National Nuclear Security Administration

Stewardship Science Today

Office of Research, Development, Test, and Evaluation (RDT&E)

VOLUME 2 | NUMBER 4 | DECEMBER 2020

Stewardship Science Today (SST) highlights the stewardship science and academic programs supported by the Department of Energy/National Nuclear Security Administration (DOE/NNSA). SST is published quarterly by the NNSA Office of Research, Development, Test, and Evaluation. Questions and comments regarding this publication should be directed to Terri Stone via email at terri.stone@nnsa.doe.gov.

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CALENDAR

1/6/2021
Applications due for the Stewardship Science Graduate Fellowship (SSGF)

1/13/2021
Applications due for the Computational Science Graduate Fellowship (CSGF)

2/16-18/2021
Stewardship Science Academic Programs Symposium (virtual), registration deadline: 2/1

3/17/2021
Applications due for the Laboratory Residency Graduate Fellowship (LRGF)

INSIDE

*Contractor Support **National Laboratory Detailee

The Office of Research, Development, Test, and Evaluation continues to recruit stellar talent to our ranks. In this issue, we welcome two new members to our team, Dr. Kevin Jackman and Dr. Heather Whitley. We also congratulate Dr. Jolie Cizewski of Rutgers University for her recent mentoring award from the American Physical Society Division of Nuclear Physics.

NNSA congratulates Dr. Jolie Cizewski (far right), recipient of the 2020 American Physical Society Division of Nuclear Physics Mentoring Award (see page 4). She is pictured with a current and former student and a former postdoctoral researcher.

This issue features recent work at the Omega Laser Facility that, through well-designed experiments and innovative diagnostics, has shown that heat transport is well-modeled in indirect-drive inertial confinement fusion (ICF) experiments. This result suggests that the drive-deficit in this ICF approach is due to factors other than heat transport—an important step-forward for ICF work.

The COVID-19 pandemic continues to plague the world. Yet, the Center for Research Excellence on Dynamically Deformed Solids (CREDDS) was able to quickly put together a Summer School for Dynamic Deformation of Solids using an online platform and the cooperation and creativity of lecturers from across academia and the national laboratories. We thank CREDDS for their contributions to advancing the knowledge and research initiatives of graduate students whose work and careers are important to our mission. As this pandemic enters a time of record new cases, please practice social distancing, wear a mask, and wash your hands. It is up to us to protect each other.

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

Research, Development, Test, and Evaluation's Office of Experimental Sciences Welcomes Dr. Kevin Jackman and Dr. Heather Whitley

The Office of Experimental Sciences (OES) is pleased to welcome two new members to the team.

Kevin Jackman

Dr. Kevin R. Jackman comes to DOE/NNSA, Office of Defense Programs, from the National Geospatial-Intelligence Agency where he served as a Supervisory Research Scientist on hypersonic and counterproliferation programs. From 2015-2018, Dr. Jackman was a LANL Technical Advisor supporting the DOE/NNSA DNN R&D – Office of Proliferation Detection. Prior to that, Dr. Jackman worked in LANL's Nuclear and Radiochemistry Group performing quantitative assay of radioactive materials for nuclear forensics and environmental monitoring programs. His research includes fission product yield measurements from NCERC irradiations, radiochemical analysis of nuclear debris, and gamma-ray spectroscopy. Dr. Jackman has formerly served on the DOE/NNSA DFO and DTRA Pacific Technical Support Group nuclear emergency response teams.

Dr. Jackman has a PhD and MS in Nuclear and Radiation Engineering, BS in Physics, and BA in Astronomy, from The University of Texas at Austin. Dr. Jackman has over a dozen journal articles, numerous internal lab reports, and presented at several international conferences. Dr. Jackman is a recipient of LANL Distinguished Performance Awards (2014, 2011, and 2006) and the Joe C. Walters Endowed Presidential Scholarship, and he is an Eagle Scout.

(continued on page 4)

Validating Heat Transport Models Using Directly-Driven Spheres at OMEGA

by William Farmer[1], George Swadling[1], Joseph Katz[2], Dana Edgell[2], Colin Bruulsema[3], Mark Sherlock[1], Mordy Rosen[1], and Wojciech Rozmus[3]

[1]Lawrence Livermore National Laboratory
[2]Laboratory for Laser Energetics
[3]University of Alberta

The indirect-drive approach to inertial confinement fusion (ICF) uses lasers to heat a radiation oven, or hohlraum. The radiation drive ablatively implodes a capsule filled with deuterium and tritium. Hohlraums are notoriously difficult to simulate due to the complex interplay of difficult-to-model physical processes. These processes include radiation and atomic physics which generate the x-ray drive, laser-plasma interactions (LPI) which govern how the laser couples to the hohlraum, and heat transport which determines how energy is partitioned. Further, integrated simulations of both a hohlraum and a capsule almost universally predict a capsule bang-time earlier than observed, colloquially referred to as the drive-deficit.[1,2]

The hohlraum modeling framework has been developed over the years through simpler experiments, e.g., gold disk emission experiments,[3] vacuum hohlraums,[4] and gold sphere experiments.[5] As a natural development of this effort, recent experiment and simulation work has been performed isolating the effect of heat transport using a directly driven, solid beryllium sphere.[6] These experiments were fielded on the OMEGA laser facility and utilized the state-of-the-art optical Thomson scattering (OTS) and laser coupling diagnostics. The OTS diagnostic precisely measured plasma conditions, and the laser-coupling gave an accurate assessment of scattered laser energy which is important for understanding the energy partition within the system. Comparisons to two-dimensional Lasnex simulations showed striking agreement with the data so long as certain heat transport models were chosen.

The OTS measurements rely on the state-of-the-art 4th Harmonic Thomson Scattering diagnostic developed at the Laboratory for Laser Energetics. Use of a 263 nm probe beam expands the range of plasma conditions that can be accessed, enabling the study of high-density plasmas. However, this introduces technical challenges, because this places the spectrum in the ultraviolet range. Broadband imaging in this spectrum is notoriously difficult due to the limited number of transparent glass types available and their rapidly varying index of refraction. To overcome these issues, the Thomson Scattering diagnostic on OMEGA was upgraded in 2012 to a fully-reflective optical system which delivers achromatic, diffraction-limited imaging performance across a broad spectral range.[7] Two streak-camera-coupled spectrometers simultaneously record scattered light from fluctuations within the plasma providing a highly resolved measurement of the complete Thomson scattered spectrum. Improved spatial resolution allows the precise definition of the volume of plasma sampled, enabling the proper treatment of spatial gradients in the data analysis.

The Thomson scattering technique allows experimenters to measure key parameters characterizing the experimental plasma such as the density and temperature. Figure 1 shows the spectrum of scattered light, which is determined by the underlying, thermally-excited plasma fluctuations. To extract measurement of the plasma parameters, the recorded spectrum must be fitted using a theoretical model that describes the relative amplitudes and phase velocities of these fluctuations. Analysis is complicated by the presence of strong plasma emission and by spatial gradients within the plasma. To produce accurate and consistent results, an improved fitting framework was developed that properly accounted for these effects. This resulted in precise, quantitative measurements of the temporal evolution of the plasma temperature and density that can be directly compared to simulations.

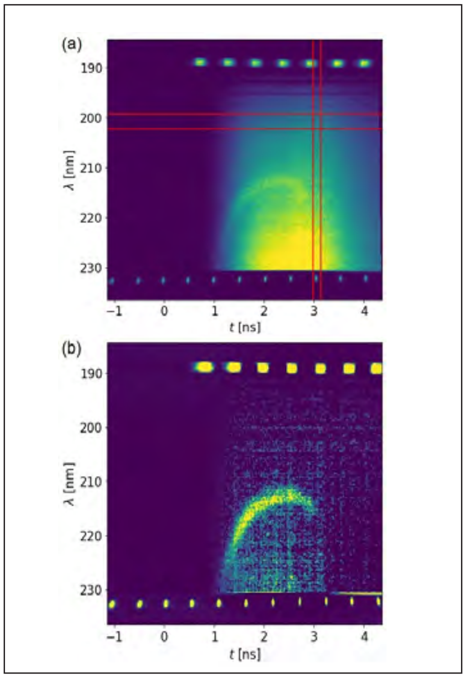

Figure 1. Scattered light observed by the OTS measurement. The vertical and horizontal axes correspond to time and wavelength, respectively. (a) With background. (b) With background subtracted. Bright spectral feature can be used to determine plasma conditions within the probe volume.

The uncoupled laser light was measured using the scattered light calorimeters and spectrometers on OMEGA. The offline, absolutely-calibrated calorimeters give the total time integrated uncoupled light while the time-varying history of the unabsorbed light is recorded by the spectrometer streak camera. Multiple channels are averaged for each measurement. Two drive intensities were used (10^{14} W/cm^2 and 2.5 x 10^{14} W/cm^2), and the diagnostics

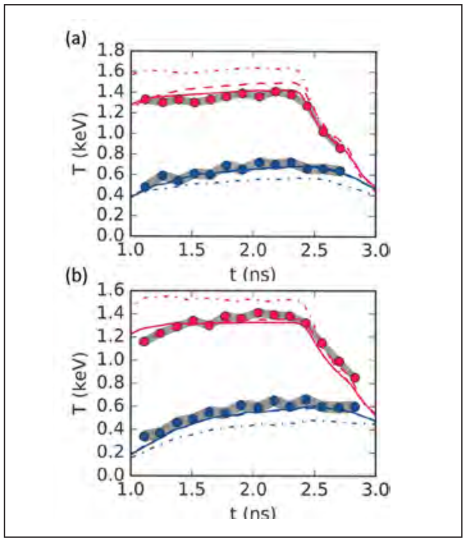

Figure 2. Comparisons of measured and simulated temperatures with nominal intensity 2.5×10^{14} W/cm^2. Panels (a) and (b) correspond to probe positions 200 and 400 μm from the surface of the sphere. Measurement is given by the circles, and the three models (a local heat flux model, a nonlocal heat transport model, and a restricted heat flux model) are given by the solid, dashed, and dash-dotted lines respectively. Red and blue colors correspond to electron and ion temperatures.

measured 3% and 10% scattered light for the low and high drive intensities, respectively.

Two-dimensional simulations, which included the Thomson probe beam, were performed in Lasnex using three commonly used heat transport models as shown in Figure 2. Remarkable agreement with the measurement is obtained with the nonlocal model (dashed curve in the plots) which agrees so well in panel (b) that the dashed curve is obscured by the measured data. Simulations predicted that scattered light typically was only 1% of the incident power, which does not match the measurement. The agreement with the plasma conditions suggests that heat transport is being modeled correctly and that deficiencies in modeling are in other processes. The understanding developed here is being applied to gold sphere experiments and ultimately will feed into progress toward a more predictive hohlraum model.

References

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[7]J. Katz et al, Rev. Sci. Instrum. 83, 10E349 (2012).

This work was performed under the auspices of the Department of Energy/National Nuclear Security Administration by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. ◆

Center for Research Excellence on Dynamically Deformed Solids Delivers Online Summer School *by CREDDS*

The COVID-19 crisis disrupted research plans for many Stewardship Science Academic Alliances-supported students: conference travel was cancelled, access to experimental facilities was restricted, and internships at national laboratories were postponed. In response, the Center for Research Excellence on Dynamically Deformed Solids (CREDDS) at Texas A&M University organized the online Summer School on Dynamic Deformation of Solids (SSDDS). It aimed to provide fundamental knowledge on dynamic deformation of solids to PhD students working on collaborative projects with NNSA laboratories. However, participation was unrestricted.

The school consisted of 13 weekly lectures delivered via Webex by faculty at U.S. academic institutions and technical staff at NNSA laboratories. The lecture topics and lecturers were:

1. Dynamic Deformation in Nature and in Technology, K.T. Ramesh (Johns Hopkins University)
2. Equilibrium Properties of Compressed Materials, Lorin Benedict (Lawrence Livermore National Laboratory)
3. Stress Waves in Solids, Bill Anderson (Los Alamos National Laboratory)
4. Shock Compression of Materials, Bill Anderson (Los Alamos National Laboratory)
5. Strain Rate Dependence of Plastic Deformation and Defect Microstructures, Amit Misra (University of Michigan, Ann Arbor)
6. Basic Mechanisms of Slip, Michael J. Demkowicz (Texas A&M University)
7. Basic Mechanisms of Twinning in Metals, Irene Beyerlein (University of California, Santa Barbara)
8. Experimental Techniques for Dynamic Deformation of Solids, Frank Zok (University of California, Santa Barbara)
9. Diagnostics of Dynamically Deformed Solids by Optical Velocimetry, Dan Dolan (Sandia National Laboratories)
10. Deformation Behind Shock Waves, D.J. Luscher (Los Alamos National Laboratory)
11. Hydrodynamic Instabilities, Bruce Remington, Ye Zhou, Robert Rudd (Lawrence Livermore National Laboratory)
12. Flow Localization, Mukul Kumar (Lawrence Livermore National Laboratory)
13. Dynamic Fracture, Justin Wilkerson (Texas A&M University)

The summer school ran from June 1 to August 27, 2020. Starting with the second lecture, participants were given take-home problems to reinforce concepts, and a review session was held a few days later to go over solutions. Ultimately, over 160 individuals registered for the summer school, representing a wide range of universities (Texas A&M University, Stanford University, Johns Hopkins University, University of California, San Diego, etc.), several national labs and user facilities (SLAC National Accelerator Laboratory, LLNL, LANL), and even industry (Baker Hughes). All the lectures and review sessions were recorded and made available on a public YouTube channel: https://www.youtube.com/channel/UCu3F29xeWUm23zcvGdtEctw. In addition to serving as a permanent resource for the research community working on dynamic deformation of solids, these recordings also will provide a starting point for planning the 2022 version of the SSDDS, which is expected to occur in person.

This work was performed under the auspices of the U.S. Department of Energy/National Nuclear Security Administration under Cooperative Agreement DE-NA003857. ◆

Dr. Jolie Cizewski, Rutgers University, Receives 2020 APS Division of Nuclear Physics Mentoring Award

by Dennis P. McNabb (LLNL)

Dr. Jolie Cizewski is this year's recipient of the American Physical Society (APS) Division of Nuclear Physics Mentoring Award. She is being recognized for the countless hours she has spent helping young scientists pursue their dreams and make career decisions. The citation reads—

"For her exceptional commitment to undergraduate and graduate education which has had an enormous and continued impact on the lives of first-generation college students, women in physics, graduate students and early career scientists."

We know her for the numerous undergraduates, graduates, and postdoctoral fellows who were introduced to the National Nuclear Security Administration and DOE/NNSA national laboratories through the Stewardship Science Academic Alliances Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science. This Center pioneered research in surrogate reactions, where the properties of nuclei important for understanding nucleosynthesis in exploding stars and neutron star mergers are measured, and advanced detector array development, specifically the production and implementation of GODDESS—a high efficiency and resolution particle γ-ray spectrometer. The significance of this work is presented in *Nature* and in *Physics Today*, where her work was highlighted on the cover of the August 2010 issue. In the broader community, she is recognized for numerous additional accomplishments, including hosting an APS Conference for Undergraduate Women in Physics and presenting "how to get into graduate school" talks at many undergraduate conferences.

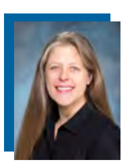
In 2018, Dr. Cizewski celebrated the Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science's 15th year of operation with former students, postdocs, and others.

Upon joining Dr. Jolie Cizewski's team, students are introduced to a supportive and constructive environment that grooms them for success. When previous team members attend group gatherings, she introduces them and discusses their accomplishments both with her team and in their subsequent positions. Dr. Jolie Cizewski's mentees gain the highest level of hands-on training through long-term placements at national laboratories, which she encourages, so they can become vital and integral contributors to future experimental campaigns.

Dr. Cizewski has mentored nineteen PhD students, including her four current students, 12 masters students, and 21 postdoctoral researchers. Notably, four of her former graduate students and seven former postdocs currently work at DOE/NNSA national laboratories. Her emphasis on facilitating scientific interaction between national laboratory staff and her mentees may be the key to her success in placing so many early career scientists at national laboratories. These impressive statistics span three decades, and her work with early career scientists continues to grow. Dr. Cizewski's counsel has supported NNSA Defense Programs in other capacities as well. As a member of the Defense Program Advisory Committee and laboratory committees, she has been an insightful contributor to the program mission and approach.

Congratulations, Dr. Cizewski! ◆

OES Welcomes Drs. Jackman and Whitley *(continued from page 1)*



Heather Whitley

Dr. Heather Whitley comes to OES from Lawrence Livermore National Laboratory (LLNL), where she served as a Group Leader and the Program Working Group Leader for Plasma Science in the Weapons and Complex Integration Directorate. Her work has supported the materials data needs for stockpile stewardship and high energy density experiments. She also led the Level 1 Milestone in Nominal and Off-Nominal Secondary Performance that was successfully completed in September 2019. During her assignment, she will be working with Federal Program Managers to develop program plans, specifically focusing on collaborations between OES and Advanced Simulations and Computing.

Dr. Whitley completed her graduate studies of quantum systems at the University of California, Berkeley and first joined LLNL as a postdoctoral researcher in September 2007. She has authored more than 30 peer reviewed journal articles and numerous reports. She was a recipient of the 2011 Presidential Early Career Award in Science and Engineering, and the 2002 National Defense Science and Engineering Graduate Fellowship. She has mentored several students who were participants in NNSA and LLNL academic programs. ◆

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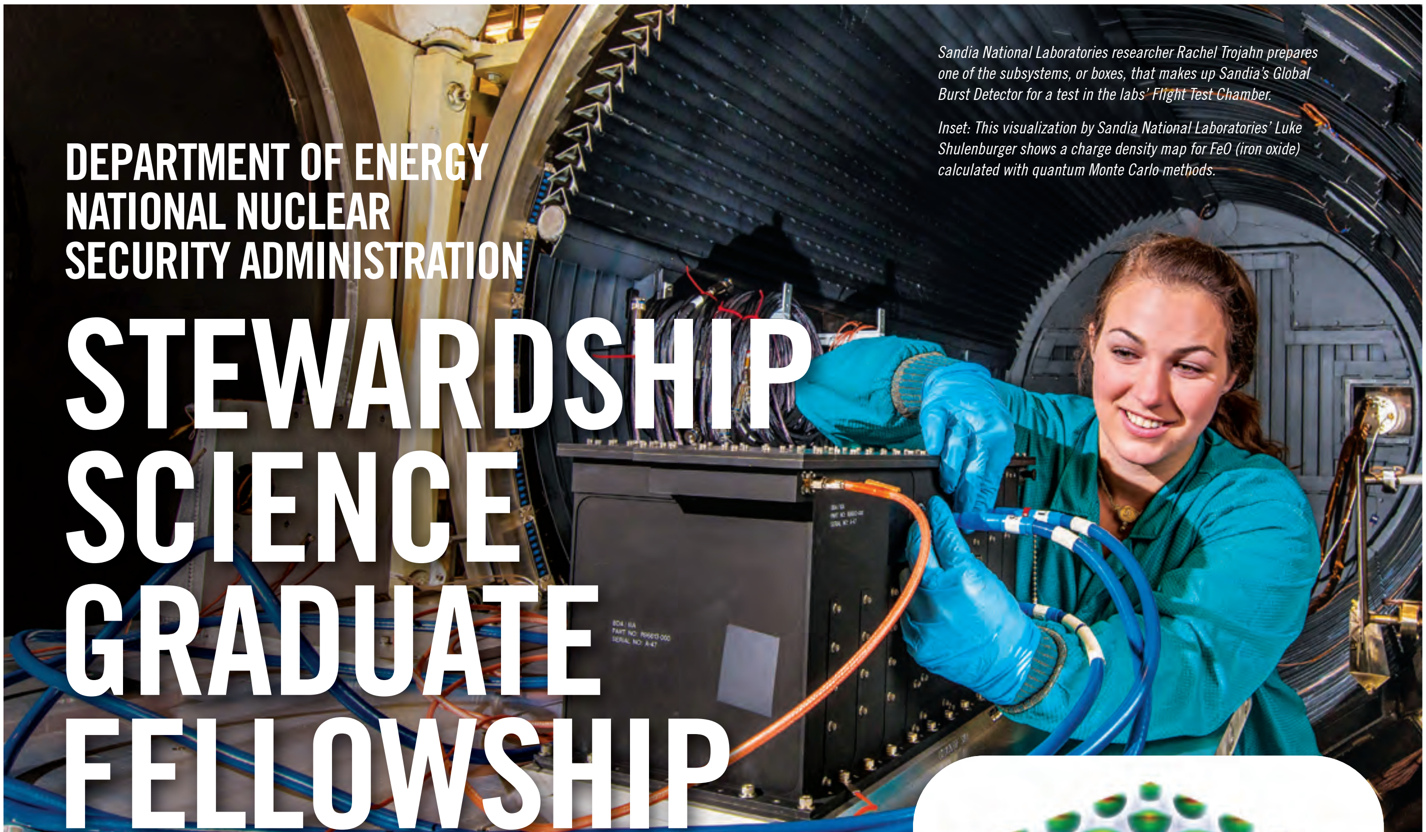
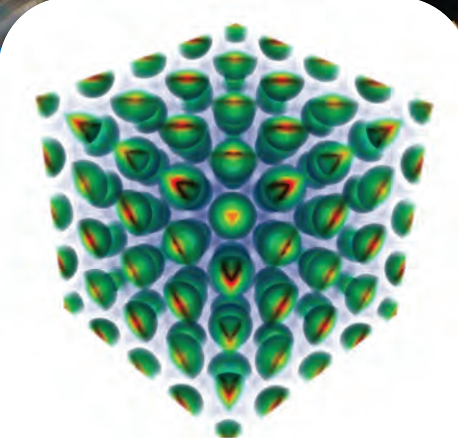


Sandia National Laboratories researcher Rachel Trojahn prepares one of the subsystems, or boxes, that makes up Sandia's Global Burst Detector for a test in the labs' Flight Test Chamber.

Inset: This visualization by Sandia National Laboratories' Luke Shulenburger shows a charge density map for FeO (iron oxide) calculated with quantum Monte Carlo methods.



SSGF

The Department of Energy National Nuclear Security Administration Stewardship Science Graduate Fellowship (DOE NNSA SSGF) provides outstanding benefits and opportunities to students pursuing a Ph.D. in areas of interest to stewardship science, such as **properties of materials under extreme conditions and hydrodynamics, nuclear science,** or **high energy density physics.** The fellowship includes a 12-week research experience at Lawrence Livermore National Laboratory, Los Alamos National Laboratory or Sandia National Laboratories.

BENEFITS

- $36,000 yearly stipend
- Payment of full tuition and required fees
- Yearly program review participation
- Annual professional development allowance
- 12-week research practicum experience
- Renewable up to four years

The DOE NNSA SSGF is open to U.S. citizens who are senior undergraduates or students in their first or second year of graduate study.

Applications Due 1.6.2021 ··· www.krellinst.org/ssgf

This equal opportunity program is open to all qualified persons without regard to race, gender, religion, age, physical disability or national origin.

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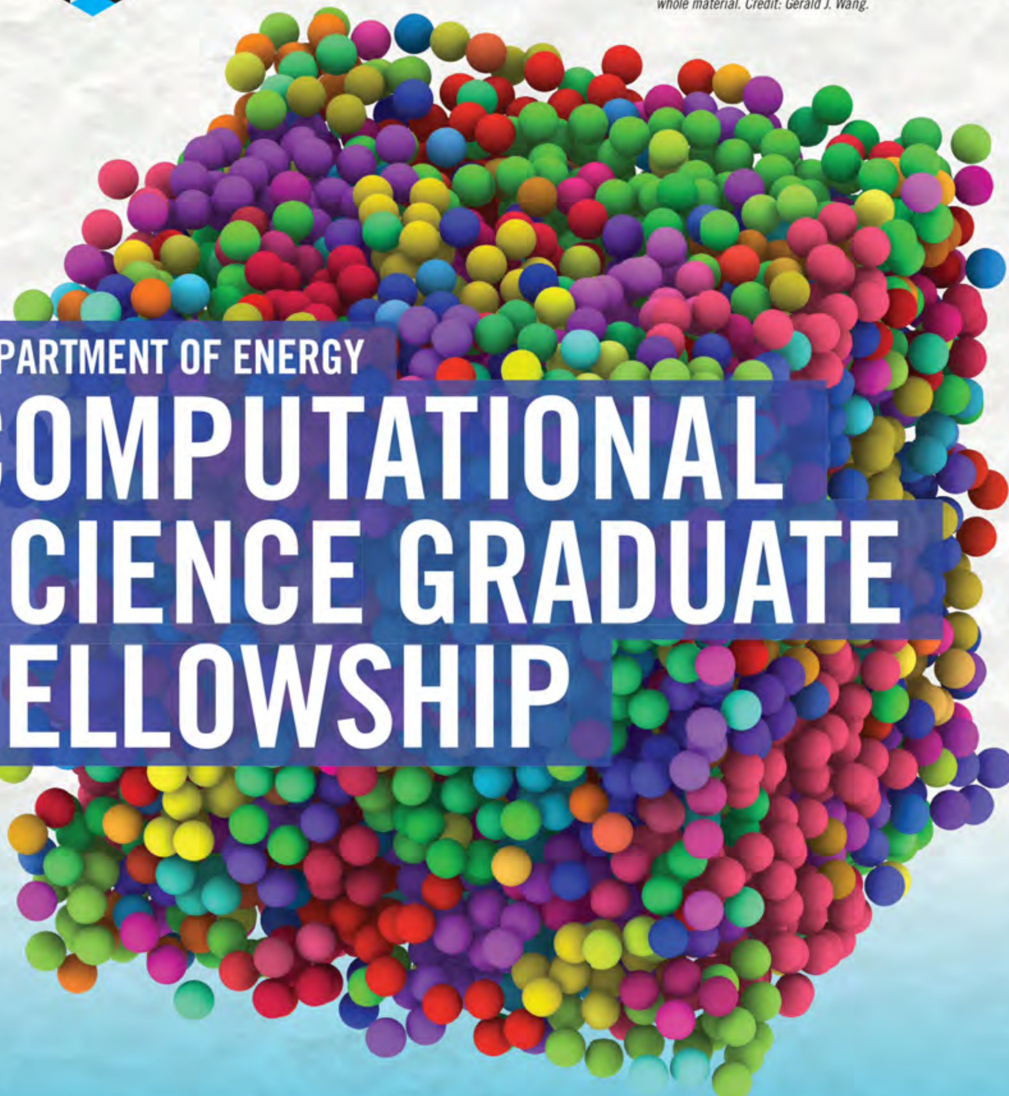
DOE CSGF

Closely packed particles in a colloidal suspension with friction, from a simulation by DOE CSGF alumnus Gerald J. Wang of Carnegie Mellon University. The colors differentiate particle groups whose motions are particularly interrelated, affecting the stickiness of the whole material. Credit: Gerald J. Wang.



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COMPUTATIONAL SCIENCE GRADUATE FELLOWSHIP

The Department of Energy Computational Science Graduate Fellowship (DOE CSGF) provides up to four years of financial support for students pursuing doctoral degrees in fields that use high-performance computing to solve complex problems in science and engineering.

The program also funds doctoral candidates in applied mathematics, statistics or computer science who undertake research that will contribute to more effective use of emerging high-performance systems. Complete details and a listing of applicable research areas can be found on the DOE CSGF website.

BENEFITS

+ $38,000 yearly stipend
+ Payment of full tuition and required fees
+ Yearly program review participation
+ Annual professional development allowance
+ 12-week research practicum experience
+ Renewable up to four years

The DOE CSGF is open to senior undergraduates and students in their first year of doctoral study.

Applications Due 1.13.2021 ... www.krellinst.org/csgf

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LABORATORY RESIDENCY GRADUATE FELLOWSHIP

The Department of Energy National Nuclear Security Administration Laboratory Residency Graduate Fellowship (DOE NNSA LRGF) provides outstanding benefits and opportunities to U.S. citizens who are entering their second (or later) year of doctoral study to work at premier national laboratories while pursuing degrees in fields relevant to the stewardship of the nation's nuclear stockpile.

LAB RESIDENCY Fellowships include at least two 12-week research residencies at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Sandia National Laboratories, or the Nevada National Security Site. Fellows are encouraged to extend these residencies to carry out thesis research and other studies at the DOE NNSA facilities.

Applications Due 3.17.2021 --- www.krellinst.org/lrgf

FIELDS OF STUDY

ENGINEERING & APPLIED SCIENCES	pulsed power; particle accelerator physics and design; detector and data processing; fluid mechanics
PHYSICS	atomic, nuclear and plasma physics; shock physics
MATERIALS	additive materials; dynamic materials; energetic materials physics and chemistry
MATHEMATICS AND COMPUTATIONAL SCIENCE	multiscale, multiphysics theory and numerical simulation; PIC/fluid hybrid simulation

BENEFITS

- $36,000 yearly stipend
- Payment of full tuition and required fees
- Yearly program review participation
- Annual professional development allowance
- Two or more 12-week-minimum national laboratory residencies
- Renewable up to four years

PHOTO: At the National Ignition Facility at Lawrence Livermore National Laboratory, a fully assembled target for laser ignition experiments incorporates a tented capsule, hohlraum, thermal-mechanical package, and silicon cooling arms.

This equal opportunity program is open to all qualified persons without regard to race, gender, religion, age, physical disability or national origin.

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