Defense Science Quarterly

News about the Science Campaign | Fall 2009

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Message from the Director
Chris Deeney, Defense Science Division

The use of X for *Extreme* in the title of National Academy of Sciences report *Frontiers in High Energy Density Physics: The X-Games of Contemporary Science* (www.nap.edu) is exceedingly accurate. In this quarter, we highlight extreme states of matter, extremely accurate and calibrated diagnostics, and extremely brilliant and talented individuals. Each is essential to making stockpile stewardship an enduring success!

In two articles, our National Nuclear Security Enterprise yet again demonstrates the ability to produce new extreme conditions to develop fundamental data. On Z, the Sandia National Laboratories (SNL) team has produced flyers at 45 km/s, allowing for pressures in the 20 Mbar range to be generated and equations-of-state to be accurately measured. On the OMEGA laser, a Lawrence Livermore National Laboratory-led team has demonstrated the measurement of an isentrope for diamond to 8 Mbar – this starts to move into pressure ranges that exceed Z's isentropic compression capability. The National Ignition Facility (NIF) should provide even higher pressures with improved accuracies, and the pulsed power community (Z and high explosive pulsed power systems) may still have the ability to develop new higher pressure techniques. This excellent technical comprehension in a critical field of stewardship science is essential to meeting our goals.

The article by the National Security Technologies and SNL team amplifies the need for the careful development and calibration of diagnostics. This was a key skill in the days of underground tests and, as the shots on our larger facilities become a valuable commodity, it ensures that the quality of diagnostics will remain very important. Furthermore, the demands for accuracy driven by uncertainty quantifications put a premium on calibration.

All of this technical progress is driven by the excellence of our community. This has been acknowledged on many levels. Dr. Ed Moses and Dr. Riccardo Betti recently received the Edward Teller Medal. Dr. Moses and his team have delivered a phenomenal capability in the NIF, and the early results are indicating that NIF is exceeding our expectations. Dr. Betti has provided great insights into ways to achieve fusion, especially techniques that could reduce the driver energy requirements. Well deserved, Ed and Riccardo! From the technical leaders of today to those of tomorrow, the chain of excellence is not broken. The recent Stewardship Science Graduate Fellowships Symposium clearly showed the quality of the students attracted by the scientific challenges of our work. Brigadier General Harencak applauded the students, and he challenged them to make a difference. His speech was inspirational and memorable. •

Grant Awards Total More Than $20 Million

The National Nuclear Security Administration (NNSA) awarded more than $20 million in grants to 28 researchers in 13 states. The awards were made through NNSA's Stewardship Science Academic Alliances (SSAA) program and the High Energy Density Laboratory Plasmas (HEDLP) program, a joint program with grants funded by NNSA and the DOE Office of Science.

An SSAA objective is to be a long-term recruiting tool to help the national laboratories attract the next generation of nuclear security professionals. Approximately 70 SSAA-supported students have been hired at the labs since the program's inception in 2002.

NNSA and the DOE Office of Science awarded 23 research grants totaling $9.9 million as part of the HEDLP program. The grants span work from astrophysics to laser plasma simulation and from electric magnetic field mapping to innovative ideas for inertial fusion energy. DOE's Office of Science and the NNSA provided $6.5 million and $3.4 million, respectively. A total of 128 proposals were received.

Comments

Questions or comments regarding the *Defense Science Quarterly* should be directed to Terri Batuyong (Terri.Batuyong@nnsa.doe.gov).

Technical Editor: Christina Coulter

Advances in Performance of Microchannel Plate Detectors for HEDP Diagnostics

by Ming Wu, Craig Kruschwitz, Ken Moy (NSTec); Greg Rochau (SNL)

In recent years, a team from National Security Technologies (NSTec) and Sandia National Laboratories (SNL) has built a unique capability to develop microchannel plate-based framing x-ray cameras for high energy density physics (HEDP) diagnostics. At the SNL Z facility, multistrip microchannel plate (MCP) detectors to record up to eight channels are employed in two-dimensional, sub-nanosecond time-resolved imaging and time- and space-resolved spectroscopy diagnostics.

Progressively more stringent technical temporal resolution and response uniformity requirements have necessitated a systematic design approach based on iterative modeling of the MCP using inputs from electrical circuit characterization. An inherently large exponential dependence in MCP gain, $V^{11.5}$, has mandated a firm understanding of the applied voltage pulse shape propagating across the strip. We pioneered direct measurements of the propagating waveform using a Picoprobe® and developed a Monte Carlo code to simulate MCP response to compare against test measurements. This scheme is shown in Figure 1.

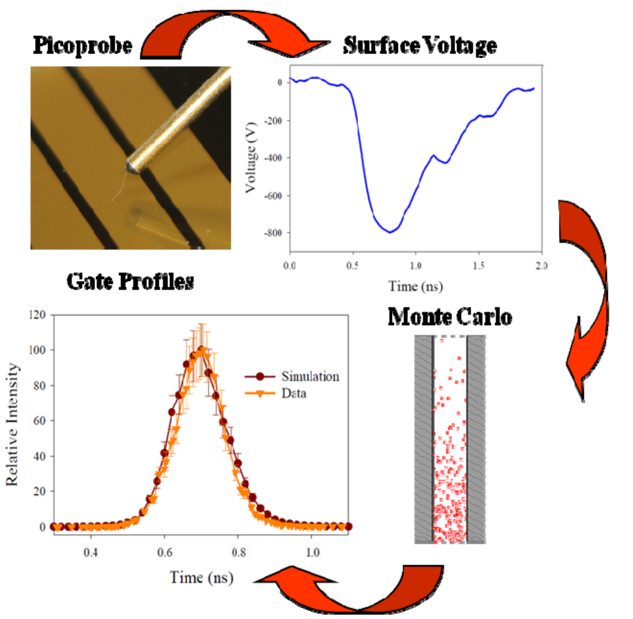

Figure 1: A systematic approach for developing an advanced MCP detector

The simulation detailed a physical model of the cascade and amplification process of the MCP[i,ii] that includes energy conservation for the secondary electrons, the effects of elastic scattering of low-energy electrons from the channel wall, and gain saturation mechanisms from wall charging and space charge. Our model can simulate MCP response for both static and pulsed voltage waveforms.

Using this design approach, we began to characterize the newly developed second-generation detector (H-CA-65) by using a Manson x-ray source to evaluate the following direct current characteristics: MCP sensitivity as a function of bias voltage, flat-field uniformity and spatial resolution, and variation of spatial resolution and sensitivity as a function of phosphor bias voltage. Dynamic performance and temporal response were obtained by using an NSTec short-pulse laser to measure optical gate profiles, saturation, and dynamic range. These data were processed and combined to obtain the gain variation and gate profiles for any position along an MCP strip. Typical position-sensitive gate profiles of the detector are shown in Figure 2.

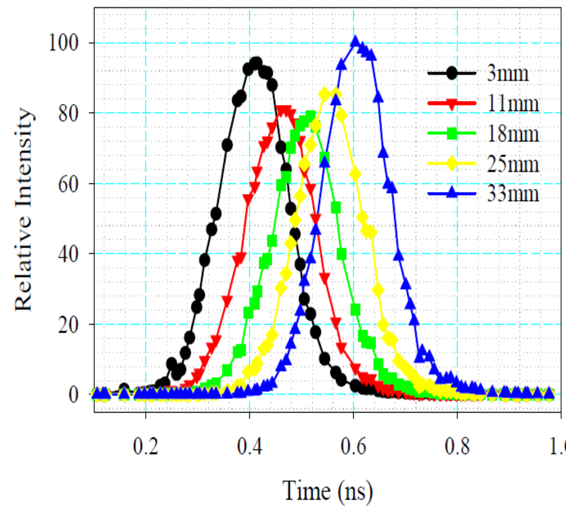

Figure 2: Typical position-sensitive gate profiles of NSTec H-CA-65 MCP detector with a 300 ps FWHM PFN and Z-fielding cables

The measured gate profiles for the latest design have shown excellent agreement with Monte Carlo simulations.[iii] This modeling success provides us with a powerful tool for designing and optimizing MCP detectors that will meet specified requirements. For example, the pulse-forming network (PFN) pulse width can be chosen based on Monte Carlo simulation to achieve the shortest gate profiles without loss of significant gain. In Figure 2, a 150-ps Full-Width Half-Maximum (FWHM) gate profile was determined to be the inherent response time of our detector. This is close to the transit time of the electrons inside the MCP. The difference between design and measured performance of the H-CA-65 is within experimental errors. The most exciting outcome from the characterize/model process is that MCP gain uniformity can be achieved by adjusting output circuit impedance and judiciously selecting an appropriately wide voltage pulse waveform to drive the MCP strip. The combination of impedance, reflection ratio, and pulse shape/width can be optimized to provide a uniform pulse to propagate across a strip.

Figure 3 shows the sensitivity measured across an MCP strip for an old-style SNL detector and the H-CA-65. The H-CA-65's uniformity is 30% or better for a strip driven by a 300-ps FWHM PFN (yielding a 150-ps FWHM optical gate profile), compared to a factor of five or less for the old detector. For the time-resolved spectroscopy diagnostic at Z, gain uniformity across the strip is a much more critical criterion than a narrow optical gate. A gain uniformity of 10% along the MCP strip was achieved when driven by a 700-ps FWHM PFN (yielding a 250-ps FWHM optical gate), an order of magnitude improvement of two. The developments that produced the H-CA-65, which are now part of our MCP design process, have reduced product cost and the time it takes to develop and characterize the new MCP detectors. An illustration of three MCP-based cameras is shown below deployed on SNL's Multi-Layer-Mirror diagnostic (see Figure 4).

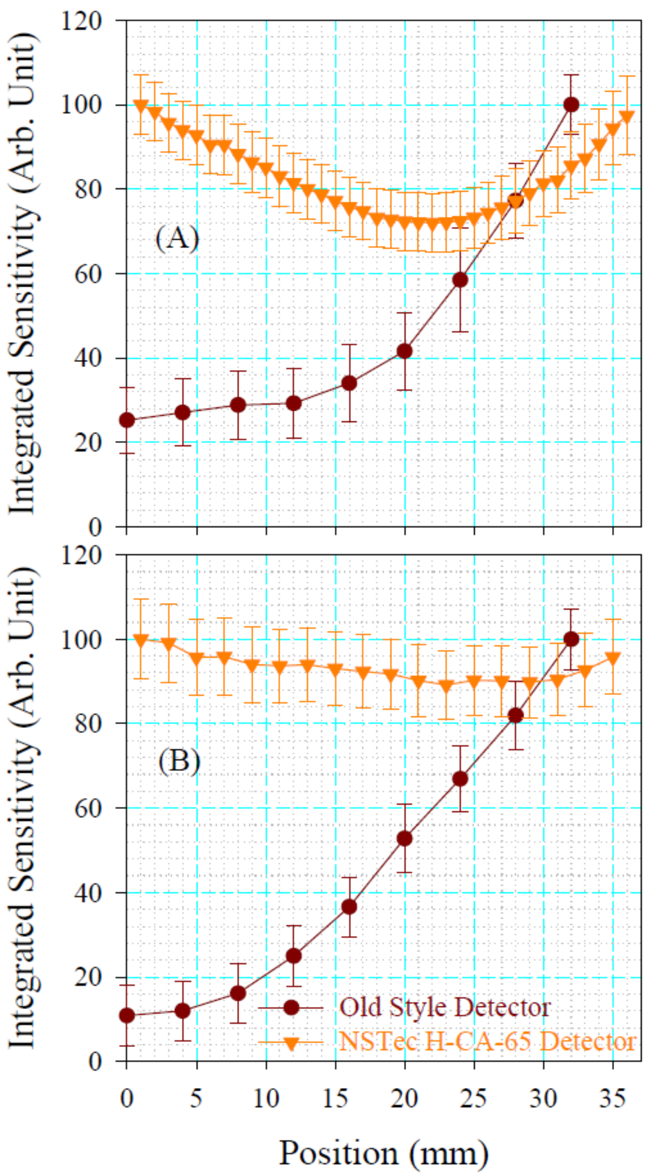

Figure 3: Comparisons of sensitivity variations along MCP strips between NSTec H-CA-65 and old-style SNL detectors using (A) a 300-ps FWHM PFN and (B) a 700-ps FWHM PFN with Z-fielding cables

Generation I cameras also are fielded on TREX (time resolved elliptical spectrometer) and axial package diagnostics. The system has also been deployed successfully on a new Z diagnostic, the Gated Re-entrant Axial Pin Hole Imaging Camera (GRAPHIC). A Generation II camera has been successfully deployed on the TREX system and will continue to undergo testing to ensure reliability prior to beginning a larger production run in FY 2010.

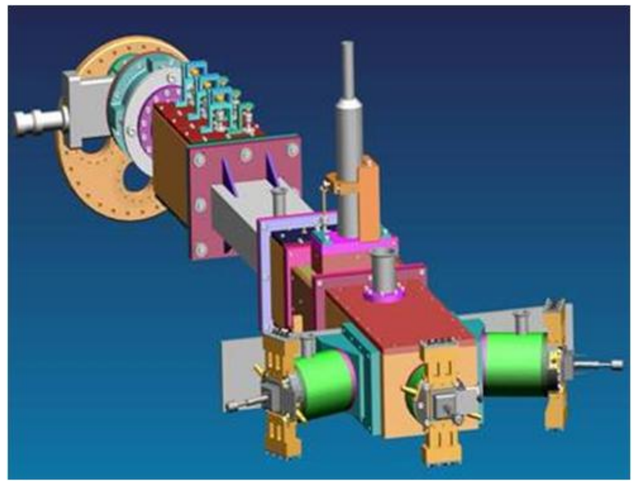

Figure 4: Illustration of three MCP-based cameras deployed on SNL's Multi-Layer-Mirror diagnostic

[i] M. Wu, C. A. Kruschwitz, D. V. Morgan, and J. Morgan, Rev. Sci. Instrum. 79, 073104 (2008).
[ii] C. A. Kruschwitz, M. Wu, K. Moy, and G. Rochau, Rev. Sci. Instrum 79, 10E911 (2008).
[iii] G. A. Rochau, M. Wu, C. Kruschwitz, N. Joseph, K. Moy, J. Bailey, M. Crain, R. Thomas, D. Nielsen, and A. Tibbitts, Rev. Sci. Instrum. 79 10E902 (2008). •

JMP Receives DP Award of Excellence

The DOE/DoD Joint Munitions Program (JMP) Team is the recipient of this year's Defense Programs Award of Excellence. The program is an ongoing jointly funded effort among Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories, and it has been in place since 1985. The team performs work at DOE national security laboratories developing and utilizing specialized skills, facilities, and computational tools to the joint benefit of both departments and the nation. JMP's contributions led to the achievement of critical Level 2 milestones, including ones that address model and code development.

Flyer Plate Accelerated to Over 100,000 mph on Z by Marcus Knudson, Ray Lemke, and Jean-Paul Davis (SNL)

A shot series was recently completed on Z to evaluate the use of a new stripline load geometry for high velocity flyer plate impact experiments. Five experiments were executed to explore the use of different stripline widths (15 and 11 mm) and both one- and two-sided geometries. All shots produced velocimetry (VISAR) data. Peak aluminum flyer plate velocities ranged from 30.5 to 45.7 km/s (which equates to 68,000 to 102,000 mph). This represents a more than 30% increase in the peak velocity in comparison to the pre-refurbished Z machine. The peak accelerating magnetic pressure exceeded 6 Mbar in the shot that produced the highest velocity. These experiments also provided equation of state (EOS) data for quartz and sapphire for impact pressures up to 15.7 and 20.7 Mbar, respectively. In addition to the EOS data, the results obtained will also enable improvements in our magneto-hydrodynamic (MHD) modeling of these types of loads, which will allow for further optimization of the load geometries and pulse shapes used to accelerate the flyer plates. In particular, it is expected that suitable experimental designs can be identified to successfully obtain EOS data with impact velocities approaching 50 km/s.

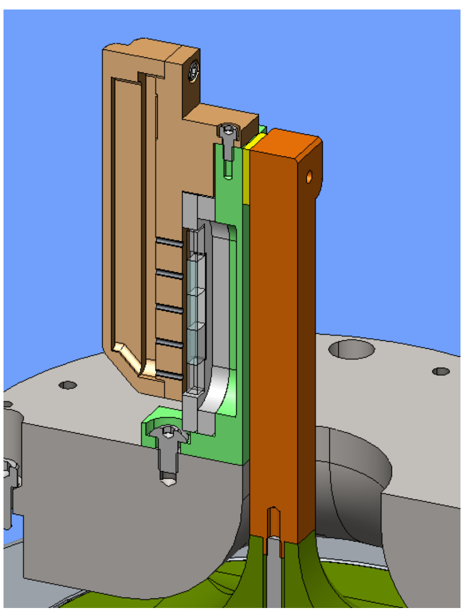

Figure 1: One-sided stripline geometry

Both one- and two-dimensional MHD calculations were performed to design the experimental geometry, to determine the current pulse shapes, and to determine the appropriate flight distances (i.e., the initial flyer to target separation). As can be seen in Figure 2, the MHD simulations accurately predicted the experimental results.

It should be noted that the prediction represents an average of three simulations which used three different

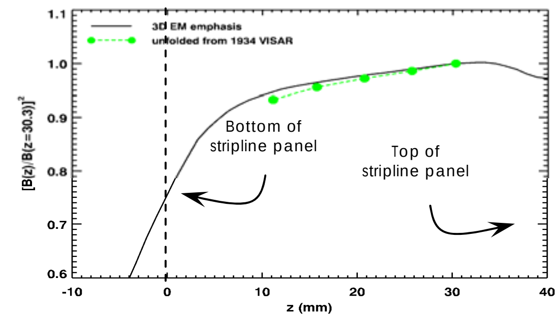

Figure 2: Experimental measurement and MHD predictions for Z1933, an 11 mm-wide, one-sided stripline geometry

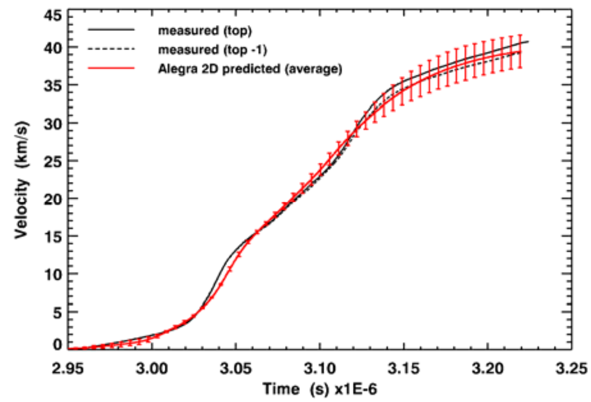

Figure 3: Experimental measurement and Emphasis predictions for the magnetic field uniformity along the height of the stripline load

assumptions about the time dependent current loss in the transmission line convolutes. The experimental data provides a measure of this current loss, as well as a much more accurate description of the late-time current, both of which influence the predicted peak velocity.

This experimental series also provided data that enabled an evaluation of the variation in magnetic pressure along the height of the stripline. This magnetic pressure gradient is due to three-dimensional effects which result in current flow outside the ak-gap, along the sides and back of the stripline conductors. The experimental results are shown in Figure 3 along with a pre-shot prediction obtained from Emphasis, a three-dimensional electro-magnetic particle-in-cell code. This data provides validation of the Emphasis results, suggesting that the code can be used to determine a tapered panel design that will minimize the magnetic field gradient along the length of the stripline load. •

A New Generation of Exploring Matter at Extreme Conditions

by G. Collins, J. Eggert, M. Bastea, D. Hicks, R. Smith, P. Celliers, D. Bradley, R. McWilliams, D. Braun, R. Rygg (LLNL); P. Loubevre (CEA), D. Spalding (UCB), S. Brygoo (CEA), T. Boehly (LLE)

A breakthrough in studies of materials at high compressions (to ~100 fold) is underway due to several new compression and diagnostic techniques.[1,2] Recent experiments show that at even a fraction of these compressions, material behavior becomes somewhat exotic, with helium transforming to a metal at ~2 g/cc,[3] diamond melting at a constant temperature (T) at pressures (P) from 0.6 to greater than 1 TPa, fluid carbon being a polymeric metal to 2 TPa,[4] and aluminum exhibiting remarkable strength when rapidly compressed to 100 GPa.[1] These capabilities will allow us to explore the nature of solids to several TPa, complex chemistry to 100 TPa, and the nature of helium and hydrogen in the deep interiors of Jupiter and even super-giant exoplanets.

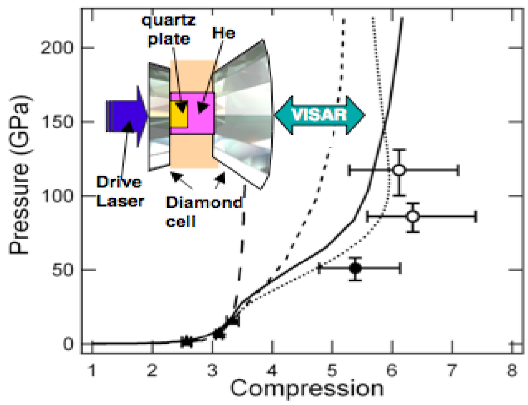

Figure 1: Shock pressure versus compression data for initial ρ = 0.123 g/cc. New data (○,•)[3] Gun data(*)[6] chemical models (-)[7](¨),[8] DFT/PIMC (---)[9], and expected Hugoniot without ionization (–)

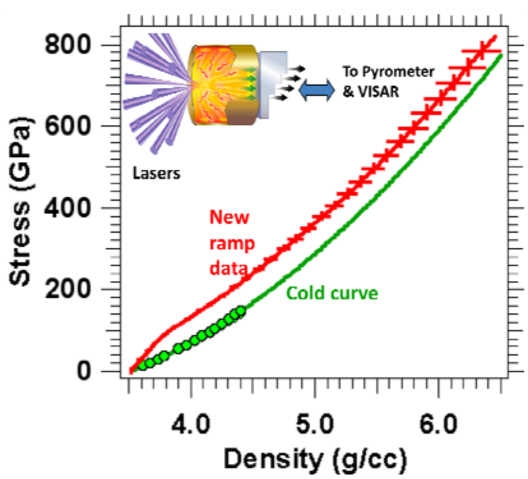

Figure 2: Stress versus density of ramp compressed diamond (red) compared to cold curve[11] data and model extrapolation (green). Accuracies are comparable or better than the most recent laser-driven diamond shock wave data on diamond[12].

Figures 1 and 2 show examples of how new laser compression techniques are exploring matter at extreme densities. Figure 1 shows pressure and density (ρ) for dense helium (He), produced by laser shock compression of He precompressed in a diamond anvil cell.[2] Data show an increase in compressibility at onset of ionization.[3] Since the initial density can be tuned by setting the initial pressure, this technique provides a new way to measure fundamental properties of hydrogen (H) and He, over a broad range of densities. Moreover precompression enables the study of dynamically compressed hydrogen mixtures (H-He, H-Krypton, etc.) starting in the fluid or solid phase, and which cannot be produced cryogenically.

Turning the drive laser intensity versus time can produce a ramp (shockless) compression wave used to study solids in the TPa range. Figure 2 shows the absolute stress-density for ramp compressed diamond to 0.8 TPa.[5] Offset from the cold curve, the smooth trend in pressure-density shows diamond is strong and stable to 0.8 TPa. This technique is now being used to explore a variety of metals to very high stress, and to map phase transition kinetics for metals with complicated phase boundaries.[10]

1. R. F. Smith *et al.*, PRL. 98, 065701 (2007).
2. P. Loubeyre *et al.*, High Press. Res 24 (2004). R. Jeanloz *et al.*, PNAS 104 (2007).
3. J. Eggert *et al.*, PRL. 101, 124503 (2008).
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9. B. Militzer, PRL, 97, 175501 (2006).
10. R. Smith *et al.*, PRL, 101, 065701 (2008).
11. F. Occelli *et al.*, Nature Materials 2, 151 (2003).
12. M. Pavlovskii, Sov. Phys.-Solid State 13, 741 (1971). S. Brygoo *et al.*, Nature Materials 6, 274 (2007). H. Nagao *et al.*, POP 13, 052705 (2006). M. Knudson, *et al.*, Science 322, 1822 (2008). D. Hicks *et al.*, PRB 78 (2008). •

2009 Edward Teller Medal Recipients

The American Nuclear Society presented 2009 Edward Teller Medals to National Ignition Facility director **Edward Moses** and to **Riccardo Betti** of the Fusion Science Center of Extreme States of Matter and Fast Ignition, University of Rochester during the international conference on Inertial Fusion Science Applications in San Francisco in September.

Moses was cited for his "leadership in the development and completion of the National Ignition Facility," the world's largest and most energetic laser. Betti was cited for his "seminal contributions to the theory of hydrodynamic instabilities, implosion dynamics and thermonuclear ignition in inertial confinement fusion."

Established in 1991, the Edward Teller Medal recognizes pioneering research and leadership in inertial fusion sciences and applications. Congratulations to our esteemed colleagues!

Publication Highlights by Douglas Drake

This section highlights recent publications in high-impact scientific journals of research supported by the NNSA Science Campaigns.

Observation of Terahertz Radiation Coherently Generated by Acoustic Waves, M.R. Armstrong, E.J. Reed, K. Kim, J.H. Glownia, W.M. Howard, E.L. Piner and J.C. Roberts, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Nitronex Corp., Nature Physics 5, pp. 285-288 (2009)

Terahertz radiation has been in the news of late because of its potential for enabling passive detection of contraband such as weapons and explosives. Such *T-rays,* lying more or less in the wavelength region between microwave and infrared radiation, have the interesting property of lying in the frequency range where sound and light waves overlap.

Researchers at Lawrence Livermore National Laboratory and Los Alamos National Laboratory now report success in demonstrating the theoretically predicted detection of terahertz-frequency acoustic waves via observation of the terahertz radiation emitted when they propagate past an interface between materials of differing piezoelectric coefficients. The acoustic waves were generated by focusing an ultrashort (~100 fs) optical pulse onto a sample of gallium nitride (GaN) with a surface coating of aluminum. A thin (10 nm) layer of aluminum nitride was embedded in the GaN. It was predicted that terahertz radiation would be produced by the polarization currents generated when the acoustic wave traversed the boundary between these two materials with differing piezoelectric responses. This process would differ substantially from commonly used terahertz generation methods in which the radiation results from conversion of an optical pulse due to the optical response of the sample. The predicted radiation was, in fact, observed, representing the first experimental demonstration of direct sound to radiation conversion. The new process could potentially improve production methods for computer chips, light emitting diodes, and transistors, and have additional applications in ultrafast materials science and T-ray generation.

The Effects of Target Mounts in Direct-drive Implosions on OMEGA, I.V. Igumenshchev, F.J. Marshall, J.A. Marozas, V.A. Smalyuk, R. Epstein, V.N. Goncharov, T.J.B. Collins, T.C. Sanster, and S. Skupsky, Laboratory for Laser Energetics, University of Rochester, Physics of Plasmas 16 (2009)

The targets used in inertial confinement fusion (ICF) experiments must be positioned with very high accuracy to insure precise illumination by the laser beams used to drive them. The University of Rochester Laboratory for Laser Energetics (UR/LLE) recently conducted a study of the effects of two types of target mounts, stalks and spider silks, on the implosion of direct-drive ICF targets using both experiments on its OMEGA laser system and two-dimensional computer simulations. Two kinds of implosion experiments were performed. One observed that the signatures of a jet of hot plasma developing from mounting stalks in a sequence of x-ray snapshot images taken at the time of formation of the hot spot. Another experiment showed time-integrated images of asymmetric hot spots, in which the asymmetry is caused by the stalk assembly. These were compared with the results of previous experiments carried out with planar targets to study the effect of various spider silk mount configurations on drive symmetry. It was found that spider silks are the more damaging type of mount since the silks are arrayed over the target surface, whereas the stalk meets the target at only a single point. The glue spots used to affix targets to the stalk were found to significantly degrade implosion symmetry. The LLE team suggested that significantly improved performance could be achieved if spot diameters were reduced.

Energy Transfer Between Laser Beams Crossing in Ignition Hohlraums, P. Michel, L. Divol, E.A. Williams, C.A. Thomas, D.A. Callahan, S. Weber, S.W. Haan, J.D. Salmonson, N.B. Meezan, O.L. Landen, S. Dixit, D.E. Hinkel, M.J. Edwards, B.J. MacGowan, J.D. Lindl, S.H. Glenzer, and L.J. Suter, Lawrence Livermore National Laboratory, Physics of Plasmas 16 (2009)

In the indirect-drive approach to ICF that will be used in the National Ignition Campaign to achieve fusion ignition, large bundles of laser beams cross each other on their way to illuminate the inner walls of a hohlraum, generating the x-rays that actually drive the target. Energy transfer between these crossing beams can have a significant effect on the implosion symmetry of the fuel capsule due to an effect known as induced Brillouin scattering. In this process, the beat wave generated by the interference pattern of two crossing laser beams resonantly excites an ion acoustic wave that can, in turn, transfer energy from one beam to another when the beams are at the same wavelength. The effect can be especially damaging near the hohlraum's laser entrance hole. As a result, various techniques for detuning the beams have been implemented on the National Ignition Facility (NIF). In this paper, results are presented of the full-scale, three-dimensional numerical modeling of crossed-beam energy transfer in ignition hohlraums with realistic laser and plasma conditions. It was found that the long interaction lengths and large powers at ignition scale will lead to energy transfer despite the NIF's detuning capabilities. However, the models demonstrated that it would be possible to tune the frequency shift between the laser beams so as to allow control of the power balance between the inner and outer cones in NIF and thereby maintain good implosion symmetry. •

Stewardship Science Graduate Fellowship Program

DOE/NNSA Stewardship Science Graduate Fellow **Miguel Morales** is gaining attention for his research into the properties of hydrogen and helium under high pressures, and for his ability to work under pressure.

Morales, a student at the University of Illinois at Urbana-Champaign, performed approximately 250 simulations and used more than 3 million CPU hours in his summer 2008 practicum at Lawrence Livermore National Laboratory (LLNL), generating a paper published in Proceedings of the National Academies of Science this February[i]. Morales is lead author with his doctoral adviser, David Ceperley; Eric Schwegler, Sebastien Hamel and Kyle Caspersen of LLNL; and Carlo Pierleoni of the University of L'Aquila in Italy.

The research performed first-principles molecular dynamics calculations, based on density functional theory (DFT), of hydrogen-helium mixtures at Mbar pressures and temperatures ranging from 4,000 to 10,000 K. The model is important for understanding the interior atmospheres of Jupiter, Saturn and other Jovian planets. It also has implications for inertial confinement fusion and other high-pressure, high-temperature hydrogen-helium regimes.

The paper says the calculations provide the most accurate prediction of hydrogen-helium immiscibility to date. By determining the DFT-based equation of state for the system, the researchers found the demixing temperature is high enough to support a scenario in which helium becomes partially miscible over a large part of the interior of Jovian planets.

The calculations appear to fit with the theory that helium and hydrogen phase separate in the planets' atmospheres. The helium droplets that form act as a source of energy by releasing latent heat and by dropping deeper into the planet's center, helping explain why Jovian planets typically radiate more energy than they absorb from the sun.

According to the group calculations, the region in which helium is miscible is larger in Saturn than in Jupiter, explaining why Saturn is more luminous than predicted.

Morales' practicum experience with DFT-based methods affected the direction of his doctoral research. In one recent paper[ii] authored with Pierleoni and Ceperley, Morales used the Coupled Electron-Ion Monte Carlo method to calculate the equation of state, including the free energy, of hydrogen in its atomic liquid phase for pressures beyond 150 GPa. The researchers used this more accurate method to test predictions made with the DFT-based Born-Oppenheimer Molecular Dynamics approach and found good agreement.

The calculations, however, found that the Saumon-Chabrier-Van Horn multiphase equation of state, used for years to study planetary interiors, produces inaccurate results in the subatomic regime. "This suggests that planetary models should be reinvestigated with a more accurate equations of state, such as the one presented in this work," the paper concludes.

Morales will next serve as a postdoctoral fellow with Gustavo Scuseria at Rice University.

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[i] M. A. Morales, E. Schwegler, D. Ceperley, C. Pierleoni, S. Hamel, and K. Caspersen: "Phase separation in hydrogen–helium mixtures at Mbar pressures", Proceedings of the National Academy of Sciences (2009), doi:10.1073/pnas.0812581106.
[ii] arXiv:0906.1594.

Forrest Doss, another DOE/NNSA Stewardship Science Graduate Fellowship recipient, is contributing to research that may explain unexpected phenomena in high energy density shock tube experiments.

The University of Michigan doctoral student, a third-year fellow, is working with R. Paul Drake, Professor of Atmospheric, Oceanic and Space Sciences and Professor of Applied Physics. Drake also is director of Michigan's Center for Radiative Shock Hydrodynamics (CRASH), a part of the NNSA's Predictive Science Academic Alliance Program (PSAAP).

Doss helps design, implement, and analyze the experiments, which are key to understanding the hydrodynamics that drive supernovae and other phenomena in high energy density regimes. The experiment system is a 20-micron beryllium drive disc launched into a 625-micron diameter polyimide tube filled with gaseous xenon at 0.006 g/cc. A high energy laser pulse, typically supplied by the OMEGA facility at the University of Rochester, drives the disc.

Researchers have assumed that in such experiments, the tube's evolution has only small effects on the shock and the material ahead of it. That assumption isn't necessarily accurate, say Doss, Drake, recent University of Michigan doctoral graduate Carolyn Kuranz, and Harry Robey of Lawrence Livermore National Laboratory (LLNL).

The primary shock develops a *kink* a finite distance from the tube walls. Experiments show this is due to interaction with a secondary, radially converging shock Doss and his colleagues call a *wall shock*.

The researchers postulate that if the shock is fast enough, it generates radiation that heats or even vaporizes parts of the upstream tube wall, creating the observed wall shock. When the shock speed is too slow to generate radiation, Doss and his colleagues believe wall shocks may be caused by preheating, i.e., energy deposited throughout the tube as a side effect of the driving event, that appears to vaporize regions of the tube early on time.

Doss and his colleagues also have shown how the wall shock structure can be used to diagnose dynamics in the experiment, including Mach number for the primary shock.

In his practicum at LLNL in early 2008, Doss learned HYDRA, the lab's radiation-hydrodynamics code, and applied it to radiating shock experiments. Doss quickly produced results that elucidated previously unexplained features found in the tests. The research also has helped explain, in terms of preheat-driven wall shocks, shock features observed in early National Ignition Facility experiments.

Another aspect of Doss' research targets instability in radiating shock experiments and how it may relate to the astrophysical case of thin-shell instability of a decelerating shock theorized by Vishniac and others. Working with Drake and Robey, Doss omitted compressible effects and modeled the post-shock flow as a finite thickness layer of constant density. Even with compressibility suppressed everywhere except the shock surface, they found characteristic modes that were driven unstable by shock deceleration.

The Stewardship Science Graduate Fellowship supports students pursuing doctorates in areas of interest to stewardship science. The program now supports 19 students at 14 universities. •

JASPER Update by Robert Hanrahan (NNSA) and Raffi Papazian (NSTec)

On August 5, 2009, the Joint Actinide Shock Physics Experimental Research (JASPER) investigative team issued a report detailing their analysis of the shot 86 contamination incident. The document (LLNL-TR-415531) concludes that the contamination was not due to cross contamination or any identified problems with the conduct of operations or transfer of facility operations to National Security Technologies (NSTec). The team concluded that the samples were damaged due to storage under vacuum in the target assemblies resulting in exposure to reactive gases released from the assembly itself and possible compatibility issues. As a result, the sample was corroded prior to the experiment and the bellows assembly contaminated with reaction products.

Subsequent forensics and analysis efforts led to the concurrent development and implementation of a joint Lawrence Livermore National Laboratory (LLNL)/NSTec project for a Return to Operations (RTO). The RTO project is underway and is comprised of three sub-projects: recovery of the facility's capability to support experiments, LLNL programmatic modifications to reduce the probability and consequence of future contamination events, and readiness activities which were already planned for achieving Hazard Category 3 non-reactor nuclear facility status.

JASPER experiments are planned to resume in the fourth quarter of FY 2010, immediately following the designation of JASPER as a Cat-3 facility. An integrated FY 2010 JASPER schedule is under development to include all three RTO sub-projects plus radiometry integration, critical maintenance actions, and the conduct of JASPER experiments.

The recovery sub-project includes removal of the contaminated secondary containment chamber (SCC), piping, and experiment support hardware; installation of the spare SCC to restore the as-built configuration prior to shot 86; modifications to reduce future risk to the facility (primarily additional valves and filters in vacuum and vent lines to further limit the potential extent of future contamination); and facility startup activities. The contaminated SCC was removed the first week of October; it will be stored temporarily as waste material until a final decision is made concerning disposition. Several LLNL programmatic modifications have been proposed and are being pursued. Those programmatic modifications which must be fully implemented before recovery/startup activities primarily involve the primary target chamber, target assembly, and control system; they are being identified and tracked within the integrated JASPER schedule.

Highlights

Hydro Test Conducted in Contained Firing Facility

Lawrence Livermore National Laboratory carried out a hydro test (974M) in the Contained Firing Facility on August 31, 2009 for the Science Campaign's Secondary Assessment Technologies subprogram. The hydro test included radiography, Photonic Doppler Velocimetry probes, and soft capture.

Six Shots Fired on PRad

In late August and early September, the proton radiography team fired six shots: one cookoff, to finish off that series; two high strain rate shots; and three equation-of-state shots using the powder gun driver.

LANSCE CD-1 Approved

The Energy Systems Acquisition Advisory Board Equivalent Briefing for the LANSCE Refurbishment Project was held September 16, 2009. The CD-1 decision to proceed to Preliminary Design with appropriated FY 2009 PED funds was approved.

Stewardship Science Academic Alliances (SSAA)

Mark your calendars for the annual SSAA Symposium to be held on January 20-22, 2010 at the Carnegie Institution of Washington in Washington, DC. Visit www.orau.gov/ssaas2010 for details beginning the second week of November.