IHEDS: SNL & UTEXAS

Science with High-Power Lasers and Pulsed Power:

Report on the inaugural workshop, Santa Fe, July 28 – 30, 2009

8/10/2009

The findings of a workshop to discuss options for science in the broadest national interest, using the high power lasers and pulsed power facilities at both the Sandia National Laboratories and The University of Texas, are summarized.

Contents

Executive Summary

A workshop on "Science with High Power Lasers and Pulsed Power" was held in the Santa Fe Hilton Hotel, July 28 through July 30, 2009. It was organized under the auspices of the Institute for High Energy Density Science (IHEDS), a joint University of Texas (UTEXAS) and Sandia National Laboratories (SNL) Institute. This institute was created in part to encourage and enable national access to the unique High Energy Density (HED) facilities at the Sandia National Laboratories and the University of Texas, and in so doing to enable the best User-involved science in the broadest national interest, and to grow the national HED User community.

The primary objectives of the workshop were to discuss high impact HED-related science that could be performed at SNL and UTEXAS, and in so doing to expand the User community for HEDS in general. The deliverable hoped for was a prioritized list of research concepts worthy of pursuit, involving new and existing national Users. Four research areas were considered, determined by: current and past interest at both UTEXAS and SNL, input from UTEXAS and SNL scientists, and interest generated in the national HED community by the workshop. These four areas were: laboratory astrophysics, beams and particles, fusion science (including high magnetic field), and 'high energy density science'. This last area (HEDS) was specifically intended to accommodate ideas not falling neatly into the other three areas.

Organizers for each of the four areas (see Appendix 1 for a list of the organizers) were chosen with input from SNL and UTEXAS scientists; these organizers were then responsible for a plenary session, a break-out session (see Appendix 2 for the full list of attendees), and a summary session in each of the four areas (see Appendix 3 for the agenda). Individual presentations can be found at the workshop web address:

http://www.ph.utexas.edu/~iheds/IHEDS2009_presentations.html

The plenary session provided overviews of relevant ongoing research, ideas for new research at UTEXAS and SNL, and some of the realities of performing experiments at these institutions. The break-out sessions developed new research ideas further. The summary session documented the break-out sessions' deliberations, with the intent of providing a prioritized list in each area of high impact concepts, involving national Users, worthy of further pursuit.

Table 1 below documents the proposed research concepts in each area, as highlighted during the summary sessions. The four laboratory astrophysics research concepts were ordered by least perturbation to the SNL facilities. The two particles and beams research concepts were ordered by perceived highest impact in a ~5-year timeframe. The two fusion concepts were not prioritized, and the one High Energy Density Science concept was discussed at length.   Also noted (in 'Comments') are new members of the HED User Community who would be involved.

Working groups involving potential new members of the HED community have already developed for some of the concepts, and will be encouraged in all the areas discussed. Based on the ensuing development of the concepts, proposals will be sought for submittal for funding. To assist in the main objective of the workshop and IHEDs, namely to encourage and enable the use of these NNSA-funded facilities to execute the best peer-reviewed User-involved science in the broadest national interest, and to grow the national User community, four recommendations are provided:

Recommendation 1. Working groups should be encouraged for each of the new concepts to further develop the ideas. Essential to carrying out this process is to incorporate scientists and engineers familiar with the relevant facility requirements at SNL and UTEXAS into each working group.   Required is a plan and conceptual design for an experimental campaign, with estimated effort, cost, diagnostics requirements, target requirements, and facility shot time. If necessary, assistance in the form of facility scientists' time, and seed funding, should be made available.

Recommendation 2. The conceptual experimental plans that are satisfactory to the facility organizations should be submitted as part of a national call for proposals for User-involved research at SNL and UTEXAS, to be peer reviewed and considered for funding. This process could be overseen by the joint Institute for High Energy Density Science.

Recommendation 3. SNL and UTEXAS management should develop a consistent mechanism for peer review and submittal for funding. These processes could be overseen by the joint Institute for High Energy Density Science.

Recommendation 4. An annual SNL / UTEXAS Users' Meeting should be considered, as a continuation of the workshop summarized here. Progress in current concepts and new ideas would be discussed. In addition technical, operational and managerial issues relevant to User access could be are discussed by the expected growing User community. This process could be overseen by the joint Institute for High Energy Density Science.

Area	Research concept	Impact	Comment
Laboratory astrophysics	X-Ray Radiative Transfer in Photo-ionized Black Hole Environments	Elucidate the role of general relativistic effects in emission line formation and enable mass loss measurements in black hole winds; Provide much needed physical data for international X-ray spectroscopic missions, both present and future	Extension of current User Program topic at SNL (UN-Reno)
	Measuring Line Profiles at White Dwarf Photosphere Conditions	Ages of WDs (age of the universe); Measurements of WD evolution constraining axions as candidates for dark matter; Asteroseismological analyses of the composition, structure and EOS of WD interiors (includes determining gamma of crystallization of dense Coulomb plasmas); Determinations of depth of convection zones in pulsating WDs	Grows the User community (UTX-A astronomy)
	Collisionless Shocks and Coronal Mass Ejection Interactions in the Earth's Magnetosphere	Understanding relative importance of electron acceleration from: Shock heating, Magnetic reconnection, Parallel electric fields	Extension of preliminary work at UTX-A
	Kinetic Dissipation of Large Amplitude E&M Waves in Collisionless Plasmas	Solving grand challenge problems in pulsar winds and jets	
Fusion	Cluster Fusion	Source for first principles materials studies; in-situ calibration source; generic issues in magnetized electron and electrostatic ion regime	New theoretical contributions to an ongoing program from UTX-A theory: grows User community (IFS)
	Magnetized Liner Inertial Fusion	Alternate concept: options for theoretical and experimental involvement	New theoretical contributions to an ongoing program from UTX-A theory: grows User community (IFS). Experimental development of target plasma (UTX-A)
Beams & particles	Laser Wakefield Acceleration	Compact HEP sources, compact ultrashort coherent x-ray source that complements LCLS, astro-physics (inter galactic jets, pulsar behavior)	A grand challenge; grows User community (UTX-A physics)
	High Energy Proton Development	Proton radiography: 250Mev for medical applications, isochoric heating	Work with MD Anderson; theoretical contributions from UTX; grows Uswer community (MDA, IFS, UTX-Institute for Advanced Technology)
	Pulsed Thermal Neutron Source	Temperature diagnostic for warm dense matter	
HEDS	Properties of Iron at Earth-core Conditions	Understandiing the earth's core, and implications for the dynamo.	Peer review; involves national and international commmunity (CEA)

IFS: Institute for Fusion Studies at the University of Texas at Austin. UTX-A: University of Texas at Austin. MDA: MD Anderson Cancer Center. CEA: Commissariat à l'énergie atomique

Table 1. Outcome of panel deliberations: concepts deemed worthy of further pursuit

Workshop Objectives and Deliverables

The objective of the workshop was to discuss and propose projects worthy of further pursuit, which would likely satisfy the following criteria:

1. Be performed using the UTEXAS or SNL (or both) high power lasers or pulsed power (or both)
2. Involve the national or international scientific community
3. Facilitate a proposal to a specific funding agency
4. Produce great science in the broadest national interest
5. Produce results publishable in high-impact journals
6. Produce results in either a short term (~3 year) or longer term (~5 year) timeframe
7. Be in either basic or applied science areas
8. Cover low-hanging fruit through grand challenges (with apologies for mixing metaphors)

The deliverable expected was to provide sufficient information to down-select a few projects to develop into proposals to a funding agency, either individually or as a bundle. Table 1 satisfies this deliverable.

Workshop Organization

This workshop grew out of multiple needs, specifically to support the mission of IHEDS (see below), as a follow-up to the report on Advancing the Science of High Energy Density Laboratory Plasmas (January 2009, report number DOE SC/0112), as a precursor to the HED workshop in November 2009 (chaired by Bob Rosner and Dave Hammer), to expand the HED User community in general, and to discuss what is the best HED-related science that should be done at SNL and UTEXAS.

The four scientific areas (laboratory astrophysics, beams and particles, fusion science, HEDS) were chosen through a process based on: current and past interest at both UTEXAS and SNL, input from UTEXAS and SNL scientists; and interest generated in the national HED community by the workshop. The area 'HEDS' was specifically intended to accommodate ideas not falling neatly into the other categories. The number of topics was chosen to give about 5 to 10 people in a break-out session, with a total around 40 to 50 scientists.

The break-out session participants were asked to report back to the full workshop on their discussions, in particular the ideas discussed, with prioritization and the basis for prioritization. They were asked to consider requirements, impact, readiness to start, where work would be done, and any additional capabilities required.

The Institute for High Energy Density Science

The workshop was held under the auspices of the Institute for High Energy Density Science (IHEDS), a joint institute between the Sandia National Laboratories and the University of Texas. Its creation was driven by:

1. A growing and common interest in: HED and related science, Developing as User Facilities, Growing the User community, and Involvement in great science in general
2. Existing collaborations
3. Complementary experimental capabilities

A vision (being developed) is: *To enable of science in the broadest national interest at NNSA-funded facilities, in particular the HED programs of SNL and UTEXAS, and in so doing grow the national HED user community.*

A mission statement (being developed) is:

1. To provide an intellectual center and support for the exploration of fundamental and applied science and technology using the high intensity lasers and pinches at the Sandia National Laboratories and the University of Texas
2. To enhance access to the unique facilities at the Sandia National Laboratories and the University of Texas, to both University and Laboratory researchers, <u>and to the larger scientific community</u>
3. To contribute to science education, strengthen existing programs, and develop new initiatives

Recommendations

The process of enabling the best peer-reviewed User-involved HED-related science in the broadest national interest at SNL and UTEXAS, and the growth of the national HED User community, is only initiated by this workshop. To continue the process through proposal writing, funding, execution and publication requires dedicated effort and oversight, for example by the Institute for High Energy Density Science. Which concepts progress to the point of suitability for execution must be determined by the scientist involved in the working groups, but encouragement and guidelines can be provided to assist. As such four recommendations follow. The first and fourth were introduced at the workshop summary session. The second is an extension of existing processes already in place at SNL and UTEXAS. The third was discussed at a separate workshop breakout session.

Recommendation 1. Working groups should be encouraged for each of the new concepts to further develop the ideas. Essential to carrying out this process is to incorporate scientists and engineers familiar with the relevant facility requirements at SNL and UTEXAS into each working group. Required is a plan and conceptual design for an experimental campaign, with estimated effort, cost, diagnostics requirements, target requirements, and facility shot time. If necessary, assistance in the form of facility scientists' time, and seed funding, should be made available.

Recommendation 2. The conceptual experimental plans that are satisfactory to the facility organizations should be submitted as part of a national call for proposals for User-involved research at SNL and UTEXAS, to be peer reviewed and considered for funding. This process could be overseen by the joint Institute for High Energy Density Science.

Recommendation 3. SNL and UTEXAS management should develop a consistent mechanism for peer review and submittal for funding. These processes could be overseen by the joint Institute for High Energy Density Science.

Recommendation 4. An annual SNL / UTEXAS Users' Meeting should be considered, as a continuation of the workshop summarized here. Progress in current concepts and new ideas would be discussed. In addition technical, operational and managerial issues relevant to User access could be are discussed by the expected growing User community. This process could be overseen by the joint Institute for High Energy Density Science.

Summary of the laboratory astrophysics break-out session

Laboratory Astrophysics

- X-Ray Radiative Transfer in Photo-ionized Black Hole Environments
  -D. Liedahl (LLNL), E. Behar (TI), R. Mancini (UNR), G. Rochau (SNL)
- Measuring Line Profiles at White Dwarf Photosphere Conditions
  -D. Winget (UT), G. Rochau (SNL)
- Collisionless Shocks and Coronal Mass Ejection Interactions in the Earth's Magnetosphere
  -W. Horton (UT), T. Ditmire (UT), D. Ampleford (SNL), A. Wooton (UT)
- Kinetic Dissipation of Large Amplitude E&M Waves in Collisionless Plasmas
  -H. Lie, D. Montgomery (LANL), E. Liang (Rice)

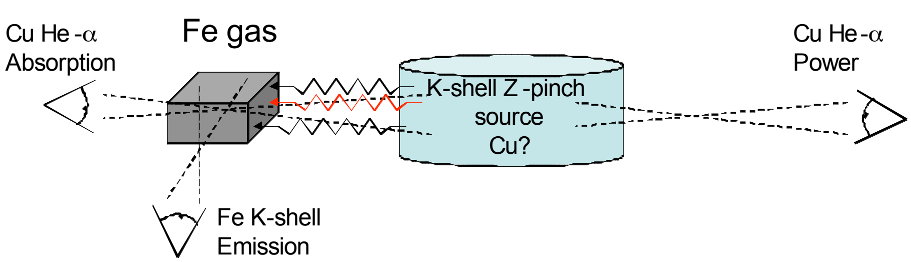
X-Ray Radiative Transfer in Photo-ionized Black Hole Environments

- Astrophysical Context:
  - Characterize spectroscopic properties around black hole accretion disks as influenced by hard X-ray emission, strong gravity, ionization, and kinematics
- Impact:
  - Elucidate the role of general relativistic effects in emission line formation and enable mass loss measurements in black hole winds
  - Provide much needed physical data for international X-ray spectroscopic missions, both present and future
- Approach:
  - Use Z (in ride along mode) to photo-ionize a plasma to the L shell and measure K shell emission and the radiative transfer through the sample.
  - Use Cu He α emission from the wire array implosion to create K-shell vacancies in the sample ions
- Plasma requirements:
  - $n_e = 10^{17} - 10^{19}$, $kT_e = 10 - 200$ eV, steady state or uniformity not required

X-Ray Radiative Transfer in Photo-ionized Black Hole Environments

- Diagnostic requirements:
  - High spectral resolution, E/ ΔE ~ 1000
  - Simultaneous absorption and emission spectroscopy (time -integrated)
- Sketch of the experiment:
  - See previous set ups by Bailey et al. 2001, Foord et al. 2004, Mancini et al. 2009
- Experimental/Theoretical Challenges:
  - Measure emission between 6.4 - 7 keV and de -blend different charge states
  - Use of Fe gas desirable but not necessarily required
  - A challenging atomic state kinetic problem that requires experimental guidance
- Key personnel:
  - Roberto Mancini (and co -workers), Greg Rochau, Jim Bailey(?), Ehud Behar (and students), Duane Liedahl

X-Ray Radiative Transfer in Photo-ionized Black Hole Environments



Measuring Line Profiles at White Dwarf Photosphere Conditions

- Astrophysical Context:
  - Line profiles of H, He, and/or C in White Dwarf Photospheres are important for determining surface gravity and effective temperature. These line profiles are not tested against experimental data. There are reasons to think that standard theory may be inaccurate.
- Impact:
  - Provide benchmarks for general theory of line broadening.
  - Improved measurements of gravities and temperatures in WD atmospheres directly impact:

    +Ages of WDs (age of the universe)

    +Measurements of WD evolution constraining axions as candidates for dark matter

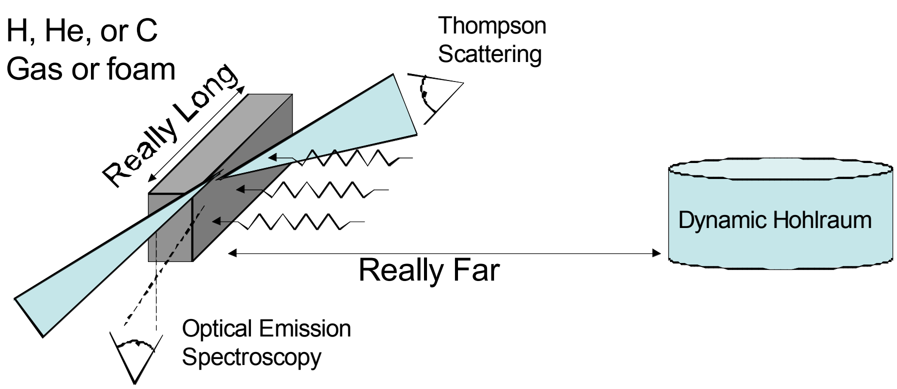
    +Asteroseismological analyses of the composition, structure and EOS of WD interiors (includes determining gamma of crystallization of dense Coulomb plasmas)

    +Determinations of depth of convection zones in pulsating WDs
- Approach:
  - Use Z (in ride along mode) or other suitable driver to uniformly heat a large sample of H, He, and/or C gas.
  - Characterize the plasma conditions and measure the line profiles.
  - Compare experimental results to existing theoretical models with the aim of improving line -broadening calculations.
- Plasma requirements:
  - $n_e = 10^{17} - 10^{18}$, $kT_e = 0.5 - 5$ eV, near steady -state may be required.

Measuring Line Profiles at White Dwarf Photosphere Conditions

- Diagnostic requirements:
  - Accurate determination of Te, and ne separate from spectroscopy (Thompson scattering)
  - Optical spectroscopy with resolution suitable for detailed line profile.
  - Measurement of plasma uniformity
- Sketch of the experiment:
- Experimental/Theoretical Challenges:
  - Uniform plasma: how uniform?
  - Re-implementation of optical spectroscopy on Z
  - Thompson scattering
- Key personnel:
  - D. Winget (co -workers/post -docs/students), Greg Rochau, others?

Measuring Line Profiles at White Dwarf Photosphere Conditions



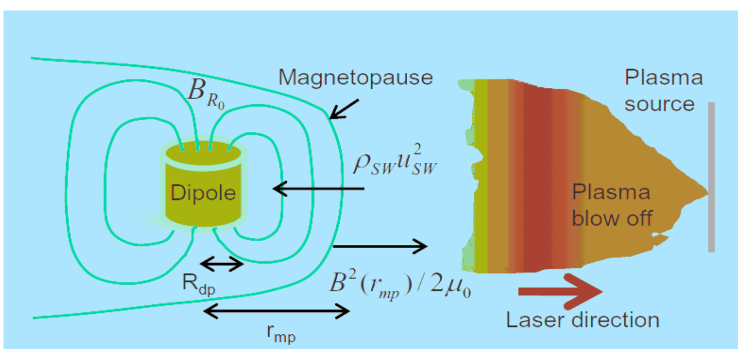
Collisionless Shocks and Coronal Mass Ejection interactions with the Magnetosphere

- Astrophysical Context:
  - The interaction of the Coronal Mass Ejections (CME) with the Earth's magnetosphere and the associated collisionless shock is not well understood.
- Impact:
  - *Societal* : Understanding giant CMEs compressing the magnetopause inside geosynchronous orbits and potential effect on communications/GPS.
  - *Scientific* : Understanding the relative importance of electron acceleration from three processes: Shock heating, Magnetic reconnection, Parallel electric fields (nature 10eV ♉ MeV electrons)
- Approach:
  - Use ZBL to create a plasma 'wind' and use Z to create a 10 T field.
  - Characterize the B -field, plasma conditions in the bow shock, and emission from the polar caps and magnetic reconnection tail
- Plasma requirements:
  - $n_e = 10^{15}$ in the wind, kT_e = 10 eV, Mach > 5

Collisionless Shocks and Coronal Mass Ejection interactions with the Magnetosphere

- Diagnostic requirements:
  - Thompson scattering
  - Gated self -emission
  - B-field mapping?
- Sketch of the experiment:
- Experimental/Theoretical Challenges:
  - Creation of B -field for ~500 ns: new Z load design
  - Characterization of B -field
  - Thompson Scattering
- Key personnel:
  - W. Horton (UT), T. Ditmire (UT), D. Ampleford (SNL), A. Wooton (UT)

Collisionless Shocks and Coronal Mass Ejection interactions with the Magnetosphere



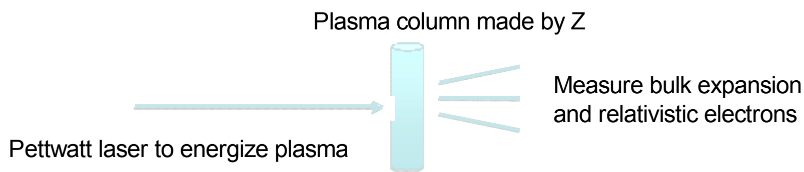
Kinetic Dissipation of Large Amplitude E&M Waves in Collisionless Plasmas

- Astrophysical Context:
  - The energy dissipation process of pulsar winds is not well understood.
- Impact:
  - Solving grand challenge problems in pulsar winds and jets.
- Approach:
  - Use Z to create a plasma with appropriate conditions
  - Use petawatt to energize the plasma.
  - Measure bulk plasma expansion and electron energies
- Plasma requirements:
  - $n_e = 10^{21}$, kT_e = 3-8 keV
- Laser requirements:
  - $a_0 > 1$, >= 1ps

Kinetic Dissipation of Large Amplitude E&M Waves in Collisionless Plasmas

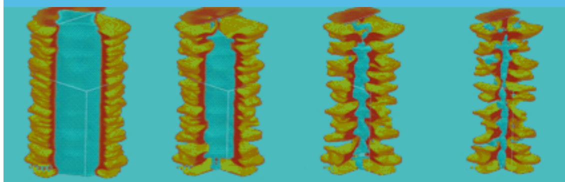
- Diagnostic requirements:
  - Measurement of plasma Te and ne
  - Measurement of sample expansion
  - Measurement of electron energization
- Sketch of the experiment:
- Experimental/Theoretical Challenges:
  - May require new Z load design
  - Difficult plasma to create
  - Requires petawatt coupled to Z
  - How to measure electron energization
- Key personnel:
  - Hui Li, David Montgomery (LANL), SNL team (???), Edison Liang (Rice)

Kinetic Dissipation of Large Amplitude E&M Waves in Collisionless Plasmas



Summary of the fusion science break-out session

Suppression of the Magneto -Rayleigh Taylor instability is desired



Preliminary 3D Gorgon simulations (J. Chittenden)

Magneto -Rayleigh Taylor (MRT) instability are the most significant concern for Magnetized Liner Inertial Fusion experiments

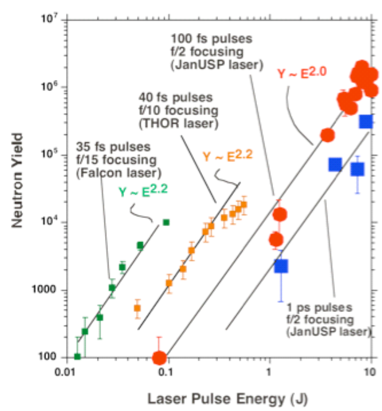
We would like to compare our code calculations with analytical models

We are interested in possible ways of suppressing the MRT instability, any analytical insight into this would be very useful

Sandia National Laboratories

Magnetic enhancement of neutron yield from clusters is being studied in a joint UT/Sandia LDRD

- Theoretical support is needed to understand cluster explosion and plasma confinement
- Design for experiments is underway and tests will begin within 6 months
- Immediate application could be calibration of neutron diagnostics on Z



3

Summary of the beams and particles break-out session

Santa Fe workshop
29 July 2009
Particle generation Breakout session

Matthias Geissel

Marius Schollmeier

Briggs Atherton

Marcus Roth

David Montgomery

Mike Downer

- Laser Wakefield Acceleration
  - Mission statement: To develop the technology to extend laser wakefield acceleration to 100GeV and convert the electron energy to high brilliance coherent x -rays.
  - Impact: future compact HEP sources, compact ultrashort coherent x -ray source that complements LCLS, astro-physics (inter galactic jets, pulsar behavior)
  - Readiness to start
    - Build on 20 -years LWFA worldwide experiences at sub GeV level
    - Preliminary multi -GeV LWFA experiment in progress at Texas Petawatt at $n_e \sim 10^{17}$ cm^{3}
      - Extensive modeling of LWFA initial experiments at the Texas PW system has been completed
    - Initial milestones
      - Obtain multi -GeV electron bunches with nano -coulomb charges
        - » Understand current vs. input energy and interaction length
      - Use result from UT experiments as inputs to model LWFA at lower density at $n_e \sim 10^{16}$ cm^{3} and meter scale propagation length
      - In collaboration with SNL develop a way to guide a Petawatt laser over meters in $n_e \sim 10^{16}$ cm^{3} plasmas
        - » Use pulse power in conjunction with laser initiated filaments to form a fully ionized meter scale guide channel
        - » Establish parameters required for guiding a Z -Petawatt pulse over meter scale with relativistic intensity
      - Convert and optimize LWFA multi GeV electrons to multi keV x -rays.
  - Where to be done
    - Initially University of Texas Petawatt laser facility (best suited and most probable for success)
    - Develop laser guided channel at SNL
  - Additional capabilities needed
    - Develop and field diagnostics for LWFA experiments
    - Feedback to make robust modeling of input parameters
    - Pulse power and laser trigger for guide channel

- High energy proton development (>100's MeV)
  - Mission statement: Achieve high energy (500MeV), high current ($>10^8$) mono - energetic ($\Delta E/E<10\%$) protons beams.
  - Impact (proton radiography, 250Mev for medical applications, isochoric heating)
  - Readiness to start:
    - The community has started
    - Establish an approach to achieve the goal (milestones)
      - Pre pulse, energy, pulsewidth, energy density, target geometry, polarization, wavelength of laser, contrast, how these parameters effect proton production
    - Need better characterization diagnostics of the laser pulse on target
      - Standard diagnostics for laser facilities
        - » Allen Wooton to invite people from (SNL, LANL, LLNL, UT, LLE, RAL, GSI, LULI, CEA, ILE, JAEA) for laser diagnostics standardization and protocols to HEDP Washington DC for breakout session
        - » Cross calibrations between the different laser facilities
    - Use spectrum of protons for astro -physics applications
  - Where to be done
    - Laser labs (SNL, UT)
  - Additional capabilities needed
    - Laser improvements
      - Polarization control and diagnostics (circular)
      - High contrast control and diagnostics (>10^9)
    - Target fabrication capabilities
    - Theory and simulation capabilities
      - Consolidate theoretical and modeling approaches to proton production

- Pulsed thermal neutron source
  - Mission Statement: Develop an intense sub eV prompt neutron source (< μs).
  - Impact: Temperature measurement of macroscopic warm dense matter.
  - Readiness to start:
    - Developed 10^9 neutron source established (not thermal)
  - Where to be done:
    - UT and SNL
  - Additional capabilities needed:
    - Develop theory and modeling (including nuclear physics input) to obtain temperatures from scattered thermal neutron spectra.
    - Develop theory and modeling (including nuclear physics input, activation cross -sections) to optimize thermal neutron source
    - Compact Reliable moderator

Summary of the High Energy Density break-out session

Participants in breakout: Erik Brambrink, Gilliss Dyer, Ray Lemke, Jean-Paul Davis, Alvin Trivelpiece, Alan Wootton, Pravesh Patel.

Description of problem:

The main components of the earth's core include Fe, Ni, and Si. The melting curve of iron in the 100-400 GPa pressure range is one of the most important constraints for the chemical composition and energy balance of telluric (earth-like) planetary cores. Of special interest is the boundary between the inner and outer core, which is a transition from solid to liquid iron. The solidification process of iron at this boundary is an important contribution to the dynamics of the earth core, including generation of the earth's magnetic field.

The relevant pressure and temperature are 3.5 Mbar and 6000 K (shown in dashed circle of Fig. 1). To date, measurements using shock compression techniques do not attain sufficient material compression (see Fig. 1), and static techniques do not attain sufficient temperatures.

In this regime uncertainties in the iron phase diagram remain. It is necessary to perform off-Hugoniot measurements to access a broader region of the phase diagram to complete the description of the Equation of State (EOS).

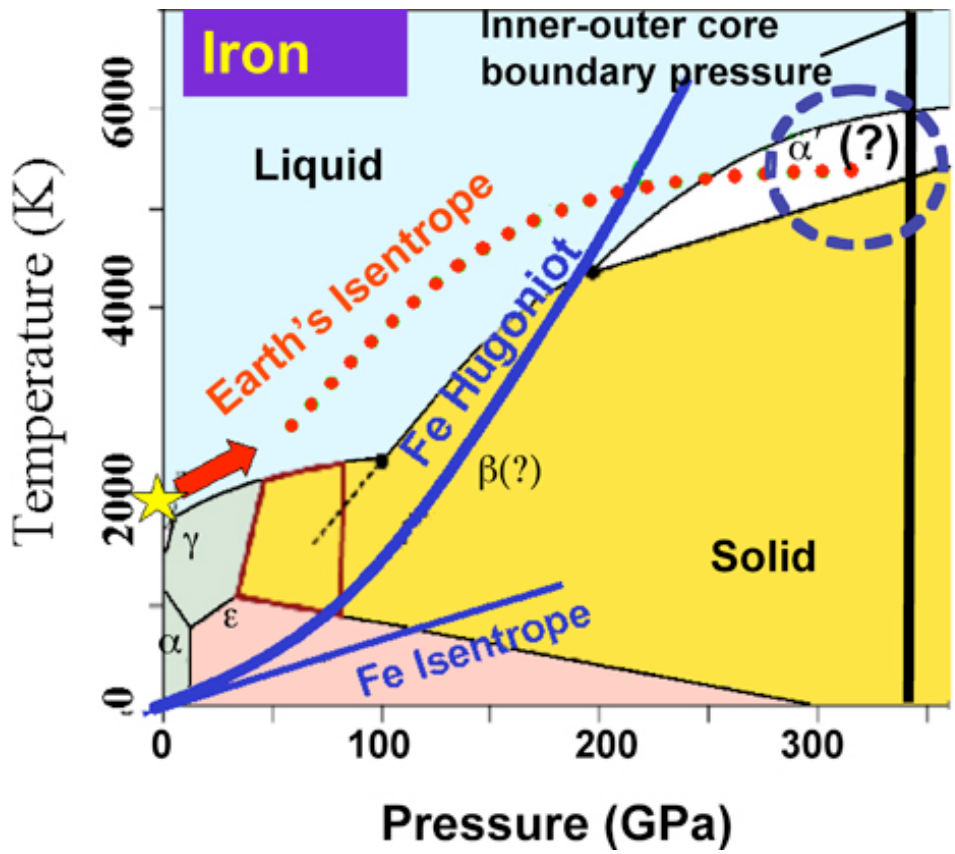


Figure 1: Iron phase diagram. Principal Hugoniot curve and isentropes are just indicative

Envisioned experiment:

A promising method is to isentropically compress a pre-heated target using the magnetic pressure of the Z-machine. Experiments on the Z machine have demonstrated the capability to measure principal isentropes to ~400 GPa with an accuracy of 1-2% (e.g. Ta). With the additional capability to preheat samples, the required temperatures should also be attainable.

Technical considerations:

Preheating

Minimizing thermal gradients before the shot.

Attaining appropriate temperatures (2000 K) in the presence of the heat sink of the rest of the system.

During the preheat process, maintaining void-free intimate mechanical contact between materials in path of the ramp wave

Target Fabrication

Planar compression target with release window.

Rugged enough for the preheat process.

Diagnostics

Low temperature pyrometry – measures preheat and compressed temperature

X-ray radiography

X-ray diffraction (time-resolved) – a probe of crystal lattice structure

VISAR – for measuring release isentrope at back surface

X-ray Thompson and Compton scattering – a density and temperature diagnostic in development

Likely experimental setup:

Preheat will be achieved potentially by inductive or proton heating. This technological developmental effort leverages previous work at all institutions involved. Inductive heating on Z has been preliminarily developed at Sandia. Proton heating has been developed at LLNL, UT, LULI, and Sandia. Inductive heating has the benefit of being conceptually simple, but requires a time-duration (~20 s) over which heat conduction into the rest of the setup becomes important. Pyrometry for the measuring of the preheat temperature will be developed using techniques used at LULI for this purpose. Proton heating is technically challenging, but has the benefits of being a rapid and local process so that the rest of the system is not affected. This technique of preheating has the additional advantage of potentially attaining much higher temperatures. The proton source size would be small (mm scale), and would have to be a filtered ~22 MeV source to achieve more uniform heating throughout the target thickness. The source could be timed to heat immediately (microseconds) before the Z shot.

The target will be a planar compression target configuration commonly used on Z, to attain pressures of about 4 Mbar.

The diagnostics include those that are already commonly used at Z, such as VISAR, X-ray radiography. A capability for time-resolved X-ray diffraction will be developed for this experiment, leveraging experience within the UT group, LLNL. Capability for X-ray Thompson scattering is currently being developed at Sandia.

Roadmap:

Develop heating technique (resistive/inductive)

Test proton heating feasibility

Develop pyrometer

Develop x-ray radiography

Develop x-ray diffraction (off-line on Al single crystals, melting process)

Final target design (heating, compatible with diagnostics)

Distributed Tasks:

University of Texas

- Investigate question of proton heating over large areas to 0.1 eV.
- Single-crystal production of Al for benchmarking time-resolved X-ray diffraction.
- Using UT petawatt for x-ray source studies (radiography, diffraction)
- Full time student devoted to these activities at Sandia
- Contact planetary physicists at UT
- Computing facilities (Ranger, Lonestar)
- Pulsed power machine under development, coupled to PW laser for testing – 2 MA capabilities planned

Sandia

- Facility (Z-machine, ZPW)
- Heating technology (resistive technique already under development, 700 K reached; previous preliminary work on inductive technique for higher temperatures is not currently being pursued)
- MD (VASP), MHD calculations – note that VASP is not export controlled
- VELOCE facility for testing – 2.5 MA, outside the main area
- Target development
- Computing facilities: Tbird (8960 CPUs); Red Storm (9600 nodes)

LLNL

- Expertise in proton heating, optimization
- Complementary experiments using lasers

LULI

- Pyrometer
- MD/Hydro/QMD simulations and computer clusters (IDRIS)
- Planetary physics expertise (Paris university)
- X-ray diffraction and radiography
- Complementary laser experiments and test beds

Question for discussion:

How do we implement this new collaboration under the auspices of the Joint Institute?

What other materials are of interest?

What are the applications relevant to even higher temperature and pressure regimes?

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Future directions:

Eventually, it will be important to consider the influence of impurities (mainly silicon, nickel, oxygen and sulfur).

The cylindrical liner compression technique could be fruitful for achieving >20Mbar pressures for studying giant telluric (rocky) planets.

This technique of preheating has the additional advantage of potentially attaining much higher temperatures, which, in conjunction with cylindrical compression geometries (see future directions), may enable research into regimes of large planets, WDM regimes interesting to those studying opacity and ICF, as well as more extreme regions in the parameter space.

Appendix 1: Organizing committee

General Organization:

Alan Wootton, The University of Texas at Austin, Ramon Leeper, Sandia National Laboratories, Roger Bengtson, The University of Texas at Austin

Astrophysics:

Edison Liang, Rice University and Greg Rochau, Sandia National Laboratories

Fusion:

Boris Breizman, The University of Texas at Austin, Mark Herrmann, Sandia National Laboratories and François Waelbroeck, The University of Texas at Austin

Particles and Beams:

Briggs Atherton, Sandia National Laboratories and Todd Ditmire, The University of Texas at Austin

High Energy Density Physics:

Aaron Bernstein, The University of Texas at Austin, Gilliss Dyer, The University of Texas at Austin and Ray Lemke, Sandia National Laboratories

Appendix 2: Attendees

Aaron Bernstein, The University of Texas at Austin,
Aaron Edens, Sandia National Laboratories
Alan Wootton, The University of Texas at Austin
Alexey Arefiev, The University of Texas at Austin
Alvin Trivelpiece, Oak Ridge National Laboratory, Retired
Boris Breizman, The University of Texas at Austin
Briggs Atherton, Sandia National Laboratories
Carolyn Kuranz, University of Michigan
Chris Fryer, Los Alamos National Laboratory
Christopher Kueny, Sandia National Laboratories
Dale Welch, Voss Scientific
Damon Giovanielli, Los Alamos National Laboratory, Retired
David Ampleford, Sandia National Laboratories
David Montgomery, Los Alamos National Laboratory
David Rose, Voss Scientific
Don Winget, The University of Texas at Austin
Duane Liedahl, Lawrence Livermore National Laboratory
Edison Liang, Rice University
Ehud Behar, Technion Israel Institute of Technology
Erick Lindman, Los Alamos National Laboratory
Erik Brambrink, Ecole Polytechnique
Everet Beckner, NNSA
François Waelbroeck, The University of Texas at Austin
Gilliss Dyer, The University of Texas at Austin
Greg Rochau, Sandia National Laboratories
Hui Li, Los Alamos National Laboratory
Jean-Paul Davis, Sandia National Laboratories
John Porter, Sandia National Laboratories
Keith Matzen, Sandia National Laboratories
Ken Struve, Sandia National Laboratories
Marius Schollmeier, Sandia National Laboratories
Mark Herrmann, Sandia National Laboratories
Markus Roth, Technische Universität Darmstadt
Matthias Geissel, Sandia National Laboratories
Michael Cuneo, Sandia National Laboratories
Michael Montgomery, The University of Texas at Austin
Mike Campbell, Logos Technologies, Inc.
Mike Downer, The University of Texas at Austin
Nathan Joseph, National Security Technologies LLC
Pravesh Patel, Lawrence Livermore National Laboratory
Ramon Leeper, Sandia National Laboratories
Ray Lemke, Sandia National Laboratories
Roberto Mancini, University of Nevada, Reno
Rodney Mason, Research Application Corporation
Roger Bengtson, The University of Texas at Austin
Ross Falcon, The University of Texas at Austin
Steve Slutz, Sandia National Laboratories

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Tom Intrator, Losa Alamos National Laboratory
W. Kirk Levedahl, NNSA
Wendell Horton, The University of Texas at Austin

Appendix 3: Agenda

Tuesday, July 28

8:30 – 6:00 Plenary Session

- 8:30 - 8:45 Opening remarks, objectives: Alan Wootton (UT)
- 8:45 - 9:15 An overview of SNL facilities, user experiments and user access: John Porter (SNL)
- 9:15 - 10:00 An overview of The Texas Petawatt and other laser research programs: Aaron Bernstein (UT)
- 10:00 – 10:15 Break
- 10:15 – 12:30 Astrophysics research using lasers and pulsed power. This session organized and chaired by Edison Liang (Rice) and Greg Rochau (SNL)
  - 10:15 - 10:45 Edison Liang (SNL)-*An overview of laboratory astrophysics experiments*
  - 10:45 - 11:15 Roberto Mancini (UNR)-*Photo ionized plasmas as related to astrophysics*
  - 11:15 - 11:45 Ehud Behar (TIIT) -*Laboratory Astrophysics of Active-Galactic-Nuclei Outflows with Powerful Z Pinch Experiments*
  - 11:45 - 12:15 Greg Rochau (SNL)-*Astrophysics on Z*
  - 12:15 - 12:30 Discussion
- 12:30 – 1:45 Lunch
- 1:45 – 3:45 Fusion research using lasers and pulsed power. This session organized and chaired by Mark Herrmann (SNL), François Waelbroeck (UT) and Boris Breizman (UT)
  - 1:45 - 2:45 Boris Breizman (UT) and Roger Bengtson (UT)-*Cluster fusion*
  - 2:45 - 3:30 Steve Slutz (SNL)-*Magnetic liner inertial fusion*
  - 3:30 - 3:45 Discussion
- 3:45 - 4:00 Break
- 4:00 – 6:00 Particles and Beams research using lasers and pulsed power. This session organized and chaired by Briggs Atherton (SNL) and Todd Ditmire (UT)
  - 4:00 - 4:30 Marcus Roth (GSI)-*Laser driven proton beams and medical applications*
  - 4:30 - 5:00 Mike Downer (UT)-*Wakefield accelerators*
  - 5:00 - 5:30 Pravesh Patel (LLNL)- *An Overview on Proton production and Electron Cone Fast Ignition*
  - 5:30 - 5:45 Erik Brambrink (Ecole Polytechnique)-*Laser generated x-ray sources*
  - 5:45 - 6:00 Marius Schollmeier (SNL) -*Laser generated protons*

Wednesday, July 29

8:30 – 10:30 Plenary Session

8:30 – 10:30	High Energy Density Physics research using lasers and pulsed power. This session organized and chaired by Aaron Bernstein (UT), Gilliss Dyer (UT) and Ray Lemke (SNL)	
	8:30 - 9:00	Ray Lemke (SNL) - *Producing HED material states via magnetically driven planar and cylindrical configurations on Z*
	9:00 - 9:30	Mike Cuneo (SNL) - *X-ray and magnetic-field-driven HED experiments on the Z facility*
	9:30 -10:00	David Ampleford (SNL/Imperial College) - *Creating HED jets and flows using high current pulsed power facilities*
	10:00 - 10:25	Pravesh Patel (LLNL) – *Laser-based experiments on warm dense matter*
	10:25-10:30	Discussion
10:30 – 10:45	Break	
10:45– 12:45	Parallel Breakout Sessions	

Breakout Session Schedule

Astrophysics

Organizers: Edison Liang (Rice) and Greg Rochau (SNL)

- Greg Rochau (SNL)-*Possible astrophysics experiments on Z* (5 minutes)
- Wendell Horton (UT)-*Simulating solar wind interactions; what has been done and what could be done* (20 minutes)
- Don Winget (UT)-*White dwarfs* (20 minutes)

Fusion

Organizers: Mark Herrmann (SNL), François Waelbroeck (UT) and Boris Breizman (UT)

First: Cluster fusion, organized by Boris Breizman (UT)

- *Size Distribution of Microclusters in Laser-Irradiated Plasmas* by Alex Arefiev (UT)
- *Modeling Approach for Cluster Explosion and Confinement* by David Rose (Voss)
- *Kinetic Modeling of Laser-Induced Fusion* by Peter Stoltz (Tech-X)
- *Design of High Magnetic Field Experiment* by Ken Struve (SNL)

Second: Magnetic liner inertial fusion, organized by Mark Herrmann (SNL)

Particles and Beams

Organizers: Briggs Atherton (SNL) and Todd Ditmire (UT)

High Energy Density Science

Organizers: Aaron Bernstein (UT), Gilliss Dyer (UT) and Ray Lemke (SNL)

Thursday, July 30

8:30-12:30 Plenary Session

8:30 – 9:15	Summary and discussion of astrophysics breakout session, with proposed research: Edison Liang and Greg Rochau
9:15 – 10:00	Summary and discussion of Fusion breakout session, with proposed research: Mark Herrmann, François Waelbroeck and Boris Breizman
10:00 – 10:15	Break
10:15 – 11:00	Summary and discussion of particles and beams break-out session, with proposed research: Todd Ditmire and Briggs Atherton
11:00 – 11:45	Summary and discussion of High Energy Density Physics breakout session, with proposed research: Aaron Bernstein, Gilliss Dyer and Ray Lemke
11:45-12:00	General discussion, including any other ideas
12:00 noon	Closing remarks: Alan Wootton