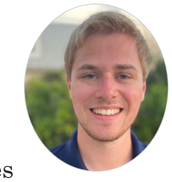
Yoni Xiong focuses her Vanderbilt University graduate research on evaluating and mitigating radiation and aging effects in electronic systems. The project, with Bharat Bhuva, builds on work she's done at the school's Institute for Space Defense Electronics. Xiong will use custom-designed integrated circuits to study the impact of radiation, including disabling total ionizing dose and temporary single-event effects, on the 7-nm and 5-nm bulk FinFET technology nodes. She also plans to characterize and model aging effects on the newest 5-nm nodes.

Laboratory Residency Graduate Fellowship

University of Michigan student **Alexander Kavner** will use Q spectroscopy with magnetic microcalorimeters (MMCs) for accurate isotope analysis of small radioactive samples. He'll focus on measuring the controversial half-life of Sm-146, a key to understanding early solar-system formation. With advisor Igor Jovanovic and LLNL mentor Stephan Friedrich, Kavner will use an MMC Q-spectrometer to measure the Sm-146 half-life from the absolute Sm-146 signal rate and from the rate relative to Sm-147, using known amounts of both. MMCs, however, are slow and can introduce uncertainties due to pile-up. Kavner has developed Monte Carlo simulations to estimate pile-up as a function of signal rise time, decay time and total signal rate. The residency will allow Kavner to test his simulations experimentally.

With Nicholas Boechler at the University of California, San Diego, **Brianna MacNider** will use optimization techniques, simulation, and experiments to study optimizing geometrically nonlinear periodic microstructures to achieve desired material behavior under dynamic loading. She'll determine the constitutive law needed to enable a desired behavior through continuum wave optimization and use topology optimization to tailor microstructures to exhibit it. MacNider will build lattices of the periodic microstructures for experimental validation. Her residency at Los Alamos National Laboratory (LANL) with mentor Dana Dattelbaum will allow her to work with experts in shock tailoring, energetic materials, and material modeling techniques. She expects to gain insight into wave optimization methods. "The experience gained through the residency will be invaluable to the development of my thesis research," she writes.

Brian Rodgers plans residencies at both LLNL and LANL to study solidification of alloys in additive manufacturing. The residencies will provide access to equipment and expertise beyond that of his university, Colorado School of Mines, and will let Rodgers develop a more complete understanding of how his model alloy, Al-Ag, solidifies. At LLNL, where his mentor is Joseph McKeown, Rodgers will perform *in situ* laser melts using dynamic transmission electron microscopy to resolve submicron structures on microsecond timeframes. Rodgers also will perform experiments he couldn't perform at Mines, where Amy Clarke is his advisor. At LANL, Rodgers plans to perform molecular dynamics modeling to predict fundamental properties of the alloys used in his research and do experiments to validate the results. He chose LANL for the expertise in modeling materials and its experimental capabilities.



With experience in the University of Michigan's Plasma, Pulsed Power, and Microwave Laboratory, **Brendan Sporer** focuses on the physics of high-field theta-pinches and field-reversed configurations (FRCs). FRCs, a type of compact toroid, are promising targets for magneto-inertial fusion. During his first residency with Steven Slutz at Sandia National Laboratories' New Mexico campus, Sporer will use the HYDRA inertial confinement fusion code to simulate such experiments. He'll also perform tests on the Mykonos facility, which is similar to the Michigan Accelerator for Inductive Z-pinch Experiments device, where Ryan McBride is his advisor. The results could warrant access to Sandia's Z machine for fully integrated implosions—the ultimate goal of Sporer's research. "Full-scale implosions could produce large fusion yields and indispensable data on magnetic reconnection, magnetic field compression, and burning plasma dynamics," he wrote. ◆

The Next Generation of Stockpile Stewards *(continued from page 1)*

shock-wave experiments and methods based in design optimization and machine learning to suppress RMI growth by altering the geometry and other properties of a shock-compressed material target.

Travis Voorhees, PhD

Sandia National Laboratories

The DOE/NNSA Laboratory Residency Graduate Fellowship (LRGF) program, managed by Krell Institute, significantly improved my graduate school experience and helped me attain my dream job. Specifically, the support that the LRGF provided me helped focus my thesis research, granted me greater exposure to the national laboratories, and improved my confidence in reaching out to experts in the shock physics field. By becoming a LRGF fellow, I no longer had to work as a teaching assistant. This increased the amount of time I could spend on my thesis research by approximately 30%, allowing

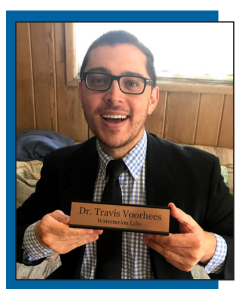


Photo was taken immediately after Voorhees successfully defended his thesis remotely because of COVID protocols. "It actually allowed far more of my friends and family members to see my defense. Overall it was a great experience," he said.

me to add an additional chapter to my dissertation. The LRGF stipend helped alleviate the various financial worries that come from being a graduate student in a relatively expensive city (Atlanta, Georgia), and I used the LRGF allowance to build a high performance Linux server that was instrumental to analyzing my thesis research. The LRGF helped expose me to the national laboratories through a variety of venues, such as my 10-week residencies at Los Alamos National Laboratory (X-Theoretical Design), networking at the summer SSGF/LRGF program reviews, and

Voorhees aligns laser probes on a target at Georgia Institute of Technology's High Strain Rate Laboratory. The target is mounted directly to the 80 mm gas gun's breach, with a 50 mm stand-off. The large steel tank behind him is the catch tank that catches targets after they've been impacted.

travel to NNSA-sponsored conferences such as the Stewardship Science Academic Programs Symposium. I believe that these factors helped me confirm and obtain my dream job—I am currently working as an R&D Engineer in the Mechanics of Materials group at Sandia National Laboratories. ◆