Defense Science Quarterly

News about the Science Campaign — Summer 2010

Inside This Issue

Message from the Director
Chris Deeney, Defense Science Division

As the Deputy Administrator for Defense Programs, Dr. Don Cook is already showing a strong commitment to the science, technology, and engineering (ST&E) underpinning of stockpile stewardship. He has created a new NA-11 organization to recognize the pivotal role of stockpile stewardship, and he has formed a science council to take on "sticky wickets" as we look to the future. At the technical level, Dr. Cook is also asking very demanding questions of the work being done, areas of improvement, etc. With this engagement and the strong support from all of our Congressional committees for the Stockpile Stewardship and Management Plan, the spotlight will be on all of us to deliver. Over the four years I've been with NNSA, I continue to marvel at the technical strength and creativity at the laboratories and sites, so I know we can deliver on the challenges of stockpile stewardship for the next decade.

This last issue of *Defense Science Quarterly* (DSQ) gives great examples of how the ST&E capabilities are being applied in our stewardship programs. Excellent progress has been made in high energy density physics (HEDP), hydrodynamic experiments, nuclear physics, and material science as demonstrated by the articles in this issue. Physics disciplines are also the focus areas for our academic programs, the Stewardship Science Academic Alliances and the Stewardship Science Graduate Fellowship (SSGF) Programs.

The Krell Institute hosted another excellent SSGF conference here in Washington, DC and introduced our new graduate fellows. As you will read in the articles about the SSGF Program, we are attracting and supporting some excellent researchers. A specific area of physics of great interest to our laboratories is the spectroscopy of high energy density plasmas.

Our HEDP center at the University of Nevada, Reno (UNR), has just graduated a new Ph.D., Nick Ouart, who is now going to do a fellowship at the Naval Research Laboratory. Congratulations to Dr. Ouart and his sponsor Dr. Alla Safronova of UNR.

With the reorganization and the formation of NA-11, we will be changing the title of DSQ to the *Stockpile Stewardship Quarterly* (SSQ). This new title will reflect the increase in scientific coverage and will also reinforce the strong experiment-theory-computation linkage required in stockpile stewardship.

The fall issue of the SSQ will also mark the start of the 2011 fiscal year. This will be a year of great opportunity and challenge: a year of petaflop computations, multiframe radiography at the Dual Axis Radiographic Hydrodynamic Test facility, ignition and high energy density experiments on the National Ignition Facility, and plutonium experiments in many venues. All of these will have immediate application to some major stockpile modernization actions. Let's Get It Done!

The 2010 NNSA Stewardship Science Graduate Fellowship Conference, held on June 21-22, drew attendees from universities, laboratories, and NNSA Headquarters. *Above* — SSGF recipient Laura Berzak, right, and her advisor, Robert Kaita of Princeton University, talk with Kim Budil, Senior Advisor to the DOE Under Secretary for Science, during the annual conference. Read about the conference on page 7.

Comments
Questions or comments regarding the *Defense Science Quarterly* should be directed to Terri Batuyong, Terri.Batuyong@nnsa.doe.gov
Technical Editors: Christina Coulter and Douglas Drake

Shock Compression of Liquid Xenon to 840 GPa by Seth Root, Rudolph J. Magyar, John H. Carpenter, David L. Hanson, and Thomas R. Mattsson (Sandia National Laboratories)

To measure the response of a material at pressures of millions of atmospheres, we utilize flyer plate impact experiments and the basic conservation laws. By impacting a target with a high-velocity flyer plate, we generate a shock wave that produces high pressures in the target. Accelerating flyer plates to high velocities is made possible using the Z accelerator at Sandia National Laboratories (SNL). Using the immense magnetic pressure created by the machine, we can accelerate an aluminum flyer plate toward a target at velocities up to 40 km/s (90,000 mph).

The high-pressure response of xenon is of specific interest to planetary science because xenon can be used to understand planetary and atmospheric evolution. Unfortunately, our understanding of xenon's high pressure behavior is rather limited. In particular, current equation-of-state (EOS) models for xenon show substantial differences in the Hugoniot above 100 GPa, prompting the need for experimental data at extreme conditions that can be used to develop an improved EOS.

Accurate Hugoniot measurements using the Z accelerator combined with simulations using quantum mechanics have greatly improved our knowledge of the behavior of matter at extreme conditions. In this work, we determine the high pressure response of xenon using shock wave compression. In the shock experiments, we measured the Hugoniot to 840 GPa[1], over 700 GPa higher than previous shock work[2-4]. The experimental results validate the use of Density Functional Theory (DFT) for predicting high pressure behavior to 500 GPa. Using the experimental and DFT results, we develop a multi-phase EOS that can be directly used in hydrodynamics simulations.

Figure 1 shows a schematic view of the shock compression experiments. The experimental target consists of a copper cell with a quartz drive plate and quartz rear window. High-purity xenon gas of natural isotope composition fills the volume between the windows, and the target is cooled to 163 K (-110°C) filling the target with liquid xenon. A velocity interferometer system for any reflector (VISAR) is used to determine shock velocities in the target. Figure 1 (bottom) shows a typical VISAR record. The VISAR tracks the flyer velocity up to impact. Sharp changes in the data indicate where the shock wave transitions from one material into another. The shock in the quartz drive plate is strong enough to melt the quartz into a conductive fluid, making the shock front reflective and we can then measure the shock velocity directly. The shock front in the xenon is also reflective, so that the xenon shock velocity can be measured directly with high precision. Using a *Monte Carlo* impedance matching method to solve the Rankine–Hugoniot equations, we determine the shock compressed densities and pressures.

Prior to performing the shock experiments on Z, we used computer simulations to predict the xenon Hugoniot response. Because the electronic structure determines a material's behavior, it is necessary to invoke quantum mechanics and solve the complex equations of DFT. DFT is a reformulation of the fundamental Schrödinger equation but the so-called Kohn-Sham equations can be solved much faster, making DFT the method of choice for large-scale simulations. The calculations are nevertheless very demanding, requiring the use of SNL's super-computer, the Tri-Laboratory Linux Capacity Cluster, and taking several days to calculate a single Hugoniot point. The simulations were performed using the code Vienna Ab-Initio Simulation Package[5] and applying two exchange-correlation functionals: the Local Density Approximation (LDA) and the Armiento-Mattsson (AM05) functional; the latter was developed at SNL[6].

Figures 2 and 3 show the Z experimental and DFT results in the U_S–U_P and ρ–P planes[1]. We emphasize that the calculations were performed prior to the experiments, demonstrating DFT-MD's predictive capabilities. Also shown are the previous experimental data[2-4] as well as the current EOS models: LEOS 540, XEOS 540, and SESAME 5190. Figure 3 also includes static compression data on solid xenon at room temperature for

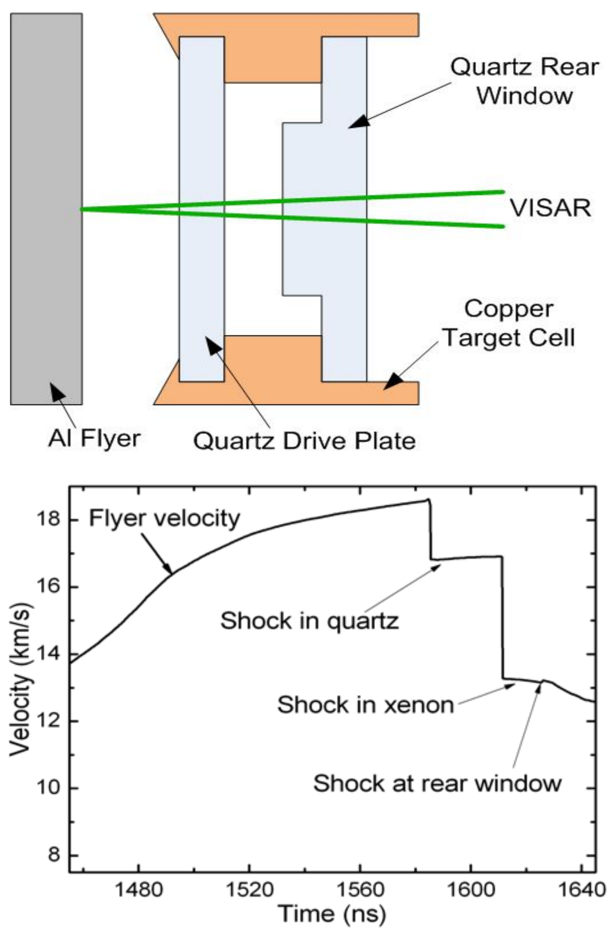

Figure 1: *Top* - Schematic view of the shock compression experiment. *Bottom*: Representative VISAR data. Impact and shock transitions are indicated by the sharp changes in the VISAR signal.

comparison[7]. The highest densities for the statically compressed solid and the shock compressed liquid xenon are similar, but the pressure in the shocked liquid xenon is ~4.2 times greater. We find that the DFT results agree well with both the static and dynamic compression data over a wide temperature range. Furthermore, the results demonstrate that current EOS models do not satisfactorily describe the xenon Hugoniot at high pressures. Although the differences in U_S–U_P for these models are small, they create large uncertainties in ρ–P. For example, at a density of 12.09 g/cm³ the experimentally determined pressure is 392.7 GPa, while the LEOS 540 and SESAME 5190 predict pressures of 533.1 and 275.2 GPa, respectively, differences of 36% and -30%.

Using the experimental and DFT results, we developed an EOS model capable of describing xenon's behavior in all three phases (i.e., solid, liquid, and gas) over a wide range of pressures and temperatures. The new EOS is identified as SESAME 5191 and is accessible from the public SESAME library at Los Alamos National Laboratory. With this new EOS, scientists have a reliable model for xenon that can be used at the extreme conditions present in planetary interiors. Complete details of this work are published in Physical Review Letters[1].

Our next series of experiments will measure the Hugoniots of liquid krypton and liquid carbon dioxide to several hundreds GPa to validate DFT predictions and the EOS models.

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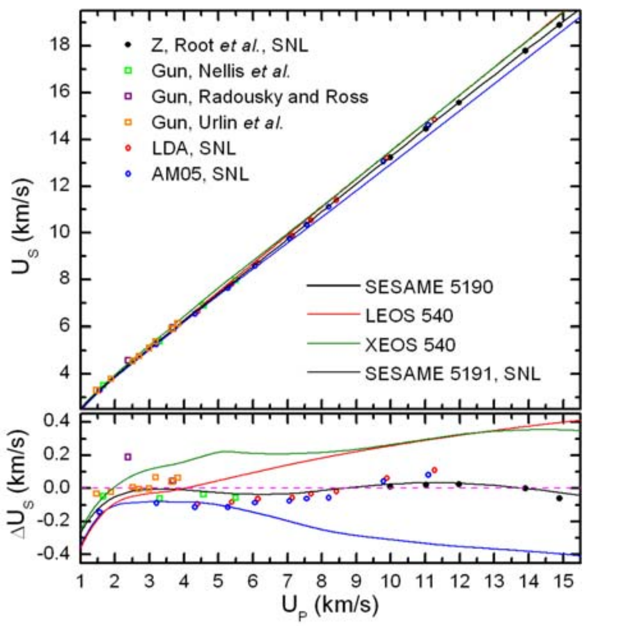

Figure 2: *Top* - U_S–U_P Hugoniot plot. *Bottom* - Absolute difference from the linear fit to experimental data. Uncertainty is on the order of the data symbol.

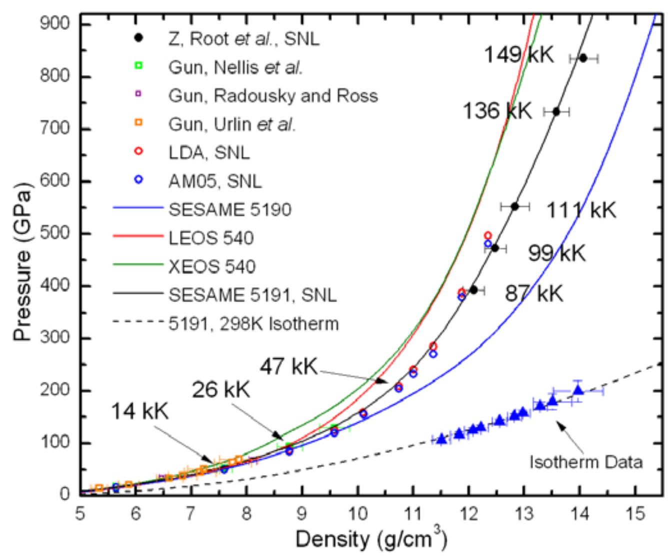

Figure 3: ρ-P Hugoniot plot. The blue triangles are static compression data for solid xenon[5]. The indicated temperatures were calculated using the SESAME 5191 EOS. Our DFT calculated isothermal data is in good agreement with the experimental data points.

The Radiative Characteristics of Z-Pinch Wire Implosions **by Nicholas Ouart (University of Nevada, Reno)**

Researchers at the University of Nevada, Reno (UNR), have been studying plasma radiation from z-pinch wire implosions using non-LTE kinetic modeling. UNR is home to the 1.7 MA (previously 1.0 MA) Zebra pulse power generator which allows for investigation of high energy density z-pinch plasmas, and also enables the experimental and theoretical groups to work in close collaboration.

Since 2005, a new compact configuration called the planar wire array (PWA) has been studied utilizing the Zebra generator[1]. In planar wire arrays, the wires are arranged in either single or multiple rows. The PWAs have demonstrated to be the most efficient x-ray radiator tested on the Zebra generator. This makes PWAs a promising candidate in a compact multisource hohlraum configuration in ICF studies[2].

In recent years, significant effort has been devoted to the study of PWA implosions. In particular, the radiative and implosion characteristics of brass (70% copper, 30% zinc) single and double planar wire arrays were studied. Brass PWAs represent a unique opportunity to study the performance of two L-shell radiators from mid-atomic-number wire materials and to investigate lower opacity effects in L-shell lines. For instance, brass single PWAs were shown to have a "spot-like" plasma formation and peak electron temperature exceeding 500 eV (see Figure 1). On the other hand, brass double PWA implosions demonstrated a "column-like" plasma formation and a larger size. L-shell modeling from brass double PWAs revealed stronger opacity effects in some lines compared to brass single PWAs, consistent with its larger plasma size[3].

UNR researchers also studied implosions of cylindrical wire arrays using six Ni-60 (96.44% copper, 3.56% nickel) wires focused on capturing radiation from an accumulation of ablated mass on the central axis prior to the main implosion, called the precursor column. Further understanding of the precursor is necessary because the precursor column can result in a back pressure to the impending implosion of the main mass that may limit the plasma density and temperature of the z-pinch. Non-LTE kinetic modeling of time-gated spectra showed peak electron temperature of >400 eV, which was significantly hotter than previously observed[4].

The implosion of many different z-pinch loads can generate energetic electron beams that excite the inner-shell electrons of ions and, subsequently, emit characteristic line radiation. The measurement of this characteristic line radiation can be useful to elucidate information about the nature and evolution of z-pinch plasma and, in particular, the behavior of electron beams. These experiments on Zebra that have focused on the time-resolved measurements of characteristic line radiation have established a foundation for future work.

The author acknowledges the help and advice of Drs. Alla Safronova (UNR), Victor Kantsyrev (UNR), Christine Coverdale (SNL), Chris Deeney (NNSA), Kenneth Struve (SNL), Brent Jones (SNL) and Andrey Esaulov (UNR) and the UNR Physics Department faculty and staff. This work was supported by the National Physical Science Consortium (NPSC) and NNSA.

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About the Author

As a doctoral candidate at UNR, Nicholas Ouart studied plasma radiation from z-pinch wire implosions using non-LTE kinetic modeling in the theoretical group of Dr. Alla Safronova. His scientific journey at UNR began under Dr. Safronova's advisement in the summer of 1999. He later graduated in May 2004 with dual B.S. degrees in Engineering Physics and Electrical Engineering and was accepted to the graduate physics program at UNR. In 2005, he was awarded a graduate fellowship from the NPSC. This year, Ouart accepted an offer from the National Research Council for a Research Associateship award at the Naval Research Laboratory (NRL), Division of Plasma Physics in Washington, DC. Nick was supported by a NNSA cooperative agreement with the UNR and a NPSC Fellowship during his graduate years at UNR.

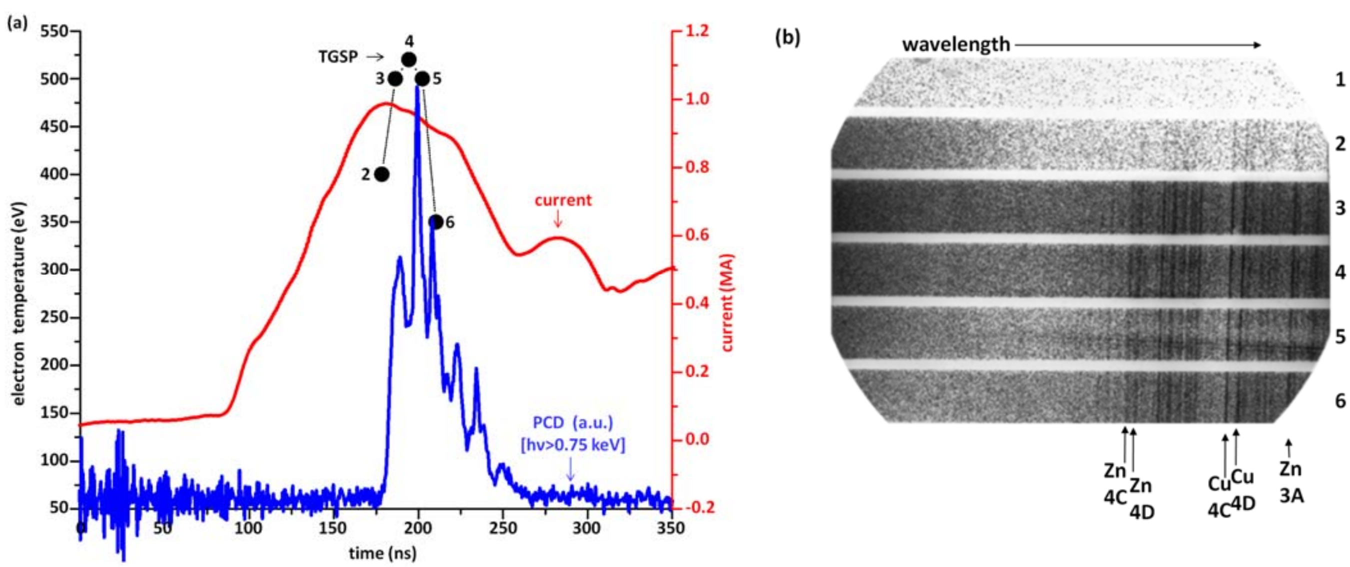


Figure 1: Non-LTE kinetic modeling of Z-pinch plasma provides important information on the electron temperature evolution. The results from the implosion of a brass single PWA (Zebra shot 810) are shown. (a) Electron temperature (black circles), photoconducting detector signal (E > 0.75 keV, blue line) given in arbitrary units, and current (red line). (b) Time-gated spectra and diagnostically important Ne-like lines of Cu and Zn are labeled.

The Status of Neutron Fission Physics by Mark Chadwick (Los Alamos National Laboratory)

There are a number of open research questions in nuclear science that are being addressed by the NNSA laboratories because of the expected impact they have on improving the predictive capability of simulations of nuclear criticality. Here, I describe a thrust in neutron fission physics that involves new experiments at the Los Alamos Neutron Science Center (LANSCE) together with nuclear theory, modeling, and simulation work being undertaken in collaboration between Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL).

Previous nuclear science work from the laboratories has played a major role in defining the existing nuclear data (e.g., cross sections, energy spectra, etc.) for fission that are included in the Evaluated Neutron Data Files (ENDF). These are unclassified databases used in many simulation applications in nuclear science and technology, including reactor design, criticality safety, and non-proliferation, as well as in defense applications. Indeed, the measurements made on fission cross sections and fission neutron energy-spectra (the neutrons emitted in fission that sustain a chain reaction) at LANL have set the standard in the field, and have been heavily influential in defining our current knowledge. Additionally, the "Los Alamos model" for neutron spectra is the basis not only for our ENDF evaluations, but for most other major databases developed in Europe, Japan, and other countries. However, in recent years we have been faced with a new puzzle that suggests our current knowledge is poorer than we had thought and that has driven the recent thrust in this area.

Two types of new data and analyses have pointed to potential problems with our existing fission neutron spectrum assessments. First, some new measurements that LANL requested be executed by researchers at Geel (a European Commission nuclear laboratory in Belgium) are suggesting 10-15% more neutrons are emitted below 1 MeV outgoing energy in fission (a measurement for thermal neutrons on uranium-235, though this tendency is expected to be similar for both thermal and fast neutrons), confirming another measurement made in Russia by Starasov. Second, Monte Carlo N-Particle transport code simulations of historical measurements of threshold (n,2n) neutron detectors placed in fast critical assemblies at LANL suggest there should 10-30% fewer neutrons at high outgoing energies above 10 MeV. If these two indications prove true, the impact on criticality simulations will be significant. We currently model the measured criticality of unclassified nuclear critical assemblies well, so if our existing fission databases do turn out to be deficient it must mean that we have other compensating errors in our simulations and the future identification and removal of such errors will be an advance for us. Indeed, the importance to the broader nuclear science community and to reactor simulations is so high that the International Atomic Energy Agency has initiated a coordinated research project to study this. The project brings together researchers from around the world, in theory and in experiment, including LANL and LLNL researchers.

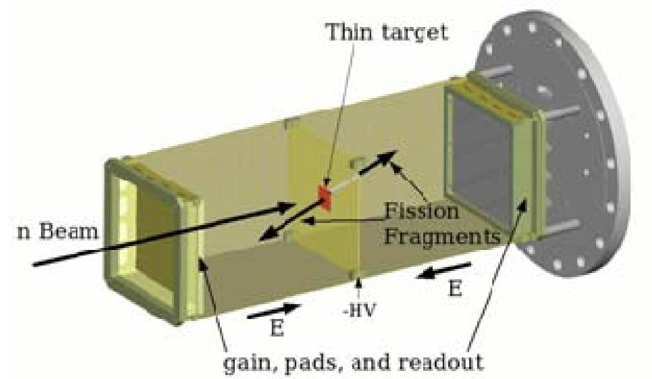


Figure 1: Illustration of the fission time projection chamber. A first prototype was recently completed at LLNL and shipped to LANSCE.

The new measurement and detector capabilities being developed at LANSCE will help solve this problem. Novel detectors are being developed to reach the accuracy levels required; in addition, the time-projection-chamber experiment will enable very high precision fission cross sections to be measured. Along with these exciting developments in experimentation, new theory work is being undertaken to provide higher fidelity understanding of the fission process. Our goals are to advance our predictive capabilities for defense applications, but also to provide accurate data that will positively benefit the broader nuclear science community for applications such as advanced reactor design.

National Laboratories Welcome Carnegie/DOE Alliance Center (CDAC) Post-Doctorates

Three CDAC post-doctorates have accepted positions with the national laboratories. Raja Challeppa joined LANL to work with Dana Dattlebaum in the Shock & Detonation Physics Group in the Weapons Experiments Division. SNL welcomed Luke Shulenburger whose work will encompass the *ab initio* computation of materials properties under high pressure and temperature to be used in conjunction with experimental work on the Z machine. Amy Lazicki is joining Rip Collins' group at LLNL this month. She will be performing laser shock compression studies of low-Z materials at extreme pressures.

NNSA Grant Sends 37 Students to 2nd Omega Laser Facility Users Group (OLUG) Workshop

The Omega Laser Facility Users Group held its second workshop on April 28-30 at the University of Rochester's Laboratory for Laser Energetics. The workshop, intended to facilitate communication among the parties, was at full capacity for the second year with 115 registrants. Among them were 37 students/postdoctorates who were able to attend via a $50K grant from NNSA for travel expenses. A new component of this year's workshop was the job fair. The presentations and posters will be posted online in the future (www.lle.rochester.edu/02_visitors/02_usersgroup.php).

Publication Highlights by Douglas Drake

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

Limitation on Prepulse Level for Cone-Guided Fast-Ignition Inertial Confinement Fusion, A.G. MacPhee et al., Physical Review Letters 104, 5, February 2010

Intermediate scale facilities continue to play an essential role within Defense Sciences, providing a flexible toolset for high energy density (HED) research, allowing key physics issues to be resolved before experiments are fielded on larger facilities such as the National Ignition Facility and Z, and enabling collaboration with researchers in academia on issues of mutual interest. Recent experiments on Titan, a petawatt class laser in Lawrence Livermore National Laboratory's Jupiter suite, investigated issues relating to the generation and propagation of the highly energetic electron beams (e-beams) required for hot spot ignition in the "fast-ignition" approach to inertial confinement fusion (ICF). As currently envisioned, these beams will be generated by energy transfer from powerful laser beams, which are to be fired into special cones inserted into the sides of targets after other drivers have compressed them to high density. In order to generate e-beams sufficiently energetic and intense to ignite the target, lasers capable of delivering a large amount of energy in a very short pulse will be necessary, resulting in intensities near the tips of the cones in excess of 10^{20} W/cm^2.

This paper describes experiments on Titan designed to determine whether the laser pre-pulse expected from such powerful beams, amounting to anywhere from 10^{-5} to 10^{-6} of the energy in the main beam, will create a preplasma capable of severely degrading the forward going e-beam by interfering with the propagation of the main laser pulse in the cone. The experimental results, which agreed well with computer simulations, revealed that laser pre-pulse can easily generate plasmas capable of breaking the main laser beam into multiple filaments far from the optimum point of focus, halting its progress and causing energetic electrons to be generated mostly transverse to the beam instead of in the desired forward direction. The authors conclude that limiting pre-pulse will, therefore, be critical to the success of full-scale fast ignition experiments.

Planar Wire-Array Z-Pinch Implosion Dynamics and X-Ray Scaling at Multiple-MA Drive Currents for a Compact Multisource Hohlraum Configuration, B. Jones et al., Physical Review Letters 104, 12, March 2010y

Z-pinch soft x-ray sources are attractive as drivers for ICF implosions because of their high efficiency and relatively low cost per radiated joule. However, to realize this potential, it is necessary to find a way to efficiently couple the copious energy available from z-pinch sources into ICF targets. Doing so in a way that allows the necessary control over capsule symmetry has been a challenging problem. In earlier experiments on Z, double-ended configurations were tried, with two primary, z-pinch driven hohlraums mounted coaxially on either end of a secondary hohlraum containing the ICF capsule. Excellent control of asymmetries was demonstrated in these experiments, but coupling efficiencies were low because of the large size of the primary and secondary hohlraum surface areas required, resulting in low drive temperatures.

In this paper, a multiple z-pinch configuration is proposed to alleviate this problem. It would involve mounting several primary z-pinch soft x-ray sources around a secondary hohlraum equipped with a shine shield to achieve the required symmetry of illumination. The paper describes experiments on Saturn with planar wire array z-pinches, which offer advantages over previous cylindrical configurations for achieving the necessary coupling efficiencies. When scaled to possible future multi-source hohlraum experiments on Z, the results achieved in these experiments with single pinches indicate that drive temperatures of 90 eV might be achieved, equaling the highest values obtained in earlier indirect drive experiments with single sided illumination, but with much higher drive symmetry.

Pulse Generation and Preamplification for Long Pulse Beamlines of Orion Laser Facility, D. Hiller, D. Winter, and N. Hopps, Atomic Weapons Establishment (AWE), Applied Optics 49, 16, June 2010

The Orion laser facility currently under construction at AWE will consist of 12 beamlines, including 10 long-pulse lines capable of delivering temporally shaped pulses with durations between 100 ps and 5 ns and delivering a maximum of 5 kJ at 351 nm. The remaining two beamlines will be short pulse with chirped pulse amplification, allowing petawatt class performance (500 J in 500 fs). If desired, it will be possible to use them as conventional backlighters.

This paper describes the design features of the system, which will include pulse generation, preamplifier and disk amplifiers similar to those found on other large laser facilities such as the National Ignition Facility (NIF), Laser Megajoule (LMJ) and OMEGA. The authors note that a significant difference between Orion and these related systems will be the use of a high-power seed laser, which will make it possible to avoid the necessity of inserting fiber amplifiers after the coarse chopping stage. They anticipate that this will allow them to avoid the problems with amplified spontaneous emission that have been reported elsewhere, including at LMJ and the NIF. Orion's pulse generation and preamplication system will feature two-dimensional smoothing by spectral dispersion (SSD), designed so that it will be integral to the laser preamplifier (PAM) and, when not in use, will form a passive component. This will allow users to activate SSD on demand without affecting the alignment or energetic characteristics of the PAM, so that the system will be able to operate with minimum downtime for system setup. The authors note assistance from personnel at the University of Rochester Laboratory for Laser Energetics in designing Orion's SSD system, and from LLNL on issues relating to PAM design.

Stewardship Science Graduate Fellowship (SSGF) Program by the Krell Institute

Focus on High Energy Density Research

First-year NNSA Stewardship Science Graduate Fellow **Alex Zylstra** is helping develop instruments that can provide a better picture of what's happening in high energy density (HED) experiments like inertial confinement fusion (ICF). Under advisor Richard Petrasso, he is part of the HED physics group at the Massachusetts Institute of Technology (MIT) working on diagnostics for the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory.

Zylstra outlined research on one instrument, a wedge range filter (WRF), in his poster for June's SSGF conference. The WRF is designed to diagnose implosions containing Deuterium and Helium-3 by measuring the proton spectrum. Fusion protons generated in the implosions pass through a wedge-shaped aluminum filter and are detected by a CR39 foil. The MIT researchers, working with colleagues from the University of Rochester Laboratory for Laser Energetics, Lawrence Livermore, Sandia and Los Alamos national laboratories, and General Atomics, Inc., developed a three-dimensional Monte Carlo code to model several components contributing to broadening of the D^3He-p spectrum. They used the results to calculate an ion temperature based on Doppler broadening for D^3He implosions on the OMEGA laser. The group also used the code to constrain the amplitude of high-mode asymmetries in a NIF implosion.

Zylstra also is collaborating on research into other instruments. In one paper under preparation, the researchers used advanced spectrally resolved, fusion-product and time-gated proton radiograph imaging to detect new phenomena in indirect-drive ICF implosions on OMEGA. The tests found three types of spontaneous electric fields differing in strength by two orders of magnitude. They also found an absence of the stochastic filamentary patterns and striations around the imploded capsule that are common features in direct-drive ICF implosions. The researchers also used the methods to observe and examine other implosion phenomena.

Another paper describes a compact neutron spectrometer based on CR39 nuclear track detectors. It's designed to measure yields of 2.45-MeV neutrons generated in ICF experiments using Deuterium. A polyethylene filter covers half of a piece of CR39. Incident neutrons scatter protons into the CR39, where they generate tracks. By subtracting the number of tracks per unit area in the unshielded CR39 from the number behind the shield, the researchers can get a number proportional to the neutron fluence, but independent of intrinsic noise in the CR39. In tests using a modified Cockroft-Walton accelerator, the instrument demonstrated a dynamic range from about 10^5 to 10^8 neutrons per square centimeter. Preliminary tests of the CR39-based neutron detectors on several early NIF shots generated promising results, the authors say.

Four other current NNSA SSGF recipients are working on HED-related research. They have been featured in previous issues of *Defense Science Quarterly* (DSQ) and are highlighted below.

Fourth-year fellow **Laura Berzak**, a doctoral student at Princeton University, is studying magnetic properties of the lithium tokamak experiment (LTX) at DOE's Princeton Plasma Physics Laboratory. The LTX is investigating the use of liquid lithium inner walls for a magnetic-ally confined toroidal plasma. *DSQ Summer 2009*

University of Michigan doctoral student **Forrest Doss**, a fourth-year fellow, is designing, implementing and analyzing high energy density shock tube experiments, which are key to understanding the hydrodynamics that drive supernovae and other phenomena. *DSQ Fall 2009*

Matthew Gomez, a third-year fellow at the University of Michigan, is working with the Michigan Accelerator for Inductive Z-pinch Experiments (MAIZE), focusing on magneto-Rayleigh-Taylor instability studies with foil loads and current loss due to plasma formation in post-hole convolutes. *DSQ Winter 2010*

Luke Roberts, a third-year fellow at the University of California, Santa Cruz, is studying how the neutrino-driven wind (NDW) that follows a core-collapse supernova may contribute to the formation of elements heavier than iron. *DSQ Spring 2010*

Stewardship Science Graduate Fellowship Program Hosts Another Successful Conference

Approximately 50 fellows, advisors, guests, and laboratory and headquarters staff attended the annual NNSA Stewardship Science Graduate Fellowship conference held June 21-22 in Washington, DC, an increase from the 34 attendees in 2009. The program's first alumnus, Miguel Morales, joined fourth-year fellows Dylan Spaulding, Forrest Doss and Laura Berzak in presenting their research in formal lectures. Another 15 fellows displayed posters, with Harvard University's Richard Kraus taking honors for the best one. DOE Under Secretary for Science Steven E. Koonin delivered the keynote speech. Kim Budil, Senior Advisor to the Undersecretary for Science, and Christopher Deeney, Director of the Office of Inertial Confinement Fusion and the National Ignition Facility Project, also spoke. Other talks focused on the defense laboratories' large experimental facilities and overviews of stewardship science's thrusts: High Energy Density Physics, Nuclear Science and Materials Under Extreme Conditions. The agenda, with links to the poster session and abstracts is available at www.krellinst.org/conf/ssgf/2010-conference/conference-agenda.

Congratulations to Richard Kraus of Harvard University for his overall winning poster entitled *Shock Devolatilization of Hydrated Minerals*!

Highlights

The JASPER Team hosted visitors from NNSA Headquarters in early June.

Advanced Certification on DARHT

Phase 1 of the Advanced Certification preparatory surety hydro for the Dual Axis Radiographic Hydrodynamic Test facility was performed, obtaining 1,400 radiographic images for a quantitative "Computer Tomography Scan" of a surety theme. This is progress in completing an Advanced Certification level 2 milestone.

Sandia National Laboratories (SNL) Selected to Develop New Supercomputer Prototype Systems

SNL has been selected as one of four institutions to develop new supercomputer prototype systems for the Defense Advanced Research Projects Agency's Ubiquitous High Performance Computing program (UHPC). The goal of the UHPC program is to overcome current limiting factors, including power consumption and architectural and programming complexity, by developing new computer architectures and programming models.

Ten Shots Fired at OMEGA

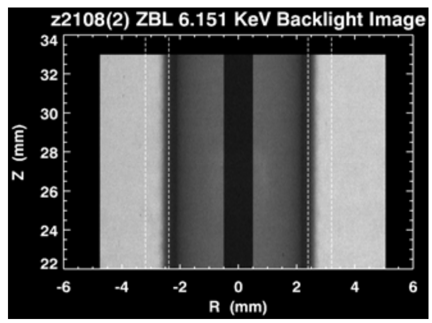
Lawrence Livermore National Laboratory completed a successful 2-day run at OMEGA. Ten shots were fired looking at the dynamic strength characteristics of three different forms of tantalum: 1) small-grain wrought (D~15um), 2) large-grain wrought (D~150um), and 3) very small-grain sputtered (D~.7um). The strength is inferred from observing the growth (from Rayleigh-Taylor instability) of pre-formed ripples in the targets. The goal is to quantify the effect of grain-size on yield strength (Hall-Petch effect). Six drive targets were also shot to accurately measure the strength of the drive.

Two Planar Damage Surface Hydro Experiments

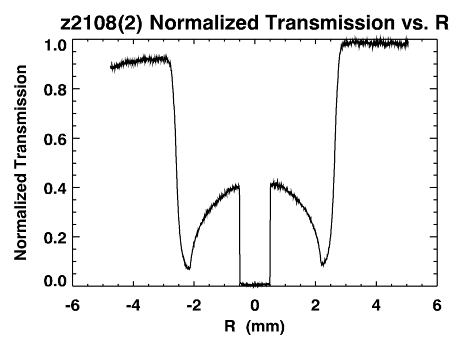
These experiments are tests of Los Alamos National Laboratory's ability to detect and measure ejecta produced from a shocked surface. These shots were planar geometries shocked by a high explosive lens system, but they are in support of the Precision High-Energy Liner Implosion eXperiment (PHELIX) program, which will use pRad to study the same phenomena in convergent cylindrical geometries driven by a pulsed power system. The first real shot using the PHELIX driver is expected next year.

First Beryllium Liner Shots on Z

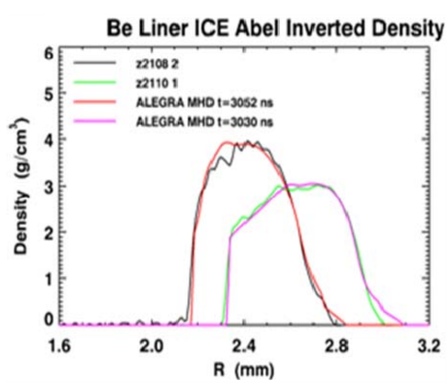
We conducted four shots on Sandia National Laboratories' Z facility to evaluate and begin developing a new technique to obtain high-pressure equation-of-state (EOS) data. This new technique exploits the fact that higher pressures are achievable in a cylindrical z-pinch configuration than in planar geometry. Time- and space-dependent density profiles of the imploding liner are obtained by Abel inversion of the x-ray images and then used to calculate the pressure on either the Hugoniot or the isentrope of the material. Beryllium was chosen for the liner so that the x-ray radiography could be performed at 6.151-keV on the Z-Beamlet laser. Our magnetohydrodynamic (MHD) simulations show that the density profiles are consistent with shock compression to about 4 Mbars for the two Hugoniot shots and with quasi-isentropic compression to 3 Mbars for the two isentropic compression experiment (ICE) shots. These results represent the first use of x-ray radiography of a z-pinch implosion with a shaped current pulse on Z to obtain high-pressure EOS data. Additional experiments will continue in FY 2011 to evaluate and develop this promising technique. — R.W. Lemke, R.D. McBride, M.R. Martin, M.D. Knudson, J-P. Davis, and D.G. Flicker (SNL)



X-ray image of isentropically compressed beryllium liner. Black is zero transmission and white is 100% transmission. Vertical dashed lines indicate initial position of liner.



Lineout of transmission averaged over axial distance Z versus radius R.



Comparison of early- and late-time Abel-inverted densities of isentropically compressed Be liner with those from MHD simulation.